

ASPHALT RESEARCH CONSORTIUM STRATEGIC PLAN

May 14, 2007

Mission:

The mission of this Consortium is to, over the next five years, build upon prior asphalt and modified asphalt research as well as prior asphalt pavement research in order to substantially improve the understanding of the mechanisms of asphalt pavement failure modes; and employ this improved understanding of pavement failure modes to devise user-friendly, validated test methods applicable to all materials (including engineered materials) and construction methods to predict pavement performance. The improved understanding, which will lead to improved and unified models as well as refined test methods, will be communicated effectively to all stakeholders through publications, web sites, Expert Task Group reviews, symposia and workshops.

Benefits to Stakeholders:

Accurate characterization and proper matching of pavement materials with pavements which are well designed for the use and environment within which they are to function reduces the risk of early pavement failure.* These stakeholder benefits will improve traffic safety and reduce life-cycle cost.

* Definition: Early pavement failure is defined as degradation of pavement safety (pavement condition) and ride quality to the point that major rehabilitation or reconstruction is warranted well before the expected time considering the original design.

The overall deliverables that will benefit stakeholders may be divided into fundamental and applied categories. The fundamental deliverables are a clearer understanding of asphalt failure modes together with validated models that predict pavement performance. The applied deliverables are fundamentally sound, validated, user-friendly test methods that differentiate among pavement design methods, materials, and construction methods so as to minimize the risk of early pavement failure. The research hypotheses, research objectives and deliverables are more specifically described in the following sections.

Moisture Damage

Research Hypotheses

The Consortium working hypotheses for the development of tests that rapidly and reliably predict the moisture susceptibility of mixes are:

- The development of tests that reliably predict the moisture susceptibility of mixes is dependent upon the identification of the mechanisms that contribute to moisture susceptibility.
- Aging of asphalt, pH of the water, aggregate structure, and surface energy of the asphalt and the aggregate play a role in determining the moisture susceptibility of a mix.

Research Objectives

- Identify the mechanisms that contribute to moisture susceptibility of mixes.
- Understand the contribution that aging of the asphalt, pH of the water, aggregate structure, and surface energy of the asphalt and aggregate make to the moisture susceptibility of mixes.
- Develop and validate the utility of tests to evaluate the moisture susceptibility of mixes. The validation will be conducted using the materials obtained during the construction of the validation sites that are planned as part of the Consortium research effort and other appropriate sites and/or materials.

Deliverables

- Prediction of moisture damage susceptibility.
 - Improved understanding of major mechanisms of moisture damage.
 - Components of a system to predict moisture damage.
 - Tests for mixture components.
 - Tests for mixtures.
 - Model to predict performance.
- Research and laboratory procedures.

Fatigue Damage

Research Hypothesis

Fatigue damage is the result of the growth of small cracks and voids to form larger cracks that result in damage. The initiation of cracks to a critical size and the propagation of these larger cracks can be successfully explained and evaluated based on the principles of viscoelasticity and viscoplasticity, dissipated pseudo strain energy, micromechanics, and fracture mechanics. A unified model of fatigue damage must be based on sound principles of mechanics and pertinent materials characteristics and must also consider adhesive and cohesive bond strengths of the mixture, the ability of the mixture to heal or recover damage between load cycles, the impact of the mixture's internal structure on stress distribution within the mixture, and the impact of moisture on mixture properties and the rate of damage in the composite mixture. The damage model should be able to predict fatigue damage from the material properties discussed above and from the dissipated pseudo strain energy measurements derived from fatigue experiments whether they are performed in the controlled-stress or controlled-strain modes of loading.

Research Objectives

- Develop a fundamental understanding of the material properties and mechanics associated with fatigue.
- Develop a unified fatigue damage model, which incorporates and integrates the important mixture properties and responses that affect fatigue life. These properties and responses include cohesive and adhesive bond strengths, viscoelastic properties, fracture properties, energy dissipation, cohesive and adhesive bond strengths, healing and/or recovery during rest periods, and the internal structure of the mixture composite. The unified model will

be capable of evaluating fatigue when loading is applied in either the controlled-stress or controlled-strain modes.

- Assess the impact of modification and aging on the binder and mastic and the impact of filler type and quantity on the mastic and/or fine aggregate matrix, using the unified model.
- Develop testing protocols for mixture, mastic, and binder characterization that provide the information required in the unified model for binder, fillers, mastic, and the total composite mixture.
- Implement the unified fatigue damage model by integrating it into a numerical scheme to assess the fatigue behavior of mixtures under different laboratory and field boundary conditions.
- Verify the unified model using microstructural measurements of fatigue damage by monitoring crack evolution through such non destructive techniques as computer assisted x-ray tomography.
- Validate the unified model and testing methods through comparisons of prediction made based on the model and full scale field testing and evaluation of pavement test sites.
- Develop component selection guidelines for perpetual pavements based on the unified approach.

Deliverables

The deliverables support the ability to predict fatigue damage susceptibility and more specifically:

- Improved understanding of fatigue damage and healing mechanisms.
- Micromechanics model to predict mixture behavior.
- Unified fatigue damage model that can be integrated into structural design.
- Structural model that incorporates unified fatigue damage model.
- Test protocols to determine properties required for the unified fatigue damage model.
- Component selection guidelines for perpetual pavements based on the unified approach.

Engineered Paving Materials (EPMs)

Research Hypotheses

The Consortium working hypotheses for EPMs are:

- By using additives and or new production processes, modified asphalt binders and mixtures can be designed to deliver superior performance that can tolerate extreme traffic and climatic conditions.
- By using fundamental engineering principles in design of mixtures, superior performance and reduced impact on the natural environment can be optimized using a high concentration of recycled asphalt mixtures, emulsions, or warm mixture additives.

- Practical and effective protocols for testing and modeling of superior materials can be developed. Such protocols would provide guidance for “engineering” high performance materials with predictable (less risky) performance.

Research Objectives

- Develop guidelines for producing and selecting engineered pavement materials to reduce risks of pavement failures.
- Develop guidelines for high level use of recycled pavement mixtures, warm mixtures, and cold mixtures.
- Validate these guidelines using laboratory damage resistance testing and field full scale trials.

Deliverables

- Design methods and guidelines for components used in:
 - RAP mixtures
 - Warm mixtures
 - Cold mixtures
 - Thermal resistant mixtures
 - Traffic resistant mixtures

Vehicle-Pavement Interaction

Research Hypotheses

The Consortium’s working hypotheses for Vehicle-Pavement Interactions are:

- HMA mixtures can be designed and evaluated in the laboratory under realistic stresses and strains conditions.
- Friction courses can be designed to optimize their skid resistance under realistic shear stresses at the tire-pavement interface.
- Base course and subgrade materials can be evaluated in terms of their properties and behavior under dynamic stresses that are encountered in the field.
- The mechanistic structural design of flexible pavements can follow a more fundamental approach where:
 - Accurate and realistic stress distributions at the tire-pavement interface are incorporated into the design process.
 - Recent advances in the characterization of the HMA mixture in terms of the dynamic modulus can be fully incorporated in the design process.
 - Fatigue and rutting analyses of HMA pavement will be based on more realistic dynamic stresses and strains to predict long-term performance.
- The interaction between road roughness and vehicle dynamics can be predicted and used to estimate the long-term performance and rehabilitation needs of the pavement system.

Research Objectives

- Develop models to predict dynamic loads of moving vehicles and their effect on flexible pavement.
- Design surface courses to increase safety by increasing the friction and or skid resistance.

Deliverables

Products that can be used to improve the understanding of and prediction of vehicle-pavement interaction as follows:

- A near-term computer model and database to estimate pavement responses to dynamic loads for user agencies.
- Dynamic load model and database to serve as input for future integration with comprehensive pavement structural model.
- Method to estimate noise and friction properties of asphalt mixtures as a part of the mixture design process.

Validation

Research Hypotheses

The Consortium working hypotheses for Validation are:

- Field validation sites built on public highways in cooperation with state DOT's that have a stored supply of original materials, documented location, and monitored performance are useful and necessary for validation of methods, models, and theories developed in research programs intended to improve asphalt pavement performance.
- Field validation using accelerated loading facilities to compare performance of compositionally different materials are also useful for validation of methods, models, and theories developed in research programs intended to improve asphalt pavement performance and offer the advantage of acquiring performance data in a shorter period of time.

Research Objectives

- Construct comparative pavement validation sites on public highways in cooperation with State DOT's or at accelerated loading facilities using compositionally different asphalts and perhaps different additives such as RAP, polyphosphoric acid, lime, or liquid anti-strip.
- Collect and store sufficient material from the construction of comparative pavement sites in order to support the research activities of the Consortium and other researchers as approved by the Consortium Program Manager and the AOTR.
- Monitor the comparative validation sites annually, or more often if necessary, to document pavement performance.

- Assist State DOT's with the implementation of the MEPDG. Validation through MEPDG Sites and Revisions of the MEPDG Asphalt Materials Models
- Continually assess the SuperPave[®] PG specifications for improvements derived from Consortium or other research.

Deliverables

- Comparative pavement validation sites on public highways in cooperation with State DOT's or at accelerated load facilities that will be constructed and monitored under the ARC grant.
- Materials reference library for materials used in comparative pavement sites in order to support the research activities of the Consortium and other researchers.
- Validated MEPDG Asphalt Materials models.
- Guidelines for improved or additions to SuperPave PG Specifications based on findings from this research.

Technology Development

Through the Technology Development projects, Consortium partners will begin the process of refining selected products from the Moisture Damage, Fatigue, Engineered Pavement Materials, and Vehicle Pavement Interaction research programs into useful tools for practicing engineers and technologists. These may take the form of new or improved standard test methods, improved specifications, improved performance models, or specific design guidance for improving the performance of flexible pavements.

Deliverables

- New or improved standard test methods.
- Proposed specifications and guidelines.
- Models for materials and pavements.
- Specific design guidance for improving the performance of flexible pavements.

Technology Transfer

The Technology Transfer program includes a number of activities designed to disseminate research results to a wide audience, recommend implementation strategies for various research products, and for those products considered ready- for-implementation, develop training materials and conduct training workshops.

Deliverables

- Refereed publications
- Presentations at National and International Conferences such as TRB, AAPT, etc.

- Consortium website
- Workshops
- ETG Project reviews
- Fliers and Newsletters

In addition, the Consortium members will stay well advised of the work plans and the progress being made in other projects including, for example, “Fundamental Properties of Asphalts and Modified Asphalts, III”, NCHRP 9-30A, NCHRP 9-43, etc.