Overview

1. Mechanism
2. Application

(Focus → materials; Construction and Structure → Equally important)
Overview – The different length scales

- Moisture transport
- Erosion
- Diffusion
- Cohesive softening
- Stripping
1. Moisture Transport

1. Generally referred to as “diffusion” but transport may be a better term

2. Driving forces include pressure, capillary action, RH gradient

3. It can be measured for asphalt mixtures using psychrometers (Kassem et al.)*

4. Air void structure has a strong influence on the rate of transport (Arambula et al. and Masad et al.)*


Overview – The different length scales

2. Erosion

1. More prominent in porous mixes that can facilitate “pumping action” under moving wheel load
2. Strictly speaking erosion combined with mechanical failure
3. Mastic erosion can be numerically (Kringos et al.)*
4. Measuring associated material properties is not trivial

3. Diffusion

1. Same as before but at a different length scale
2. In a mortar diffusion can occur through the bitumen (and aggregate)
3. Diffusion can be measured at mortar or bitumen length scales (Vasconcellos et al.)*

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4. Diffusion is strongly history dependent

4. Cohesive softening

1. Most studies focus on the overall behavior of the composite (Caro et al.)*

2. Poker chip test has been used to measure dry cohesive failure (Sultana et al.)*

3. Influence of moisture on adhesive failure has also been studied using similar set up

4. More work is needed to study softening (or perhaps even hardening) in isolation due to moisture in bitumen


**Overview – The different length scales**

- Moisture transport
- Erosion
- Diffusion
- Cohesive softening
- Stripping

### 5. Stripping

1. Driven by thermodynamic potential and mechanical interlock (Bhasin et al.)*

   **Thermodynamic potential**
   
   \[ W_{\text{WAS}} = \gamma_{\text{WA}} + \gamma_{\text{WS}} - \gamma_{\text{SA}} \leq 0 \text{ !!(Typically)} \]

5. Stripping

1. Driven by thermodynamic potential and mechanical interlock
2. Required inputs, surface free energies, can be measured
3. Energy ratio is strongly tied to performance (all other things being constant)
Overview – How do we combine all these?

1. Mechanism

2. Application
Application

The answer is in a short story by Jorge Luis Borges...

En aquel Imperio, el arte de la Cartografía alcanzó tal Perfección que el Mapa de una sola Provincia cubrió el espacio de toda una Ciudad y el Mapa del Imperio toda una Provincia. Con el transcurso del tiempo, estos extensos mapas se encontraban insuficientes, por lo que el Colegio de Cartografos desarrolló un mapa del Imperio que era de la misma Escala que el Imperio, coincidiendo punto por punto. Menos atentas al Estudio de la Cartografía, las Generaciones venideras llegaron a juzgar un mapa de tal magnitud y tan engorroso, y, sin Piedad, lo abandonaron a las inclemencias de sol y la lluvia.

Application – **Indicator Tests**, Fundamental Properties, Modeling

**Torture Tests**
(e.g. HWTD, Boil, Wet/Dry)
Application – Indicator Tests, **Fundamental Properties**, Modeling

### Fundamental Properties

#### Data Acquisition & Calculation
- **Wilhelmy Plate Method**

#### Balance for Force Measurement
- **Asphalt Coated Slide Dipped in Reference Liquid**

#### Magnetic Suspension Balance to Measure Mass
- **Sample Chamber**
- **Vapor Level**

#### Universal Sorption Device

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**Application – Indicator Tests, **Fundamental Properties**, Modeling**

#### Fundamental Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Gravel A</th>
<th>Gravel B</th>
<th>Granite A</th>
<th>Limestone A</th>
<th>Limestone B</th>
<th>Quartzite A</th>
<th>Sandstone A</th>
<th>Sandstone B</th>
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**Application – Indicator Tests, **Fundamental Properties**, Modeling**

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The University of Texas at Austin

1. Mechanisms (transport, softening, adhesive failure, cohesive failure)
2. Geometry
3. Constitutive models
4. Material properties


Application – Indicator Tests, Fundamental Properties, **Modeling**

- Improved understanding of what is important and when
- Better specifications
Acknowledgements and concluding thoughts...

Practicing engineers, policy makers, and researchers need to work very closely with each other.

There is no single magic test that can give us all answers...

...but the pursuit of this goal has been humbling and has created a lot of insight.

Many thanks to a number of exemplary researchers and scholars who have tolerated to have me work by their side!

Muchas Gracias

One more remark...

Academy of Pavement Science and Engineering

www.pavements.academy