Asphalt Research Consortium

Moisture Damage

Hypothesis

Material and mixture properties can be used to model the moisture damage process. This moisture damage model can be integrated with other distress models to predict pavement performance

Material properties

- aging of binder – interfacial adhesion; moisture transport
- pH of water – interfacial adhesion
- surface energy – interfacial adhesion and mastic cohesion

Mastic & Mixture properties

- void structure – moisture transport; pore pressure
- moisture content – mechanical properties
- filler type & content – mechanical properties

Moisture Damage

Objectives

- Identify the mechanisms for moisture damage
  (Interaction of material – mastic – mixture properties and their effect on moisture damage)

- Understand relative contribution of material and mixture properties
  (Isolate properties that have significant effect on the process and are essential for modeling and prediction)

- Develop and validate:
  - tests to evaluate the moisture susceptibility of mixes, and
  - models to predict effect on performance due to moisture induced damage

Moisture Damage

Deliverables

- Improved understanding of moisture damage mechanisms

- Components of system to predict moisture damage
  - tests for mixture components
  - tests for mixture
  - moisture damage prediction model that will be integrated (along with fatigue cracking and plastic damage) into overall pavement performance prediction model

- Research and laboratory procedures

Budget

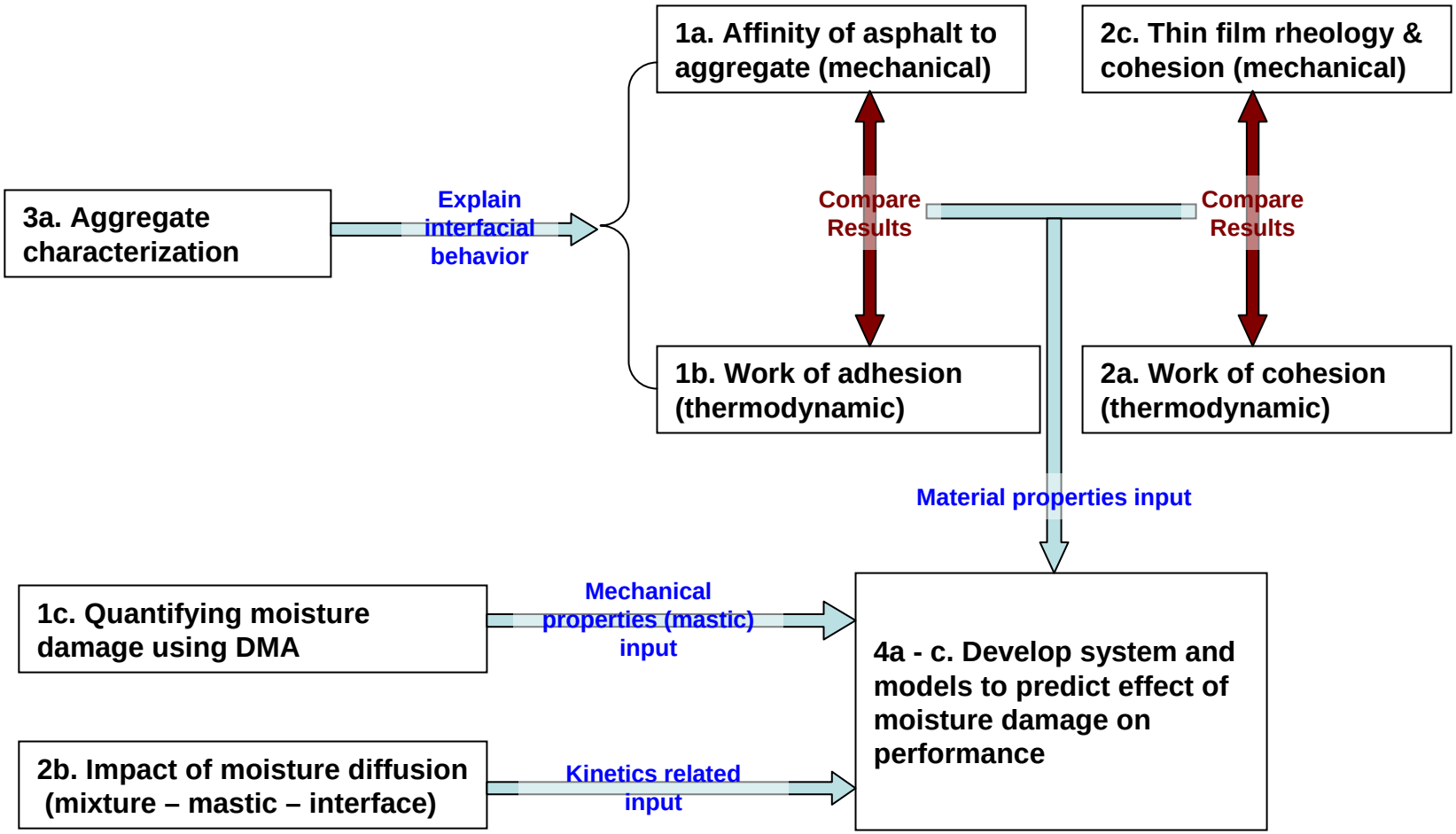
$ 4.99 M for 5 years

Moisture Damage

Category	Specific Work Element	Consortium Partner				
		WRI	TTI	UWM	UNR	AAT
M1. Adhesion	a) Affinity of asphalt to aggregate (test)			X		
	b) Work of adhesion	X	X			
	c) Quantifying moisture using DMA		X			
M2. Cohesion	a) Work of cohesion (surface energy)	X	X			
	b) Impact of moisture diffusion		X			
	c) Thin film rheology and cohesion			X		
M3. Aggregate	a) Aggregate surface characterization		X			
M4. Modeling	a) Development of model		X			
M5. System	a) Moisture damage prediction system	X	X	X	X	X

Moisture Damage

Work Elements ⟷ Hypothesis



Fatigue

Hypothesis

Fatigue damage is a result of the growth of small cracks and voids to form larger cracks that result in damage

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
- impact of aging on mixture properties

Fatigue

Objectives

- Develop a fundamental understanding of the material properties and mechanics associated with fatigue

- Develop an implementable unified fatigue damage model for asphalt mixtures that integrates relevant factors
  (cohesive and adhesive bond strengths, viscoelastic and viscoplastic properties, healing, aging etc.)

- Implement the unified fatigue damage model using micromechanical FE/DE methods and continuum damage models to assess the fatigue behavior of mixtures and pavements subjected to different laboratory and field boundary conditions

- Develop testing protocols for modified and unmodified binders, mastic, mixture for the unified model

Fatigue

Deliverables

- Improved understanding of fatigue damage and healing mechanisms
- Micromechanics model to predict mixture behavior
- Unified fatigue damage model that can be implemented in 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

Budget

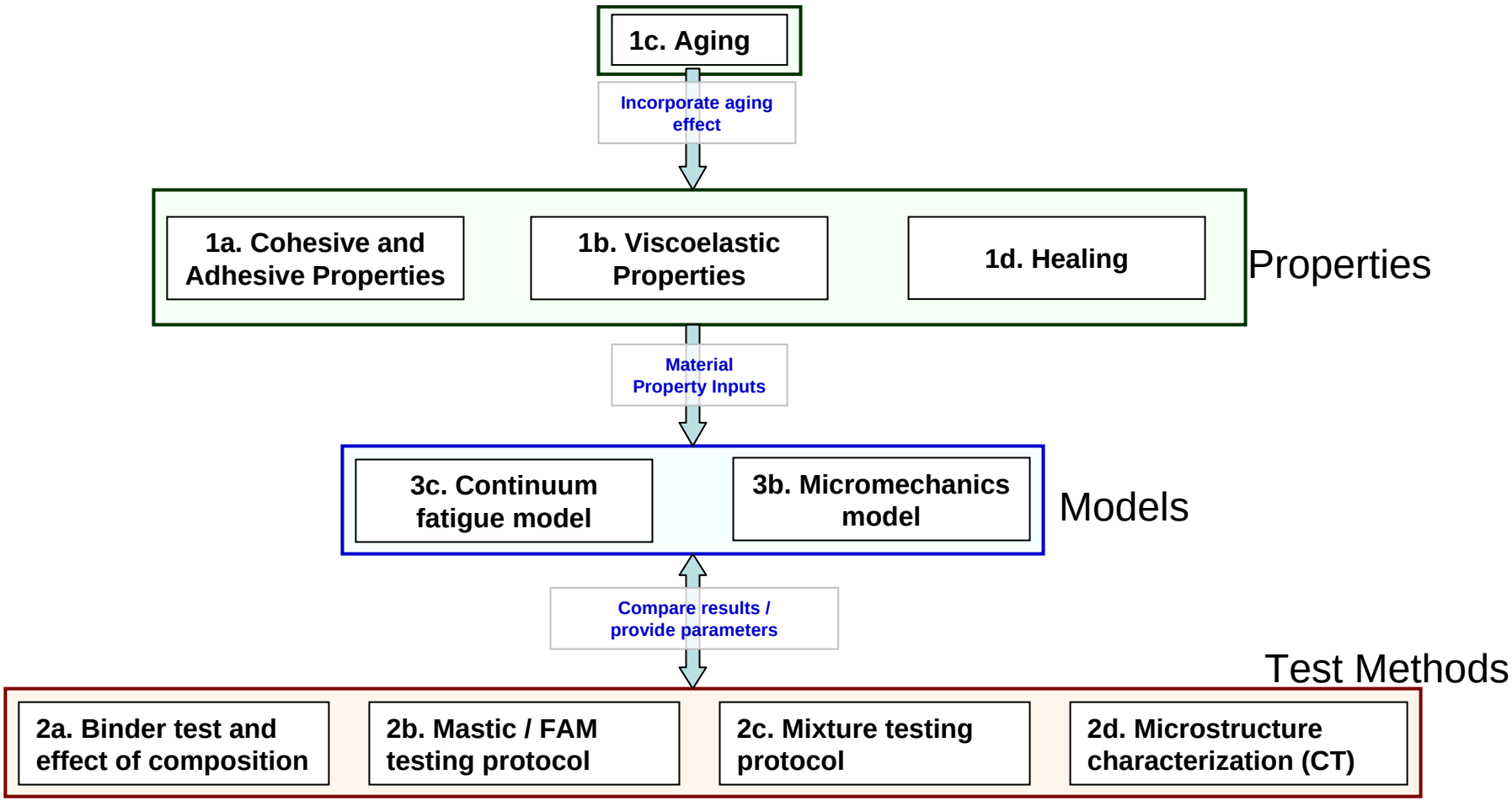
$ 5.52 M for 5 years

Fatigue

Category	Specific Work Element	Consortium Partner				
		WRI	TTI	UWM	UNR	AAT
F1. Material / Mixture Properties	a) Cohesive and adhesive properties		X			
	b) Viscoelastic properties		X			
	c) Aging		X			
	d) Healing			X		
F2. Test method Development	a) Binder tests and effect of composition			X		
	b) Mastic testing protocol		X			
	c) Mixture testing protocol		X			
	d) Microstructure characterization (X-Ray CT)		X			
	e) Verification (DSR vs. mixture fatigue)		X	X		
F3. Modeling	a) Asphalt microstructure model	X	X	X		
	b) Micromechanics model		X			
	c) Unified continuum fatigue model		X			
	d) Calibration and validation		X	X	X	

Fatigue

Work Elements ⟷ Hypothesis



Engineered Materials

Hypothesis

1. Materials that comprise the asphalt concrete composite have mechanical and geometric properties which may be combined, using micromechanics, to obtain the net properties of the composite materials

2. Using additives and/or new production processes, modified asphalt binders and mixtures can be designed to tolerate extreme traffic and climatic conditions

3. Superior performance of materials and mixtures incorporating high concentration of recycled asphalt mixtures, emulsions, or warm mixture additives can be achieved by using fundamental engineering principles

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

Engineered Materials

Objectives

- Develop analytical models for the properties of binders, mastic, and mixtures using the principles of mechanics
- Develop guidelines for producing and selecting engineered pavement materials focused on limiting risk 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

Engineered Materials

Deliverables

Design models and guidelines for components used in:

- RAP mixtures
- Warm mixtures
- Cold mixtures
- Thermal resistant mixtures
- Stable mixtures

Budget

$ 3.68 M for 5 years

Engineered Materials

Category	Specific Work Element	Consortium Partner				
		WRI	TTI	UWM	UNR	AAT
E1. Modeling	a) Analytical and micro-mechanics based models for composite mixture behavior		X			
	b) Damage resistance characterization for binders			X		
	c) Warm mixtures			X	X	
E2. Design Guidance	a) Comparison of modification techniques			X		
	b) Use of high percentage of RAP	X		X	X	X
	c) Critically designed HMA mixtures				X	
	d) Thermal cracking resistant mixes for intermountain states			X	X	
	e) Design of fatigue and rut resistant mixtures					X

Vehicle Pavement Interaction

Goal

- Develop simplified tools to compute dynamic tire-pavement interaction for special loading conditions
- Use existing knowledge of macro and micro texture to design mixtures to enhance safety

Objective

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

Vehicle Pavement Interaction

Deliverables

- 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

Budget

$ 1.05 M for 5 years

Vehicle Pavement Interaction

Category	Specific Work Element	Consortium Partner				
		WRI	TTI	UWM	UNR	AAT
V1. Workshop	a) Workshop on super single tires				X	
V2. Design Guidance	a) Mix design to enhance safety and reduce noise			X		
V3. Modeling	a) Pavement response model to dynamic loads				X	

Validation

Goal

Evaluate selected existing specifications and validate research products from this study under realistic loading and environmental conditions encountered in the field

Objective

Validate and refine research products using data from validation sites including MEPDG sites

Validation

Deliverables

- Construct and monitor comparative pavement validation sites on public highways in cooperation with State DOT's or at accelerated loading facilities

- Develop a materials reference library for materials used in comparative pavement sites in order to support the research activities of the Consortium and other researchers

- Evaluation of the MEPDG Asphalt Materials Models

- Improved Superpave PG specifications based on findings from this research

Budget

$ 5.78 M for 5 years

Validation

Category	Specific Work Element	Consortium Partner				
		WRI	TTI	UWM	UNR	AAT
V1. Field Validation	a) Monitoring of Warm Mix pavements	X				
	b) Construction and monitoring of additional pavement sections					
V2. Accelerated Pavement Testing	a) Third-Scale Model Mobile Load Simulator		X			
	b) Construct sections at the Pecos RTC		X			
V3. R&D Application	a) Continual Assessment of Specifications			X		X
	b) Validation through MEPDG sites and evaluation of the MEPDG Asphalt Materials Models				X	

Technology Development

Goal

Develop implementable products from this and other related research

Objective

Begin refining selected products from the Fatigue, Moisture Damage, Engineered Pavement Materials, and Vehicle Pavement Interaction research programs into useful tools for engineers and technologists involved in the design, construction, and maintenance of asphalt pavement systems

Technology Development

Deliverables

- New or improved
  - standard test methods
  - proposed specification type guidelines
  - models for materials and pavements

- Specific design guidance for improving the performance of flexible pavements.

Budget

$ 3.94 M for 5 years

Technology Develpoment

Category	Specific Work Element	Consortium Partner				
		WRI	TTI	UWM	UNR	AAT
TD. Technology Developme nt	1) Prioritize and select products for early development					X
	2) Develop early products					
	3) Identify products for mid-term and long-term developments					X
	4) Develop mid-term and long-term products					X

Technology Transfer

Category	Specific Work Element	Consortium Partner				
		WRI	TTI	UWM	UNR	AAT
TT1. Technology Transfer	a) Consortium web site				X	
	b) Communications				X	
	c) Presentations and publications	X	X	X	X	X
	d) Materials database				X	
	e) Research database				X	