

**Minutes of FHWA Recycled Asphalt Pavement Expert Task Group  
Meeting date: July 24, 2012**

Recycled Asphalt Pavement Expert Task Group Purpose:

The primary objective of the FHWA Expert Task Group is to coordinate, develop, and improve national guidance and recommendations for the asphalt pavement recycling program. This group will provide feedback as well as encourage correct utilization of recycling technologies and address construction problems with current state-of-the-practice solutions.

A regular meeting of the Recycled Asphalt Pavement (RAP) Expert Task Group (ETG) was held at the Radisson Hotel in Arlington, VA on July 24, 2012. The meeting convened at 8:00 AM, Chairperson Gerald Huber presiding, and Lee Gallivan, secretary. A total of 40 individuals attended the meeting (17 members, 21 visitors, and 2 contract personnel). Attachment A is the meeting Agenda, Attachment B includes a listing of the ETG members, Attachment C is a listing of the committees and task groups of the RAP ETG, and Attachment D is the listing of Questions for the AASHTO SOM Materials Recycling Survey.

**1. Call to Order**—Chairperson Gerald Huber (Heritage Research) called the meeting to order at 8:00 AM.

***Welcome and Introduction:***

Chairperson Gerald Huber (Heritage) welcomed all to the meeting, and reported the last meeting of the RAP ETG was on May 11, 2011 so he wanted everyone to introduce themselves before starting the meeting. Huber also reported the last meeting resulted in a long list of action items.

***Roll Call; Members in Attendance:***

Members of the FHWA Recycled Asphalt Pavement ETG that were in attendance at the July 24, 2012 meeting included:

Gerald Huber,	Heritage Foundation (Chairperson)
Lee Gallivan,	FHWA (Co-Chairperson)
Audrey Copeland,	NAPA
John D'Angelo,	D'Angelo Consulting
Jo Daniel	University of New Hampshire
Jon Epps,	Texas A&M University
Mike Harnsberger,	WRI
Ed Johnson	Minnesota DOT
David Lippert,	Illinois DOT
Becky McDaniel,	Purdue University
Andy Mergenmeier	FHWA
Jim Musselman,	Florida DOT
Jim Pappas,	Delaware DOT

Ron Sines,	Old Castle Materials
Randy West,	National Center for Asphalt Technology
Dale Williams	Missouri Asphalt Pavement Association
Richard Willis	National Center for Asphalt Technology

***Members Not in Attendance:***

Hussain Bahia,	University of Wisconsin-Madison
Phil Blakenship	Asphalt Institute
Don Brock,	Astec Industries, Inc.
Bob Forfylow,	LaFarge Canada, Inc.
Hamid Moussavi,	Caltrans
Kurt Williams,	Washington State DOT

***Contract Personnel:***

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

***“Friends” of the ETG in Attendance:***

Haleh Azari, AASHTO	Ala Mohseni, Pavement Systems
Gaylon Baumgardner, Paragon Tech. Serv.	David Newcomb, Texas A&M University
Jason Bausano, MWV Asphalt Innovations	Gerald Reinke, Mathy Construction
Ryan Clark, Municipal Group of Companies	Chuck Paugh, ESC Inc./FHWA
Matthew Corrigan, FHWA	Gerald Reinke, Mathy Construction
Everett Crews, MWV Asphalt Innovations	Roger Sandberg, Maxam Equipment, Inc.
Danny Gierhart, Asphalt Institute	Richard Schreck, Virginia Asphalt Pavt. Assoc.
Nelson Gibson, FHWA	Annette Smith, PQ Corporation
Elie Hajj, University of Nevada at Reno	Chris Williams, Iowa State University
Greg Harder, Asphalt Institute	
Tom Harman, FHWA	
Edward Harrigan, NCHRP	

After the introductions, Huber announced copies of the agenda and list of members are being passed around the room. Lori Dalton passed a sign-up sheet around the room for the visitors to log in their attendance. Huber noted anyone wanting to be a friend of the committee should check the box on the visitor’s sign-up sheet. Huber asked if there were any questions or comments relative to the agenda. None were noted.

***Purpose/Mission of the ETG:***

Huber reminded the group on the purpose and mission statement of the RAP ETG. He read the purpose statement of the ETG, and reported the agenda for the meetings is structured around specific topics related to that mission statement.

***Review of Action Items from 2011 Meeting:***

Huber summarized the status of action items from the May 2011 meeting.

Coordination Effort for Selecting Virgin Binder/Blending Issues

1. Listing of research projects and findings being accumulated by Lee Gallivan will be submitted to the ETG members prior to the next ETG meeting.

STATUS: Huber reported this action item will be on-going to increase the amount of information available relative to the amount of virgin asphalt to be added. One of the tasks of this group was to provide information to states that do not use or use low percentages of RAP. He also reported Becky McDaniel is working with TRB to produce a circular on this topic to increase the use of RAP.

Target Low RAP Usage States Standing Committee:

2. Copeland will send the Tech Briefs on successes, studies, and fact sheets on using high RAP mixes to West for use in visiting agencies restricting the use of higher RAP content mixes.

STATUS: Continuing.

3. McDaniel will explore another venue for publishing the TRB circular.

STATUS: Will be discussed at meeting; item is on the agenda.

RAP Use Survey Standing Committee:

4. Pappas will ask to be on the agenda for the next SOM meeting related to the use of higher RAP contents.

STATUS: On-going survey to be discussed at the meeting.

Research Needs Standing Committee:

5. Epps and Corrigan will prepare a research needs statement on the use of recycling agents for determining mix properties for improved performance.

STATUS: One item from this group is there are issues still unknown, so a Research Needs Statement (RNS) is a major product relative to this item.

6. Brock and Forfylow will prepare a RNS on the use of anti-stripping additives and quantifying the effects of high RAP mixtures to improve performance.

STATUS: Both were unable to attend this meeting.

High RAP Performance Task Group:

7. McDaniel will attend the next LTPP meeting and make a case for the forensic investigations. If the support for this effort does not materialize, a RNS will be prepared to sponsor the forensic investigations.

STATUS: This activity is to answer the question: What effect does high RAP mixtures have on performance? The task group is looking at conducting forensic investigation studies for the LTPP sections that are going out of service. This action item is not included on the agenda.

8. West and McDaniel will prepare a listing of the SPS-5 projects and test sections of those still in service and those already taken out of service.

STATUS: Continuing.

9. Information Sharing: Daniel will forward their case study to Copeland; West will send the Florida information to Copeland; Copeland will summary this information and forward it to other agencies on the ETG.

STATUS: Huber reported on the website for advertising information from this group, in that this activity is important for getting information out for people to use and consider.

RAP ETG Website Standing Committee:

10. D'Angelo will forward the specifications from selected agencies (FL, TX, IL, OH, UT, and VA) to Willis in the near future for including them on the website.

STATUS: Some of these have been provided, but activity is continuing.

RAP Variability Task Group:

11. Reinke and Chaignon will share their data on variability with West.

STATUS: Continuing.

12. The webinar on "Best Management Practices" will be redone in the future. West and Huber will plan the Webinar.

STATUS: Continuing.

Framework for Building/Monitoring High RAP Content Mixes Task Group:

13. Copeland will distribute the document with comments on the framework to the ETG.

STATUS: Huber reported that Copeland has been involved in preparing a report for using high RAP content mixtures.

Case Studies Task Group:

14. Audrey Copeland will send the final list of items shown on the screen to the ETG for further comment and review.

STATUS: Continuing and D'Angelo has been looking at this.

Mixing and Compatibility of RAP/Virgin Binders:

15. Gaylon Baumgardner will send Kalberer some of his samples for expanding the database. Kalberer requested virgin and RAP binder samples (2 grams each) be sent to him for inclusion in the study. This request includes projects where softening occurred when adding RAP to the mix. He also requested the individuals send the physical properties of the binders. Two grams of asphalt is needed unless the individuals request other tests to be performed.

STATUS: Continuing and group has been looking into this.

Recycled Binder Percentages for AASHTO M 323 Task Group:

16. Peter Sebaaly will send his study reports and results to Frank Fee (Mixture ETG) for review and comment.

STATUS: Huber reported Gallivan has been leading but Copeland has been heavily involved in this activity. This activity is included on today's agenda.

17. Audrey Copeland will forward the revised M 323 to AASHTO (Rick Harvey) after making some minor changes.

STATUS: Done.

Huber reported this gives a picture of where we are at and what the ETG has been doing since the May 2011 meeting. Huber asked for questions from the group relative to the action items. None were noted. Huber turned the meeting over to Lee Gallivan.

## **2. Approval of Minutes from Last Meeting – Lee Gallivan (FHWA)**

Gallivan reported minutes and agenda were sent to all ETG members prior to the meeting and asked if there were any comments or revisions to the minutes. None were noted, so he noted the minutes are considered approved. Gallivan noted the sign-up sheets were passed around the room.

Gallivan reported this will be the last official meeting of the RAP ETG, because the RAP ETG is being combined with the Mixture ETG. He stated the action items will continue within that group of the Mixture ETG. He also reported the Warm Mix Asphalt (WMA) technical working group will be incorporated into the Mixture ETG.

Gallivan announced that a few members from the RAP ETG have been submitted for membership to the Mixture ETG. He reported the members nominated will be contacted to get their approval before adding them to the Mixture ETG membership. Tom Harmon requested that the next Mixture ETG meeting be announced. Gallivan announced; the next meeting will be on Sept. 24 in Minneapolis Park Place. The electronic notification of the meeting has been sent out; Lori Dalton is the person coordinating the meeting and invitation to the meeting for the membership.

## **3. Standing Committees and Task Groups Reports**

### ***3.1 Research Needs Statement (RNS): Experimental Design for Field Validation of Tests to Predict Cracking in Asphalt Mixtures - Updated*** – Randy West (NCAT)

#### Summary Report:

Randy West gave a verbal report on this topic. He reported the RNS was drafted some time ago and emphasized we need better tests to predict cracking. His opinion: we need to develop an experimental plan with that focus of developing/selecting better tests to predict cracking – both mix effects and pavement effects. We need actual, well-documented test sections (in terms of structural and other data elements) to be used. West's opinion: the best way to develop the experimental plan is through the use of accelerated testing facilities. Thus, the RNS objective is to develop a plan between the APT facilities to develop one or more tests for predicting cracking. The plan was sent to one of the tech groups of AASHTO and discussed at Vermont meeting about two years ago. West reported it did not move forward from that meeting, because minor corrections were to be made. He asked if more information was available on this item.

#### ETG Comments, Questions, and Discussion:

Audrey Copeland reported: the AASHTO tech group said the way the RNS was written was more like a proposal, so it needed to be rewritten in terms of a RNS. She commented; they liked the idea but did not like its format. Copeland reported; it was also submitted to Georgine Geary, rather than Eileen Sheehy in AASHTO. John D'Angelo commented accelerated loading excludes aging and noted the effect of aging on cracking must be included. He did not remember whether or not aging was a part of the proposal and thought that was another reason for AASHTO's

objection or not forwarding the RNS along. West replied to Copeland's comment; he remembered the RNS was criticized in being too detailed.

Jon Epps commented he and Matt Corrigan were assigned another RNS that is not on the agenda. Huber stated this is the time to review its status. Jon Epps reviewed some of the previous discussion and the result from that discussion was to bring it up at the next meeting. Matt Corrigan noted the title and the intent of the RNS – Use of Softer Asphalt or Recycling Agents in Mixes (with Recycling Agents). He referred to the sites to be used and the use of a strong or detailed literature review to ensure there is minimal duplication from other projects. Epps referred to some of the issues of age hardening and use of softer asphalts. Huber asked: what is the plan for the RNS? Epps answered if we do not get it to AASHTO right now, we might as well drop it. Becky McDaniel noted Ship Paul has taken over for the AASHTO group relative to this item and has been more active in getting RNSs moved forward. She also stated state agency personnel can push this one forward and recommended Skip Paul be contacted about this one. The suggestion was to have Lee Gallivan contact Skip Paul to make sure he is aware of this RNS. McDaniel volunteered to contact Skip Paul about this RNS, and noted the TRB committee overseeing this item was not planning to move it forward. D'Angelo commented AASHTO is looking for this group to recommend RNSs to be moved forward. Epps stated he sees no need for a detailed literature review on this topic, and asked if McDaniel was taking this RNS to Paul to find a champion to move it forward? McDaniel agreed. Huber asked for comments from other ETG members about the importance of this RNS topic. Epps noted Texas and South Dakota are interested in this topic and have RNS out on this topic. A friend of the ETG commented she was unsure whether there was a definitive need for more work on this topic at the national level. Huber asked: where do we go with this RNS? D'Angelo suggested Huber send the draft or latest version of the RNS to one of the tech groups as being the chairman of the RAP ETG. Huber agreed; he will contact Tom Baker and ask that Baker consider it at the AASHTO Subcommittee of materials. Epps commented; what is missing in the RNS is a detailed literature review. McDaniel's noted there have been a lot of recent studies that included literature reviews, so she does not see that as being an issue to hold it up.

Huber asked if anyone knew what the Netherlands is doing because most of their mixtures contain more than 50 percent RAP. He noted Imad Al-Qadi is visiting the Netherlands and Al-Qadi reported to him about the high RAP values being used on a routine basis. Huber stated it was unclear about how this was being done from a volumetric standpoint. Dave Newcomb referred to some of the findings from the WMA trip to Europe. Gaylon Baumgardner stated most of the Netherlands contractors know their materials a lot better, and heat and treat their RAP differently than we do – this usually requires a lot more processing of the RAP. Huber noted the issue he was asking about was the use of recycling agents as a softening additive. He commented it looks like they are at the leading edge for this technology. It was also noted the reason the Netherlands are using much more RAP is they do not have an adequate supply of good aggregates. Richard Schreck reported they have worked with a Japanese group and the standard policy is to use 80 percent RAP in base mixtures and 60 percent RAP in surface mixtures. He reported the Japanese would be out of business if they were limited to using 40 percent RAP. Epps commented this item is more important than we think it is. Huber agreed with that

comment and asked Corrigan to make some minor revisions/corrections to the RNS and he will follow up with Tom Baker.

Huber asked West about a specific recommendation for the RNS to develop-improve a test to predict cracking, but also asked West to send him the RNS. Huber will forward it to Tom Baker. D'Angelo suggested the RNS be submitted with a letter so that AASHTO will have something to act on. Huber noted that is why he asked West and Epps to send him their specific RNSs.

### **3.2 RAP Use Survey for 2013 and Beyond – Jim Pappas (Delaware DOT)**

#### Summary Report:

Jim Pappas started his report with a summary of the questions to be asked and asked the group what type of questions should be asked. He reported this survey dovetails with the one Audrey Copeland has been doing. He reported on and overviewed the survey in terms of RAP and recycled asphalt shingles (RAS) use and where this information can be obtained – report and survey information is available at [www.asphaltpavement.org](http://www.asphaltpavement.org). He asked: what questions do we ask relative to RAP and RAS? Pappas also reported he is no longer the representative from Delaware. Another person with the Department will push this survey out the door. Copeland stated another item previously discussed was to add rubber to the list of questions. Jim Musselman agreed with that comment because they get bombarded with surveys so combining them is a good thing. Jon Epps asked; is there anything about performance in the questionnaire? Pappas replied yes, and stated they do not plan to send it out until after another 1 to 2 months; so anyone wanting to add something to the questionnaire can certainly do so. Just send him the items to be added or revised.

Pappas showed the questions they were planning to ask (see Attachment D to the minutes), starting with the basic ones. He showed the questions included on the 2010 RAP survey, including WMA, and reviewed each one on the list. He considered question #10 an important one – identify research needs or guidance. After reviewing the questions for RAP, he then moved to the questions for RAS and recycled concrete asphalt (RCA).

#### ETG Comments, Questions, and Discussion:

Shane Buchanan asked: can you break the information presented down by layer? Pappas replied yes; the states that replied broke it out by layer. Ron Sines asked about contractors returning the RAP to the agency and how it is being used or reported – as a maintenance material? He also asked if including gradations were provided. His last comment; it would be nice to see if the answers are the same between the agency and contractors, as opposed to what the agency thinks the contractors are doing. Pappas noted a 70 percent response, and after bugging them, all but one or two states responded. Basically all states responded to the questionnaire. Richard Schreck suggested that the same survey be sent to the State Asphalt Pavement Association executive to see how different the answers are between the two organizations. He commented many times the answers provided by the agency are incorrect. If they are different, then you can or need to focus on the differences. Copeland agreed with that suggestion and recommended they send the survey out to the Asphalt Pavement Associations. Pappas agreed with the recommendation. He also

requested the questions be included in the minutes. He asked any suggestions or comments be sent to him and he will revise the questions prior to sending them out to the individuals.

### **3.3 NAPA/FHWA Survey Update – Audrey Copeland (NAPA)**

#### Summary Report:

Audrey Copeland gave a verbal report on this topic. She reported the survey was done last year between Dave Newcomb and Kent Hanson. Copeland briefly summarized the results and reported this information is available on the NAPA website – [www.asphaltpavement.org](http://www.asphaltpavement.org). She passed out a summary of the survey, and reported this survey is being repeated right now and encouraged all contractors involved to respond to the survey. Ron Sines asked: why the total tonnage reported went down, while the average percent RAP increased in HMA? Copeland agreed that was confusing. Copeland then overviewed the RAS information from the survey, which was also included in her summary report. After RAS, she summarized the use of WMA as an overview. She reported the percentage of WMA will be around 25% in 2011. She also stated foaming was the more common technology used. Newcomb agreed the percentage decreased between 2009 and 2010 on the use of WMA regarding plant foaming.

#### ETG Comments, Questions, and Discussion:

Huber noted about Richard Schreck's suggestion to send the same survey to the State Asphalt Pavement Association executives. Copeland commented different surveys are being sent. The survey she reported on and is referring to is the one that goes to their member companies – so no, it will not go to the Asphalt Pavement Association directors or executives.

### **3.4 Shingles – Best Practices Guide: NAPA Update – Richard Willis (NCAT)**

#### Summary Report:

Richard Willis gave a verbal report on this topic and summarized the work that has been done related to shingles. To this point, the Construction Recycling Association has put out its Best Practices Guide which is more for processing the shingles and is not related to including shingles in HMA mixtures. That Guide only briefly talked about the end use; there was only a paragraph or two on mixture design. They decided to prepare a different guide to provide more guidance on materials characterization and recommend the best method to determine the shingle gradation related to its use in HMA. Willis reported they are developing a document that will go through a peer review. That document focuses on material characterization. He also reported Chris Williams is looking into what impact shingles have on the HMA mix characterization – how to determine the properties themselves and not how to put them into the mixture design process itself. The two groups are trying to minimize the overlap between the two products.

#### ETG Comments, Questions, and Discussion:

Huber asked Willis about the status and review of the three documents being prepared: processing the shingles, determining properties, and the effect of shingles on performance. His goal is to send the document for determining properties to the committee by the end of next week. Willis agreed with that comment. Lee Gallivan asked about sending the reviewed or updated version back to the steering committee before it is distributed to the group. Huber noted

the steering committee would see it and then the ETG can take that document and go forward. Gallivan noted that answered his question.

Huber asked if there anymore questions for Willis. None were asked.

#### **4. Performance of Recycled Asphalt Shingles in Hot Mix Asphalt – TPF Project, Conclusions and Recommendations – Chris Williams (Iowa State University)**

Presentation/Report Title:     *Performance of Recycled Shingles in HMA Update of Pooled Fund Study TPS-5(213)*

##### Summary Report:

Chris Williams reported this is a 3 year study and it should be completed by December of this year. His report will summarize the results from this study. He acknowledged Andrew Cascione, Debra Haugen, Mihai Marasteanu and Jim McGraw which are involved in the study. He also acknowledged Audrey Copeland was FHWA's point person on the study before joining NAPA and Lee Gallivan is now that point person. Williams stated Missouri is the more aggressive agency related to this topic because they are the lead agency for the pooled fund study. The other partners for the study include: Iowa, Minnesota, Indiana, California, Illinois, Colorado, Wisconsin, and FHWA.

He overviewed the nine tasks of the study before getting into more of the details from the study. He reported and summarized the research interest of each agency partner included in the RAS study, including: Iowa on percentage of RAS; Minnesota on post-manufactured versus post consumer RAS; Missouri, Indiana, and Colorado on replacement of RAP with RAS; Illinois on RAS in SMA; and Wisconsin on RAS with RAP and 3G as a late compaction aide. Williams presented the laboratory testing plan and the tests completed by the partner agencies. This summary included the RAS properties in terms of gradation and how they varied by agency, the binder content, and high PG value.

William's report then focused on a review and summary of the demonstration projects, starting with the Iowa Demonstration project; summarizing their experimental plan which included 0, 4, 5, and 6 percent RAS. He reported that shingles do have an impact on gradation but it is very minor. He presented results from some of the performance testing completed for this project, which included:

- The mixtures dynamic modulus data start to deviate on the high temperature side but are close on the cold temperature side.
- The flow number significantly increases with higher RAS.
- The four point bending beam test shows a decrease with increasing RAS.
- The SCB fracture energy for low temperature cracking suggests there is an optimum RAS value but that lead into many more questions in terms of why the values or mix reacted as it did. For example: Is it a process of the test, mixture, etc.?

Williams showed some photos of the pavement surface over time; reflective cracking from the JPCP has occurred, and summarized the Iowa Pavement Evaluation comparing the amount of

transverse cracking between sections. He emphasized; they are seeing in the field after a couple of years what the SCB test predicted.

The Minnesota Demonstration project was the next one reviewed. This demonstration project compared 30 percent RAP mixes to 5 percent manufactured RAS and 5 percent post-construction RAS. The mix properties were illustrated and summarized in the same manner as for the Iowa Demonstration project. Williams reported; not a lot of difference between the high and low temperature sides across the board. He showed and compared the gradations, and reported similar results to the Iowa study but more divergence with some of the mixtures.

- The mixes with the shingles are performing better than the mix with the RAP in terms of fatigue cracking.
- No difference between the shingles and 30% RAP related to the SCB test results.
- Pavement evaluation: there are performance differences between the different mixtures related to transverse cracking, but it might not be that great – time will tell.

The Missouri Demonstration project included a comparison of fine versus coarse grind to a control mixture. The control mixture included 15 percent RAP, while the fine versus coarse RAS grind included 5 percent RAS with 10 percent RAP. Missouri decided to go with the fine grind mixtures based on visual observations after placement and compaction --- it was very evident that the fine grind was better. William's showed a photo of the surface texture of both the fine and coarse grind. He then presented a summary of the comparison of mixture properties. William's reported:

- There is a significant difference between the fine and coarse grind in terms of low and high temperature properties.
- Dynamic modulus results are similar to what others have found and reported.
- No flow number failure between all mixtures, so they compared the percent strain value at 10,000 cycles.
- No statistical difference between the SCB results of all samples.
- Pavement evaluation: the control had a lot less cracking within a year. The coarse grind section had much more cracking.

The Indiana Demonstration project included a comparison of a mixture with 15 percent RAP, 3 percent RAS in HMA, and 3 percent RAS in WMA. Becky McDaniel asked whether there was any difference in the RAS source between the HMA and WMA mixes – the slide shows post-manufacturer for the HMA mix and post-consumer for the WMA mix. Williams answered; the slide in error – both HMA and WMA included post-consumer RAS. Williams commented they followed the LTPP distress identification manual on all pavement surveys in all demonstration projects. For the Indiana Demonstration project, the WMA section exhibited a lot more cracking than the other ones.

John D'Angelo asked: was any long term aging done on the specimens? Williams answered; no long term aging was included – they only looked at up front or initial conditions. D'Angelo also asked looking at the last slide in this section, is this more of a post-consumer effect or a difference between WMA and HMA? Williams commented there are interactions or effects but the focus was on shingles and what was their impact on the WMA. It is difficult to define the

interaction, so it is hard to say or identify what is the pure contribution effect on cracking between WMA and HMA.

The Colorado Demonstration project included a control mix with 20 percent RAP as compared to a mix with 3 percent RAS and 15 percent RAP. Williams showed photographs of the pavement condition prior to overlay – extensive cracking. He summarized the mix properties but noted they did not have all of the test results for this report to show how the high and low temperature properties of the binder changed.

Williams reported not all of the tests had been completed for the Illinois Demonstration project. This demonstration project compared different PG grades with 5 percent post-consumer RAS for field produced and laboratory procedure test specimens. In addition, not all of the tests had been completed for the Wisconsin Demonstration project. The Wisconsin project compared mixtures with and without 3G Evotherm and included 5 percent Post-manufactured RAS and 13 percent RAP.

Williams provided a summary and comparison of the mixture properties between the demonstration projects for the four point bending beam (k1 versus k2 values) and SCB fracture energy tests. There was a consistent relationship between k1 and k2 for all of the mixtures tested, while the SCB results were significantly different.

Williams identified the remaining work, which included: continue to evaluate pavement performance, continue laboratory testing and analyses of results, complete the testing of the Illinois and Wisconsin Demonstration projects, develop specification recommendations, and complete the technology transfer products. He then spent some time on the RAS education part of the project, and emphasized there are a lot of individuals in industry that do not have a lot of knowledge about this technology. His point; you need to know where the shingles come from or their source and what qualifies them to be used. He referred to the different plant configurations and mentioned that one size does not fit all. Williams noted it is a good idea to introduce the shingles closer to the hot zone, which will prevent the shingles from clumping up. Related to volumetric properties, about 80 percent of the binder in the shingles can be utilized – not the entire amount. Typically, the value is closer to 70 percent, and you have to determine the RAS effects on the VMA and other volumetric properties. It is best or recommended to capture the effect of the fibers by doing tests. He reported Iowa is using the Hamburg device for comparing the different mixtures, and encouraged others to consider the use of shingles in SMA. His opinion; SMA is the best mix for utilizing the RAS.

#### ETG Comments, Questions, and Discussion:

John D'Angelo asked: is Iowa doing any long term aging of these mixtures? His point; you are assuming the long term aging is the same as for other mixes. Williams agreed with the comment and stated mixtures will not age the same. He continued with his discussion or explanation on this topic in terms of important factors that affect long term aging but noted that would have significantly expanded the experiment, which was not an option. The agencies made the decision on the factors to be included in the experiment and they decided not to consider long term aging. Williams pointed out; as of 2009, the “right” protocol to simulate long term aging had not been

agreed to or there was no consensus on the method to be used. He ended his reply that he agreed with D'Angelo's point about long term aging.

Gerald Reinke commented shingles age very quickly, and if you look at the recovered binder relaxation modulus or mix relaxation modulus you will see a big difference in the slopes between RAS and no RAS. Reinke mentioned initially the properties look great before aging at day 1, but after aging, the RAS mixes look significantly worse. He suggested we need to look at aging before making a final decision on this topic, and must not lose sight of this last step. Williams reiterated the decision was made after a lot of discussion between the partners and was based on information and tests available in 2009. Reinke asked: what was the production temperature for the WMA that exhibited more cracking; was the temperature below the softening point of the shingles? Maybe the production process did not soften the shingles asphalt sufficiently. Williams answered; all temperatures were about the same.

Randy West asked, based on the available data: did the SCB test do a good job to simulate field performance in terms of cracking? Williams replied; in some cases it did a good job, while in other cases it did not. He acknowledged you do see differences in the SCB test results between different labs in testing the same mix. He also noted the differences in age between when the projects were completed and tested. West's second point was related to mix design – shingle binders and others. Williams recognized more work needs to be completed in this area. West stated he disagrees with the factor included in the current AASHTO mixture design procedure, and believes you cannot combine all of the factors and make a decision about the mixture. He would rather do the individual mix testing. Williams agreed with that comment, especially with the low temperature cracking properties.

Frank Fee asked: do you have all of the information about the plants and how the material was handled during construction? Williams answered; yes and it will be included in the reports.

Huber followed up on West's question relative to mix design; if he understands what was done, the process Williams described and explained is fairly close to the AASHTO process or procedure; you have to add more asphalt. Williams disagreed with that comment because they get different asphalt utilization with different RAS types and amounts. West commented that is exactly what AASHTO recommends, but the assumption that fibers have no effect is incorrect. There was a significant debate between Huber, West, Williams, Bonaquist, and others on the impact of asphalt utilization for use of RAS and what factors are affecting the design of the mixture. Huber commented the asphalt contribution from the shingles is significant and there is a contribution but not for the entire amount of asphalt contained in the shingles. Ray Bonaquist stated his point or opinion is: someone needs to create a mechanism for monitoring these projects over time to evaluate whether raveling and other material distresses start to occur to answer this debate about binder utilization from the RAS on whether it is being properly or improperly considered.

## **Break**

Huber reconvened the meeting. Lee Gallivan reminded all attendees to sign the sign-up sheet.

## 5. NCHRP 9-46; High RAP Mix Design – Conclusions and Recommendations – Randy West (NCAT)

Presentation/Report Title:     *NCHRP 9-46 Improved Mix Design, Evaluation, and Materials Management Practices of HMA with High RAP Content*

### Summary Report:

Randy West reported he will provide a short version of the procedure, so there will be more time available for discussion. He started his report with the Project Objectives which included: provide guidance on characterizing RAP; revise mix design procedure for high RAP contents; and recommend performance tests for modulus, moisture sensitivity, rutting resistance, fatigue cracking resistance, and low temperature cracking resistance.

Best Practices for RAP Management. West overviewed the contents of the Best Practices for RAP Management. He also acknowledged that Ron Sines, Huber and he have done webinars on this topic which are available from the NCAT website. He briefly identified the contents within the document, which were covered in the webinars, and include: sources of RAP, processing, inventory analysis, sampling guidelines, handling RAP in the lab, testing options, and consistency of guidelines. He reported these items will be included in his report.

West identified the factors included in the experimental plan for the project, which included: 4 sets of materials from New Hampshire, Utah, Minnesota, and Florida; RAP contents of 0, 25, and 55 percent or 0 and 40 percent; and two binder grades and two binder sources. The tests and comparisons included volumetric and other fundamental properties. The next part of his report included an overview and comparison of the volumetric properties and other test results from the experiment.

- From the volumetric properties – changing the virgin binder source or PG does not appear to affect the volumetric properties; bumping the binder grade should not affect the optimum or design asphalt content; and incompatibility of binders may not be evident in volumetric design.
- Dynamic modulus testing used for two purposes: estimate the effective binder properties, and assess how RAP content stiffens the mix in terms of how it affects pavement design. West mentioned they have looked at these issues from the test track data and if used properly, it can be beneficial in stiffening the mix. He overviewed a summary of the E\* statistical analyses: RAP content had a significant effect on E\* at all temperatures and referred to Chris Williams' presentation in that log-log plots may not show the difference that really exists; E\* of high RAP content mixes were significantly higher than for virgin mixes; virgin binder grade did not have a significant effect on E\* at low temperatures – the influence of the virgin binder grade on E\* increased with higher test temperatures; and the virgin binder source was significant on E\* but only at the lowest and highest temperatures.

- AASHTO T 283 was used to evaluate the moisture damage susceptibility and increasing the RAP contents generally increased conditioned and unconditioned tensile strengths. West pointed out the TSR value can be misleading; although both conditioned and unconditioned tensile strengths increase, TSR values can decrease. A lower TSR criterion with a minimum conditioned tensile strength can help. West also noted the use of an anti-stripping agent can increase low TSR values.
- The Flow Number test was selected for evaluating a mixture's resistance to rutting for the experimental plan. West noted they started using a confined test procedure, but had to discontinue use of a confining pressure, because they were not getting any flow. He recommends going forward without using any confinement for the Flow Number test. He believes the preliminary criteria put forth are reasonable. The results indicate high RAP content mixes had statistically equal deformation compared to the virgin mixtures, and although not statistically significant using a lower virgin PG binder resulted in greater deformations. West recommendation is to use the unconfined flow number test and criteria included in NCHRP Report #673.
- West identified the tests used and considered for fatigue cracking. He mentioned they were planning to use the NCSU simplified viscoelastic continuum damage test but it had not been completed when this project started. He also reported they are not a fan of using the Texas Overlay Tester because of the unrealistically high strains that are recommended in this test. They considered the Semi-Circular Bend and IDT fracture energy tests. West explained the fracture energy test and how it is used for comparing mixtures. He did note that sometimes the RAP mix had lower fracture energy than the virgin mixtures. He also noted that the smaller NMASS had higher fracture energies.
- For low temperature cracking, they used Mihai Marasteanu's procedure for the Semi-Circular Bend (SCB) test. West noted information in the low temperature cracking slide is incorrect. With higher RAP contents, fracture toughness went down and the fracture energy increased. The others on the slide are correct; with increasing RAP contents – creep stiffness increased while m-value decreased. West noted the critical thermal cracking temperature is dominated by the virgin binder low PG and adequate thermal cracking resistance can be obtained with high RAP content mixes.

West provided some general guidelines in terms of their results but started with some initial comments and definitions. When we talk to RAP terminology we need to make sure we understand the terminology being used and to use that same terminology. He started with the definitions for processing, fractionation, RAP content, RAP binder ratio which he prefers to use, and warm mix asphalt.

West emphasized quality control (QC) of RAP is very important and they have recommendations for sampling the stockpiles multiple times but not to combine the samples so that variability can be determined, reducing samples to test portions, and inspection for deleterious materials. West opinion: deleterious materials content is very important and determining it is worthwhile. West summarized what they are recommending for the sampling and testing guidelines for asphalt

content, recovered aggregate gradation, recovered aggregate bulk specific gravity, binder recovery, and PG grading. He referred to and acknowledged the study done with Elie Hajj at UNR for developing these guidelines. West noted there are errors in some of the method for determining BSG that should not be used for high RAP content mixes. West identified problems with the solvent extraction, aggregate correction with the ignition oven, and asphalt absorption. West believes this is one of the most important findings from the study – no longer calculate aggregate bulk specific gravity because of potential errors but measure the recovered aggregate bulk specific gravity by AASHTO T 84 or T 85.

West recommended the aggregate properties must meet Superpave criteria for high RAP content mixture designs. For mix design, he is using the term RAP – Binder Ratio (RBR) rather than Binder replacement. Virgin binder selection is based on the RAP binder ratio as the following:

- RBR less than 0.15 use binder grade required for environment, traffic, and structural layer (i.e. may include polymer modified binder).
- RBR values of 0.15 to 0.25 use the standard binder grade for the climate (no polymer modified binder). If the mix is produced 25 F lower than the equiviscous mixing temperatures, the RAP binder ratio may be increased to 0.35 with the standard binder grade. This is the most controversial recommendation because adding polymer modified binder to higher RAP mixtures could make the mix stiffer and create more cracking. West mentioned some of these recommendations have been based on results from the NCAT test track and are not directly from this project.
- If the RBR value exceeds 0.25, the virgin binder grade is determined by a relationship based on the different temperatures. West provided the relationship in his presentation.

West overviewed their recommendations for mix designs for high RAP content mixes; in that the design should meet AASHTO M 323 and the following: always include moisture susceptibility using TSR or Hamburg device; use the AMPT Flow Number or APA for mixes in the top 50 mm for permanent deformation, but mentioned the Flow Number test is not needed for many mixtures with high RAP contents; fatigue cracking for surface and base mixtures are only needed for information purposes only, because he is not comfortable recommending a fracture test or cracking test that can be used on a routine basis (this is the reason for pursuing their RNS that was presented earlier in the meeting); for cold climates use some type of low temperature cracking test, but no specific recommendation for a test was identified.

West ended his report with the statement that the draft final report went to the panel a couple of weeks ago.

#### ETG Comments, Questions, and Discussion:

Hiafang Wen asked: what did you base your recommendations on – field or laboratory results? West answered; we used both to come up with our recommendations, it is a collection of data and information from different sources. Wen asked: how convincing are the laboratory tests? West replied; there is a body of work out there to show certain tests are better for estimating performance, but he was not recommending one over the other to identify a good test suitable for routine use for predicting a mixture's resistance to cracking.

D'Angelo commented; for a high RAP content mix, the impact for high volume roads with a thick structure might result in improved performance but its use on a low volume road might make it more susceptible to cracking because of increased deflections. West agreed that was a great point and agrees we need to consider properties and how they are used in pavement structural design to ensure improved performance. West referred to a slide explaining the perpetual pavement concept to reduce strains below some critical value. He noted where RAP mixtures do really well is when they are used in the middle layers – high stiffness mixtures. He cautioned against putting high RAP layers at the bottom because they are less strain tolerant or resistant to cracking. D'Angelo referred to some of the examples where mixtures at the bottom layer are stiff but use a higher binder content to make them more strain tolerant. West agreed with using those mixtures or SMA in the surface with RAP and RAS.

Friend of the ETG asked: do you have any recommendations for fractionating the RAP? West answered; fractionating did not necessarily improve the RAP but it is useful from a mixture's volumetric property basis, so he is not against fractionating the stockpiles. In other words, fractionating RAP is not needed from a production standpoint, but is useful from a mixture design standpoint. Another question was related to the use of film thickness. West stated he is not a fan of using film thickness because it is a calculated parameter and is heavily dependent on minus 200 material.

Richard Schreck commented; when SMA was first brought to the U.S. you had to use one grade stiffer to ensure good performance based on climate. He believes we need to be looking at higher binder contents because you have a stiffer mix. He believes we, as an industry, are making a mistake in that we are trying to stay at the same binder content for higher RAP mixtures. He believes you have to look at the true binder grade for the virgin binder – must know where you are starting from with the true grade of the RAP binder. West agreed with Schreck's comments, and definitely agreed with the comment about the binder content needing to be higher for higher RAP content mixes. West explained they looked at different test properties and found they needed a higher asphalt content to improve the properties from a performance standpoint. This was confirmed by Richard Willis' work. West commented there are some things a mix designer can do for improving the cracking resistance of a mix, but believes we need tests to indicate whether adding additives and/or higher binder contents is cost effective and can be substantiated for making an improvement.

Elie Hajj asked: how does adding dust change the process or properties or is it important? West replied; for designing all mixtures they stayed within the current criteria which controlled the amount of fines in the RAP that could be used.

Huber asked: what are the next steps coming out of this project? West replied; the normal process is to get feedback from the panel and then publish the final report. West reminded everyone, if you go back and look at the earlier presentations given to the ETG, things have changed since those first presentations – this is evolving as we go forward.

**6. High RAP Mixtures: Properties of Plant Mixes Containing High Asphalt Binder Replacement – Conclusions and Recommendations – Gerald Huber (Heritage Foundation)**

Summary Report:

Huber reported this effort was set up to determine how much RAP can you put through a plant and have a quality product that meets all of the mix design requirements. The considerations used in determining that value were quality of the product as typically measured during construction. Huber reported the trials included up to 70 percent RAP. He also mentioned he likes the term used by West in the last presentation – RAP Binder Ratio. Huber

Huber summarized Phase I of the project in terms of plant details, materials used, and the type of mixtures included. Huber showed photographs of the drum plant used for mixture production. This information also included the aggregate, drum, and mix discharge temperatures from the plant. Drum temperature was measured on the outside of the drum. Huber also showed photographs of the mixtures with different amounts of RAP to provide a visual image of how their visual appearance differed. He mentioned that the 60 percent RAP mixes looked pretty good, but the 70 percent RAP mixes did not mix as well or have good coating. From this production standpoint, they decided 50 percent RAP was the maximum.

Huber then summarized Phase II of the experiment and identified the equipment used. He showed photographs of the plant used in Phase II, and summarized details of the mix components and asphalt binder replacement values used. He also showed photographs of the different mix component materials included in the experiment. The next part of Huber's report was a summary of the production details (temperatures and amounts of materials) and mixture properties. He reported most of the properties were as expected.

Huber provided a summary and demonstration of the blending analysis and identified the details or information they were most interested in – the calculated and measured high and low grade temperatures. He showed a comparison of the calculated and measured high and low PG values. There was a consistent difference between the calculated and measured low grade temperatures and less bias for the high grade temperatures. The other test used in the experiment was the Cantabro Loss Test for durability. This is the LA abrasion test but without the use of steel balls. This durability test did not show any problem or difference between the different mixtures.

Huber overviewed details of the mix placement, and identified some specific details of the construction conditions and summarized some observations from the paving crew. Observations from the paving crew included: the mix flows through the paver, the mat lays well and required little handwork, and the mat compacted well without any signs of tenderness. He mentioned this project was not a density acceptance product. He also showed photographs of the existing condition of the pavement prior to overlay, the laydown operation, the surface of the uncompacted mat surface texture, the compaction operation, and compacted mat surface texture.

Huber summarized the results and conclusion from each phase of the project: Phase I – producing 50 percent RAP is a reasonable maximum value with a conventional counterflow drum; and for Phase II – durable mixtures can be produced and volumetric properties controlled with 50 percent RAP and with 67 percent asphalt binder replacement values.

ETG Comments, Questions, and Discussion:

Frank Fee asked: did the binder grade make a difference? Huber referred back to a graph or slide and replied no, there was no difference. Fee clarified his question: what about in the field? Huber answered; no difference in the field.

Lee Gallivan asked: where would you like to go with this? Huber commented there was not a lot of elaborate testing on this project, but noted there is a lot of RAP available in this area so the county engineer was interested in accepting higher RAP content mixes than allowed by the current specifications. Huber noted some of the upper limits for the technology, but commented we are doing or using amounts of material above those limits today and it appears 50 percent to be the value from this project.

Chris Williams noted there are some cost effective rejuvenators in the market today that can improve things and still increase the upper limit. Huber agreed with the comment.

Ron Sines asked: what about the length of the mixing chamber, where they different between the two plants, and was there any consideration given to looking at the different flight designs for lower volume production on the mixtures? Huber answered; the embedded burner was a Gencor but he was unsure about the length of the mixing chamber. Huber agreed the limitation on the volume of RAP through the chamber can be dependent on where RAP is introduced in the drum.

Shane Buchanan asked: what was the storage time of the mix? Huber replied; he did not recall what the storage times were for the two projects.

John D'Angelo asked some production questions: whether the RAP stockpiles are covered, was it dry weather, etc.? Huber replied the material was damp, and the stockpiles were not covered. Richard Schreck noted an item not typically discussed is the equipment or plant limitations that can limit the amount of RAP through a plant. His comment was related to a typical production process – whatever percentage we are trying to run, let's just heat up the virgin aggregate to heat the RAP. He commented this is not the current approach being used by others in the world. The RAP is preheated to decrease the amount of heat of the virgin aggregate. Heating the virgin aggregate to very high values, ages the mix. He noted there are other ways of getting there. Huber agreed with Schreck's comments, related to severely aging the binder with high production temperatures for heating the virgin aggregate to high levels for heating the RAP. Geoff Rowe also commented on the effect of heat transfer and on the impact of aging the binders. Rowe commented; we probably need to redesign the drums for these high RAP content mixes. Huber agreed with that comment.

**Lunch**

Huber reconvened the meeting at 1:15PM.

**7. Northeast High RAP Pooled Fund Study – Conclusions and Recommendations – Jo Daniel (University of New Hampshire)**

Presentation/Report Title:     ***TPF-5(230) Evaluation of Plant-Produced High-Percentage RAP Mixtures in the Northeast***

Summary of Report:

Jo Daniel commented she will give the group a quick update on the status of this project and will focus on recently collected data. This data includes binder tests on the recovered asphalt and different mixture tests. She plans to leave time for discussions on what is being suggested for the remaining 2 years of the project.

Jo Daniel started her report by acknowledging the participants for this pooled fund study, which include: the New Hampshire DOT (the lead agency), Maryland DOT, New Jersey DOT, New York DOT, Pennsylvania DOT, Rhode Island DOT, and Virginia DOT. She also acknowledged contractors have volunteered to produce different mixtures with different RAP contents. The study activities include: mixes samples and taken to lab for testing, SGC specimens compacted at the time of production, and data being collected on plant operations, materials, placement condition, and taking field cores – if possible. Daniel reported testing has been completed. She also acknowledged Gerald Reinke has been involved in this study and doing some of the testing. Daniel acknowledged the team which included the University of New Hampshire, Rutgers, University of Massachusetts at Dartmouth, and North Carolina State University. Daniel reported she will provide a summary of what has been completed under Phase I in terms of stiffness, fatigue, and low temperature cracking, as well as under the phase II silo storage study through the use of extracted binder and stiffness measurements.

Daniel presented a summary of the Phase I mixtures in terms of 2010 production, and noted they have a batch plant and two drum mix plants included in the study. She provided a summary of results already published under Phase I; the AAPT 2012 paper by Mogawer, et al. Some of the results included in that document are: increased RAP generally increased stiffness and decreased cracking resistance, softer binder grade is effective in some cases for mitigating increase in stiffness and cracking, there is an apparent effect of plant production (silo storage temperature) on stiffness, and reheated materials are stiffer in terms of effect of RAP and/or silo storage times – this issue lead to the storage study to explain some of the differences in results as part of Phase II.

Daniel reported, in the interest of time, she is just going to present the results from Phase I for the New York mixes rather than for all mixes, but testing have been completed for all mixes.

- Fatigue life prediction for NY PG 64-22 mix: As you increase the RAP content they are seeing better performance in terms of fatigue. At the 40 percent RAP mix; the rankings change at the higher strain level. At the lower strain level the rankings are different and consistent with increasing fatigue life with increasing RAP level up to 40 percent.
- Endurance limit for NY PG 64-22 mix: The endurance limit is increasing with RAP content. Daniel also demonstrated the effect of temperature and RAP content on the endurance limit, but noted this is probably a stiffness effect.

- SVECD fatigue summary: higher RAP contents generally result in higher load cycles to failure. Daniel mentioned they have yet to complete the SVECD, but will have it completed in the near future.
- Low Temperature extracted binder results: Four different methods were used for looking at critical cracking temperatures with increasing RAP content. The critical cracking temperature is the BBR. Two mix tests were used here, the IDT and the TSRST. The IDT resulted in much warmer temperatures in terms of critical cracking temperatures and they are still looking into what caused the warmer temperatures with the IDT. The analysis methods being looked at are becoming very important in terms of initial temperatures and cooling rates. Daniel presented the different initial temperatures and cooling rates used. She reported they used the TCMODEL to evaluate the impact of cooling rate using the NY40 percent RAP PG64-22 material.
  - John D'Angelo mentioned SHRP looked into the cooling rate effects and found differences. He also mentioned the cooling rates at the surface and at the center of the specimen are different and stresses built up differently. Daniel stated when presenting data from different tests, these values are usually not reported or considered but they can be important because you need to know where you are on the relaxation curve. Elie Hajj mentioned they are calculating the relaxation modulus and use different cooling rates. Geoff Rowe also noted Poisson's ratio effect in terms of loading conditions which can make a significant difference in the results.

Daniel reported they found warmer cracking temperatures with increasing RAP content, but softer virgin binder can help mitigate that effect. She also noted the impact of the starting temperature and cooling rate is important and noted further investigation and analysis on this topic is continuing.

The next topic covered in Daniel's report was the silo storage study. She reviewed the materials and conditions studies in Phase II. The mix was identified as a Callanan 12.5 mm mix with a PG 64-22 binder. Two mixes included: a virgin and 25 percent RAP mix. The silo storage times included: 0, 2.5, 5.0, 7.5, and 10 hours. The test specimen condition included plant compacted specimens, and loose mix collected and compacted in the lab. The testing on these specimens included: E\*, fatigue, and TSRST. The binder extraction and recovery was done by Gerald Reinke.

Daniel showed graphical comparisons from the test results under Phase II on the storage time. For the binder: longer storage times result in higher stiffness of the binder. For plant compacted dynamic modulus with 25 percent RAP mix; 0 and 10 hours storage time were statistically different, while the others were considered indifferent. For lab compacted mix; no significant difference in the dynamic modulus for the cooler temperatures; but the dynamic modulus values began to diverge for the warmer test temperatures for the storage times in comparison to no storage time. There is a significant difference in the effect of storage times between the plant and laboratory compacted test specimens, which was difficult to explain. Daniel noted some of the difference could be related to air voids and reheating the mixture for compaction between the two sets of specimens but those would not explain the large differences observed.

Daniel identified some general observations from the silo storage summary related to the use of dynamic modulus and binder stiffness: stiffening of the binder increases with longer storage times; general increases in mix stiffness with longer storage times; and reheating stiffens the mix in comparison to plant compacted without reheating but the difference between the two decreases with longer storage times.

West noted the terminology used by Daniel was somewhat confusing and suggested using the terminology of hot compacted and reheated in terms of identifying what types of specimens were used.

Daniel summarized the TSRST results in terms of the effect of longer silo storage times on the test results. For the high temperature grade recovered from the virgin binder, the results showed longer storage times created softer materials. Daniel noted they do not understand why this was happening so they reran some of the tests. Ron Sines asked: what type of fuel was used at the plant? Daniel answered; she did not know. West asked: where was the material sampled relative to the cone in terms of temperature? An answer to West's question was not given. Frank Fee asked: was an anti-stripping additive used? Daniel answered; she did not think any anti-stripping additive was used. The plant operator told them different asphalt was used to empty the tank at the end of the year; harder asphalt was used at the beginning in comparison to what was used at the end. Daniel noted because of this finding, all of the time zero specimens and mixtures are being redone.

Daniel reviewed the work that is continuing. Phase II mixtures includes the New Hampshire mixes and field sections, Virginia mixes and 2012 mixes, and new virgin silo storage study mixes. NCSU is doing work to refine the fatigue criterion for RAP mixes using the SVECD approach, and the low temperature analysis using the actual cooling rates and initial temperatures.

#### Discussion, Questions, Comments:

Nelson Gibson asked Jo Daniel to comment on the strain level for these mixes based on the pavement structures for the different projects. Daniel replied; they have not calculated the strain levels as yet, but plan to do so in the near future.

Geoff Rowe noted a key item is to link the binder and mix properties and suggested Daniel take the binder analysis and rheology properties and compare those binder properties to the same parameters determined from the mix. Daniel agreed with the suggestion. Rowe volunteered to work with Daniel on that topic. Daniel replied she like to have Rowe work with them.

### **8. Recycled Binder Percentages for AASHTO M 323 – Lee Gallivan (FHWA)**

#### Summary of Report:

Lee Gallivan reported the AASHTO M 323 revisions were forward to AASHTO last year and issued a thank you to Audrey Copeland. The actual revisions to the standard were submitted as a ballot. The ballot for these revisions resulted in some comments and a couple of negatives. The

comments were basically in three areas: the reviewers did not like where shingles were discussed, there were inconsistencies between the Appendix and binder replacements, and it was difficult to follow on what was being revised or included in the standard. Gallivan reported the standard has been revised based on the comments. His intent is to bring it back to the ETG and get inputs prior to sending it forward to AASHTO this fall or within a couple of weeks.

Gallivan noted John Harvey made an executive decision to remove everything related to RAS because of the comments. Gallivan reported everything related to RAS is gone. He also noted he will skip the editorial comments. The item to be discussed is related to the inconsistencies between the Appendix and the discussion on binder replacement. Gallivan noted the reviewers could not understand or follow what we were trying to do with Appendix X – Procedures for Evaluating RAP Stockpiles. Gallivan noted the purpose of this appendix was identifying what is out there in terms of stockpiles and how to evaluate those stockpiles.

Jim Musselman asked about the value of section X.1.2.4 on separating RAP with PMA from RAP without PMA. Becky McDaniel and others suggested this paragraph become more general by removing the word polymer. Richard Schreck noted they are separating out the PG76 because it is modified and they also separate out micro-surface because of the high binder content. His opinion; you do need to separate out the materials with different binder contents – this is stockpile management. It was agreed that the word polymer would be removed.

There was discussion regarding PAV aging of the RAP Binder. McDaniel noted PAV aging of the RAP binder should not be done. There was debate between Fee and D'Angelo in terms of what this was intended to do. Copeland checked and there is no PAV aging of the RAP required but noted the way it is written is confusing – treat the RAP binder as if it is PAV aged.

Gallivan noted they are looking at the average low and high temperatures between the stockpiles. Musselman noted he missed the last conference call. Musselman noted they are dropping the high temperature requirement because only the RAP controls the low temperatures and vice versa. D'Angelo noted the high temperature is supposed to be run via the standard, but it will not control the amount of RAP. There was continued discussion and debate between D'Angelo and Musselman on why run or determine the high temperature grade determination.

#### Discussion, Questions, Comments:

Ron Sines asked; does there need to be a caveat in the standard about changing binders within geographical areas, if they change? Richard Schreck stated you can have binders coming from different crude sources so the actual grade will change. He suggested watching the true grade regardless of where it came from. Schreck commented the true grade is not being captured here. McDaniel stated the purpose of this part of the standard or appendix is getting someone familiar with how the RAP stockpiles can change within an area or between areas. But you are still doing or evaluating the materials for a specific project. McDaniel agrees with Schreck and it is important, she is just unsure whether it fits within that paragraph; “evaluation of asphalt binder in RAP stockpiles in a typical geographical area ...” Ron Sines suggested adding a statement about understanding what virgin binder is being supplied to a specific area. There was debate between Musselman, D'Angelo, and others on whether the high temperature grade should be excluded or

included. McDaniel agrees with Jim Musselman. Musselman is of the opinion that both high and low temperature ends should be considered. Schreck commented you have to look at availability of the material. D'Angelo commented to keep this thing from getting to be a large document, it does not tell us to ignore the high temperature, but to focus on the low temperature. Ron Sines tends to agree with D'Angelo – he understands, but understands what Musselman is saying. Sines does not believe it is necessary from a contractor's point.

Chris Williams stated you can add a rejuvenator with this standard, but you are leaving yourself open if you only refer to just using the low temperature requirement. McDaniel stated she has worked with conditions requiring the mix to be too stiff – like shoulders. Her opinion is we need to look at the high temperature side to know how stiff it is. D'Angelo suggested taking out the low temperature term from the paragraph. McDaniel agreed with the suggestion. There was a lot of discussion on this topic of high versus low temperature values. Gallivan agreed he would remove the word “LOW”.

Gallivan reported a note was added, Note X7, as an example. He read the note and reported the note was added based on a comment from Musselman. Gallivan noted if the stockpiles are too variable within a geographical area, you may need to do this on a project by project basis. Ron Sines recommended you may need to just reduce the size of your geographical area.

Gallivan reminded everyone this does not address the big issue about eliminating all the additional RAP information from M 323 and creating an additional standard. Gallivan asked if this was acceptable to the ETG. Ron Sines asked: can this move forward with what he is going to mention? He has a problem with table 2 by adding a statement to the no-mans zone - above 25 percent RAP. He asked whether this can move forward as two separate items, one of which would be a caveat and consider this analysis. Gallivan answered probably not. D'Angelo referred to Bukowski's comment from the previous meeting that changing table 2 would probably create too many comments and negatives. His opinion, all Ron Sines was asking is to consider this in the future. Jim Musselman asked about the purpose of this appendix for revising table 2 from an individual state perspective and noting this is the purpose of the appendix for creating your own table 2. It was reported Rick Harvey did not want to do this initially because it would create more problems at least in his opinion. Audrey Copeland also noted that many individuals were of the opinion that would create too many problems. She noted, however, many agencies are now using this appendix for that specific reason. Corrigan asked Sines and others if you want something brought up at the AASHTO meeting, give him the write up and he will bring it up at the meeting. Sines asked Gallivan: how do you want to handle this? Gallivan asked Sines to send him the note and he will find an appropriate place to put it in. Gallivan noted Corrigan and Copeland will attend the AASHTO meeting, so it can be discussed then.

## Break

### 9. APT Experimental Design; Next Generation – Nelson Gibson (FHWA)

Presentation/Report Title:     ***Full Scale Accelerated Pavement Test; Cracking Performance of High RAP + WMA – Experimental Design and Timeline***

Summary of Report:

Nelson Gibson passed out feedback forms to get input and comments from the RAP ETG on the next APT experiment being planned which will focus on WMA mixtures with RAP. Gibson reported he is here today to get feedback and recommendations from the RAP ETG on the next APT cycle. He opened his report with a presentation on what they are looking for. Gibson first reviewed what they are requesting from the ETG through the feedback form: Does the experimental design look sound enough to write specifications up to the pre-bid stage? Gibson provided a brief review of the APT Turner-Fairbanks facility.

Gibson summarized the combined pooling results based on stakeholder input on the next ALF experiment. Gibson listed six items with the first and most important one being – Fatigue Performance of High RAP HMA and Overlays. The two initiatives being pushed to date include high RAP content and Warm Asphalt mixtures. The advantages of both were summarized by Gibson. The objective of the experiment based on the input from the stakeholders and issues related to both technologies is: *establish realistic boundaries for high-RAP mixtures employing WMA technologies based on percent binder replacement and binder grade changes when using high RAP with WMA.*

Gibson addressed and summarized key features of the experiment. The key features listed included: (1) the focus will only be on fatigue cracking with a temperature controlled condition at 20C – no high temperature rutting; (2) a three year completion schedule is being proposed with two years of loading and two ALF units that allow simultaneous loading; (3) an unmodified binder PG64-22 binder will be used for all lanes and all mix designs are to be the same; (4) the WMA technology which does not change the PG grade will be used in the experiment; and (5) the purpose this time is to use a load equivalent to a legal axle load – 20 kip equivalent axle load and the same pavement structure between the test lanes – 4 inches of the asphalt layer.

Gibson showed the experimental design layout or sampling matrix. He discussed the one cell that is impractical, so they are considering adding an additional cell by increasing the binder content of one cell with the highest RAP content. Gibson explained there are 4 sections for each test pad or lane. He explained that one section will be tested and the other three sections saved for a later date to evaluate long term aging and other items like the extension of life through the application of pavement preservation strategies. He would like suggestions on this from the ETG on this plan.

Gibson illustrated the planned loading sequence for the APT experiment. Audrey Copeland asked; why the value amounts of 25 and 40 percent were selected? Gibson explained how those values were determined. Richard Schreck stated; 30 percent is the typical value, so Gibson is beginning to push the bar with using higher RAP levels. Jon Epps pointed out the 350F was different than what was listed in the experimental plan. Gibson replied that was a typo, it should be 300F.

Gibson went on to show and summarize the laboratory characterization to address field sequencing. This included: plant produced, lab compacted and plant produced, field compacted.

He also stated they are planning to conduct bending beam fatigue tests on the plant produced, field compacted samples recovered after completion of the loading of each ALF pad. John D'Angelo is very skeptical about running fatigue tests on unaged material or mix. He asked; does this really tell us what the mix is going to look like 10 to 15 years down the road? Gibson answered and explained; what needs to be done for aging the mixtures is in terms of real field conditions in terms of what has been done in the past and what is planned for the pads – the pads will not be long-term aged themselves.

Gibson reported the portable seismic analyzer and FWD will be used in the field test program.

Discussion, Questions, Comments:

Dave Newcomb suggested adding one cell at 0% RAP which would be consist with reality and represent the baseline. Newcomb also commented on the small production sample of 1900 tons of mix. This amount is really small and would have concerns on variability through the plant for that small amount of mix. Gibson agreed with that comment and reported they were planning to produce more mix to be placed in other parking lots at the Turner-Fairbanks facility. Becky McDaniel suggested using 0, 20, and 40 percent RAP. Richard Schreck does not agree with using 0% RAP and suggested adding a cell with slightly higher binder content for the higher RAP cells. Jon Epps asked about how they plan to schedule the paving of the parking lots relative to the test pads. His experience is the chances of producing a mix that exactly meets the mix design or job mix formula initially through the plant is very small. Gibson replied; they have considered this issue which is the reason they have included additional areas to be paved outside the test pads. Epps also mentioned the thin versus thick issue (4 and 6 inches) for this experiment. The thickness of test pads is between those two thicknesses.

Huber wants to put one question on the floor: are there any plans to include shingles in the experimental plan or sampling matrix because of what Audrey Copeland showed this morning in her presentation – 1 million tons of HMA with shingles placed and this amount will grow over time. Gibson asked; does the ETG feel that shingles should be included in the APT experiment? His question was not answered prior to other comments being made on the experimental plan.

Huber commented; mixtures with RAP react differently between lab and field produced mixes with the shingles being added to the mix. Randy West asked about hot compacted or reheated samples being tested. Gibson replied; hot compacted samples will be produced – they will not be cooled and then reheated.

Haifang Wen asked; will the volumetric properties between all mixtures be the same? Gibson answered; they feel the volumetric properties will be under control when the test pads are placed based on the testing that has already been done in other experiments.

**Break**

**10. Identify Top Priorities to Transition to Mix ETG (Action Items) – Gerald Huber (Heritage Foundation)**

Gerry Huber commented; we need to look at where we go from here since the RAP ETG is being wrapped into the Mix ETG. The RAP ETG will probably become a task group under the Mix ETG, so he requested discussion on items to be forwarded to the Mix ETG. He first identified some items related to case studies, especially related to shingles, which he believes is a big hole. Huber's point was to identify issues for moving forward to the Mix ETG. For example, shingles as well as WMA that can be looked at under the mix ETG. His question; should these be put together or kept as separate topics, and what about rubber and other materials? Huber opened up the meeting for discussion on where we go from here.

- Randy West replied in terms of the case studies. West pointed out the WMA used in trial projects or demonstration projects for getting started and suggested something similar be established for RAS. Huber asked; is there a document or presentation that has already been put together for those items that should be included in case studies? Becky McDaniel thought that there was only a presentation on what should be included in the case studies, but it did not include any of the details. West agreed with McDaniel's memory and recommended that something be put together for summarizing the existing case studies that could be used to establish new ones for the future.
- Jon Epps asked; has anything been put together as a follow-up for evaluating materials and their performance – similar to what has been done for WMA? An answer to this question was not given before moving to the next comment.
- Dave Lippert agreed with what Randy West said earlier in the meeting and stated; we do not have a cracking test, so they have sponsored a study in Illinois for evaluating cracking and to determine basic properties for determining a mix's acceptability. This project was sponsored to identify what is needed to ensure Illinois DOT does not get into trouble.
- Tom Harman asked; what about training and are there gaps in training for taking full advantage to implement this technology? West answered; NCAT put together a package that considered RAP, RAS, and WMA individually. This was done separately for each material technology, but maybe we need something for combining these together that can be delivered at other venues. Gallivan replied; FHWA has received requests for training in each of these areas. Harman commented; with turnover in the State DOTs, how do we ensure adequate technician knowledge in these areas? D'Angelo agreed; training is a big issue – but some have been using RAP for a long time.
- Huber referred back to the issue of binder replacement value and asked; is it all active or is it all available? He stated there is a lot that we do not know and there is a lot of disagreement or debate on this issue in industry. Chris Williams commented; volumetric properties are a starting point, but the issue is – where should we spend our effort. Jo Daniels following up on what Williams said; many have seen some of the same and different things so the answer is – it depends. You can take the materials and put them through different production plants and the results will be different. Williams suggested about getting Joe Sher's (with Missouri DOT) experience and thoughts on what they (Missouri DOT) have been doing. Jo Daniel's

opinion; contractors need to know what they should do and understand what is happening for improving the performance of the mix.

- Jon Epps opinion; we are having difficulty in taking bits and pieces of information from laboratory studies for providing bits and pieces of field performance in providing guidance because of the diversity in the results of the test programs to date. It is not unusual to have bit and pieces, but we are having difficulty in making suggestions or providing guidance because of this difference.
- Frank Fee commented about the need to have a cracking test to predict performance. He believes this one should be the first one on the list.
- Epps believes that some information presented at today's meeting needs to make its way to the surface, so that it can be used.
- John D'Angelo mentioned about not using RAP in thin flexible pavements, but his question was; why does it not work and how can we design the mix so that it works. Epps opinion; there are technical solutions to all of these questions, but we have not focused on specific solutions. West replied; small mixes are still a good mix that can be used which was recommended from the 4.5 mm study – a good maintenance mix but did not work its way to the surface. Epps comment on that topic; we will be putting thin HMA overlays on poor performing roadways or roadway with a lot of distress – eventually we will be doing, so how do we do this?
- Haifang Wen suggested the performance model, as a whole, and the materials model need to be combined into one system.
- Jim Musselman following up on what needs to be done; his opinion – development of a cracking test needs to be first and foremost. The second item is related to M 323 and getting these things out to the users. His opinion; in the absence of experienced people, personnel are still going to make decisions. This group is an ETG which includes the experts, so we need to get things together for the agencies to use. Becky McDaniel suggested benchmarking items which can be really helpful, as was done during the Superpave development effort. We also heard about peer pressure, which can be real helpful. She suggests using results from the survey to reinforce and deciding what needs to be dropped and added to the list.
- Gallivan commented about a couple of agencies that started to get on board with increasing the RAP content. The idea is to hand a list of items to the mix ETG that need to be completed or need to be pursued. Newcomb asked; which agencies are we referring to? Gallivan referred to California. Huber summarized what was asked from California in terms of RAP use. He summarized the information provided to California during the visit which opened their eyes and allowed them to come to some middle ground in using higher amounts of RAP.
- Newcomb believes the tool box is important to continue to support.

- Gallivan asked about the importance of the website. Newcomb and McDaniel replied; it is essential. Gallivan asked; what updates need to be done? Richard Willis answered; the webpage has been recently updated and most reports are posted on that webpage. West suggested someone needs to look at the organization of the webpage to make sure it is organized properly. Jo Daniel agreed with others regarding an important place to find focused information on the use of RAP. Willis replied; it will take a little time to organize the webpage. Ron Sines stated; the website or webpage is the place to disseminate information for others in terms of marketing information related to the use of RAP. Sines opinion; this activity will be important in terms of marketing the technology and use of RAP.

Gallivan reported; they will take these recommendations and put them in some organized fashion for submitting to the Mix ETG. Huber asked Sines about marketing and what is the most critical thing to put forward. Sines replied; do not underestimate the importance of the surveys and trying to overcome the bias that exists in industry.

Jim Pappas stated; one of the biggest detriments is that agency personnel are too conservative, and there is a risk because they do not understand. Some agencies are allowed more freedom to try different materials and technologies, while others are restricted from taking risks. Pappas believes marketing the facts is important and is a good thing. He noted; a few good products is a good thing, but with trying something new, there are going to be issues that must be overcome – will not have 100 percent success. Sines also noted; remember, young engineers coming up through the ranks were trained by the older engineers that are retiring, so they can have the same biases.

D'Angelo noted there are items that can be overcome by doing some research that has not been looked in the recent past – this comment was related to the rejuvenators being used with RAP mixtures.

Corrigan stated; looking at the list that had been previously presented, is it suppose to be RAS best practices. Answer was yes. He suggests putting together a comprehensive document with putting RAP and RAS together. He believes this will be valuable to the AASHTO members and without that type of document he believes we will have a difficult time selling this technology.

Huber stated; remember, a while back only 14 agencies allowed more than a minimum amount of RAP in surface mixtures. Right now only 3 agencies restrict the higher percentages of RAP in wearing surfaces. Huber thanked everyone for making this happen. Huber asked for any additional items to be moved to the mix ETG. No additional ones were provided.

#### **11. Accomplishments of RAP ETG and Acknowledgements – Gerald Huber (Heritage Foundation)**

Huber reminded that sometimes we forget to say thank you for items well done. Huber noted that Lee Gallivan prepared a certificate for saying thank you to the individual members for participating on the RAP ETG over the years. These were handed out at the meeting.

**12. Other Business**

Huber asked for any other business to be brought before the ETG. None was noted.

**13. Adjournment**

As there was no other business of the RAP ETG, Huber adjourned the meeting at 4:45 PM.

**ATTACHMENT A:  
Recycled Asphalt Pavement Expert Task Group Meeting Agenda  
July 24, 2012  
Washington, DC**

8:00-8:15	Welcome and Roll Call (Introductions) Action Items from 2011	Huber
8:15-8:30	Approval of Minutes from last meeting(s)	Gallivan
8:30-9:20	<b>Standing Committees &amp; Task Groups</b> RNS: Advancing Studies, e.g., 9-55 etc. RNS: Experimental Design for Field Validation of Tests to Predict Cracking in Asphalt Mixtures- Updated RAP Use Survey for 2013 and beyond NAPA/FHWA Survey Update Shingles - Best Practices Guide: NAPA Update	Pappas West  Pappas Copeland Willis
9:20-10:00	Performance of Recycled Asphalt Shingles in Hot Mix Asphalt - TPF project, Conclusion & Recommendations	Williams
10:00-10:30	BREAK	
10:30 – 11:30	NCHRP 9-46 High RAP Mix Design - Conclusions & Recommendations	West
11:30 – 12:00	High RAP Mixtures: Properties of Plant Mixes Containing High Asphalt Binder Replacement – Conclusions & Recommendations	Huber
12:00-1:15	LUNCH	
1:15-1:45	Northeast High RAP Pooled Fund Study – Conclusions & Recommendations	Daniel
1:45 – 3:00	Recycled Binder Percentages for AASHTO M 323 – Resolution of AASHTO Comments	Gallivan
3:00 - 3:30	BREAK	
3:30 – 4:30	Identify top priorities to transition to Mix ETG (action items) Need for case studies Roll of Shingles – Development of Technical Information RAS Best Practices Combination of WMA, RAS, RAS RAP in rubber modified pavements AASHTO & NAPA Surveys	Huber
4:30 – 5:00	Accomplishments of RAP ETG and Acknowledgements	Huber

*All are welcome to stay for the Warm Mix Asphalt Technical Working Group Meeting starting tomorrow at 8 am!*

## Attachment B

### FHWA Recycled Asphalt Pavement Expert Task Group Members

Chairperson:

**Gerald Huber**

Heritage Research Group  
7901 West Morris Street  
Indianapolis, Indiana 46231  
Phone: 317-390-3141  
[gerald.huber@heritage-enviro.com](mailto:gerald.huber@heritage-enviro.com)

Co-Chairperson:

**Lee Gallivan**

Federal Highway Administration  
Office of Pavement Technology  
575 N. Pennsylvania St., Room 254  
Indianapolis, Indiana 46204  
Phone: 317-605-4704  
[Victor.gallivan@dot.gov](mailto:Victor.gallivan@dot.gov)

Members:

**Hussain Bahai**

University of Wisconsin-Madison  
3350 Engineering Hall  
1415 Engineering Drive  
Madison, Wisconsin 53706-1691  
Phone: 608-265-4481  
[bahia@engr.wisc.edu](mailto:bahia@engr.wisc.edu)

**Phil Blankenship**

Asphalt Institute  
Lexington, Kentucky  
Phone:  
[pblankenship@asphaltinstitute.org](mailto:pblankenship@asphaltinstitute.org)

**Don Brock**

Astec Industries, Inc.  
P.O. Box 72787  
Chattanooga, Tennessee 37407  
Phone:  
[dbrock@astecindustries.com](mailto:dbrock@astecindustries.com)

**Audrey Copeland**

National Asphalt Pavement Association  
5100 Forbes Blvd.  
Lanham, Maryland 20706  
301-731-4748  
[Audrey@asphaltpavement.org](mailto:Audrey@asphaltpavement.org)

**John D'Angelo**

D'Angelo Consulting  
8528 Canterbury Dr.  
Annondale, Virginia 22003  
Phone:  
[johndangelo@dangeloconsultingllc.com](mailto:johndangelo@dangeloconsultingllc.com)

**Jo Daniel**

University of New Hampshire  
W171 Kingsbury Hall  
Durham, New Hampshire 03824  
Phone: 603-862-3277  
[Jo.daniel@unh.edu](mailto:Jo.daniel@unh.edu)

**Jon Epps**

Texas A&M University – TTI  
3135 TAMU  
College Station, Texas 77843-3135  
Phone: 979-458-5709  
[j-epps@tamu.edu](mailto:j-epps@tamu.edu)

**Bob Forfylow**

LaFarge Canada, Inc.  
10511 15<sup>th</sup> Street S.E.  
Calgary, Alberta, Canada T2J 7H7  
Phone: 403-292-1585  
[Bob.forfylow@lafarge-na.com](mailto:Bob.forfylow@lafarge-na.com)

**Mike Harnsberger**

Western Research Institute  
365 North 9<sup>th</sup> Street  
Laramie, Wyoming 82072  
Phone: 307-721-2334  
[mharns@uwyo.edu](mailto:mharns@uwyo.edu)

**David Lippert**

Illinois DOT  
Phone: 217-782-7200  
[David.Lippert@illinois.gov](mailto:David.Lippert@illinois.gov)

**Andy Mergenmeier**

FWHA  
Phone: 410-962-0091  
[Andymergenmeier@dot.gov](mailto:Andymergenmeier@dot.gov)

**Jim Musselman**

Florida DOT  
5007 NE 39 Avenue  
Gainesville, Florida 32609  
Phone: 352-955-2905  
[jim.musselman@dot.myflorida.com](mailto:jim.musselman@dot.myflorida.com)

**Jim Pappas**

Delaware DOT  
Phone: 302-760-2400  
[james.pappas@state.de.us](mailto:james.pappas@state.de.us)

**Randy West**

National Center for Asphalt Technology  
277 Technology Parkway  
Auburn, Alabama 36830  
Phone: 334-844-6228  
[westran@auburn.edu](mailto:westran@auburn.edu)

**Kurt Williams**

Washington Department of Transportation  
P.O. Box 47365  
Olympia, Washington 98504-7365  
Phone: 360-709-5410  
[WilliKR@wsdot.wa.gov](mailto:WilliKR@wsdot.wa.gov)

**Ed Johnson**

Minnesota Department of Transportation  
1400 Gervais Avenue  
Maplewood, Minnesota 55109  
Phone: 651-366-5465  
[eddie.johnson@state.mn.us](mailto:eddie.johnson@state.mn.us)

**Becky McDaniel**

Purdue University  
P.O. Box 2382  
West Lafayette, Indiana 47906  
Phone: 765-463-2317; ext. 226  
[rsimcdamni@purdue.edu](mailto:rsimcdamni@purdue.edu)

**Hamid Moussavi**

Caltrans  
916-274-6176  
[Hamid.moussavi@dot.ca.gov](mailto:Hamid.moussavi@dot.ca.gov)

**Dave Newcomb**

Texas Transportation Institute  
3135 TAMU  
College Station, Texas 77843  
Phone: 979-458-2301  
[d-newcomb@ttimail.tamu.edu](mailto:d-newcomb@ttimail.tamu.edu)

**Ron Sines**

Oldcastle Materials  
14 Monument Square, Suite 302  
Leominster, Massachusetts 01453  
Phone: 978-840-1176  
[rsines@oldcastlematerials.com](mailto:rsines@oldcastlematerials.com)

**Dale Williams**

Missouri Asphalt Pavement Association  
P.O. Box 104855  
Jefferson City, Missouri 65110  
Phone: 573-635-6071  
[dalewilliams@moasphalt.org](mailto:dalewilliams@moasphalt.org)

**Richard Willis**

National Center for Asphalt Technology  
277 Technology Parkway  
Auburn, Alabama 36830  
Phone: 334-531-3150  
[Willi59@auburn.edu](mailto:Willi59@auburn.edu)

## **Attachment C**

### **Organization of FHWA's RAP ETG**

#### **Standing Committees**

- **Targeting Low RAP Usage States**
  - Purpose: Identify agencies with low or no RAP, identify what is restricting contractors from using more RAP if it is allowed in a state, and assemble information to provide to state agencies with low or no RAP
  - Lead: West
  - Members: Sines, Musselman, Pappas
  - Activities:
    - TRB Webinar "Design and Production of High Reclaimed Asphalt Pavement Mixes" <http://www.morerap.us/RAP%20Resources/webinar.html>
    - NAPA document How to Increase RAP Usage and Ensure Pavement Performance
    - Identify target states to go to and promote RAP usage
    - Pamphlet on RAP FAQ (West)
      - Review by Gallivan, Copeland, Corrigan, Newcomb, Sines
  
- **Coordinating Development of Research Needs Statements**
  - Purpose: To coordinate the RNS developed by the RAP ETG and present the RNSs to the appropriate AASHTO tech section.
  - Committee Lead: Pappas
  - Members: West, Huber, Copeland
  - RAP RNS
    - Cracking – outline for broad project including ALF, labs, etc., lab prediction test, link to performance, Lead: West
    - WMA & RAP/RAS , Lead: Corrigan
  - RAS RNS
    - RAS use and processing (expanding on Chaignon's presentation at Shingle Forum), Lead: Huber
  
- **RAP Use Survey**
  - Lead: Pappas (Cecil Jones)
  - Members:
  - Survey was conducted in 2007, 2009, and 2011.
  
- **High RAP performance from previous projects and field studies**
  - Lead: West
  - Members: Epps, Daniel, Musselman
  - Activities:
    - Request reports on performance of RAP mixes from state engineers
    - Contact states with 25% or more RAP for performance data
    - Analysis of LTPP SPS-5 RAP sections
  
- **RAP ETG website**
  - Lead: Willis

- Members: Sines, Mergenmeier, and Copeland
- [www.moreRAP.us](http://www.moreRAP.us)

### **Task Groups**

- RAP variability document
  - Lead: West
  - Report title: Summary of NCAT Survey on RAP Management Practices and RAP Variability <http://www.morerap.us/RAP%20Resources/reports.html>
- RAP State-of-Practice
  - Lead: Copeland
  - Assist: D'Angelo, Musselman, Weigel, Newcomb
  - Develop a best practices manual based on current best practices of RAP
  - Final draft ready for publication
- Performance tests for RAP mixes
  - Lead: McDaniel
- Document with 6-10 case studies
  - Lead: McDaniel
  - Assist: Daniel
- Develop Framework for Building/Monitoring High RAP Projects (similar to WMA framework)
  - Lead: Copeland
  - Members: Musselman, Pappas, Harnsberger, Epps
- RAP as percentage of binder
  - Leads: Gallivan/Copeland
  - Members: McDaniel, Sines, D'Angelo, Musselman, Corrigan, Mergenmeier, Williams
  - Framework recommendation to AASHTO for binder replacement/contribution

### **Other responsibilities for review and comment:**

- NCHRP 9-46 recommendations (West)
- Asphalt Research Consortium
  - Binder evaluation (Bahia)
  - Aggregate properties (NCAT rep, Haaj)
- NE States pooled fund study for RAP (Daniel)
- Missouri pooled fund study for RAS performance (Williams)

## **Attachment D**

### **2010 AASHTO SOM Materials Recycling Survey**

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#### **RAP**

1. Do you allow the use of RAP?
2. What is the maximum percentage allowed by your state in HMA/WMA
3. What is the average percentage normally used by the contractors/producers?
4. Do you have special requirements or limitations (such as fractionating, isolating stockpiles, special testing requirements, etc) when higher percentages (>25%) are used?
5. Are you utilizing WMA technologies in conjunction with increased usage of RAP?
6. Does the contractor retain ownership of the RAP after being milled?
7. What are the major concerns or obstacles cited when limiting or precluding the use of RAP in HMA/WMA specifically in surface mixes?
8. Have you experimented with, or do you routinely use “high percentage” RAP mixes (defined as >25% RAP)? If so, please provide any available information about your experiences including how long high percentage RAP mixes have been used in your state.
9. Please provide a link to your current specifications, if applicable
10. Please identify research needs or guidance that would assist you in increasing the amount of RAP used in your state.

#### **RAS**

1. Do you allow the use of RAS?
2. If you allow RAS, do you allow pre-consumer or post-consumer shingles, or both?
3. How does the plant obtain the shingles – contractor processing or third-party processing?
4. What is the maximum allowable percentage of RAS allowed by your state in HMA/WMA?
5. What is the average percentage actually used by the contractors/producers?
6. Do you have special requirements or limitations (special testing requirements, mixing RAS with aggregate to avoid clumping, RAS gradations, etc) when using RAS?
7. Have you placed HMA/WMA with RAS (even on an experimental basis)? If so, please provide any available information about your experiences, including how long mixes have been used in your state.
8. What are the major concerns or obstacles cited when limiting or precluding the use of RAS in HMA/WMA specifically in surface mixes?
9. Please provide a link to your current specifications, if applicable
10. Please identify research needs or guidance that would assist you in increasing the amount of RAS used in your state.

#### **RCA**

1. Do you allow the use of RCA?
2. If you use RCA, what do you use it for (aggregate base, aggregate in new PCC, other)?
3. What is the maximum percentage of RCA allowed by your state in new PCC?
4. What is the percentage actually used by the contractors/producers?
5. Do you have special requirements or limitations (special testing requirements, RCA gradations, etc) when using RCA?
6. What are the major concerns or obstacles cited when limiting or precluding the use of RCA?
7. Please provide a link to your current specifications, if applicable
8. Please identify research needs or guidance that would assist you in increasing the amount of RCA used in your state.