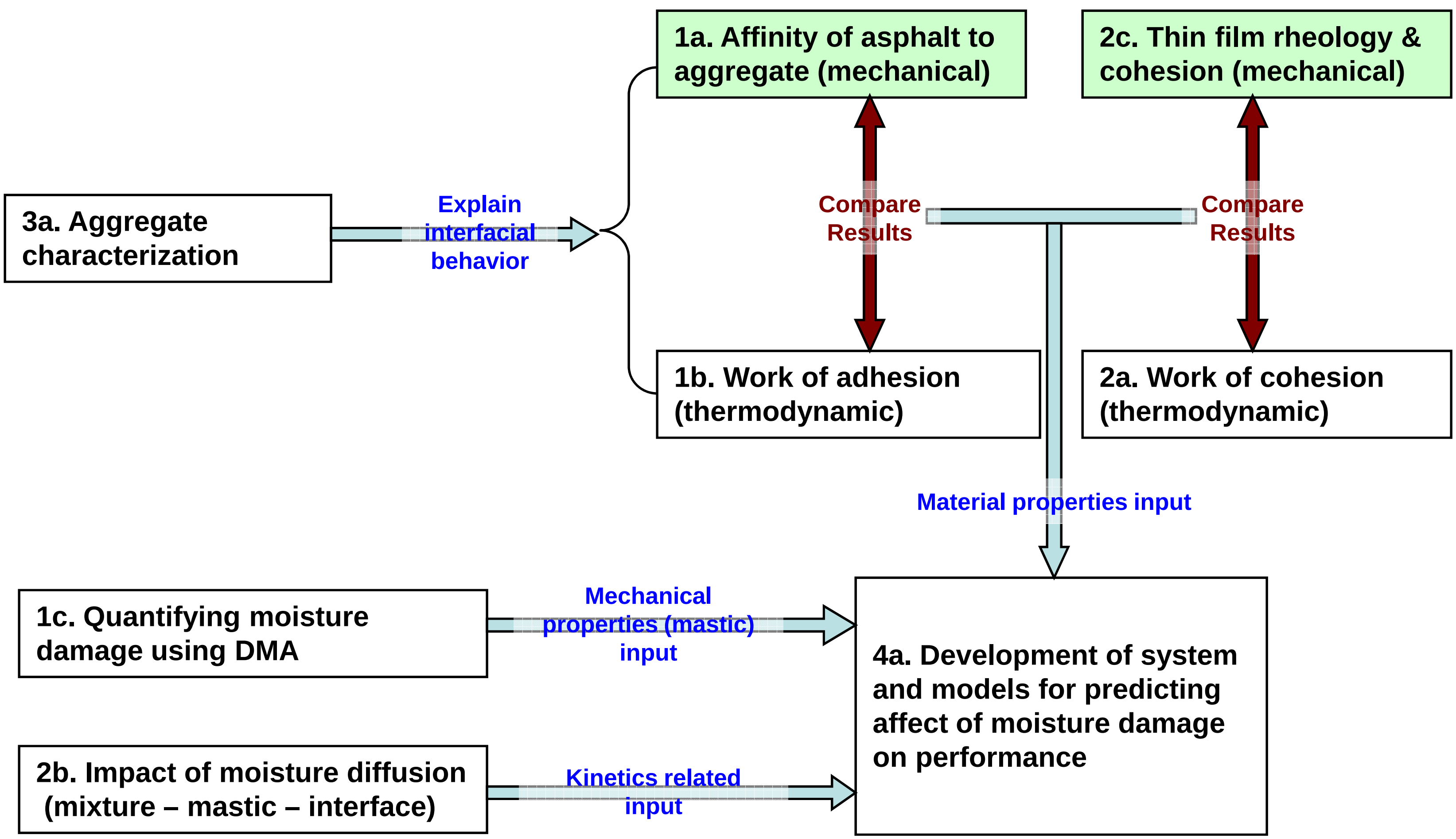
Asphalt Research Consortium

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



Moisture Damage

M1a. Affinity of asphalt to aggregate

M2c. Thin film rheology and cohesion

Objective:

To develop mechanical tests that can provide material properties related to adhesion and cohesion

Moisture Damage

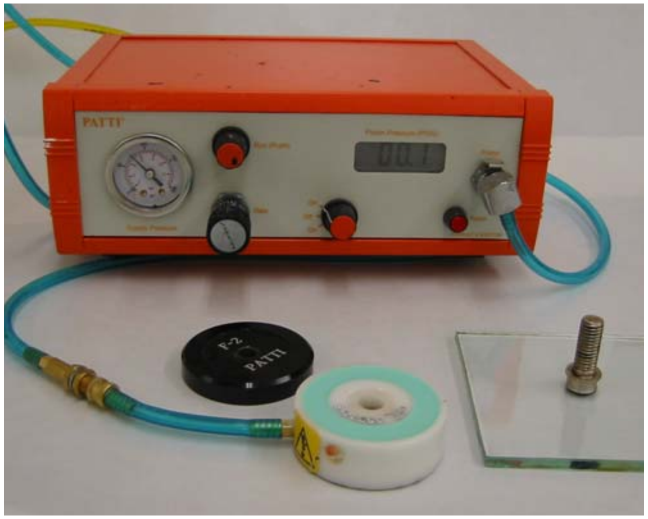
M1a. Affinity of asphalt to aggregate

M2c. Thin film rheology and cohesion

Research Approach:

1. Review available mechanical tests including DSR and PATTI tests
2. Evaluate <u>effect of moisture content and film thickness</u> on adhesive & cohesive properties
3. Extend tests to mastics
4. Compare results with mixture performance and complimentary thermodynamic properties
5. Evaluate practical aspects for implementing test method

D S R



PATTI

Moisture Damage

M1a. Affinity of asphalt to aggregate

M2c. Thin film rheology and cohesion

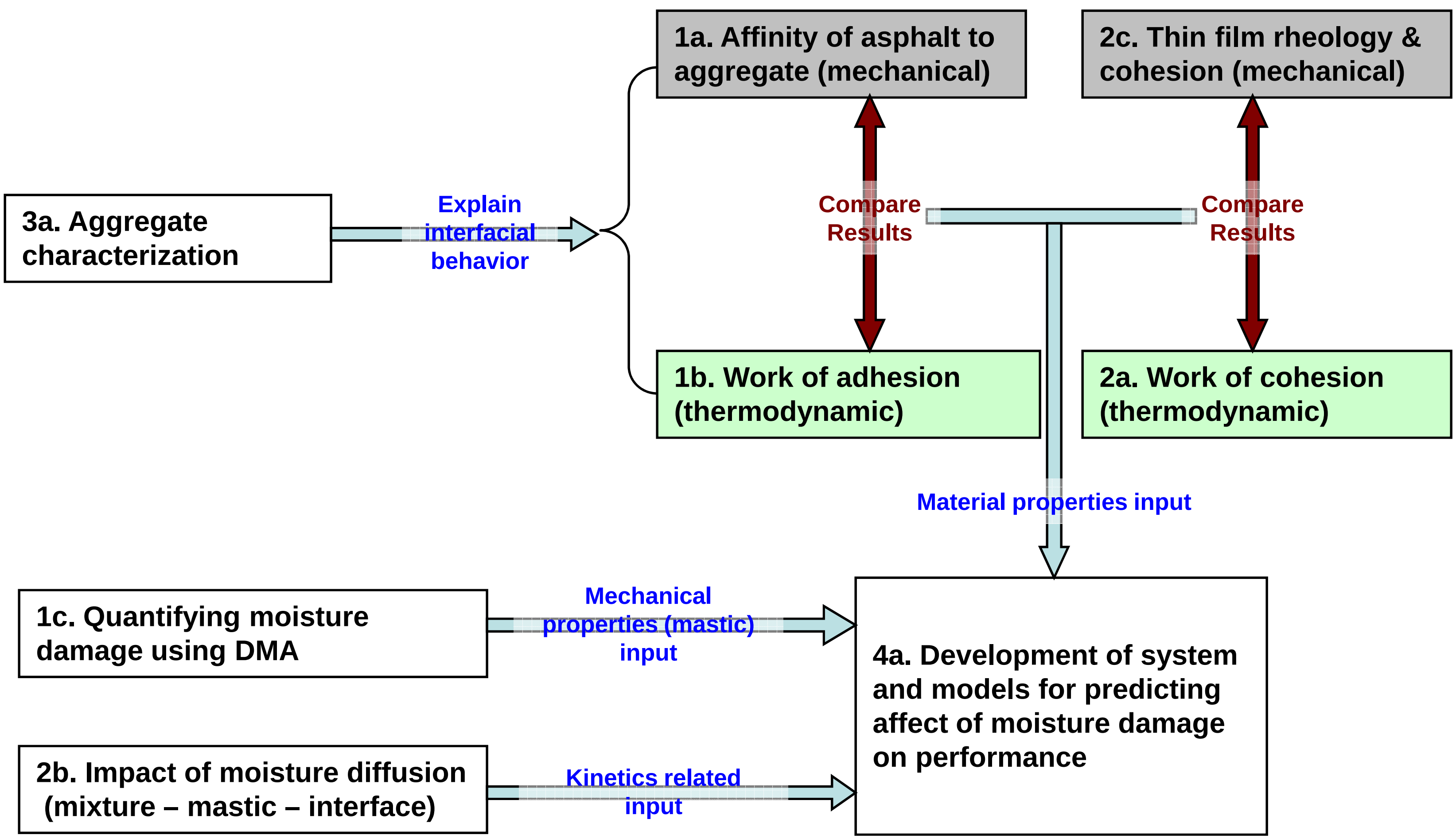
Relevance to Area Goal and Other Work Elements:

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
3. provide data for comparison of results based on thermodynamic measurements (surface free energy)

Moisture Damage

Work Elements ⟺ Hypothesis



Moisture Damage

M1b. and M2a. Work of thermodynamic adhesion and cohesion

Objectives:

1. Evaluate tests based on principles of thermodynamics to determine material properties related to the work of adhesion
2. Identify mechanisms of competition between organic molecules and water to adhere to aggregate surfaces
3. Assess work of cohesion of saturated binders / mastics based on thermodynamic approach and at nano-scale

Moisture Damage

M1b. and M2a. Work of thermodynamic adhesion and cohesion

Research Approach:

1. Compare total energy of adhesion obtained using calorimetric measurements 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
   - possible use as a surrogate test

Moisture Damage

M1b. and M2a. Work of thermodynamic adhesion and cohesion

Research Approach:

2. Measure adhesive properties at nano-scale using AFM

3. Measure cohesive properties at nano-scale and using surface energy methods to evaluate degradation of binder / mastic properties due to the action of moisture

4. Use spectroscopic techniques to determine precise interactions between model minerals and organic functional groups including;
    - SFG spectroscopy
    - IR + Raman spectroscopy

Moisture Damage

M1b. and M2a. Work of thermodynamic adhesion and cohesion

Relevance to Area Goal and Other Work Elements :

1. Recommend a test method / methods by which to select / screen materials during the mixture design process
2. Provide material properties (eg. surface free energy) that may be used as <u>inputs for modeling</u>
3. Results can be compared to or combined with complimentary data based on mechanical tests

Moisture Damage

M1b. and M2a. Work of thermodynamic adhesion and cohesion

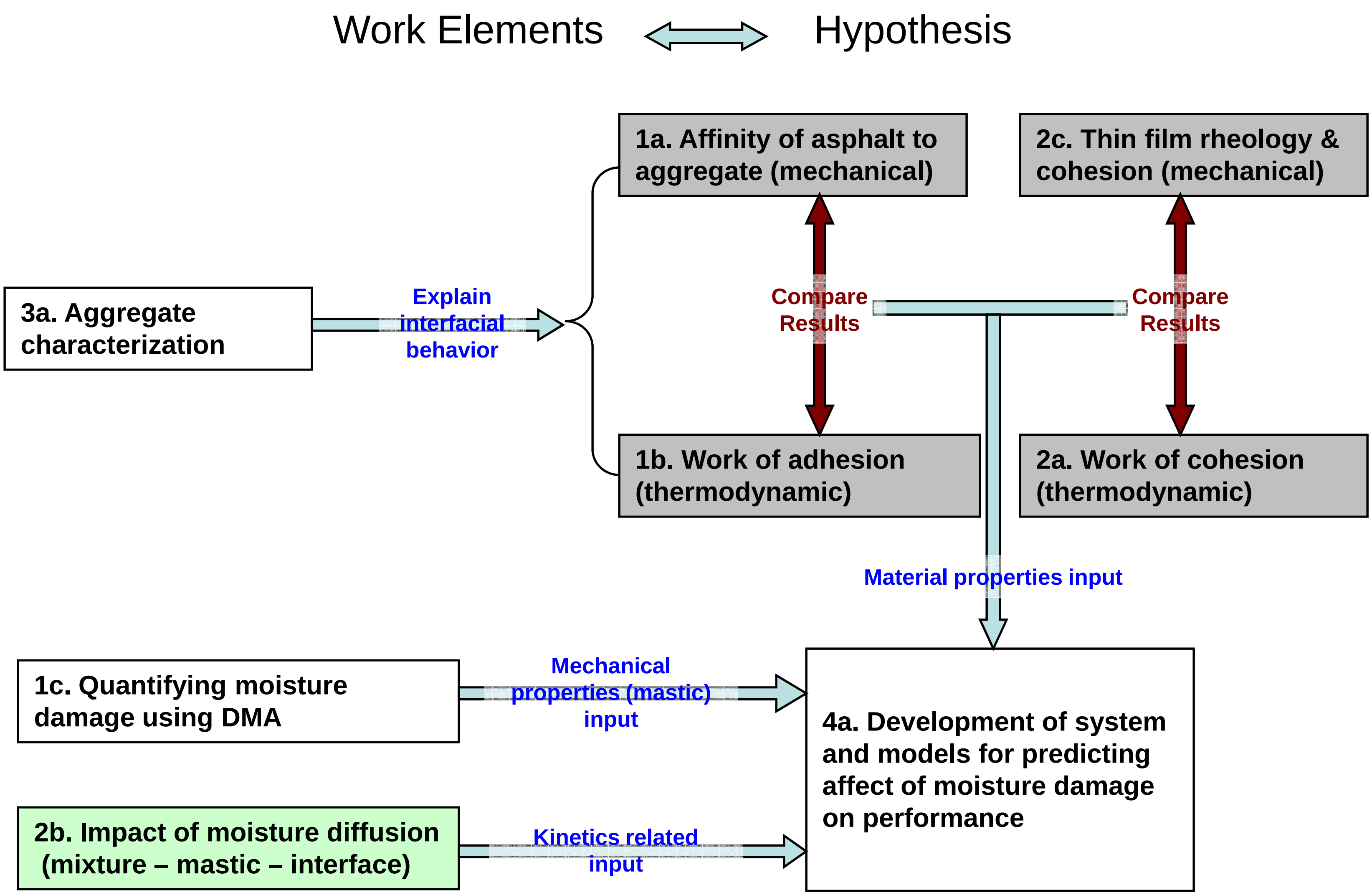
Relevance to Area Goal and Other Work Elements:

4. Provide a better understanding of the mechanisms responsible for moisture damage at binder / mastic – aggregate interface
5. Evaluate relative importance of different interactions that are critical (or insignificant) in causing interfacial failure

Lichen on limestone

– Can such mechanisms be reproduced or enhanced in asphalt mixtures?

Moisture Damage



Moisture Damage

M2b. Moisture Diffusion in Asphalt Mixtures

Objective:

Determine parameters that best represent the rate dependent characteristics of moisture damage process

Research Approach:

Evaluate the moisture transport phenomenon related to the three scales:

1. Moisture transport through the mixture dictated by its void structure
2. Moisture diffusion through binder / mastic films that coat aggregate surfaces
3. Kinetics of debonding at the binder / mastic – aggregate interface

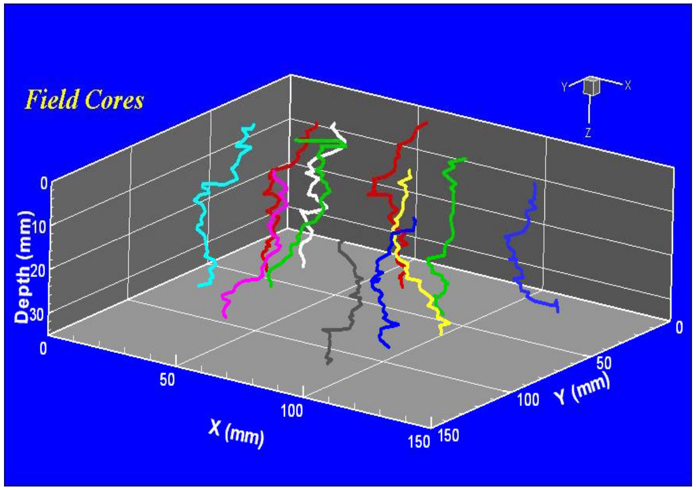
Moisture Damage

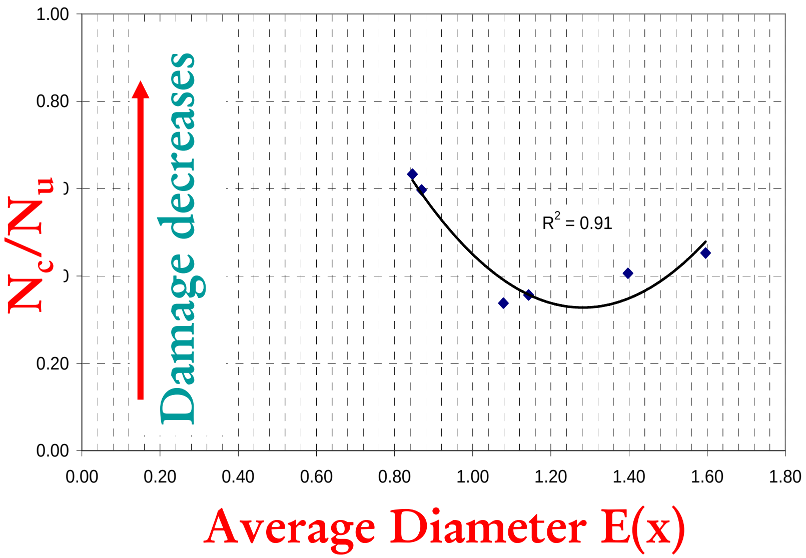
M2b. Moisture Diffusion in Asphalt Mixtures

Research Approach:

1. Moisture transport through the mixture

- Evaluate void structure, flow paths, and sample permeability using X-Ray CT images
- Determine relationship between aggregate structure and void structure in the mixture
- Determine pessimism voids for different mixtures
- Evaluate methods such as the use of psychrometer to determine moisture transport parameters for asphalt mixtures





Moisture Damage

M2b. Moisture Diffusion in Asphalt Mixtures

Research Approach:

2. and 3. Diffusion through binder / mastic films and kinetics of de-bonding at interface

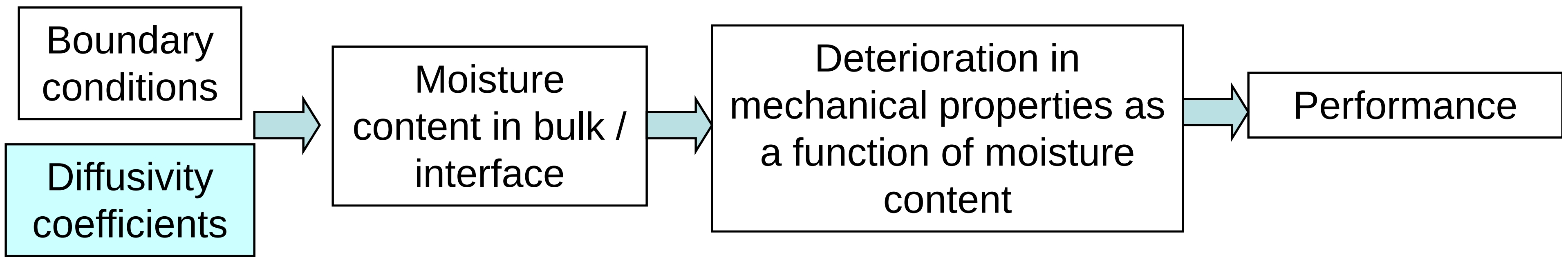
- Evaluate techniques to determine diffusivity coefficient for the asphalt binder / mastic, including FTIR and simple gravimetric techniques
- Determine diffusivity coefficients for asphalt binders / mastics and rate constants for interfacial de-bonding as well
- Evaluate possible relationship between these coefficients and other mechanical properties of the binder / mastic
- Evaluate effect of pore pressure on the diffusivity coefficients
- Evaluate hysteretic effect of boundary conditions on the diffusivity coefficients

Moisture Damage

M2b. Moisture Diffusion in Asphalt Mixtures

Relevance to Area Goal and Other Work Elements :

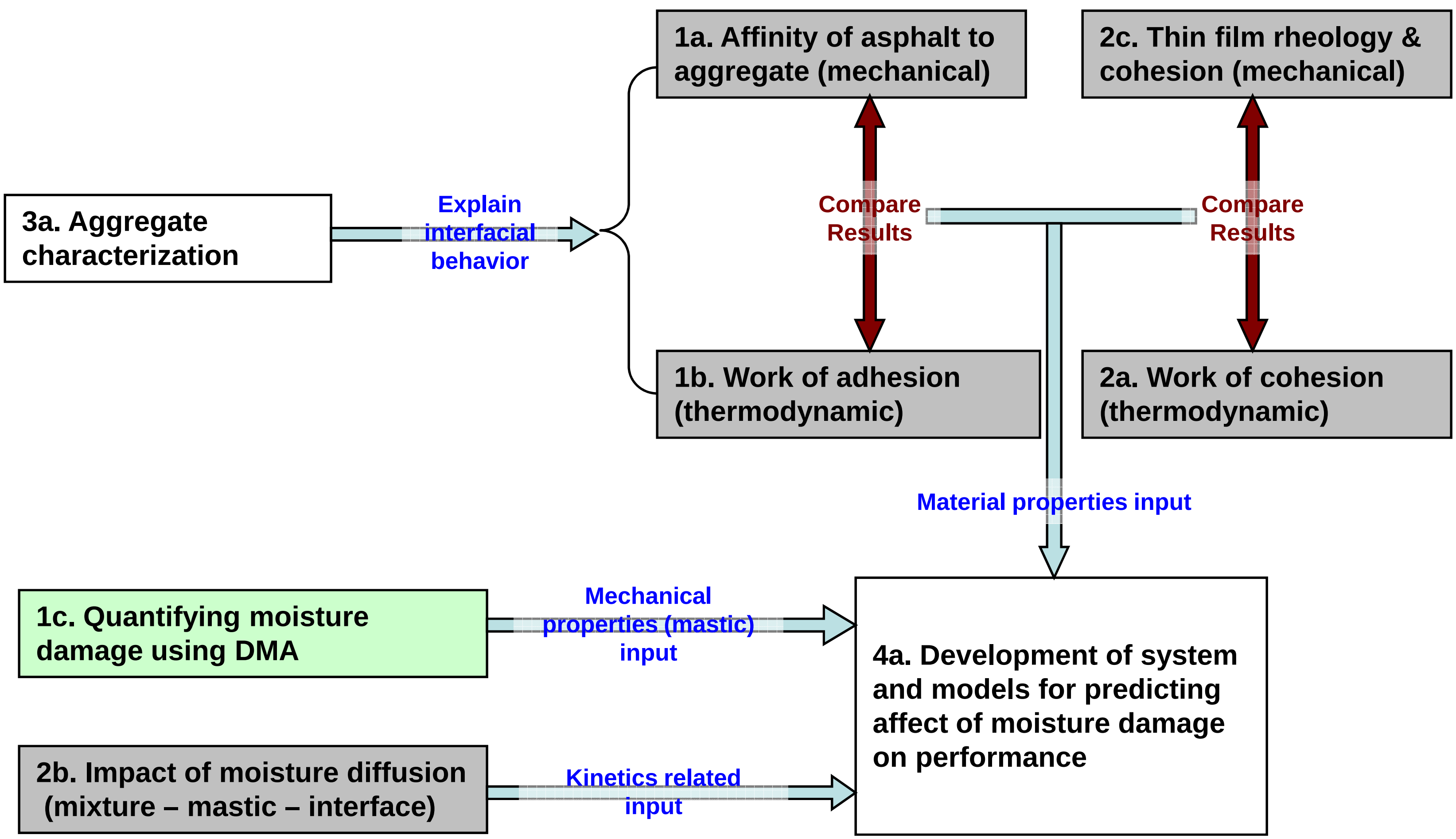
1. Provide parameters related to rate dependent characteristics of the moisture damage process to be used in modeling



2. Propose simple test methods to obtain the most critical parameters and a database for the other parameters

Moisture Damage

Work Elements ⟺ Hypothesis



Moisture Damage

M1c. Quantifying Moisture Damage Using DMA

Objective:

Develop a test protocol to assess impact of moisture damage on the performance of mastic / fine aggregate matrix

Research Approach:

Assess and refine existing test and analysis protocols to test fine aggregate matrix samples using the DMA

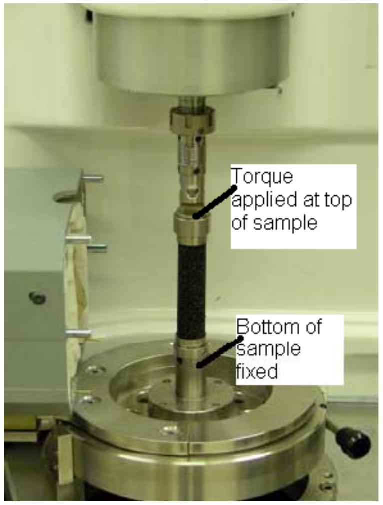
Moisture Damage

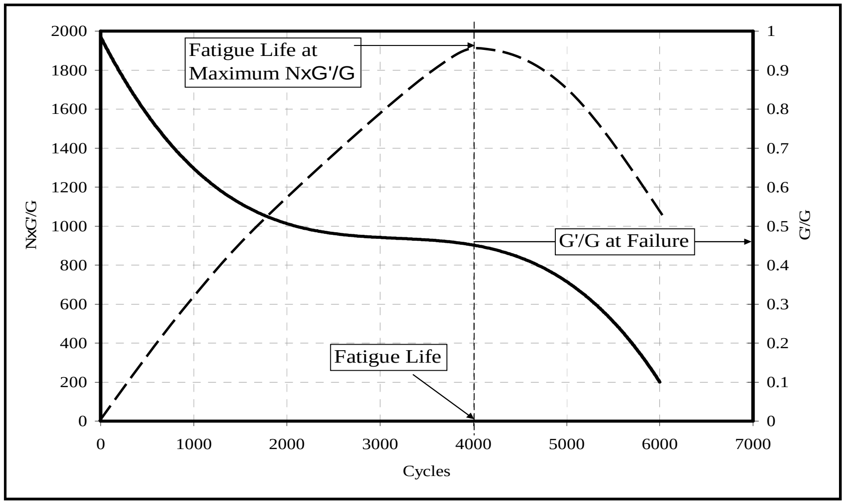
M1c. Quantifying Moisture Damage Using DMA

Relevance to Area Goal and Other Work Elements :

DMA can be used :

- as a tool to assess properties of fine aggregate matrix during the mixture design process
- to determine impact of moisture content on material properties which may be used as inputs for modeling





Moisture Damage

Work Elements ⟺ Hypothesis