Reflective Cracking

Moving HMA from a Maintenance Treatment to a Rehabilitation Alternative

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Outline of Presentation

- Background
- Why is this a problem?
- How can we solve?
- Modeling Aspects
- Materials Characterization
- Proof Testing
- Construction Considerations
- Summary

Cracking Phenomenon

- Fatigue
  - Bottom up
  - Top down
- Low Temperature
- Cracking in a stabilized base
- That other construction material that is good for going vertical!

Reflective Cracking in Washington


STOP

Background

- Reflective cracks are caused by discontinuities in the underlying layers which propagate through the HMA surface due to movement at the crack;
  - Most common in asphalt overlays placed on rigid pavements;
  - Also occurs in asphalt overlays on cracked asphalt concrete pavements;
  - Also in asphalt pavements with stabilized bases.
- One of the major failure modes in rehabilitated pavements;
- Usually overlooked during the overlay design process.
  - Reflective cracking is not considered a structural inadequacy.

Background (Cont'd)

- Cracks or joints in an underlying concrete pavement;
- Low temperature cracks in the old HMA surface;
- Block cracks induced by the old HMA surface or by subgrade soil cracking due to shrinkage;
- Longitudinal cracks in the old surface; or
- Fatigue cracks in the old surface.

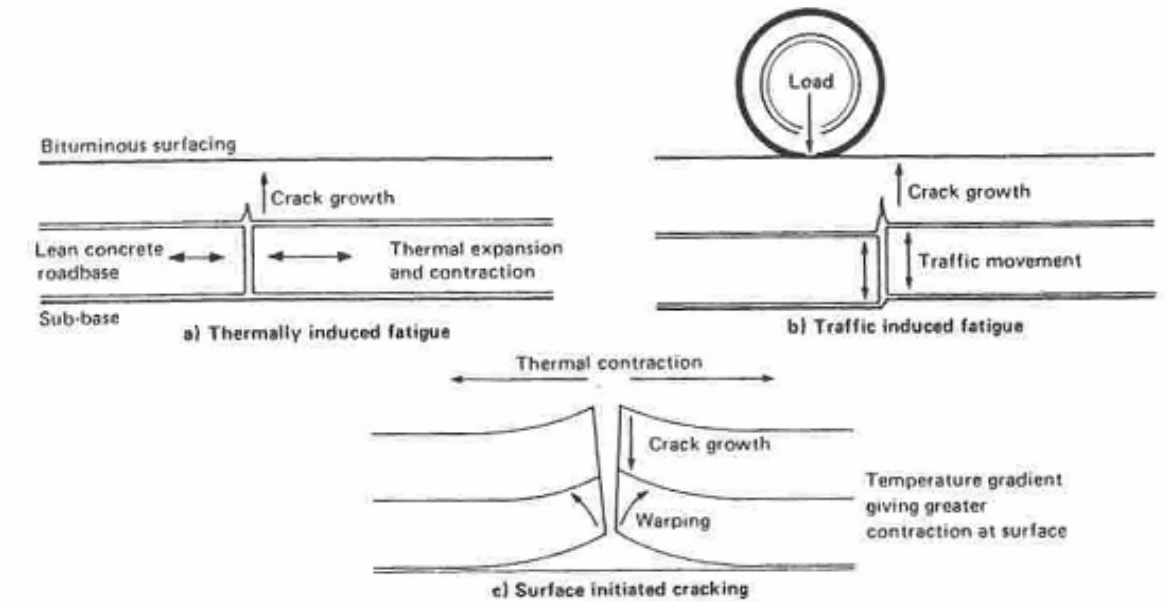
Background (Cont'd)

- Two types of reflective cracking
  - Single reflective cracking
  - Double reflective cracking

Zhou & Scullion, AAPT 2005

Background (Cont'd)

- Mechanisms of Single Reflective Cracking
  - the opening and closing of the joint or crack and temperature variations caused thermal stress and induces cracking initiation;
  - traffic loading and associated stress play a role in the second step of the crack propagation



Nunn, RILEM Conference, 1989

Why this is a problem?

- Weakening the pavement system by infiltration of water into the lower layers;
- Premature deterioration of the overlay;
- Increase in maintenance time and cost; and
- Poor ride quality and unsafe conditions.

How can we solve?

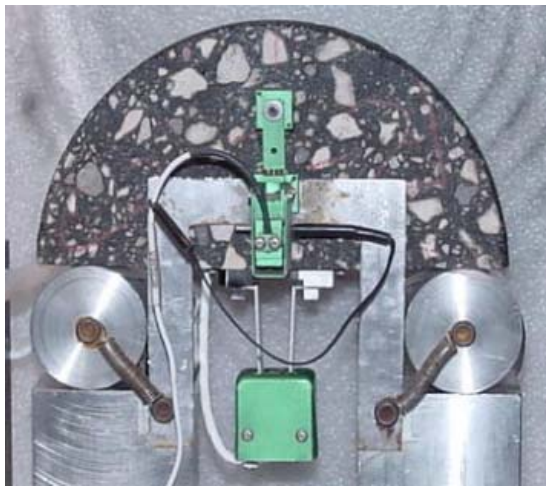
- Design asphalt mixtures with higher cracking resistance;
  - Cracking resistance measurement is a priority
- Increase overlay thickness;
- Use a modified overlay mix;
- Modifying existing pavement prior to overlay construction; and
- Use of interlayer to reduce stresses and inhibit cracks.
- Rubblize or crack & seat

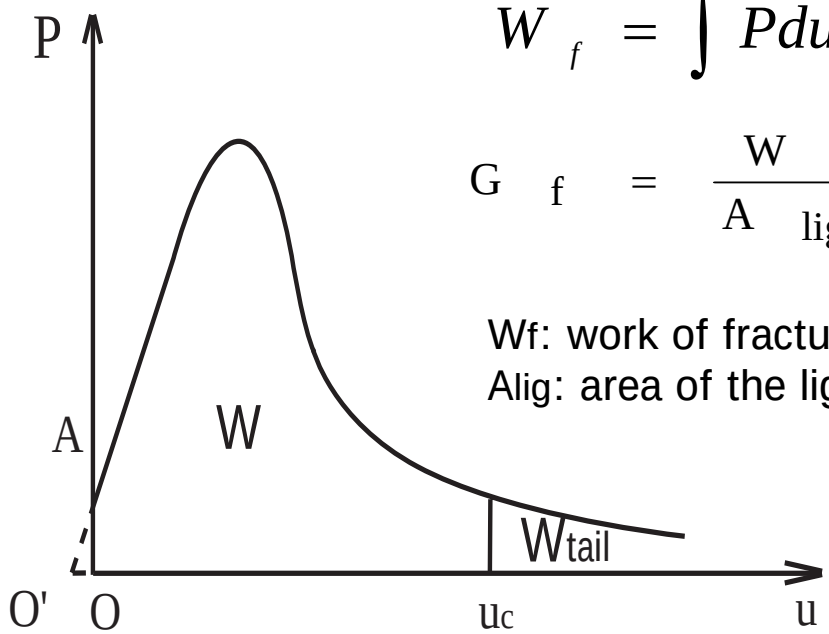
Modeling aspects?

- Fracture mechanics model
  - Linear elastic fracture mechanics
    - Fracture energy and toughness
    - Paris-Erdogan phenomenological law
  - Elastic-Plastic Fracture Mechanics
  - Time-Dependent Fracture Mechanics
- Cohesive zone model
  - Fracture energy
  - Tensile strength

Material Characterization

- Fracture energy
  - Semi-circular bending test (SCB)





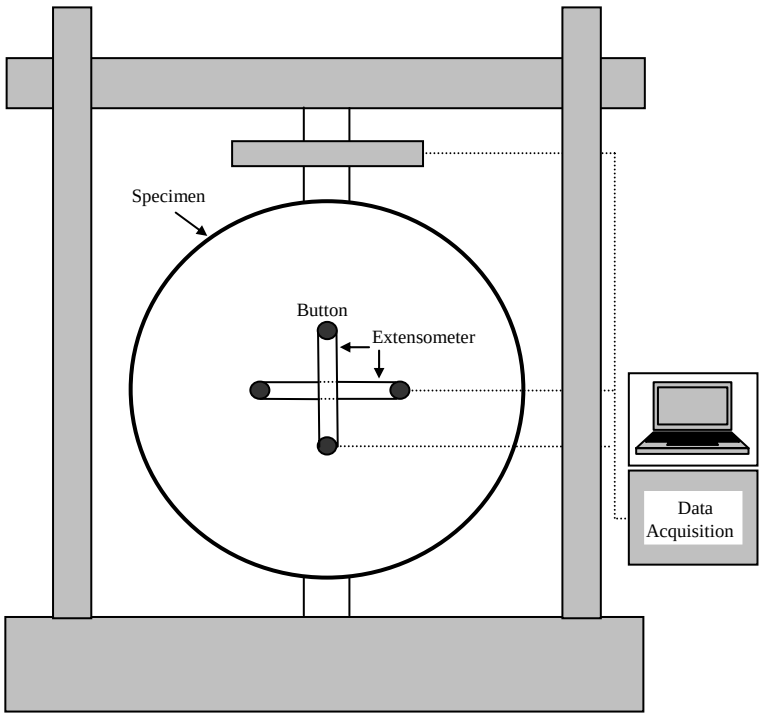
$$W_f = \int P du$$

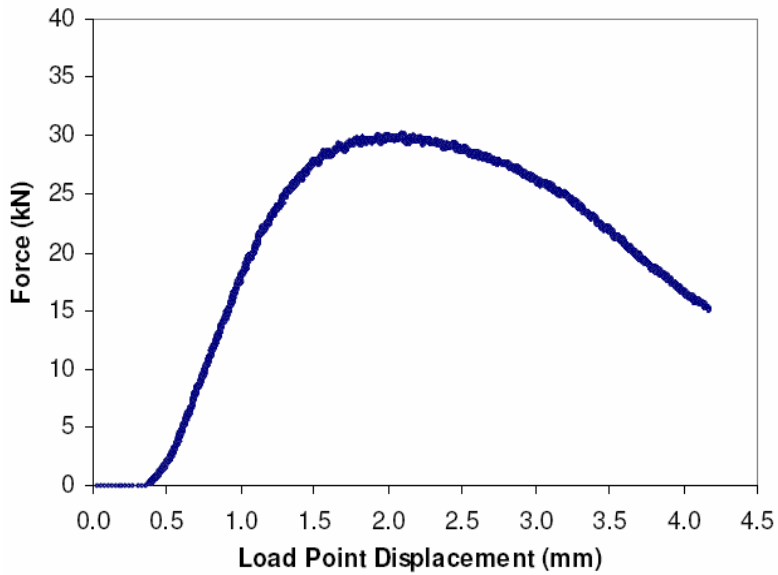
$$G_f = \frac{W_f}{A_{lig}}$$

Wf: work of fracture
Alig: area of the ligament

Material Characterization (cont'd)

- Tensile strength
  - Indirect tensile strength test (IDT)

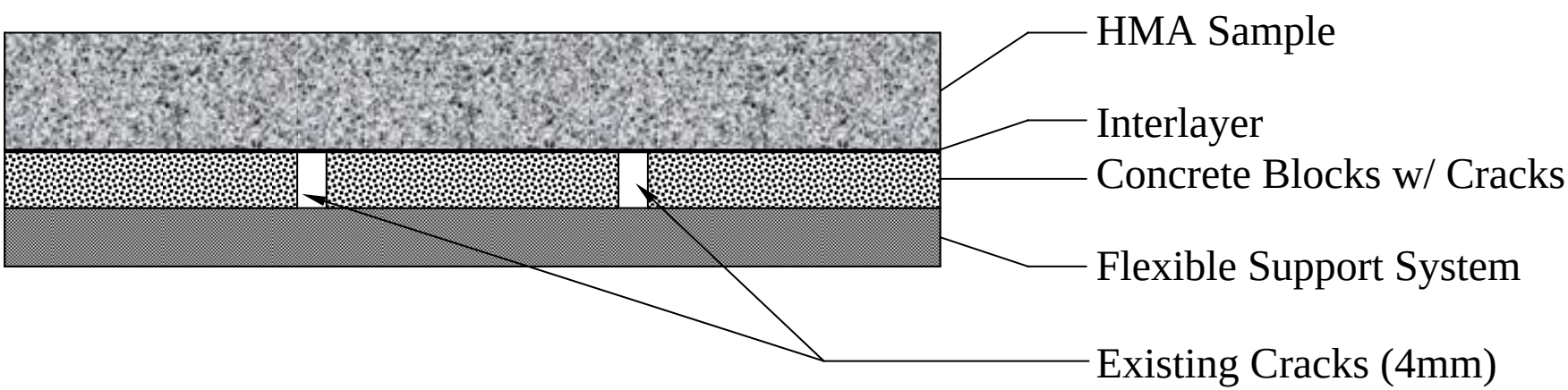




Linear Kneading Compactor

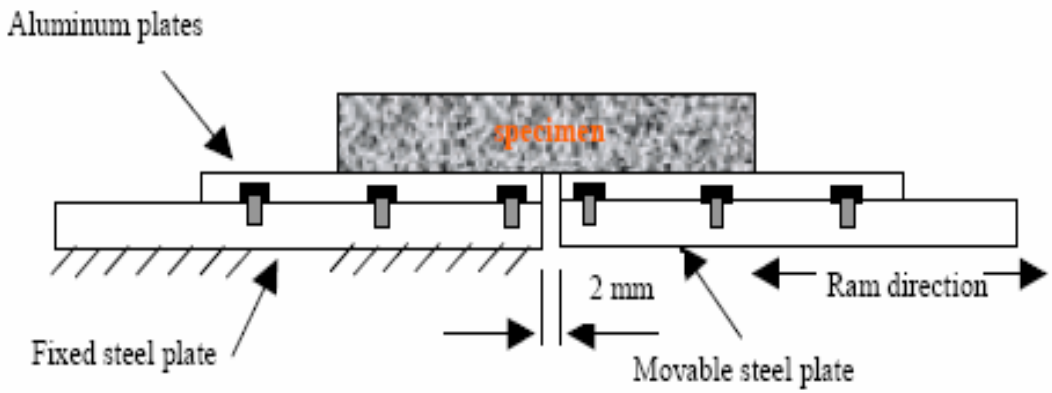
Proof Testing

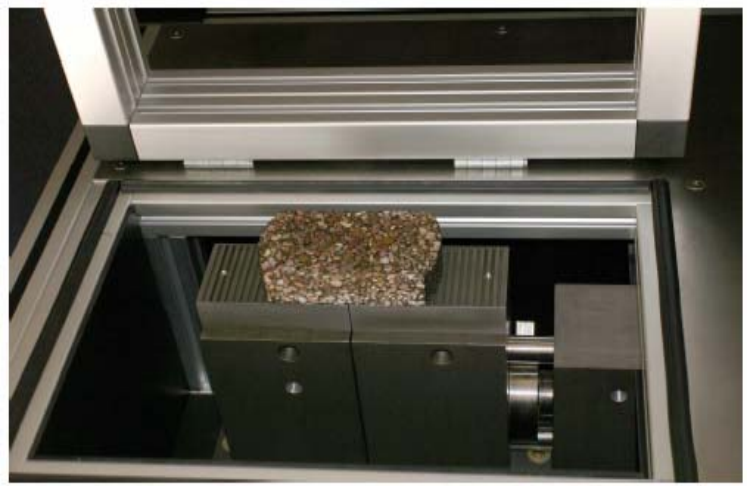
- Reflective cracking testing with APA configuration
  - Beam specimen (125mm x 300mm)
  - Existing cracks (4mm)



Reflective Cracking Testing

- Texas Transportation Institute Overlay Tester
  - Beam specimen (15mm x 75mm x 38mm)
  - Existing cracks (2mm)





Construction Considerations

- Thin stress\strain absorbing layer;
  - Asphalt rubber and geotextiles
- Reworking the top 2 to 4 inches of the old surface using recycling techniques;
- Unbound “relief” layer
- Crack & seat: breaking up the underlying slabs into smaller pieces and then seating them into the subbase layer using heavy rollers;
- Rubblize the existing concrete prior to overlay;
- Saw cut through the HMA overlay over the joint.

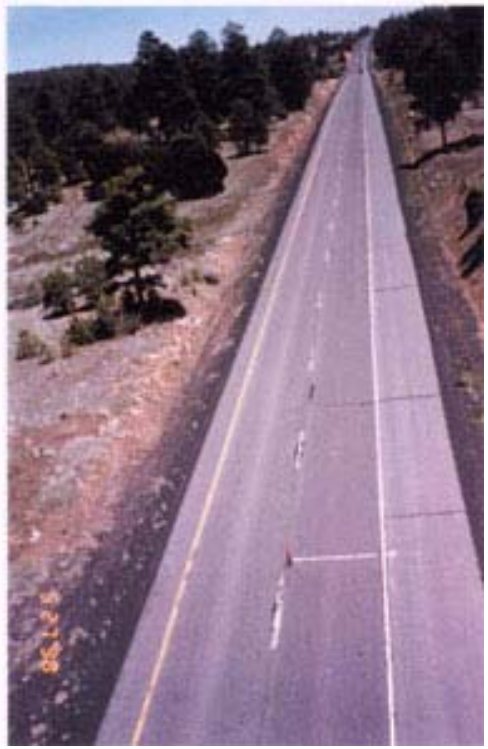
Grid System with Crack Sealing

Good construction practice is critical to the success of many techniques to mitigating reflective cracking!

I-40 in Arizona

I-40 SHRP test section
4" conventional AC
placed in 1989
Photo taken in 1998

I-40 SHRP test section
2" Asphalt-Rubber Hot Mix
placed in 1989
Photo taken in 1998



Summary

- Evaluation of mix designs for use in mitigating reflective cracks
- Tools for evaluating pavement structures for mitigating reflective cracking
- Quality construction practices and specifications

Questions?

Thank you!