FHWA
Asphalt Fundamental Properties and Advanced Modeling
Expert Task Group
July 23-24, 2007
Denver, CO

The meeting of the FHWA Asphalt Fundamental Properties and Advanced Modeling (Models) Expert Task Group (ETG) was held on July 23 and 24, 2007 in Denver, Colorado. Chairman A. (Tom) Scarpas with the Delft University of Technology, Co-Chairman Dallas N. Little of the Texas Transportation Institute., and Secretary Katherine Petros of the Federal Highway Administration (FHWA) conducted the meeting. Allen Cooley and Jimmy Brumfield of Burns Cooley Dennis, Inc. were present with Cooley acting as Secretariat and Mr. Brumfield assisting with the meeting.

*The following members of the FHWA Asphalt Models ETG **were** in attendance:*

A. Tom Scarpas, Delft University of Technology (Chairman)
Dallas N. Little, Texas Transportation Institute (Co-Chairman)
Katherine Petros, Federal Highway Administration (Secretary)
Imad L. Al-Qadi, University of Illinois at Urbana-Champaign
Jon Epps, Granite Construction
Gayle King, GHK, Inc.
Bob Kluttz, Kraton Polymers
Richard W. May, SemMaterials, L.P.
Magdy Y. Mikhail, Texas DOT
Julie Kliewer, Arizona DOT
Bob Statz, Consultant

*The following members of the FHWA Asphalt Models ETG **were not** in attendance:*

William Buttlar, University of Illinois at Urbana-Champaign
Jo Sias Daniel, University of New Hampshire
Charles Schwartz, University of Maryland - College Park
Linbing Wang, Virginia Polytechnic Institute and State University (Virginia Tech)

*The following liaison member of the FHWA Asphalt Models ETG **was** in attendance:*

Michael Anderson, Asphalt Institute

*The following **"friends"** of the FHWA Asphalt Models ETG **were** in attendance:*

Gaylon Baumgardner, PTSi
Ramon Bonaquist, AAT
John Casola, Malvern Instruments
Francois Chaignon, Colas, Inc.
Matthew Corrigan, FHWA
John D'Angelo, FHWA
Amit Bhasin, Texas A&M Univ.
Raj Dongré, DLSI
Mike Farrar, WRI
Frank Fee, Citgo Asphalt

Mike Harnsberger, WRI	Troy Pauli, WRI
Andrew Hanz, UW-Madison	Ray Robertson, WRI
Shin-Che Huang, WRI	Judie Ryan, Wisconsin DOT
Richard Kim, NC State University	Fred Turner, WRI
Nike Kringos, TU-Delft	Kevin VanFrank, Utah DOT
M. Emin Kutay, FHWA	Eric Weaver, FHWA
Eyad Masad, Texas A&M Univ.	Haifang Wen, UW-Madison
Andy Mergenmeier, FHWA	Jack Youtcheff, FHWA

OBJECTIVE

The primary objective of the FHWA Asphalt Fundamental Properties and Advanced Modeling Expert Task Group is to provide a forum for the discussion of ongoing asphalt research and also to provide technical input for future research related to fundamental properties and advanced modeling.

DAY 1 - Monday, July 7, 2007

Welcome, Introductions, and Approval of Minutes - Tom Scarpas (Delft University of Technology)

Chairman Scarpas called the meeting to order and on behalf of himself and Secretary Katherine Petros welcomed all in attendance. Scarpas then called for self introduction. After introductions were made, Scarpas asked if there were any comments regarding the minutes of the previous meeting. Hearing no comments Scarpas stated that if there were no strong objections he would like to suggest that we approve the minutes.

Copies of the agenda **(Attachment 1)** were passed around for those in attendance.

<u>WRI and Consortium Work Plan Overviews (Broad vision for entire research program)</u>

(1) WRI's Fundamental Properties Contract - Fred Turner (WRI)

Fred Turner provided an overview of WRI's Fundamental Properties contract (Attachment 2). Within the contract, the stated objectives are "… to conduct fundamental research on asphalts and modified asphalts, as well as their individual components, and through partnership with other research initiatives and innovation, significantly increase fundamental knowledge so that technological capabilities develop and superior practices proliferate in support of FHWA's Strategic Pavements Roadmap."

Turner next identified a number of areas that are included within the scope of work. The first item was to identify, initiate, and complete fundamental research in asphalts and modified asphalts. Next in the goals of research is to provide the fundamental/scientific basis for predicting and increasing the performance of flexible pavements. The third item is that research shall include, in addition to asphalt studies, fundamental aspects of aggregates and of pavements that relate to their performance in asphalt highways. The fourth item is that activities shall be in support of the five focus areas included in FHWA's Strategic Pavements Roadmap. The final item listed by Turner on the scope of work was that activities shall form an advancing understanding and testing of fundamental properties of asphalt, particularly those affecting moisture damage and fatigue.

The contract structure includes four tasks. Task 1 is entitled, "Coordination." Within this task, the researchers will maintain contact with state-of-the-art and state-of-the-science in fundamental research, monitor ongoing research, and learn the needs of the technical community to aid in planning and executing research.

The second task is entitled, "Sustaining Effort" and will include the research activities. Six topics have been identified for this task and include: moisture, damage, aging, nanotechnology, low-temperature properties, modified asphalts, and monitoring of existing validation sites. At this point, a comment was made that the FHWA has asked for additional validation sites to be added to the workplan; however, this has not yet been added. Turner indicated that the plan was to include additional sites within the workplan.

Task 3 of the contract will be indefinite delivery, indefinite quantity work. Turner listed eight potential projects which include: 1)development of new techniques for measurement or analysis of asphalt properties; 2) partnerships to develop molecular models of asphalt performance; 3) specialized analysis for FHWA; 6) complete core and sample analysis for Minnesota validation site; 7) low temperature cracking; and 8) multiple modification.

The final task of the contract is Information Deployment. This task will involve communication and outreach, a website, databases and semi-annual meetings.

Turner finished the presentation by providing the reporting requirements included within the contract.

(2) Asphalt Research Consortium – Dallas Little (TTI)

Dallas Little provided an overview of the Asphalt Research Consortium (ARC) work (Attachment 3). Little discussed six emphasis areas which included: moisture damage, fatigue, engineered materials, vehicle-pavement interaction, validation, and technology deployment.

The first area discussed by Little was moisture damage. The hypothesis for this area was material and mixture properties can be used to model the moisture damage process. This moisture damage model can then be integrated with other models to predict pavement performance. Little listed material properties as aging of binders, pH of water and surface energy. Mastic and mixture properties included void structure, moisture content, and filler type/content.

Little provided three objectives for the moisture damage area of work. The first objective was to identify the mechanisms for moisture damage (interaction of material-mastic-mixture properties and their effect on moisture damage). The second objective was to understand the relative contribution of material and mixture properties (isolate properties that have significant effect on the process and are essential for modeling and prediction). The final objective was to develop and validate: 1) tests to evaluate the moisture susceptibility of mixes and 2) models to predict effect on performance due to moisture induced damage.

One of the deliverables expected from the moisture damage area of work included an improved understanding of moisture damage mechanisms. Another deliverable included components of a system to predict moisture damage. The components will include tests for mixture components, tests for mixtures and a moisture damage prediction model that will be integrated into an overall pavement performance prediction model. Little stated that the overall budget for moisture damage was $4.99 million for five years.

Little listed five categories that will be researched relating to moisture damage. The first category is adhesion. Specific work elements related to adhesion include affinity of asphalt to aggregate (test), work of adhesion, and quantifying moisture using the DMA. The second category is cohesion. Specific work elements related to cohesion include work of cohesion, impact of moisture diffusion, and thin-film rheology and cohesion. The third category is aggregate and will include aggregate surface characterization. The fourth category is modeling. The researchers will investigate both a micromechanics and continuum damage approach. At this point, a question was asked about how the permeability of the mix (or void structure) will be taken into account. Little indicated that permeability would be taken into account in the impact of moisture diffusion part of the cohesion category. The final category of work will be development of a moisture damage prediction system. Little presented a flow diagram of how the various categories and work elements will fit together to accomplish the objectives.

Following the presentation on the moisture damage area of work, a question was asked bout how the model may predict the pumping action that causes damage. The Delft model currently includes this pumping action. Little indicated that the PATTI test has an element for pore pressures. Little's answer was followed up by asking whether there were plans to include clay or amines within the binder to see if the PATTI test would pickup the problem (emulsification). Little stated that the researchers understand the importance of the issue and will rely on the ETG to make sure this is evaluated. He also stated that the thin-film rheology and cohesion work under the Cohesion category will also evaluate this problem. Also, the affinity of asphalt to aggregate work element may provide information. Another follow up stated that scouring is the problem and how will it be handled. Little indicated that pore pressures in the PATTI test may evaluate this.

The next work area discussed was Fatigue. The hypothesis of the Fatigue area is that fatigue damage is a result of the growth of small cracks and voids to form larger cracks that result in damage. He further stated that a unified model of fatigue damage based on sound principles of mechanics must consider: adhesive and cohesive bond strengths in the composite mixture; viscoelastic properties; micro-damage fracture and flow; impact of moisture on mixture properties; ability of the mixture to heal and recover damage; stress distribution within the mixture; and impact of aging on mixture properties.

Little discussed four objectives for the Fatigue work area. The first objective was to develop a fundamental understanding of the material properties and mechanics associated with fatigue. Next, develop an implementable unified fatigue damage model for asphalt mixes that integrates relevant factors. The third objective was to implement the unified fatigue damage model using micromechanical FE/DE methods and continuous damage models to assess the fatigue behavior of mixtures and pavements subjected to different laboratory and field boundary conditions. The final stated objective was development of testing protocols for modified and unmodified binders, mastics and mixture for the unified model.

Anticipated deliverables include: improved understanding of fatigue damage and healing mechanisms; micromechanics model to predict mixture behavior; unified fatigue damage model that can be implemented on structural design; structural model that incorporates the unified fatigue damage model; test protocols to determine properties required for the unified fatigue damage model; and component selection guidelines for perpetual pavements based on the unified approach. Little stated that the budget for the fatigue area is $5.52 million over five years.

The fatigue area includes three categories of work. The first category is material/mixture properties. Specific work elements under this category include: 1) cohesive and adhesive properties; 2) viscoelastic properties; 3) aging; and 4) healing. The next category of work is test method development. Specific work elements in this category include: 1) binder tests and effect on composition; 2) mastic testing protocol; 3) mixture testing protocol; 4) microstructure characterization; and 5) verification. The final category of work is modeling. Specific work elements in this category include: 1) asphalt microstructure model; 2) micromechanics model; 3) unified continuum fatigue model; and 4) calibration and validation. Little presented a flow diagram showing how each category/work element fit together.

Engineered Materials is the next work area discussed. Little presented four hypotheses for this area: 1) materials that comprise the asphalt concrete composite have mechanical and geometric properties which may be combined, using micromechanics, to obtain the next properties of the composite; 2) using additives and/or new production processes, modified asphalt binder and mixtures can be designed to tolerate extreme traffic and climatic condition; 3) superior performance of materials and mixtures incorporating high concentration of recycled asphalt mixtures, emulsions, or warm mix additives can be achieved by using fundamental engineering principles; and 4) protocols for testing and modeling of such superior materials can be developed to provide guidance for selecting high performance materials with predictable (less risky) performance.

Little provided four objectives for the Engineering Materials work area. The first objective is to develop analytical models for the properties of binders, mastic and mixtures using the principles of mechanics. The second objective is to develop guidelines for producing and selecting engineered pavement materials focused on limiting risk of pavement failures. Next, develop guidelines for high levels of recycled pavement mixtures, warm mixtures and cold mixtures. The final objective is to validate these guidelines using laboratory damage resistance testing and field full-scale trials.

Little defined the deliverables of this work area as design models and guidelines for components used in: RAP mixtures, warm mixtures, cold mixtures, thermal resistant mixtures and stable mixtures. The budget for this work area is $3.68 million for five years.

Little described two primary work categories for Engineered Materials. The first is modeling. Specific work elements for this category are analytical and micromechanical based models for composite mixture behavior, damage resistant characterization for binders, and warm mixtures. The second category is design guidance. Specific work elements in this category include comparison of modification techniques, use of high percentage RAP, critically designed HMA mixtures, thermal cracking resistant mixes for intermountain states, and design of fatigue and rut resistant mixtures.

Following the discussion on Engineered Materials, a statement was made that is easy to design a pavement that will perform. This was followed by the question of whether there is a specific work element for constructability. Little stated that there would be more discussion later on constructability.

The next area of work described by Little is Vehicle-Pavement Interaction. The goals for this work area are to develop simplified tools to compute dynamic tire-pavement interaction for special loading conditions and use existing knowledge of macro- and micro-texture to design mixtures to enhance safety. Based on these goals, the objectives of this work area are to develop models to predict dynamic loads of moving vehicles and their effect on the response of flexible pavements and to design surface courses to increase safety by increasing the friction and/or skid resistance.

Deliverables for the Vehicle Pavement Interaction area include: 1) a near-term computer model and database to estimate pavement responses to dynamic loads for user agencies; 2) dynamic load model and database to serve as input for future integration with comprehensive pavement structural model; and 3) a method to estimate noise and friction properties of asphalt mixtures as part of the mix design process. The total budget for this work area is $1.05 million for five years.

Three different categories of work are included under the Vehicle-Pavement Interaction area. The first category is a workshop. This workshop will be on super single tires. The second category is design guidance. The specific work element in this category is a mix design to enhance safety and reduce noise. The final category is modeling, specifically a pavement response model to dynamic loads.

The next area of work discussed by Little was Validation. He stated the goal of this area is to evaluate selected existing specifications and validate research products from the ARC research under realistic loading and environmental conditions encountered in the field. Little listed a number of deliverables anticipated from this area of work. One deliverable will be to construct and monitor comparative pavement validation sites on public highways in cooperation with state DOT's or at accelerated loading facilities. Another deliverable will be a materials reference library for materials used in comparative pavement sites in order to support the research activities of the consortium and other researchers. Little stated that another deliverable of this area will be evaluation of the MEPDG asphalt models. The final deliverable presented was an improved Superpave PG specification based upon findings from the validation sites. The total budget for validation is $5.78 million for five years.

Little listed three categories of work for this area: field validation, accelerated pavement testing; and research and development applications. Specific work elements under field validation are monitoring of warm mix pavements and construction and monitoring of additional pavement sections. For accelerated pavement testing, specific work elements include third-scale model mobile load simulator and construct sections at the Pecos RTC. For R & D application, specific work elements are continual assessment of specifications and validation through MEPDG sites and evaluation of the MEPDG asphalt models.

The last area of work described by Little was Technology Development. The objective of this area is to better refine selected products from the other areas into useful tools for engineers and technologists involved in the design, construction and maintenance of asphalt pavement systems. Anticipated deliverables include new or improved test methods, specification type guidelines, and models for materials and pavements. Another anticipated deliverable is specific design guidance for improving the performance of flexible pavements. The total budget for this area of work is $3.94 million over five years.

Little listed two different categories of work: technology development and technology deployment. Specific work elements under technology development include prioritizing and selecting products for early development, developing early products, identifying products for mid-term and long-term developments, and developing mid-term and long-term products. Specific work elements under technology transfer include a consortium website, communications, presentations and publications, materials database and research database.

Following Little's presentation, there were numerous comments and questions. The initial discussion centered on the ambitious nature of the program. It was suggested that if the desired product is an implementable series of systems, it may be difficult to achieve. The ideas are good; however, if the expectation is to solve all problems there may not be enough money in the program. Little stated that this is an ambitious program. Help will be needed from the ETGs to start filtering the work down. In other words, what parts are going to be successful and isolate the areas with the most chance for success? Little described it as a living program trying to use the ETGs and others to funnel results down to a product that will be within budget and realistic. A group participant then asked how important was the end product and what is the end product. Little stated that the end product will be clearer as the meeting continues. Each subsequent presentation will define the end products of specific objectives. The deliverables will be models that predict performance.

The next discussion following Little's presentation was on the expectations for deliverables and how the deliverables can help build better pavements. Little asked the group rhetorically whether there was anything proposed that won't have a positive impact on how things are currently done. The areas of work are the researchers' perception on currently how to improve what the industry does. The research results will have a huge impact on where we are going. A participant stated that it is assumed that fatigue is worsened by moisture damage as well as rutting. Would it be beneficial to have a work element that documents whether moisture caused or impacted the observed damage using LTPP or field projects? Little stated that the researchers have scanned the literature in terms of moisture damage and they think that moisture affects the adhesion at the interface; however, having experts document field performance would help. This was followed by a participant stating that distress reports are needed to prove the problems. Little stated that these are two cornerstone projects. Moisture damage model is a subset of the fatigue model as a potential cause of fatigue. If the model is correct, moisture will be included. A participant then suggested development for a framework for moisture and a framework for fatigue; in other words, initially separate then and then look for similarities.

Another comment from the group related to fatigue is that fatigue can be caused by a lack of bond between layers. This was followed by a question about how lack of bond will be addresses. Little stated that the fatigue model would incorporate the bond energy in both a dry and moisture affected state and calculate the bond strength. To this, it was stated that they did not have a problem with stating that moisture damage has an affect on fatigue; however, we (the industry) do not have a true knowledge of fatigue damage. It was then suggested that there is a need to first address fatigue and then moisture being added later.

A comment received during the review of workplans was whether the researchers were ignoring distresses other than fatigue and moisture, specifically rutting. How are other distresses going to be incorporated into the models? The term fatigue is not a catchall for development of cracks. Little indicated that Eyad Masad would address this in a later presentation. This response was followed with the statement that what is needed is a model that will tell us performance, not a model with a predetermined cause.

There was a suggestion that all ARC members test the same materials. Little stated that this would be done.

A question was asked about the validation plans. Is there coordination to use existing sections to validate results? Little stated that there is coordination between the ARC and Fundamental Properties researchers. Not all of the current sections are useful, but they are looking for other sections.

A statement was made that one of the main causes of cracking is cracking coming from the aging of binders. Therefore, is there any intention to look at environmental cracking; especially for the FAA? Little indicated that block cracking is not being considered as of yet; however, initiation of cracks due to environmental effects (aging) will be considered within the overall project. This was followed by a comment from the group that NC State is looking at top-down cracking and that they have been able to calculate stresses due to thermal fluctuations. Thermal stresses are an order of magnitude different than loading stresses. Another participant observed that reflective cracking does not appear to be included within the program. Little stated that the model will be able to accommodate reflective cracking since the model will be based on fundamental properties. He then stated that it is important to stress and clarify what is being done. There is a difference between a material model and structural model. The material model is being worked on and then will be embedded within the structural model. The material models will likely be based within finite element code. Testing protocols and guidelines will be available to give a comfort zone.

Fundamental Properties and Modeling Aspects of each 1st Year Workplan

Moisture Damage

(3) WRI Contract (Moisture Damage) - Fred Turner (WRI)

Fred Turner presented the workplan for WRI's Subtask 2-1, Moisture Damage (Attachment 4). He listed the following topics to be covered: 1) use of the Hamburg Wheel Tracking Device to evaluate moisture susceptibility; 2) evaluation of the impact of microbes on the performance of mixes; 3) synthesis of modifiers to elucidate the combined effect of polymer and antistripping agents; and 4) correlation of freeze-thaw results with asphalt and aggregate surface energies.

One of the issues to be investigated is the nature of turbidity produced during Hamburg testing, organic and mineral materials generated from the wheel-tracking may provide clues to the moisture susceptibility of mixes. The Micro-Deval test will be used to evaluate the durability of aggregates used in the Hamburg tests and to produce fines for comparison with those generated by the Hamburg tests. The researchers will analyze organic materials extracted from the Hamburg bath and from aggregate using FTIR. Finally, the researchers will determine the mineralogy of fines from Micro-Deval and Hamburg water baths using electron-probe and powder x-ray diffraction. This work may produce clues to material combinations that do not work well together with respect to moisture damage.

Turner then described an experiment to look at the relationship between the number of freeze-thaw cycles to failure and various predictor variables. Good correlations have been found with some organic and chemical characteristics.

Following the presentation a statement was made that the researchers are not including any pore pressures in their research other than the Hamburg loadings. Failures also occur due to emulsification of the binder due to cyclic pore pressures which are not being caught by the Hamburg test. Another comment pertained to the fact that whatever you put into the system will come out of the system after Hamburg testing. How is this going to tell us anything? Turner replied that of interest are the organics that come out of the samples. The chemical analyses are highly sophisticated which will give a product that will allow for a decision to be made between certain aggregates/asphalts. Understanding the things coming out of bad mixes is important. A participant then asked whether there was a tie with field performance. Turner indicated that they would start on mixes of known poor performance and move on from there.

(4) Asphalt Research Consortium (Moisture Damage) - Amit Bhasin (Texas A&M Univ.)

Amit Bhasin presented the ARC's workplan for moisture damage (Attachment 5). He began by providing a brief overview of the categories and specific work elements included within the workplan. Next, he provided discussion on the specific work elements on affinity of asphalt to aggregate and thin-film rheology and cohesion. The objective of this work will be to develop mechanical tests that can provide material properties related to adhesion and cohesion. The research approach will include five areas which include: 1) review available mechanical tests including DSR and PATTI test; 2) evaluate effect of moisture content and film thickness on adhesive and cohesive properties; 3) extend tests to mastics; 4) compare results with mixture performance and complimentary thermodynamic properties; and 5) evaluate practical aspects for implementing test method. At this point, a question was asked about how the researchers planned to run the DSR test. Bhasin responded that there are a number of ways that the test could be run. One method would be gluing aggregates onto the plates, add the asphalt binder and run the test. To this, the questioner asked how the researchers would differentiate between adhesion and cohesion. Bhasin responded that those types of things are evolving as the work continues. They are looking at different ways to run the tests in order to determine the right way. A participant then stated that the only way to differentiate between cohesion and adhesion is to initiate a crack and define the type failure. To this Bhasin stated that these tests may not necessarily define failure; rather, they may be used to evaluate the change in fundamental properties.

Bhasin next described the relevance of the area goal and area to other work elements. The mechanical test/tests developed from this work element can: 1) serve as tools by which to select/screen materials during the mixture design process; 2) provide inputs related to material properties that may be required for modeling; and 3) provide data for comparison of results based on thermodynamic measurements (surface free energy). A comment was made that most moisture damage is observed in lower pavement layers, not surface layers. The Delft model includes emulsification of the asphalt cased by pumping. If testing is conducted in the DSR, how is "pumping" going to be taken into account? Bhasin responded that there is mechanical action to pumping; however, measures of adhesion and cohesion are needed components. Another comment had to do with strength. Strength due to thermodynamics and strength due to testing are different. What are the other factors? Next, a participant stated that after the project is completed and its time for implementation; if we are at mix design and add lime, we know it helps. What will the research add to this process? Bhasin answered that the surface free energy results may be able to tell you more than just to add lime. The research is geared to identify the weak link. The final question was about how the researchers will define cohesive failure using thermodynamics. Bhasin stated that the work in the specific work element on quantifying moisture using DMA would help answer this question.

Bhasin next discussed the planned activities on the work of thermodynamic adhesion and cohesion. Objectives of these activities include: evaluation of tests based on principles of thermodynamics to determine material properties related to the work of adhesion; identification of mechanisms of competition between organic molecules and water to adhere to aggregate surface; and assess work of cohesion of saturated binders/mastics based on thermodynamic approach and at nano-scale. The research approach to accomplish these objectives involves a number of activities. The first is to compare total energy of adhesion obtained using calorimetric measures with work of adhesion based on surface free energy to: assess secondary mechanisms of adhesion, efficacy of anti-strip agents and fillers, impact of modifiers, and possible use as a surrogate test. The next planned activity is to measure adhesive properties at nano-scale using AFM. Thirdly, measure cohesive spectroscopic techniques to determine precise interactions between model minerals and organic functional groups including: SGF spectroscopy and IR plus Raman spectroscopy. The relevance of this work and to other work elements includes: recommended test method/methods by which to select/screen materials during the mix design process; providing material properties that may be used as inputs for modeling; results that can be compared to or combined with complimentary data based on mechanical tests; providing a better understanding of the mechanisms responsible for moisture damage to binder/mastic – aggregate interface; and evaluation of relative importance of different interactions that are critical (or insignificant) in causing interfacial failure.

The next focus area discussed by Bhasin was moisture diffusion in asphalt mixtures. The objective of this work is to determine parameters that best represent the rate dependent characteristics of the moisture damage process. Bhasin stated that the researchers intend to evaluate the moisture transport phenomenon related to three scales which include: moisture transport through the mixture dictated by the void structure, moisture diffusion through binder/mastic films that coat aggregate surfaces, and kinetics of debonding at the binder/mastic – aggregate interface. For the moisture transport portion of the work planned for evaluating through the mixture, the researchers plan to accomplish evaluation of void structure, flowpaths, and sample permeability using x-ray CT images, determine relationship between aggregate structure and void structure in the mix, determine specimen voids for different mixes, and evaluate methods such as the use of psychrometer to determine moisture transport parameters for asphalt mixtures. Bhasin listed the following for the research approach related to moisture diffusion and kinetics of debonding: evaluate techniques to determine diffusivity coefficient for the asphalt binder/mastic, determine diffusivity coefficients for asphalt binder/mastics and rate constants for interfacial debonding, evaluate possible relationship between these coefficients and other mechanical properties for the binder/mastic, evaluate effect of pore pressure on the diffusivity coefficients, and evaluate hysteretic effect of boundary conditions on the diffusivity coefficients.

Bhasin next described the relevance of this work to the area goal and other work elements. The first issue described by Bhasin is that the work will provide parameters related to rate dependent characteristics of the moisture damage process to be used in modeling. Secondly, simple test methods will be proposed to obtain the most critical parameters and a database for the other parameters.

The final focus area described by Bhasin was quantifying moisture damage using DMA. The objective of this work will be to develop a test protocol to assess the impact of moisture damage on the performance of mastic/fine aggregate matrix. This research approach will entail assessing and refining the existing test and analysis protocols to test fine aggregate matrix samples using the DMA. This work is relevant to the area goal and other work elements because the DMA can be used as a tool to assess properties of fine aggregate matrix during the mix design process and to determine the impact of moisture content on material properties which may be used as inputs for modeling.

Following the presentation there was discussion on the materials to be used within the research and how to accurately define adhesion. The first question from the group was whether similar materials would be used during all of the described activities and if so will the researchers be able to pinpoint the mechanisms of failure. Bhasin indicated that similar materials would be used and that each of the work elements would be used to evaluate the same problem and provide a link to pinpointing the failure mechanisms. Then, there were a series of questions/comments on how the researchers would select materials. Bhasin responded by saying that one of the first items of the research would be to evaluate available materials lists and evaluate the availability and usefulness of the materials. SHRP materials are available and data is available. He finished by acknowledging that the selection of materials is crucial.

Following the discussion on materials, a meeting participant indicated issues with the PATTI test. It was stated that adhesion is a surface issue and if the substrate is not hot, it will affect the adhesion properties. Sample geometry is vital to getting fundamental properties and proper analysis of the test results. Bhasin answered that there is a parameter, based upon thermodynamics that will define adhesion. Procedures have been standardized with glass beads. Bhasin finished by stating that if there is something better than the PATTI, the researchers are willing to look at it.

Fatigue

(5) Asphalt Research Consortium (Fatigue) - Eyad Masad (Texas A & M University)

Eyad Masad provided an overview of planned work on fatigue through the ARC (Attachment 6). He began by providing the three categories of work and specific work elements under each category. The three categories of work are material/mixture properties, test method development and modeling. Specific work elements under material/mixture properties include: cohesive and adhesive properties, viscoelastic properties, aging, and healing. For test method development, specific work elements include: binder tests and effect of composition; mastic testing protocol; mixture testing protocol; microstructure characterization (x-ray CT); and verification (DSR and moisture fatigue). Specific work elements under modeling include: asphalt microstructure model; micromechanics model; unified continuum fatigue model; and calibration and validation.

The first work element described by Masad was aging. The objectives of this work element are to assess material and microstructure characteristics of mixtures as affected by oxidative aging and evaluate the effect of aging on fundamental material properties. Masad described three areas of the research approach for this work. First, the researchers will conduct a literature review and develop a detailed workplan. Next, the researchers will develop a transport model for oxidative aging in pavements based upon: binder oxidation kinetics, model for calculating temperatures as a function of time and depth; and model of oxygen transport and diffusion in binder. The final step will be to determine the effect of oxidative aging on material properties such as viscoelastic properties, fracture resistance and healing. Masad listed two areas where the work would be relevant to the overall goal of fatigue research and other work elements and include: the transport model can be used to determine the extent of oxidative aging and change in material properties as a function of aging will be essential input for long term modeling of pavement performance.

The next work element described by Masad was cohesive and adhesive properties. The objective of this work is to provide a fundamental material property for micromechanical modeling of asphalt mixture. Masad described three areas of research to accomplish this objective: refine existing protocols to determine thermodynamic work of adhesion/cohesion; evaluate and select models and test methods to quantify mechanical work of adhesion/cohesion; and develop relationship between thermodynamic work of adhesion/cohesion to mechanical work of adhesion/cohesion for binders and mastics. The relevance of this work is that the work of adhesion/cohesion is an important material property input for micromechanical models to evaluate mixture performance and analytical models that can be used as a part of the continuum damage model to evaluate performance. Also, the work element will produce recommendations for the damage most suitable protocol to obtain cohesion/adhesion properties.

The next work element described by Masad was viscoelastic properties. The objective of this work element is to determine linear and non-linear viscoelastic properties of asphalt materials. Masad described three items to be included with the workplan. First, the researchers will evaluate and select suitable models to capture the non-linear effect of viscoelasticity in cyclic loading. Next, a test protocol will be developed to determine the parameters for the model. Finally, the researchers will conduct cyclic load tests under different stress/strain amplitudes and apply to the model to separate viscoelastic properties and damage from the test response. Therefore, developing a model to capture non-linear viscoelastic responses is important to differentiate between the two.

The next work element described by Masad was healing. He described two objectives of this work: 1) to determine a time dependent material properly that can be used to characterize the net healing between crack surfaces and 2) to determine the relationship between these properties, healing and endurance limit. For the research approach, the researchers will evaluate the mechanisms of healing and select materials that best represent these mechanisms. Then, the researchers will review and select test methods that measure properties of healing or a time dependent material property that quantifies healing. Healing will be expressed in a form that can be readily accumulated in existing analytical models for crack growth. The relevance of this work is that healing is an integral part of the fatigue process. Determining a parameter that represents the time dependent characteristics of different asphalt materials is an essential input for any micromechanical or continuum model.

Micromechanical models were the next work element described by Masad. The objective of this element is to develop a micromechanical model that will unify material and mixture properties to predict the performance of a mixture. Masad described three steps of the research approach. First, two different approaches will be considered, DEM and FEM. Secondly, two different length scales will be considered in each model: use of binder and filler properties to predict performance of the mastic and use of mastic and aggregate properties to predict performance of the mixture. Masad indicated that the multi-scale was needed in order to handle mixtures. There are two scaling effects, one due to geometry and one due to material scale. The final activity in the research approach's validation/calibration of the models is using a combination of mechanical tests and non-destructive tests like the x-ray CT. Masad stated that micromechanical models are important to evaluate and predict materials performance.

The next work element described by Masad was continuum fatigue models. The objective of this work element is to develop a continuum fatigue model that will unify material and mixture properties to predict the pavement performance in terms of fatigue and plastic deformation. Masad then described how the researchers plan to include material properties, pavement structure, environmental factors, and loading conditions will be used to predict material distress.

The final category of work described by Masad was test methods. The objectives of this work include: 1) qualify and select materials during the mixture design process; 2) obtain material property inputs required for micromechanical and continuum modeling; and 3) to validate and/or calibrate micromechanical models.

Following the presentation, there were comments/questions. The first question was why the researchers were considering aging prior to material properties? Masad answered that the two are actually being considered simultaneously. Another question was about environmental factors; specifically, where is moisture being included? Masad stated that moisture was being included in the overall research and information from the moisture damage research area would be used with fatigue. A suggestion/comment was made that a continuum damage model alone may not be the best approach. A continuum damage model with some fracture analysis may be better. Masad agreed that this may be the case.

(6) WRI Contract (Fatigue) - Shin-Che Huang (WRI)

The next presentation was by Shin-Che Huang of WRI and was entitled, "Asphalt Aging in the Presence of Water (Attachment 7)." This work is part of the Fundamentals contract and is under Task 2-2, Asphalt Aging. The overall objectives in the area of fatigue are to aid in the development of the next version of the MEPDG and may lead to a PAV test that requires less time than the current Superpave method. Huang described how shift factors are required in order to relate the results of laboratory fatigue tests to field performance. The shift factors are influenced by various conditions, two of which are asphalt aging and moisture damage. The hypothesis of the research is that the presence of moisture during aging accelerates asphalt oxidation rates by altering the internal structure of the asphalt binder. The specific objectives related to aging in the presence of water are: to evaluate the impact of water on the long term aging characteristics of asphalt binders and to determine if there is correlation between the rheological properties and chemical properties of asphalt binders after long term oxidation aging.

Huang then presented a series of graphs to describe the concept. Initially, time temperature superposition was used to develop oxidation master curves of rheological properties of the binders. Relationships between the aging shift factor and carbonyl content were linear and strong. He then presented a relationship between aging susceptibility and Gaestel Index. However, this relationship was not as strong. Aging susceptibility was defined as the slope of the aging shift factor versus carbonyl content relationship. These various relationships were source dependent.

In summary, Huang stated that PAV aging in the presence of water accelerates the aging process. There is a linear relationship between the physical and chemical properties of asphalt binders. Additionally, water does not influence the linear relationship. Future work will entail better defining the relationship between aging susceptibility and compactibility, developing oxidative aging kinetic master curve and field validations.

Following the presentation, a participant stated that some aging studies using the same asphalt but different aggregates have shown that aggregate can affect aging. Huang stated that the researchers plan on evaluating the effect of aggregate characteristics. A question was asked about whether the researchers planned on evaluating the effect of aging on low temperatures to which Huang answered affirmative. This questions was followed by whether the researchers planned to look at shift factors or shifts in phase angel at low temperatures. Huang stated they would look at both.

(7) WRI Contract (Fatigue) - Fred Turner (WRI)

Fred Turner provided an overview of work planned in Subtask 2.4, Low Temperature Properties (Attachment 8). Turner began by providing the topics to be covered during the presentation which included: 1) glass transition region and parameters; 2) relationship of glass transition parameters to low temperature specifications; 3) was and other limitations on structural relaxation; and 4) research direction and examples. Turner was asked to define the goal of this work which he indicated was to try and develop a surrogate specification for low temperatures. Turner presented the glass transition region and typical parameters. He then presented typical glass transition values.

Turner made several observations on the correlation of glass transition with current low temperature specification. He indicated that DSC measurements correlate with Superpave low temperature specifications if BSR stiffness controls. He also sated that the DSC can be used to quantify the low temperature properties of some waxy modifiers. Turner then presented the effect of PPA on glass transition characteristics. The cumulative effect on the change in glass transition temperature was a decrease; however, change in the height and width parameters was binder specific.

Turner then presented the workplan summary. This was done through a series of graphs. Essentially, glass transition profiles will be developed. Binders will be tested in three conditions: neat, RTFO aged, and RTFO/PAV aged. The profiles will be evaluated to determine if there is something to signify that the binders are m-controlled.

(8) WRI Contract (Fatigue) - Troy Pauli (WRI)

Troy Pauli presented the workplan on the use of nanotechnology to evaluate asphalt thin film properties under the Fundamentals contract (Attachment 9). He began the presentation by providing the hypothesis of the research, which included: phase separation (transformation) mechanisms between (within) asphalt components contribute to fatigue cracking and healing and that there are compounding factors. Compounding factors include oxidation process in thin films, surface free energy as it pertains to water invasion and capillarity, effects of solvents and asphalt modification.

Pauli then provided some background for the research. First, he described the surface free energy approach and provided derivations for equations used in surface free energy determinations.

Next, Pauli discussed materials selection, specifically validation site asphalts. These are neat binders in which a significant amount of testing has already been conducted.

Pauli listed the various experimental approaches that may be investigated. The approaches were divided into three categories: thin-film coating techniques, atomic force microscopy, and nanoindentation and pull-off force work of adhesion. Methods included in the thin-film coating techniques were solvent spin-casting, thin-film smears, and light refraction/AFM determinations of thickness. For the atomic-force microscopy category, Pauli listed the following methods: phase contrast, friction adhesion, functionalized tip techniques, spinodal-blends, and fractured film development. Pauli listed aggregate hardness, aggregate friction, and asphalt thin-film thickness as methods under nanoindentation and pull-off force category.

Pauli presented a number of Year 1 goals which were setup of laboratory test equipment, development of experimental protocols and materials selection. Five-year goals included further development of fundamental material science theory, development of test methodologies derived from nanoscience to measure compositional and rheological properties of asphalt and aggregate surface properties, and development of experimental and computational tools to quantify asphalt-aggregate adhesion, propensities to fatigue, self healing, moisture susceptibility, and impact of modification.

Pauli then presented a series of slides depicting AFM measurements conducted on asphalt from the Minnesota validation site. He next described the theory of the spinodal region nucleation. Pauli finished the presentation with defining nanotechnology.

Following the presentation, a series of questions were asked. First, if the same asphalt binder is spincast twice and you put the two samples together, will they stick? Pauli stated that they would stick together. Next, will the force required to pull the samples apart change with thickness: Pauli again answered yes. Finally, will this work be tied to the binder aging work? Again, Pauli answered yes.

Engineered Materials

(9) Asphalt Research Consortium (Engineered Materials) - Andrew Hanz (University of Wisconsin - Madison)

Andrew Hanz presented an overview of work on Engineered Materials being conducted through the ARC (Attachment 10). The main research themes for this area are to use modeling to guide material design through micromechanics and phenomenological analysis along with rheology and damage resistance. Hanz indicated that there will be two main focus areas: asphalt materials from critical applications and conserving energy and natural resources. Critical applications listed by Hanz included high traffic volumes, slow moving traffic, heavy axle loads, extreme climates and perpetual service life. Increased use of RAP, evaluation of emulsions for cold mix and warm mix additives were highlighted as areas to conserve energy and natural resources.

Hanz first described the research approach related to the rutting resistance of asphalt binders. He mentioned three factors the researchers are considering: type of loading, stress level, and effect of modification on performance. For the type of loading, Hanz stated that the loading must be consistent with actual traffic loadings. He discussed the difference between cyclic and impulse loads and the subsequent effect on the type of strain observed. Hanz stated that the strain level in binders can be up to 500 times greater than the stain level realized in the mixture; therefore, non-linear behavior had to be considered. The hypothesis for this work element is that binder needs to be characterized at different stresses and loading times in order to accurately predict rutting performance of mixes. The experimental plan presented by Hanz includes five primary steps: literature review, selection of material parameters (binders and mix), analysis and interpretation, model relationship between binder and mixture rutting, and include the significant variables in prediction of traffic volume effects. Deliverables from the work element are anticipated to include standard test methods and recommendations for specifications.

The next work element described by Hanz was warm mixtures and the relationship to modeling. The focus of this work will be on quantifying the effects of various additives on binders, mixtures, and the environment. Hanz stated that models are needed in the following areas: prediction of reduction in mixing and compaction temperatures, prediction of the reduction in emission and the effect of additives on mixture durability and performance. Research on the prediction of temperature reduction will have two focus areas: asphalt binder and mixture. Work focusing on the binder will include viscosity and temperature sensitivity. Additive work will also be included in which additive type, concentration and curing/setting rate will be researched. During the mixture work, the researchers will concentrate on evaluating how trends found in the binder work are related to mix behavior. For evaluating the reduction in compactive effort when using the warm additives, Hanz stated that the Gyratory Load Plate device would be used. When modeling the environmental impact of warm mix additives, the researchers plan to conduct research to quantify emissions (dust and exhaust) and energy savings. Hanz next provided the anticipated models to be developed for this prediction of additives on binder and mixture mechanical durability and performance. Models are to be developed for rutting potential, fatigue resistance, thermal cracking and moisture damage. Field evaluation of the developed models will be conducted. Hanz stated that all of the warm mix work will be coordinated with ongoing NCHRP work.

Following the presentation, there were questions/comments. The first question was what type of fatigue test the researchers planned for the mixture testing. Hanz answered that an indirect tensile test was planned. A suggestion from the group was for the researchers to participate in the NAPA WMA working group. The next comment was that there are a wide range of WMA technologies that are available. There is a relatively, new technology called half warm mix in which France and South Africa have investigated. This led to a question asking which technologies are going to be researched and will the research be limited to WMA products? Direction from the ETG was that the researchers should initially concentrate on established WMA technologies. Other technologies can be evaluated later.

DAY 2 - Tuesday, July 24, 2007

Fundamental Properties and Modeling Aspects of each 1st Year Workplan (continued)

Engineered Materials (continued)

(10) Asphalt Research Consortium (Engineered Materials) - Peter Sebaaly (University of Nevada)

Peter Sebaaly discussed the category of design guidance for the Engineered Materials area (Attachment 11). The specific work elements, being led by the University of Nevada-Reno, are; design system for HMA containing a high percentage of RAP material, thermal cracking resistant mixes for intermountain states, and critically designed HMA mixes.

Sebaaly described the research to be conducted related to RAP. He concentrated on two issues: compactibility of RAP and virgin binders and the impact of RAP on performance. For the compatibility of RAP research, he listed two items that will be researched: wetting of new binder onto RAP particles and mutual miscibility (mixing) of molecular species. For the impact of RAP on performance, the researchers will evaluate the fundamental properties of mixes containing RAP and utilize performance models. On work related to fundamental properties, Sebaaly stated that the researchers would evaluate the impact of RAP on dynamic modulus master curves after short- and long-term aging. The research approach will also include different percentages of RAP in the mixture up to 40 - 45 percent RAP. At this point, Sebaaly was asked why the percentage of RAP was being limited to 40 - 45 percent. Sebaaly answered that the researchers first wanted to determine if the increased percentage of RAP works. If it does, higher percentages may be evaluated. This was followed-up by a question asking whether the researchers planned on dealing with stockpiled RAP or fractionated RAP. Sebaaly answered that both would be evaluated. A comment from the group was that dynamic modulus alone may not be enough to define the performance of RAP mixes. The researchers may want to consider looking at fracture or low temperature properties. Sebaaly stated that these would be looked at under the performance models.

Sebaaly described a number of performance models that will be used to evaluate the performance of high content RAP mixes. The first is resistance to moisture damage. The researchers plan to utilize short- and long-term aged samples and models developed by the ARC for these evaluations. The next performance model is resistance to fatigue. Long-term aged mixes will be tested using flexural beam fatigue tests and ARC developed models. The next performance model discussed for high content RAP mixes was resistance to permanent deformation. For this work the researchers plan to conduct triaxial repeated load testing on short-term aged mixtures. Following the presentation on performance models, there were several comments/questions. First, Sebaaly was asked whether the researchers will consider something other than beam fatigue tests for fatigue. Sebaaly stated they would utilize ARC developed tests. Next was a comment. For low temperature cracking, the TSRST test is right. However, it seems that block cracking is the problem and the TSRST will not evaluate block cracking because block cracking occurs on aged, brittle asphalt binders. Some type of test that includes fracture must be used to evaluate block cracking. It was then suggested adding a work element on block cracking. Sebaaly stated that a work element would be added. The original commentator followed this by stating that rejuvenators soften at high temperatures but may hurt relaxation properties. Sebaaly stated that this would be taken into consideration.

Sebaaly then discussed how the UNR work would be coordinated with other ARC activities. During Years 1 through 3, material properties would be determined and Years 3 through 5 the researchers would utilize the models developed within the ARC to evaluate the effect of RAP on performance. The research would also be coordinated with NCHRP research.

The next specific work element described by Sebaaly was thermal cracking. Two issues were highlighted: identify an evaluation and testing system and modeling/validation of the developed system. Research within the evaluation system will include a binder aging system for intermountain regions, evaluation of past and present WRI work on binder aging, impact of fillers, air voids and absorptive aggregates on mix aging, and development of a thermal cracking test for HMA mixtures in intermountain regions. The modeling research will entail developing a thermal cracking model for intermountain regions. Validation work will also be conducted. Finally, Sebaaly stated that the model will be expanded for other regions of the US. Following the presentation on thermal cracking, there were a series of questions. First, Sebaaly was asked to expand on the “develop model” part of the presentation and how would this model be original and different than other ARC activities. Sebaaly answered that the research would start with binder characteristics and then move into mixture properties and location (intermountain area). This answer was followed by asking Sebaaly what kind of model it will be and what kind of tests are going to be utilized. Sebaaly answered that the TSRST may be one test, but the researchers will try to develop fundamental tests and a mechanical model. Next, Sebaaly was asked if their model would be embedded within the other models created by the ARC. Sebaaly answered that the results of their research may be used by the mountain states. This was followed by asking how the model will overlap Minnesota's current research. Sebaaly answered that the Minnesota researchers are evaluating Minnesota conditions and that the UNR work will be limited to mountain states. Next, Sebaaly was asked whether the opinion was that damage being done in mountain areas is more severe that what is seen elsewhere or are there different mechanisms leading to thermal cracking in mountainous regions? Sebaaly stated that is what the research will evaluate.

The final work element discussed by Sebaaly was critically designed HMA. Sebaaly stated that every HMA mix has a critical combination of temperature and loading rate. Loading conditions beyond the critical condition will lead to failures. The research approach will involve theoretical modeling of flexible pavements that include various loading conditions. Loading conditions to be evaluated include speed, load level, and configurations. Various temperatures will also be included in the evaluations. Repeated load triaxial testing will be used to characterize the various mixes. Based upon the work, the researchers will develop a process to identify the critical combinations from laboratory testing.

Vehicle-Pavement Interaction

(11) Asphalt Research Consortium (Vehicle - Pavement Interaction – Peter Sebaaly (DLSI)

Peter Sebaaly provided an overview of the planned ACR work in the area of vehicle pavement interaction (Attachment 12). The first task in this area will be to conduct a workshop on super-single tires. Also included in this area will be mixture design methods to enhance safety and reduce noise. The final portion of research on this area will be pavement response modeling to dynamic loads.

The workshop will review progress on the use and impact of super-single tires on pavements. The workshop will be used to plan future activities. It will be held in October of 2007 at the Turner Fairbank Highway Research Center.

Sebaaly described the research for the pavement response model. The researchers plan to develop a fundamental model to predict the response of flexible pavements to traffic loads moving at a certain speed. It is anticipated that the model will be used as an advanced analysis model for intersections, heavy loads, and off-road equipment. Sebaaly described three components for developing the model. First are dynamic loadings. Factors under dynamic loads to be considered include truck suspension, road roughness, braking/acceleration, and speed. The next component is at the tire/pavement interface. Factors to be considered are inflation pressure, tire type, tire load, and speed. The final component of the model is pavement response. Inertia and material characteristics will be included.

To develop the pavement model, a truck will be used with certain dimensions. Accelerations, braking, tires, etc. will all be included and a load distribution developed. Existing data will be used for these analyses.

Both HMA and unbound materials will be included when determining the pavement response. Viscoelastic properties will be used for the HMA layer and will include accounting for inertia and internal damping. Linear elastic properties will be used for the unbound materials and will also account for inertia and damping. At this point, Sebaaly was asked whether linear elastic theory was best for the unbound materials. Sebaaly responded that work at MNRoad and the ALF indicated a linear response with different loads.

Sebaaly then provided a characterization of various flexible pavement response models. The different models were characterized as current practice, proposed practice, and future practice. The future practice, as defined by Sebaaly, is the unified model that will be developed by the ARC. There was some discussion on the various model categories. The first question was about the loads and are they moving. Sebaaly stated that the loads will be both static and moving. It was then stated that perhaps it would be cleaner to go from stationary to dynamic-stationary and then to dynamic. Sebaaly responded that the load is moving. Sebaaly then tried to clarify some issues. He stated that if a load spectrum is added to the MEPDG, the analysis takes longer. In a few years, neutral networks will be available to handle complicated models. This project is designed to bridge the gap between current practice and future models.

Sebaaly next described the anticipated model. He stated that it will be a comprehensive model. It will be delivered in a public domain package and will be time efficient. The intent is that the model will be applicable to a wide range of cases. To illustrate a special case, he showed a picture of farm equipment which is typically not covered in pavement response models.

Following the presentation, there were questions/comments for Sebaaly. The first comment was that this research is not as sophisticated as the other research being conducted by the ARC. Sebaaly answered that this study is to provide something to fill the gap between current practice and future practice. At the end of the ARC, a working model will be available; however, it is not known how long it will take to implement the product. The current practice took 40 years to implement. This research is not intended to replace the ARC work; rather it is to provide agencies a tool for the near future until the next generation of models is ready.

Field Validation

(12) WRI Contract (Field Validation) - Mike Harnsberger (WRI)

Mike Harnsberger presented work to be accomplished under Subtask 2-6, Field Validation (Attachment 13). Initially, Harnsberger described previous contract activity related to field validation. On previous projects, experimental pavement sections have been constructed with the major variable being the crude source of the binder. For these projects, a reasonable quantity of materials has been collected. Each year the performance of the different sections has been monitored. Because the various projects are located in different areas, direct comparison between different sites may be difficult, at best.

Under the current contract, it is anticipated that monitoring of the various pavement sections will take place annually. Core samples will be obtained as necessary. Also, it is planned to review the utility and availability of the Asphalt Institute's PPA sections.

Harnsberger then described different test sections that are currently in existence. Test sections are located in Wyoming, Nevada, Arizona, Kansas and Minnesota. All sections are being monitored using the LTPP Distress Survey Protocols which includes distress mapping and classification, transverse profiles and photos. Core samples are planned for post construction and after 1, 2 and 5 years of service. Harnsberger also acknowledged that pavement distress may trigger the need for core samples at other times.

Hansberger next presented some results for performance monitoring. He cautioned that the LTPP definitions for wheelpath cracking may skew some of the cracking results. In turn, this could influence the modeling of fatigue cracking.

Following the presentation, there were several questions/comments. First, Harnsberger was asked if the researchers considered any of the LTPP SPS 9 sections because these sections included different binders. Harnsberger answered that they had contracted the LTPP contractors to look for sections but they did not find any. Harnsberger stated that the Kansas section was in the bottom 60mm of the pavement section within a moist environment. The researchers are hoping that this section is a good section for evaluating moisture. Harnsberger was then asked whether the researchers were checking air voids at construction and post construction. Harnsberger answered affirmative. It was then suggested that the researchers rank the various data based upon air voids. Harnsberger was then asked how much materials were being obtained. He answered that for the Minnesota section they had about 1,000 lbs of mix and 7 to 8 gallons of binder. It was suggested to get more binder. The group was then asked if it would be a good idea to reserve space at the material reference libraries (MRLs) to which the group answered yes. However, the researchers were encouraged to develop a proposal for the quantity of materials needed in order to determine if sufficient space is available at the MRLs.

(13) Asphalt Research Consortium (Validation) - Mike Harnsberger (WRI)

Mike Harnsberger then continued the discussion on validation sites from the perspective of the ARC (Attachment 13). The initial part of this work will be to establish a materials library. Included within this work will be to evaluate current validation site materials, review SHRP library, determine geographic area of use, determine volume of use for the different available materials, and evaluate the fundamental properties of the different materials. Work elements in the validation portion of the ARC's research are field validation, accelerated pavement testing, and R&D applications. Field validation will include construction and monitoring new validation sites in cooperation with DOTs. Warm mix sections that will be placed in Yellowstone National Park have been recently included. A planned activity is to assess the effects of surface treatments on the Arizona test sections.

Accelerated pavement testing will entail accelerated loadings using the one-third scale load simulator. Test sections may also be constructed at the Pecos RTC. The researchers are investigating this possibility. Other APT sites are also being considered.

Research and Development applications will be continual assessment of specifications. This could include improvements to the PG grading system, elimination of "PG Plus" tests and/or revision of AASHTO standards. The validation sites should also provide an avenue for validation activities for the MEPDG.

Following the presentation, there were comments/questions. First, should there be a cut-off time in construction of validation sites such that useful performance responses can be obtained? Harnsberger answered that this should be discussed. Next, Harnsberger was asked if the researchers are going to monitor traffic. He indicated that the individual states were monitoring traffic. A comment was made to emphasize the importance of APTs. From a modeler's point of view, controlled sites are good, which Harnsberger agreed. The next question was about how the current data will be stored and disseminated. Harnsberger stated that right now the data is in Excel format but needs to be converted to a database as there is a substantial amount of data.

(14) WRI Contract (Field Validation) - Mike Farrar (WRI)

Mike Farrar presented the workplan for the field validation of age hardening for the Fundamentals contract (Attachment 14). He began by listing a series of goals for the research. The first goal is to develop a rapid FTIR method to map moieties, related to oxidative age hardening, on the face of a core. Secondly, review and establish correlations between carbonyl, sulfoxide and aromatic moieties and low and high temperature rheological properties. The third goal is to use the validation sites to revisit the Global Aging System. This would include either revising the current model or developing anew long-term age hardening model. The final goal is to determine if the FTIR can be applied to sealers/rejuvenators and OGFCs.

Farrar then described the Global Aging System (GAS) and listed its shortcomings. These limitations include that the GAS does not apply to modified asphalts, waxy asphalts or blown asphalts. The GAS air void adjustment factor is based on limited data and is considered optional. The model does not address solar radiation effects or account for sealers/rejuvenators. Finally, some recent research projects suggest that the long-term model needs some adjustment/modification. Using cores from the Arizona validation site, the GAS under predicted the change in viscosity.

An alternate method for evaluating age hardening would be to utilize the relationship between carbonyl content and G* using FTIR. Farrar then described the need for developing a rapid quantitative FTIR. The goal of this work would be to obtain a small portion of a core and determine the carbonyl content. The small piece from a core would allow researchers to provide a more definitive relationship between G* and depth overtime. Farrar then presented a flowchart that describes the proposed workplan.

Following the presentation, there were questions/comments. A participant asked how do you make sure that a representative sample is obtained from a core since the sample is so small. Farrar responded that because the rapid FTIR testing is so quick, you can run a number of samples (replicates). A comment was made that the researchers will have to develop new carbonyl relationships with all new binders included in the validations sites. Farrar agreed to this comment.

Technology Development/Transfer/Deployment

(15) Asphalt Research Consortium (Technology Development) - Ray Bonaquist (AAT)

Ray Bonaquist presented the planned approach for technology development/transfer/deployment (Attachment 15). The hypothesis of this work is early identification of implementable research products and for the development of those products by consortium partners will lead to more rapid acceptance by practicing engineers and technicians. The objective is to begin the process of refining selected design, construction and maintenance of flexible pavement systems. The work elements will include early products, mid-term products and long-term products. Early products will be based upon research already completed and will need approximately 10 ETG members to review the product. Mid-term products will be those that result from early ARC and Fundamentals contract studies. Long-term products will be the results from studies conducted to meet the ARC and Fundamentals contract objectives.

Next, Bonaquist presented a flow diagram that showed the proposed approach. The proposed approach began with the researchers developing a rating system in order to rank the various products by relevance to current issues and potential for implementation. Simultaneously, researchers would begin developing executive summaries. These executive summaries would be used for ranking purposes. Next, the various products would be reviewed by the FHWA/ETG. After rating the products, a prioritized list would be developed for final development.

Following Bonaquist's presentation of the approach, there was a significant amount of discussion. A participant asked whether the potential products would come from the ARC members, to which Bonaquist answered yes. It was suggested that some DOT people act as reviewers. Bonaquist responded that some ETG members are DOT people. It was recommended that the FHWA/ETG review be the first action. The large group should be reviewing potential products and then a task group can be used as product review. Bonaquist responded that once there is a decision to proceed to development, a small specific task group can be used to guide development. The next comment was that the current situation is that products come before the whole ETG and recommendations are made, why not keep this scenario. A suggestion was made to just include the ETG as the reviewers that way some products are not developed too quickly with little oversight. Bonaquist responded that would be too many people in the ranking phase. This was seconded by Julie Kliewer. A statement was then made that proceeding to development does not necessarily mean that the product is being sent to AASHTO. The Consortium does not have any power over AASHTO. The process is simply to focus on the ARC and provide direction. A participant asked how often the Product Review Committee (PRC) would meet. Initially, the PRC would meet soon and often; however, maybe once a year after that. A comment was made that it would take some discipline to go from raking to the prioritized list in order for the PRC not to become flooded. Bonaquist stated that the product development teams would change depending upon the product. At this point, a participant stated that the ETG should define the direction. Another participant then stated that to date only the year 1 research plans have been accepted. Direction can be given in subsequent years. Bonaquist then stated that the product development teams are not an ETG function; however, they are trying to use the ETGs for product review.

A question was asked about who would make the decision on PRC members. The FHWA Chairs would assign members. It was stated that no members of the ARC should be on the PRC. It was then stated that there is a time crunch. A repository for suggestions is needed. At the next ETG meeting the members should be given a clearer picture of the potential products.

A question was asked whether the group is confusing workplans and products. The discussion is about products. The workplans produce the products and the ETGs have already had the opportunity to evaluate workplans. This comment was followed by a member stating that, in truth, the ETG did not get to review the workplans because of the thick document and short amount of time to review. Another member followed by stating that the current discussion is about correcting a wrong. The group is looking for a solution to something that started wrong. The problem is the shortness of time for reviewing the workplans and approaches.

Closing Comments – Chairman Scarpas (Delft University of Technology)

Chairman Scarpas stated that he and Kathy Petros would have to get with the other ETG group leaders on when and where the next meeting would be held. He thanks all in attendance for their presence.