

# Asphalt Research Consortium

# Moisture Damage

## *Hypothesis*

The moisture susceptibility of a mixture is determined based on the combined effect of **material properties** as well as **mixture properties**.

### Material properties

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

### Mastic & Mixture properties

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

# Moisture Damage

## *Objectives*

- o Identify the mechanisms for moisture damage  
(Interaction of material – mastic – mixture properties and its effect on moisture damage)
- o Understand relative contribution of material and mixture properties  
(Isolate properties that have significant effect on the process and are essential for modeling and prediction)
- o Develop and validate:
  - o tests to evaluate the moisture susceptibility of mixes, and
  - o models to predict effect on performance due to moisture induced damage

# Moisture Damage

## *Deliverables*

- o Improved understanding of moisture damage mechanisms
- o Components of system to predict moisture damage
  - Tests for mixture components
  - Tests for mixture
  - Model to predict performance
- o Research and laboratory procedures

## *Budget*

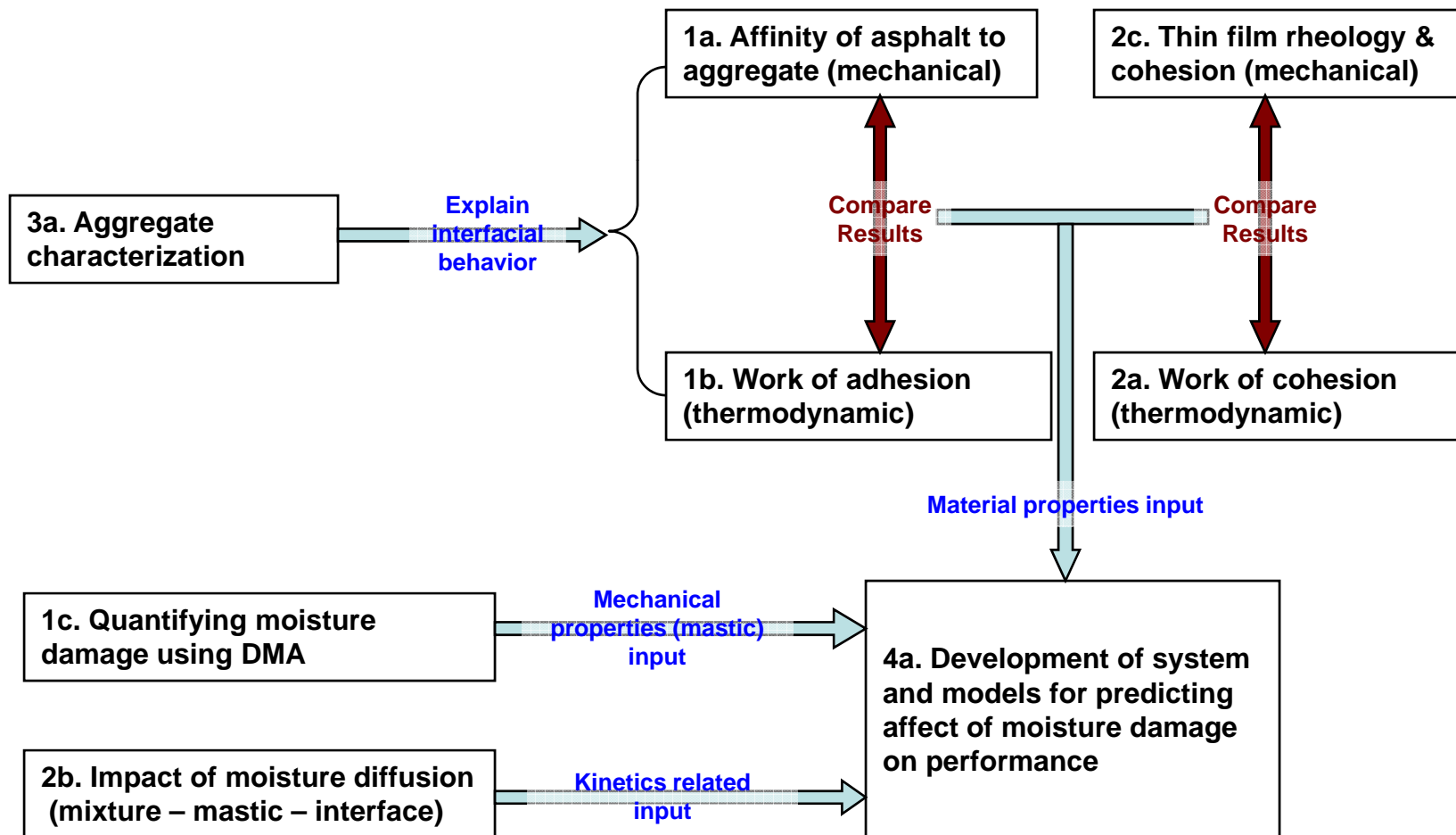
\$ 4.99 M for 5 years

# 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*

- o Develop a fundamental understanding of the material properties and mechanics associated with fatigue
- o Develop an implementable unified fatigue damage model for asphalt mixtures that integrates relevant factors  
(cohesive and adhesive bond strengths, viscoelastic and viscoplastic properties, aging etc.)
- o 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
- o Develop testing protocols for modified and unmodified binders, mastic, mixture for the unified model

# Fatigue

## ***Deliverables***

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

## ***Budget***

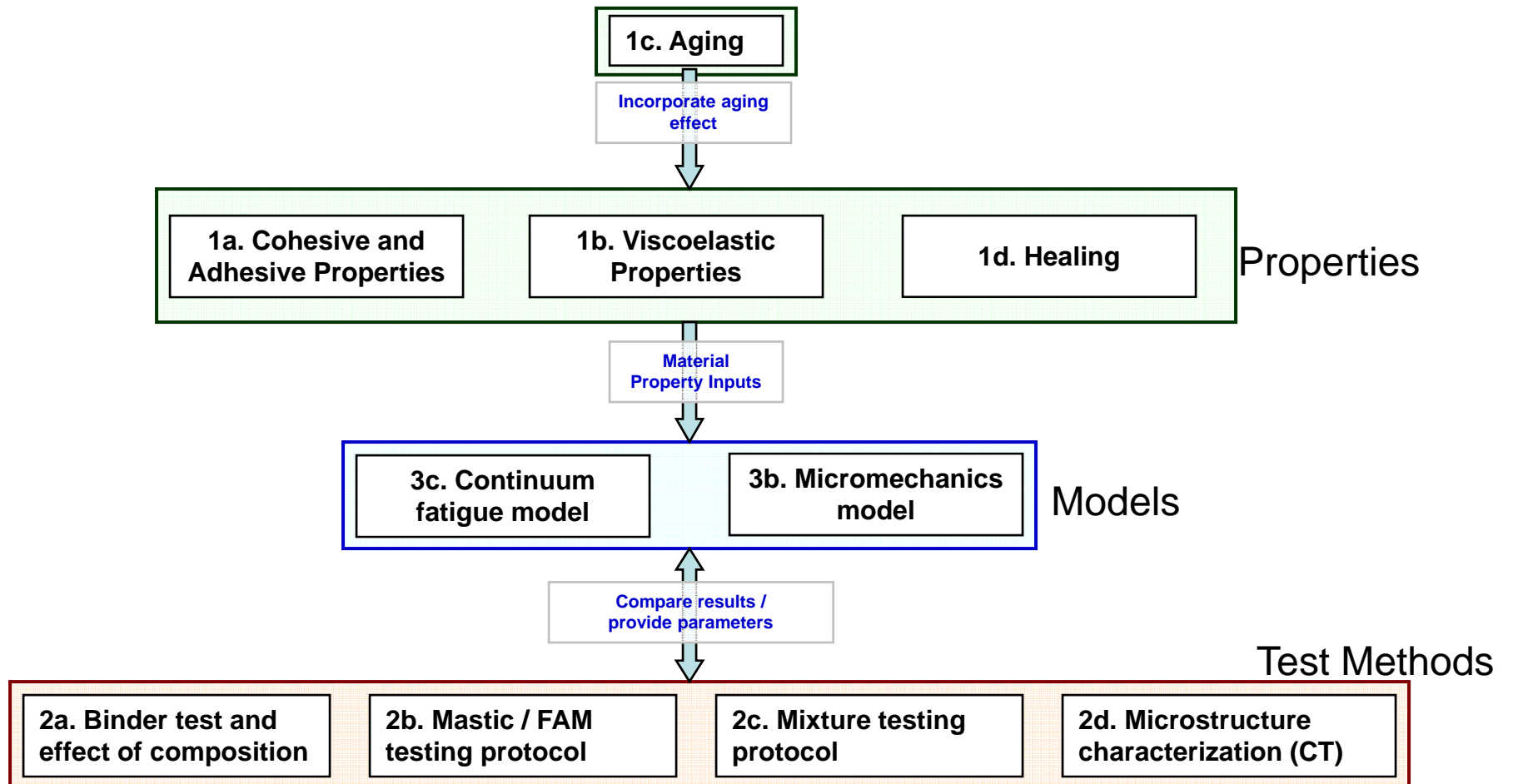
\$ 5.52 M for 5 years

# 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 Developme nt	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  $\longleftrightarrow$  Hypothesis



# Engineered Materials

## *Hypothesis*

1. All materials of which asphalt concrete is composed 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 deliver superior performance that can tolerate extreme traffic and climatic conditions
3. Using fundamental engineering principles in design of mixtures superior performance can be achieved with using high concentration of recycled asphalt mixtures, emulsions, or warm mixture additives
4. Practical and effective 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*

- o Develop analytical models for the properties of binders, mastic, and mixtures using the principles of mechanics
- o Develop guidelines for producing and selecting engineered pavement materials focused on limiting risk of pavement failures
- o Develop guidelines for high level use of recycled pavement mixtures, warm mixtures, and cold mixtures.
- o 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**

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

## **Objective**

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

# Vehicle Pavement Interaction

## *Deliverables*

- o A near term computer model and database to estimate pavement responses to dynamic loads for user agencies
- o Dynamic load model and database to serve as input for future integration with comprehensive pavement structural model
- o 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***

- o Construct and monitor comparative pavement validation sites on public highways in cooperation with State DOT's or at accelerated loading facilities
- o 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
- o Evaluation of the MEPDG Asphalt Materials Models
- o 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*

- o New or improved
  - standard test methods
  - proposed specification type guidelines
  - models for materials and pavements
  
- o Specific design guidance for improving the performance of flexible pavements.

## *Budget*

\$ 3.94 M for 5 years

# Technology Development

Category	Specific Work Element	Consortium Partner				
		WRI	TTI	UWM	UNR	AAT
TD. Technology Development	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	