RAP ETG Phoenix, AZ Meeting Notes
October 28, 2008

Gerry Huber, RAP ETG Chair opened the meeting

- Welcomed members and guests
- Self introductions around the room
- Introduced RAP website: www.ncat.us/RAP/RAP.html
- Requested information about existing high RAP content pavements

Audrey Copeland: Guidelines for RAP Management and Discussion

Audrey Copeland is heading up a group that is developing a guideline for RAP management and usage based on the current practices. She gave a brief review of the available literature on guidelines for using RAP in mixes. Some of the projects she reviewed included:

- FHWA Pavement Recycling Guidelines for State and Local Governments
  - Limited information for Superpave
  - Good information on sampling RAP
- NCHRP Report 452
  - Summarized the guidelines out of NCHRP project 09-12
  - RAP can be used within Superpave
  - Lower binder grade as RAP content increases
- NAPA IS 123 Recycling HMA Pavements
  - General guidelines on the use of RAP
- NAPA, FHWA, AASHTO QIS 124 Designing HMA mixtures with High RAP Content
  - Guidance on the use of high percentages of RAP

Audrey Copeland also addressed some of the issues associated with using RAP in mixes. Some of those issues included:

- Manner in which effective binder grade is changed by the addition of RAP
  - RAP increases stiffness
  - Extraction and recovery procedures
- Meeting volumetric requirements
  - Gradation of RAP may contain too many fines
  - Consensus aggregate properties
  - Accurate specific gravity
- Effect of RAP use on production variability
  - RAP availability
  - Stockpile management
  - RAP moisture content
  - Plant limitations
  - Temperature restrictions
- Randy West commented that many contractors look for guidance on how to handle dust from RAP and the dust's effect on volumetrics and dust to binder ratio. Some contractors have questioned the specification range for dust to binder ratio. He pointed out that the current specification range was not based on a

study. It was suggested that a study focused on dust to binder ratio could be beneficial and that it may be that the simple ratio is too restrictive if performance tests show a mix is durable and rut resistant.

- Utah DOT has some questions about the low temperature performance of high RAP pavements
    - MnROAD has RAP sections down that can be looked towards for information on low temperature performance

Audrey Copeland pointed out that there are two NCHRP projects underway that address the use of RAP in asphalt mixes.

- NCHRP 09-33 Mix design for HMA
    - Chapter on recycled materials
    - The focus of the project is on mix design in general and not specifically on RAP mixes
- NCHRP 09-46 High RAP mix design
    - The focus of the project is on designing mixes with high percentages of RAP
    - NCAT was awarded the project earlier this year
- Summary of NCHRP 09-33
    - There is a section on sampling RAP
        - Collect samples for binder and gradation
            - Determine average and standard deviation for asphalt content and sieve analyses
            - Determined feasible RAP contents based on gradation and variability
            - The recommended extraction method is centrifuge and recovery is rotavap
            - It is recommended that the recovered binder should just be RTFO aged and tested as a PAV since it is assumed that there has already been aging of the RAP binder
            - A specific solvent is not recommended and selection of one is left to the user
    - Gerald Reinke asked if anyone has looked at how RTFO affects the binder properties. He commented that some studies show that there is still aging that occurs and maybe just looking at RTFO aged recovered binders is not adequate.
    - Becky McDaniel commented that there has been some investigation at the Asphalt Institute about the aging of RAP binders
    - Gaylon Baumgardner mentioned that there is an RTFO procedure for getting rid of the solvents not intended as a method for aging binders
    - Becky McDaniel agreed with Gerald Reinke that there is room for improvements but a starting point for handling the aging of RAP binders was needed which is where the current recommendations came from. Becky McDaniel said she is concerned about binder testing at 15% RAP instead of 25% in the current NCHRP 09-33 recommendations. She is

worried that this will result in a lower percentage of RAP being used because of contractors not wanting to grade the RAP binder
- Kent Hanson asked what was the bases of having the binder properties at 15% RAP
- John D'Angelo said the basis came from studies that mixes were being overly soft by changing the grade one grade
- Dean Mauerer said Pennsylvania's procedure has been to grade at 15% or greater RAP mixes
    - Pennsylvania saw some mistakes where the binder was too soft before grading of 15% or higher was implemented
    - Usually saw the issues at 20%
- A contractor from Arizona asked if they are recommending grading a RAP stockpile once. He felt that the recommendations from NCHRP 09-33 seems like a Catch-22 for doing the mix designs. The variability of RAP would not be known during the bidding stage if the pavement still needs to be milled, therefore the contractor would not know how much RAP could be added that would result in an acceptable variability. He felt like there is a lot more work that needs to be done to use the variability approach outlined in NCHRP 09-33 for including RAP in a mix

Audrey Copeland continued explaining the recommendations from NCRHP 09-33
- Listed 5 approaches for utilizing RAP
    - HMA tools with full RAP analysis
    - Design Charts
    - HMA tools with simplified analysis and design charts
    - Approach 1 with design charts used as educational tools
    - Quality classification approach
- Approach 1
    - Complex and required substantial sampling and testing
        - 10 samples for binder content and gradation
- Approach 2
    - Use design chart based on RAP content and variability
    - On also on RAP aggregate size
- Approach 3
    - Blending variability ignored use HMA tools with simplified method
- Approach 5 was eliminated by the panel
- Panel recommended approach 3
    - HMA tools with simplified assumptions
    - There is a procedure outlined for determining the blended binder grade
    - There is some concern that the selected approach may be incompatible with existing specifications
    - Estimating the standard deviation of the RAP properties is critical to the approach

- Applied upper confidence limits – Using 80% confidence which could limit amount of RAP tends to be overly conservative
- Kent Hanson pointed out that it is really the contractors responsibility and it should be left up to the contractors since they are the ones that have to deliver a quality mix
- Someone said that the deliverable for 9-33 was a mix design manual and tools for mix design, not a new Superpave specification
- John D'Angelo said that a lot of the tools were based on the assumption that the contractors would be doing the mix designs and not the states. One of the issues with doing it as part of an NCHRP project is it could become a specification. It is agreed upon that the 80% confidence interval should be allowed to change.
- Randy West asked when is the final report due
- Audrey Copeland said the pilot is in February on the 27th in Irvine
- Utah DOT representative said the contractor has to control the gradations and that the contractor puts a request into the DOT to use a higher percentage of RAP in Utah
- Dean Mauerer commented that a designer should look at more than the variability that a mix designer needs to look at if the design works
- David Lippert said that Illinois limits variability on high type roads
- Randy West interjected that there is a perception that RAP is more variable and that this is incorrect. Several studies including one that was done in Florida have shown that the RAP variability was lower than the virgin aggregate. Although there are contractors who do not manage their RAP stockpiles well and have problems, that should not be considered the norm.
- Gerry Huber said that the researcher for NCHRP 9-33 appears to have just read a textbook on how to run a plant and does not seem to have any real experience with plant operations. The variability of RAP really is not a concern. Do the current acceptance specifications take into account the variability of materials? Gerry Huber's experience has been that mixes containing RAP are not more variable.
- John D'Angelo agreed with Randy West and Gerry Huber and said that the issue in his mind is that RAP can be prone to segregation
- Kent Hanson and Randy West disagreed that RAP is more prone to segregation because it would show up as more variable in the testing of the stockpiles
- Dean Maurer said that volumetrics are affected by regionally variable aggregates. He thinks some of the issues are that old roads have materials from different contractors not all had good management practices

- Tim Aschenbrener said that Banks Construction fractionated and said they felt comfortable going over 20%. Banks construction did not observe any segregation issues when less than 20% RAP was used. Over 20%, the segregation prevented it from meeting South Carolina specifications
- Mauerer said that Pennsylvania has seen the same thing with virgin aggregate varying significantly; it is not exclusively the RAP.
- Utah DOT representative said that good blending is needed
- Mark Blow had a question about how do you bid a job when you can only use so much RAP based on variability. What if you go out and mill up a road and the variability is higher.
- Gerry Huber asked if HMATools is this meant to be a design guidance or specification
- Audrey Copeland said it is meant to be a guidance not a specification
- Kent Hanson asked if she was sure there is no plan to make a specification of these guidelines
- John D'Angelo said correct it will not be a specification
- Jim Musselman said we need to be careful that this does not become an AASHTO specification because this could really limit the amount of RAP
- It was asked what is the best way for RAP ETG to put forth guidelines and practices. What are the bounds for the standard practice?
- Huber asked is there a need for input from this group
- John D'Angelo said yes we can take the recommendations to the NCHRP 09-33 panel
- Audrey Copeland said the final report is due in December
- Ron Sines asked when will it be taken up by the SOC
- Cecil Jones said it should be into the committee chair by May
- Gerald Reinke said it is looking at pieces of mix design and not the process. Is anyone looking at the mix design procedure?
- Gerry Huber would like to provide input to AASHTO about our recommendations
- Jim Musselman said he is confused that we are putting the whole best practices on hold for 09-33. He feels that there are other areas that we need to address. He feels that we should go ahead with the best practices and make adjustments if needed based on the outcomes of NCHRP 09-33 and 09-46
- Dean Mauerer suggested that we put out a RAP ETG report
- Randy West agreed that we should work together as an ETG to come up with a best practices recommendation
- Andy Mergenmeier said we need to identify what is stopping people from using more RAP

- The group tasked with coming up with the best practices included Audrey Copeland, Jim Musselman, Dave Newcomb, John D'Angelo, Becky McDaniel, Ron Sines and Andrea Kvasnak
    - Draft document in 6 months
    - Wants it to go to SOC
    - AASHTO needs to see it as a living document and it will need to be updated
    - Needs to be in AASHTO format
    - Cecil Jones will march it through at SOC meeting
    - Cecil Jones sees it as a provisional recommended practice
    - Do we want a section on quality control?
    - Randy West wants to merge the document with the activities related to RAP management in NCHRP 09-46
    - Dean Mauerer feels that there are already recommendations in design documents. Feels best practices are a muddy area because people will want to make it a specification.

Randy West Summary of Contractors Survey and RAP Summit

- Online survey for contractors that can be accessed through the NCAT website (www.ncat.us) or go directly to: http://www.surveymonkey.com/s.aspx?sm=qri46A2rFtk1S5XMD6yJQw_3d_3d
- 25% contractors use Batch plants
- What is the point of entry for RAP?
    - In batch plants:
        - 62% at pugmill, 31% at weigh hopper, 7% at hot elevator
    - In continuous plants:
        - 32% behind the burner, 38% outer drum, and 24% at mid-drum
- Supply of RAP - Wanted to know if we could reach higher RAP percentages with the current RAP supply
    - 51% stable, 24% declining, 25% increasing supply
    - 43% of plants only have enough RAP to do just 15%
    - A lot of contractors out there cannot get the quantities
    - 50/50 split on using single stockpile or multiple stockpiles
    - Julie Kliewer asked if the RAP stockpiling is based on RAP aggregate size.
- 74% crush to a single size
- Asked for clarification if it is crushing or screening and Randy West responded that he asked for crushing and screening in another question
- Relatively small percentage of contractors are fractionating
- Screen size that they crush to is usually ½"
- 53% do not treat RAP stockpiles differently than virgin aggregates
- Only 9% use some sort of covering in stockpiles
- John D'Angelo said it would be great to give contractors some guidance and data showing the benefits of sheltering stockpiles

- Randy West agreed that it would be great to include that type of information into a RAP best practices which addresses stockpiling
- Kent Hanson has information on superheating and moisture contents of RAP
- Greater percentages of RAP in non-surface mixes, however the peak is still around 15% RAP
- If we are going to push for higher RAP percentages we need to encourage agencies to do more milling. We need to promote that as part of our efforts.
- Contractors stated in the survey that one of the biggest factors in limiting RAP usage is the specified RAP limit
    - This is what they say but the data shows that is not the case
- The majority of contractors sample their stockpiles once per 1000 tons or less
- 85% of the contractors surveyed are using the ignition oven to determine the asphalt contents
    - The issue with the ignition oven is you need to have an aggregate correction factor
    - We really don't know what that aggregate correction factor is when using the ignition oven
    - Randy West said this issue will be answered as part of NCHRP 09-46
- Average standard deviation for the asphalt content is 0.46 the range was 0.1 to 1.5%
    - John D'Angelo commented that the standard deviation seemed rather high since many specifications allow a standard deviation of around 0.2
- John D'Angelo pointed out that agency specifications could be more than the RAP percentage and could be volumetrics, etc which could be preventing higher RAP percentages
- Randy West agrees that it could be more than the limit on RAP percentage which is why the survey also asked if volumetric requirements were a limiting factor.
- Randy West says he does not want to tie the industry's hands to doing fractionating because there are plenty of contractors using RAP at high percentages without fractionating
- Randy West said that if you have millings and it is consistent you do not need to crush it again because it creates more fines
    - This type of guidance needs to be part of the best practices for RAP management
- Randy West continued with the presentation by summarizing the RAP variability study conducted by ICAR. The main finding of the study was that increasing the RAP percentage does not increase the variability of the mix
    - It was commented that if you compare the RAP standard deviations to typical quarry products, RAP is not as variable
- Randy West then discussed the RAP Summit that was recently held in Auburn, Alabama
    - Presentations from the RAP summit can be found at http://www.ncat.us/RAP/RAP%20Events/summit.html
    - RAP Summit came about because of escalating asphalt costs and wanted states to use higher percentages of RAP to offset costs
    - Chief engineers invited because we wanted the decision makers

  - Asphalt pavement associations executives were also invited
  - Speakers were selected based on real world experience and credibility
  - Kevin Keith, MODOT Chief Engineer started the meeting and told the audience that prior to 2003 MODOT did not allow RAP, but now are big believers in RAP
  - Dennis Rickard explained that we cannot expect asphalt to come back down to $300 tons just because the crude price has come down, there are other issues that need to be factored in
  - Charlie Potts covered the history of using RAP at the summit meeting
  - Jon Epps spoke about the benefits of recycling from economics and environmental sustainability analyses
  - Randy West presented information on the performance of recycled mixes
    - There is not a lot of good information out there on the performance of RAP mixes. If ETG members are aware of reports or information for existing RAP projects that have been down for several years to please let him know
    - SPS -5 mixes were built about 13 years ago and we should be going out there and looking at the performance of these sections
  - Don Brock talked about fractionating RAP and new processes that we need to put into place at the RAP summit
  - Cecil Jones discussed the State survey and what is the major barrier of using RAP
  - Jay Winford talked about using RAP from a contractor's experience. He gave a good example of wasting RAP as a shoulder backing material
  - Ron Sines summarized points made by speakers and called out some challenges to agencies as the closing presentation at the summit
- It was commented that the Bureau of Indian Affairs does not encourage RAP usage
- Do most states pay for asphalt by the mix? It gives them an incentive to use RAP
- Arizona and a handful of other states still pay for the asphalt separately

<u>Randy West, Andrea Kvasnak, and Jo Daniel – NCHRP 09-46</u>

The National Center for Asphalt Technology, University of New Hampshire, and University of Minnesota compose the research team working on NCHRP 09-46, *Improved Mix Design, Evaluation, and Materials Management Practices for Hot Mix Asphalt with High Reclaimed Asphalt Pavement Content*. Randy West, Andrea Kvasnak, and Jo Daniel summarized the research approach and status of NCHRP 09-46.

- The interim report was recently submitted and included information on the research plan and literature review
- Design philosophy is to follow with AASHTO M 323 and R 35 as closely as possible. Some additional steps will be added to address issues associated with high percentages of RAP in mixes. One of the major differences will be in lieu of extracting the blended binder and grading the binder, dynamic

modulus testing will be used with the Hirsch Model to back calculate the effective binder grade.

- Use standard binder grade and then once the volumetrics are ironed out check the stiffness of the binder to see if it is the right binder grade to use. If the mix is too stiff then a softer grade will be used.
- One of the assumptions of the proposed mix design is that volumetrics will not change with a change in virgin binder. This assumption will be tested by evaluating the effects of different binders using the same gradation.
- It was commented that fatigue and low temperature properties are of importance. Both fatigue and low temperature testing are part of the research project.
- One of the tests that will be included is flow number. It was suggested that the researchers speak with Harold VonQuintus who is part of the research team for NCHRP 09-30A which is developing a new flow number model.
- Jo Daniel explained the approach that will be taken to evaluate blending and to back calculate the binder stiffness.
- John D'Angelo recommended looking at virgin binder stiffness to get the acceptable range of stiffness for the E* data
- It was asked if the E* method will work for polymer modified asphalts? Jo said yes it will work for both neat and polymer modified binders.
- Randy West and Andrea Kvasnak discussed the remaining mix tests that will be used in the study. The moisture susceptibility test that was recommended by the research team was AASHTO T 283. Flow number testing will be used to evaluate permanent deformation. The specimens will be short term aged for 4 hours. A fatigue test has not been selected. Three tests are being considered for fatigue testing; overlay tester, AMPT fatigue, and beam fatigue. The research team is waiting on the results of the comparison of laboratory testing to field performance for the NCAT Test Track RAP study to make a recommendation for the fatigue test. Regardless of the test selected, the mix for fatigue testing will be short term aged loose and then compacted specimens will be long term aged. The low temperature testing that will be conducted will include semi-circular bend and bending beam rheometer with mix slivers. Like the fatigue testing, the specimens will undergo both short and long term aging.

<u>Copeland and Kvasnak – FHWA Field Projects</u>

One of obstacles identified by the RAP ETG at the first meeting was a lack of information pertaining to performance of field mixes. NCAT and FHWA are working in cooperation on a research project to document construction and performance of high RAP content field projects. Both parties are sampling mix and running laboratory tests. Multiple projects have been documented. Audrey Copeland and Andrea Kvasnak presented on one project that was constructed in Daytona, Florida in December 2007. The project consisted of four mixes, two WMA and two HMA. The WMA technology used was Astec's Double Barrel Green. One WMA and one HMA used a PG 64-22. Extracted data of these mixes indicated that the blended binder was too stiff so a softer binder was used.

The softer binder selected was an RA 800. A WMA and one HMA were constructed using the RA 800. The majority of the data presented was for the two mixes containing the RA 800 binder. The HMA with the RA 800 was considered the control out of the two mixes containing the RA 800.

- The binder recovered from the control mix graded out stiffer than the binder from the WMA mix
- The notation in the graphs is as follows:
  - Green is the WMA 2560
  - Red is the Hot mix 5710
- Reinke suggested looking at the mix over an aged time for the dynamic modulus testing. He has notices changes in the dynamic modulus results when he ages mixes to different extents.
- The Francken model is being applied to the flow number data
- The softer binder could be affecting the dynamic modulus values
- One of the observations of the flow number data when the Daytona mixes were grouped with FHWA other field data, the Daytona RAP mixes were not reaching the slope at 2% strain
  - Yellow triangles are the RAP mixes from Daytona
- Majority of high RAP mixes were not reaching tertiary flow at 2% strain
- Mixes containing high percentages of RAP begin to line up with the other mixes around 4% strain
- Geoff Rowe said that it looks like creep flow was occuring instead of dilation. He also said do not read too much into the data quite yet. Same dynamic response but different plastic response.
- D'Angelo said using E* perm. Def. could get you way off
- Hanson asked what is a good Flow Number
  - Copeland said a good flow number is what is suppose to be coming out of the Mix ETG
- Maurer asked if we made a comparison between the Witzcak and Hirsch

Items that the ETG would like to see out of the FHWA RAP study:

1. Comparison between Witzak and Hirsch models
2. E* at different aging times
3. Hamburg run dry on field cores
4. IDT E* on field cores
5. IDT creep compliance

<u>McDaniel – Performance Testing for RAP mixes and update on low temperature properties of plant produces mixes</u>

- Project started with an Indiana contractor, now they are testing mixes from contractors in _____ and _____
- The results provided in the presentation are very preliminary at this point.
- Dynamic modulus testing
- Indirect Tension
- The results so far indicate that they really did not need to change binder grade at 25% RAP

- Binder extraction and recoveries using T 319 with Toulene ethanol blend
- Huber -- Some of the data was counterintuitive, one mix became stiffer with 40% and another became softer.
- Kvasnak how were the RAP recovered binders differ from plant to plant
- D'Angelo commented that relaxation testing should be done to see if there is an issue with cracking and that binder stiffness will not give that information
- McDaniel commented that based on contractor encouragement and her study Indiana is considering changing its spec to allow 25% without binder change
- Rowe suggested plotting binder stiffness at the same loading time where you get a loading as done by Heukulum in 1965 AAPT paper plot on how to differentiate a mixture with different characteristics
- McDaniel recommended performance tests

Mergenmeier – VA DOT High RAP %'s in HMA

- Looked at high RAP to reduce costs
- Brainstormed about how to measure performance
    - Asked themselves what is limiting the current mixes in terms of performance
    - Construction quality or inappropriate maintenance
- Good relationship between agency and contractors
- Changed specification in VA to change when binder bumping was needed
- Most of the contractors checked asphalt content and gradation weekly
- Analysis of conventional mix versus high RAP…conventional mix was defined as what the plant typically ran so it could have been a low RAP percentage mix
- The new specification of next year in VA was presented (SEE ANDY'S SLIDES)

Rowe – Rheology

- Looked at how all HMA properties needed for the MEPDG can be derived from mixture master curves
- Would like to see more frequencies in current test method
- Thinks you can get shift parameters from mix data
- Use better shifting techniques
- Hirsch model cannot be used when data falls below a certain stiffness
- Frequencies that Rowe and Baumgardiner are suggesting 0.63, 1.0, 1.6, 2.5, 4.0, 6.3, 10, 15, 25 set 2 .01, .016, 0.25, .063, 0.1, .25, .4
- IPC is putting new software on website tomorrow
- Jon Epps asked if we have been able to test mixes at the loading frequencies and temperature more similar to what is seen in the field

Where are we at in addressing the Top 10 List

- Harnesberger has suggested using the LTPP distress manual

- Illinois is trying to get a better handle on what is the effect of aggregate quality
    - nPb is being looked at as a solvent
    - concerned about stripping
    - Looking to adopt a split ITS in addition to the TSR value
    - Been looking at WMA with higher RAP content
- Utah DOT, Howard commented that there is a big difference between the state and city/county
    - UDOT uses three binders and drop binder with higher RAP percentages
    - If they have 15-25% RAP they will not drop to a PG -34 because they have had issues
    - Tim Aschenbrener thinks more effort needs to be made in documenting field performance of high RAP mixes and thinks there needs to be some large funds to go towards just monitoring high RAP content pavements across the country
    - It was commented that the old top 10 list of barriers needs to be revisited and a new list developed
        - Brainstorm new top 10 list is an action item for next meeting for all ETG members
    - Randy West suggested encouraging more milling

Meeting closed for the day at 5:00 PM

October 29, 2008 Meeting Notes

A video on introducing RAP into a drum plant and using foamed asphalt was shown. The video was put together by Astec. Don Brock sent it along with three hand-outs.

<u>Harnesberger – Chemical Compatibility</u>

- Effective molecular weight increases as material changes from saturates to polar aromatics
- When you age an asphalt you affect the sulfoxide and ketone
- The largest effect on molecular weight is when an associated polar partners up with an associated polar.
- As you oxidize asphalts that are less compatible you tend to form very large associated species.
- Asphalts in the midrange tend to be the best performers
- The original drive of the Heithaus test stemmed from issues with compatibility of binders at the refinery
- Troy Pauli has automated the process of looking at the compatibility of binders
- In the Altgelt's GPC slide the numbers at the top of the chart are percentage of asphaltenes in binder and the numbers in the curve are the percent of molecular weight
- It is the associations that are driving the properties of the asphalt
- Altgelt also looked at the effect of solvents on viscosity
    - Solvent effect is very important

    - Solubility parameter was used to define the good solvent versus a poor solvent
- John D'Angelo asked if you have two PG 64's binders from different sources and you started out with one of them in a tank and there was some left when you added the second if you could end up with a binder that is no longer a PG 64 but is a lower or higher grade based on the chemical compatibility
    - Mike Harnesberger and Gaylon Baumgardner both stated that it is possible to end up with a binder of a different grade with the binders are not compatible
- WRI investigated compatibility of WMA and RAP
- The AFT is the automated system that Troy came up with to evaluate the compatibility of binders and has been used by WRI to evaluate compatibility of mixes with WMA additives and RAP
    - The price of the AFT runs around $50k
- The capital P in the Heithaus table is for compatibility. A higher P is good whereas a low P number means less compatible
- WRI looked at Sasobit and one of the zeolites to investigate the compatibility of WMA additives with RAP
- If crude prices remain high than the properties of asphalt are going to change

<u>Sebaaly – Design System ? to evaluate the properties of RAP Aggregates</u>

University of Nevada and the National Center for Asphalt Technology are investigating the effects of different extraction methods on aggregate properties. The three extraction methods that are being investigated are Centrifuge with TCE, Reflux with TCE, and ignition oven. Five aggregate sources are being evaluated and both institutions are using a PG 64-22. The aggregate properties are evaluated prior to being mixed with binder to make RAP. The loose mix was aged to simulate aging in the field to make the homemade RAP. The loose mix was then subjected to one of three extraction methods. Once the aggregate was extracted the same aggregate properties were rerun. The results of the aggregate properties before and after are being compared.

- Randy West suggested calculating for FAA with the original Gsb and one with the extracted sample Gsb to determine if the changes in FAA are due to changes in Gsb or particle shapes
- Kent Hanson suggested looking at the mixing the virgin aggregate dry or with water (no asphalt) in the mixer and then re-evaluating the virgin aggregate properties to see if that might be affecting the change in aggregate properties
- Kent Hanson also suggested adding information about the asphalt content that is calculated from each extraction method
- Randy West suggested that once the best procedure is selected that we could then look at different solvents
- Kent Hanson asked if we included any aggregates that were not 100% crushed
- John D'Angelo thinks you will start to see bigger differences when the material is in the reflux for longer than 8 hours

<u>Bahia – UW RAP Binder Research</u>

University of Wisconsin is looking at methods for evaluating RAP binder properties without solvent extractions.

- Looked at BBR with mix slivers, Single edge notch beam which can be run in a BBR, and DSR with torsion beams
- For the BBR they are using a RAP mortar which is the material passing the #8 blended with virgin binder. Mixed in virgin until they created a voidless mix
- 15% virgin binder ended up being the amount needed to make a voidless mix
- Mortar is poured into the beam molds
- Changed some of the standard BBR testing parameters because the mortars were so stiff
- Had to use a load that was much higher than 1000 grams
- Settled on 4000mN for the loading
- The temperature being used are -6 and 0 C
- Specimen thickness is 12.7 mm by 10 mm
- Aggregates do not mask the affect of aging using the BBR test
- Dean Mauerer asked if there is a significance in the change in the slope
    - Hussain Bahia said there is
- Hussain Bahia presented the protocol for the BBR that his research team is suggesting
    - They have a spreadsheet set up
- Dean Mauerer asked won't you see some problems if the ignition oven gives you erroneous asphalt content values. Won't that give you problems with stiffness

<u>Kliewer -- ADOT's RAP</u>

Julie Kliewer discussed the history of RAP usage in Arizona and then gave a summary on the renewed interest in RAP in Arizona.

- SPS sites still in place with 30-35% RAP that are 16 years old and are pretty well cracked
- Tried high percentages of RAP in the past and discontinued due to performance
    - One of the problems in the past was that very high percentages were used without a full understanding of how to incorporating RAP into a mix
    - This time around with allowing RAP, AZ is starting out conservative with low percentages
- Have done some cold in place and hot in place recycling
- In the past 15 years up until the current paving season RAP was used for shoulder build up and in bases only
- There is a large stone mix that is still in place that had 15% and 20% RAP. F and F crushed the material to use in a friction course
- The big challenge is overcoming past failures
- Another challenge is extensive rubber usage
- Stiffness of RAP is another issue and some of it could be perception
- Significant amount of the plants are mobile and not fixed site plants
- There is a perception by some that RAP is an inferior product
- The issue of how they pay for asphalt cement makes it more challenging for using RAP

- This past summer they had several successful RAP projects containing 15 – 20% RAP this was done by change order or value engineering proposals
- Industry prepared a proposed new specification for using RAP. They drafted a new mix design procedure
    - 15% or less no fractionation required and no binder grade change
    - 15 – 25% fractionation required and use one grade lower unless testing shows that it is not needed
    - Pay for mix and mineral admixtures as is done now
    - Pay for total asphalt cement in mix based on ignition results
- They want to get it done ASAP
    - Industry has to get the finished proposal to ADOT in November or early December
    - ADOT will review and then the AGC needs to review and approval
    - Final step is to have FHWA review and approve
    - Once they get all of the approvals they have to look at how it will affect their computer system
    - It then has to be issued as a stored specification
    - If Julie Kliewer had to guess she thinks it will be a standard specification in June, however it can be used prior to then
        - It will be incorporated into special provisions
    - Tim Aschenbrener asked how they pay for the quantity of asphalt content now and Julie Kliewer said that they use the ignition furnace
        - There is a system in place that prevents a contractor from being paid for more binder than there are invoices for
        - This could be problematic for the use with RAP
    - The contractors are worried that if they give the DOT part of the savings back that they will be viewed as an unbalanced bid and kicked out of the running for a job
    - So far no issues with the rubber friction course because they are milling down rather deep and those lifts were only about 0.5 inches.
    - None of the jobs that they have done so far have not used a softer grade
    - ADOT's new specification has the fractionation requirement because ADOT wanted to see the use of fractionation for higher RAP percentages.
    - It has been many years since they used RAP so they don't want to be on the cutting edge and wants to stay in the comfort safe zone
    - Randy West asked if contractors are recycling for non-DOT work and the response was they have been doing some in the last 6 months that has been about 15%
    - Randy West asked if they typically mill or overlay. Julie said that they do a lot of milling. One of the issues is who is the owner of the RAP. It tends to be project by project.
    - John D'Angelo said that the binder can be accounted for by subtracting the RAP asphalt amount from the overall.
    - ADOT has a lot of issues with transverse cracking with virgin mixes so there is a lot concerns about introducing a stiff binder into the mix

- Jon Epps agrees with ADOT to go slow and not fast in increasing the usage of RAP. Big change in one year.
- ADOT has funding to be able to do a quick limited evaluation of mixes so they might be able to replicate what Becky McDaniel did in the northern Midwest
- Jo Daniel did work similar to what Becky did but in NH. For mixes with 0-15% they saw some stiffening but then above that it dropped back down.
- Illinois may have some work that would be a good item to discuss

Action Items

- Audrey Copeland and Andrea Kvasnak will get together to summarize the field data and send out to everyone
- All members of the RAP ETG should review the top ten list and be prepared to revise it at the next meeting
- At the next meeting Illinois DOT research that David Lippert has been involved in should be presented
- The ETG should develop a research needs statement for collecting field performance of high RAP pavements for NCHRP funding
- Randy West will make a request to state engineers for any reports on the performance of mixes containing RAP
- All ETG members should investigate whether or not there are existing high RAP pavements in place in their regions
- Meet in New England in April timeline