LTC-II
Project Summary and Significant Contributions

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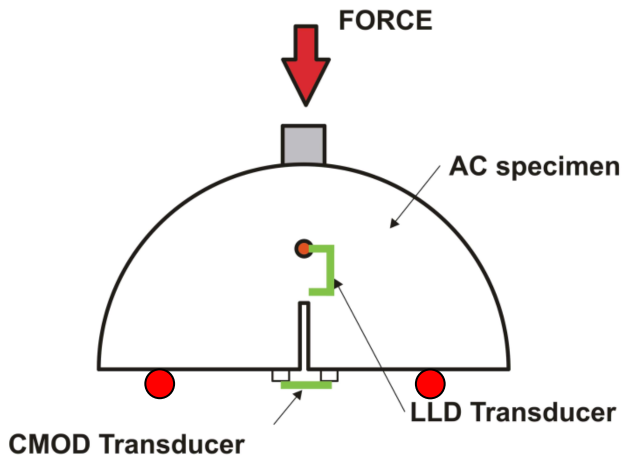
Why a LT Mixture Specification?

- For many decades "*it has been accepted*" that binder properties control low temperature performance of asphalt pavements
  - Many studies validated the current PG specification selection process
- However, the increased use of polymers and other modifiers and in particular the increase use of RAP, WMA, PPA, has made it difficult if not impossible to correctly predict low temperature pavement performance
  - **<u>Asphalt binder testing alone does not provide sufficient reliability to predict low temperature cracking of asphalt pavements</u>**

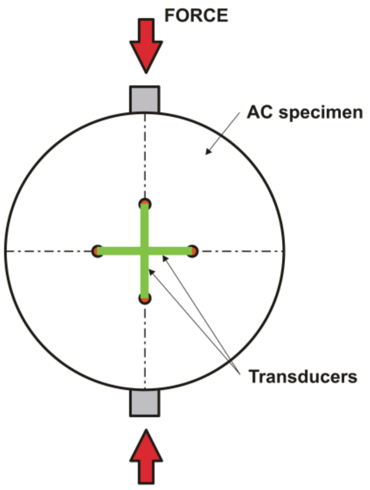
Pooled Fund Study 776 (published in 2007)

- A comprehensive investigation of low temperature cracking of asphalt pavements was performed as part of national pooled fund study
- Laboratory prepared and extracted field samples of asphalt binders and mixtures were investigated by means of mechanical testing using creep, strength and fracture tests

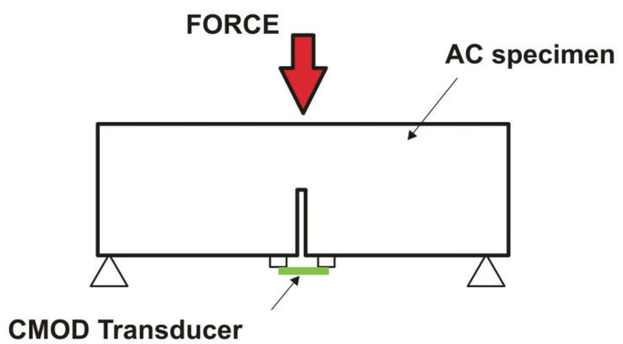
Test Methods: Mixture



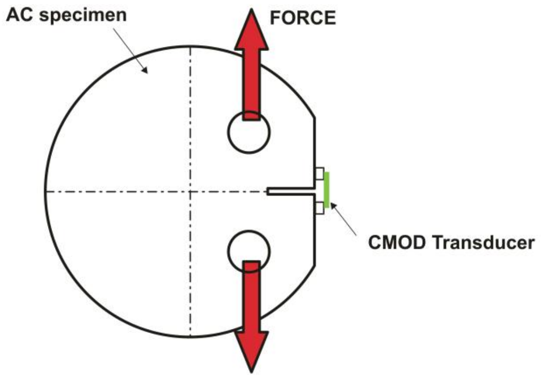
SCB



IDT



SENB



DCT

Materials

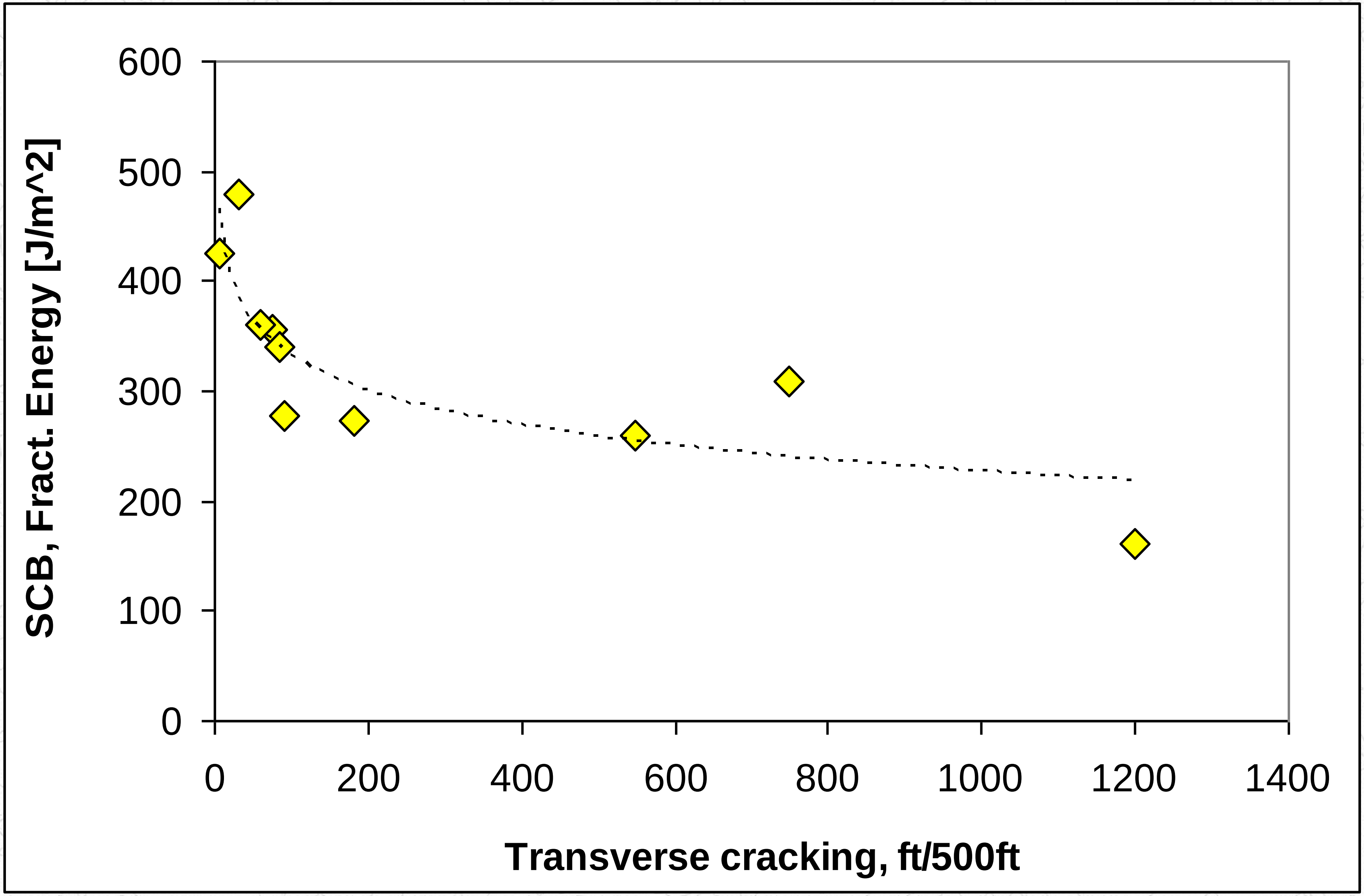
- Field cores cut into SCB, IDT, and DCT mixture specimens and field beams were used for SENB
- Binders used for BBR, DTT and DENT were extracted from IDT and SCB specimens according to AASHTO T164

ID	State	Asphalt binder
IL I74	IL	AC-20
MN75 2	MN	PG 58-28
MN75 4	MN	PG 58-34
MnROAD 03	MN	PG 58-28
MnROAD 19	MN	PG 64-22
MnROAD 33	MN	PG 58-28
MnROAD 34	MN	PG 58-34
MnROAD 35	MN	PG 58-40
US20 6	IL	AC-10
US20 7	IL	AC-20
WI STH 73	WI	PG 58-28

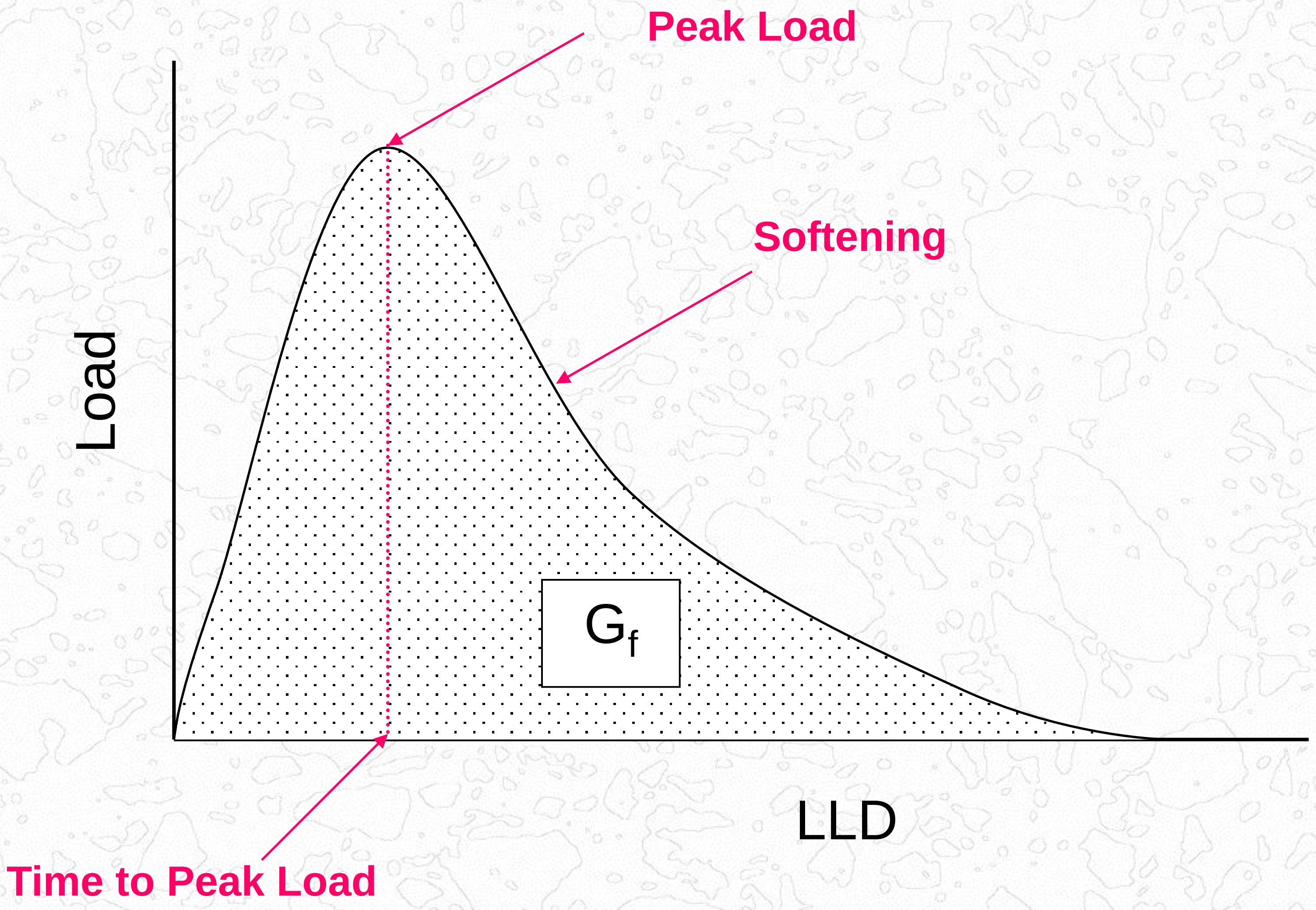
LTPP low pavement temperature at 50% reliability level

	Station	Temp. [°C]
IL I74	Urbana, IL	-16.4
MN75 2	Collegeville, MN	-24.4
MN75 4	Collegeville, MN	-24.4
MnROAD 03	Buffalo, MN	-23.8
MnROAD 19	Buffalo, MN	-23.8
MnROAD 33	Buffalo, MN	-23.8
MnROAD 34	Buffalo, MN	-23.8
MnROAD 35	Buffalo, MN	-23.8
US20 6	Freeport, IL	-19.7
US20 7	Freeport, IL	-19.7
WI STH 73	Stanley, WI	-24.7

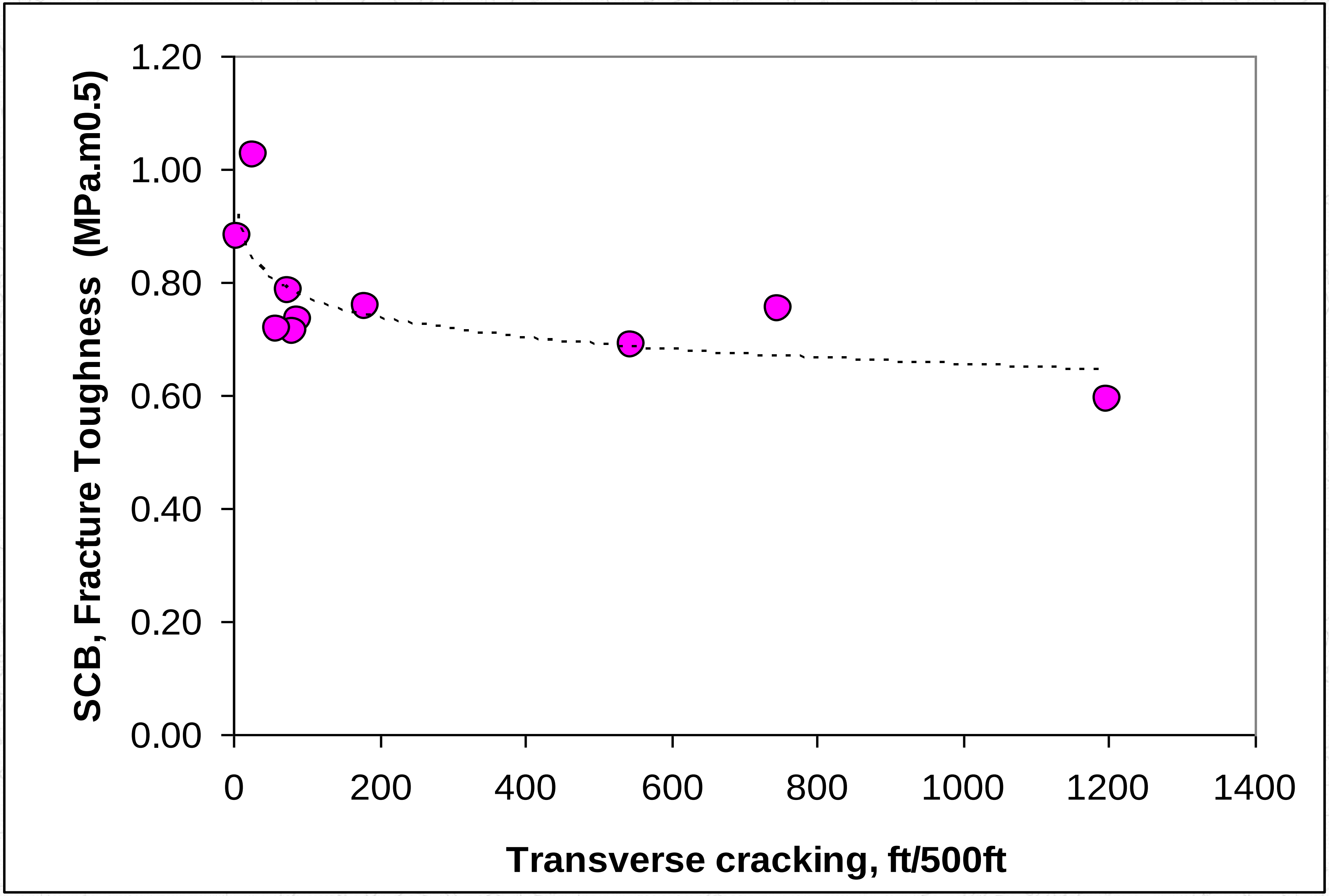
SCB Fracture Energy



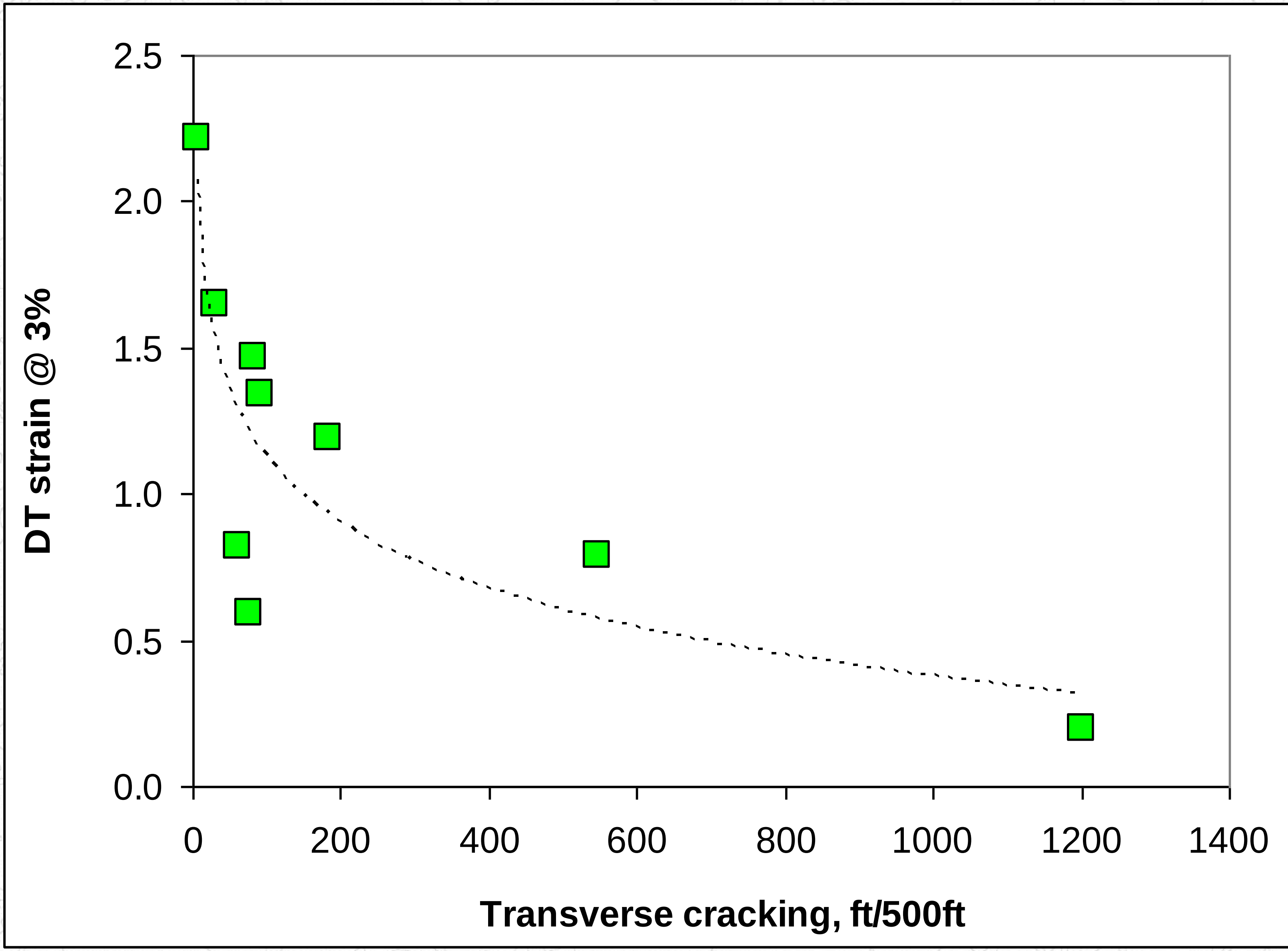
Load vs. Load Line Displacement



SCB Fracture Toughness



Direct Tension Binder Failure Strain



Pooled Fund Study 776 - Conclusions

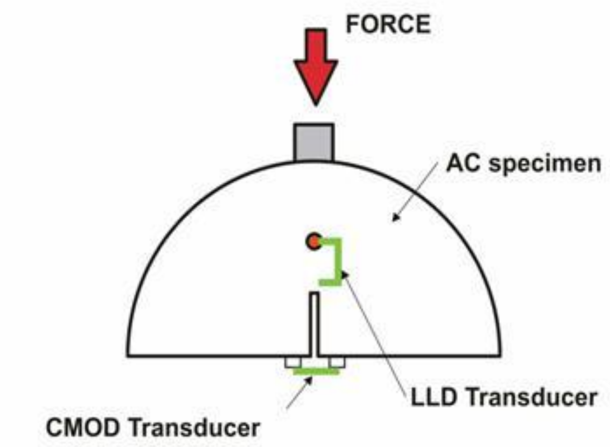
- Field performance correlates best with fracture parameters for both asphalt mixtures and binders
- The PG specification for binders provides a good start, however, other factors such as aggregate type and air voids affect fracture resistance
- At low temperature, asphalt mixtures are complex viscoelastic composite materials that are significantly temperature and loading rate dependent
- Need to develop mixture selection criteria similar to the PG system
  - Limiting values for fracture energy and possibly for stiffness, creep rate and fracture toughness

Current Pooled Fund Study

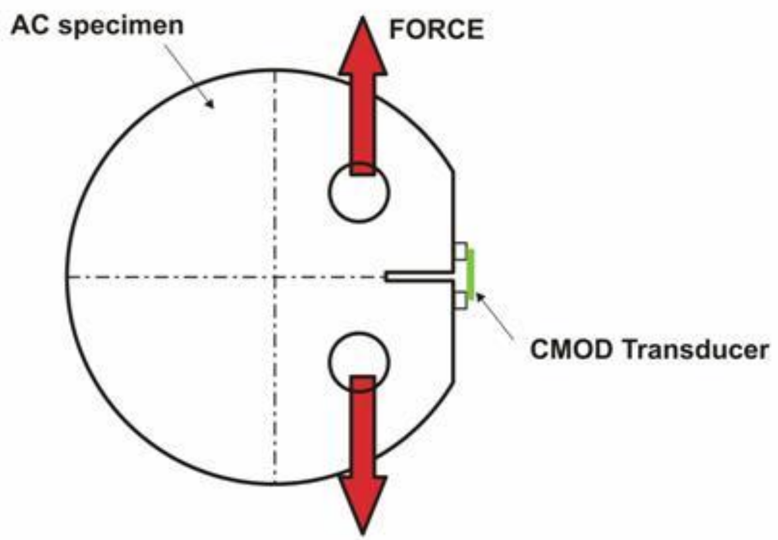
- Concept for a New Mixture Low Temperature Cracking Specification will be proposed
- Mixture selection criteria similar to the PG system
  - Main focus on fracture energy
    - From DCT or SCB
    - SCB fracture toughness limit may be added to complement the energy criterion
  - Limit on creep stiffness and possibly m-value
    - Use the current IDT method
    - Use BBR tests on mixture beams
    - Use SCB or DC(T)
    - Estimated from binder + model (Hirsch, ENTPE)

Mixture Fracture Tests

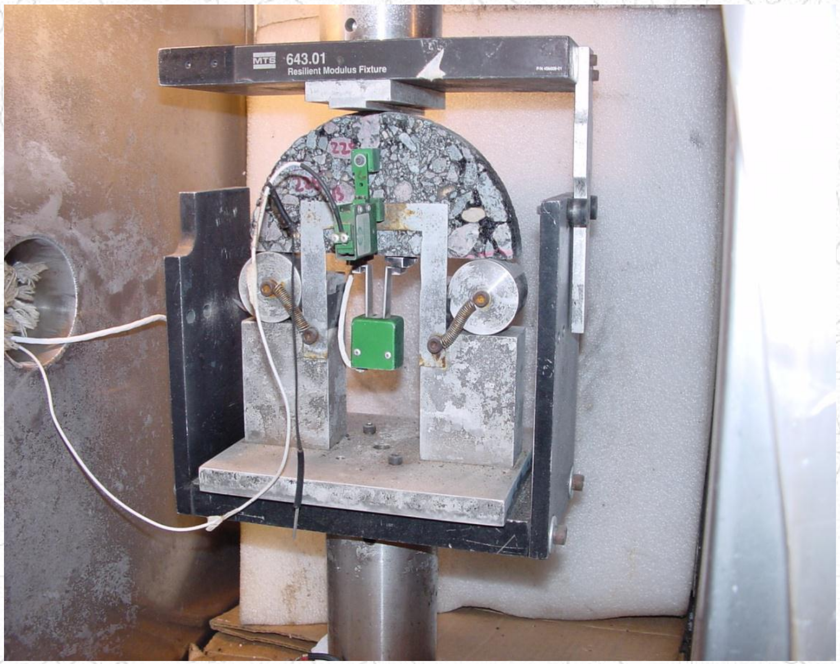
- Semi Circular Bending (SCB)

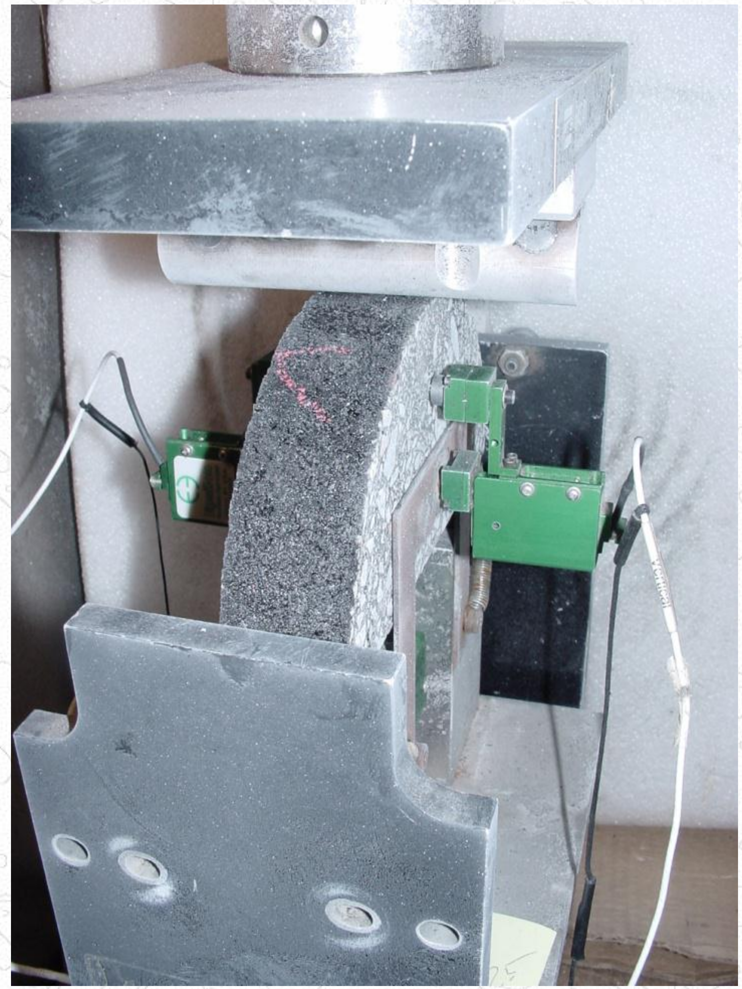


- Disc-Shaped Compact Tension DC(T)



Semi-Circular Bend (SCB) Test





Mixture Specification

- For fracture energy, a lower limit of 350 to 450 J/m^2 appears reasonable at the PG+10 temperature
- **The main difficulty** in implementing a mixture specification is related to mixture preparation procedure
  - Specification based on
    - Loose mix: mixing plant; behind the paver?
    - Cores from newly built pavement?
    - From scratch in the lab?
    - Gyratory compacted or slab compacted?
    - Air voids at 4% or 7%?
- … And to aging condition
    - Short term?
    - Long Term?

Solution

- One set of mixture preparation and aging condition will be specified for the proposed specification

- As more data will become available, relationships to take into account other preparation and aging condition combinations will be developed and implemented

Table 4.2: Recommended Low-Temperature Cracking Specification for Loose Mix DC(T)

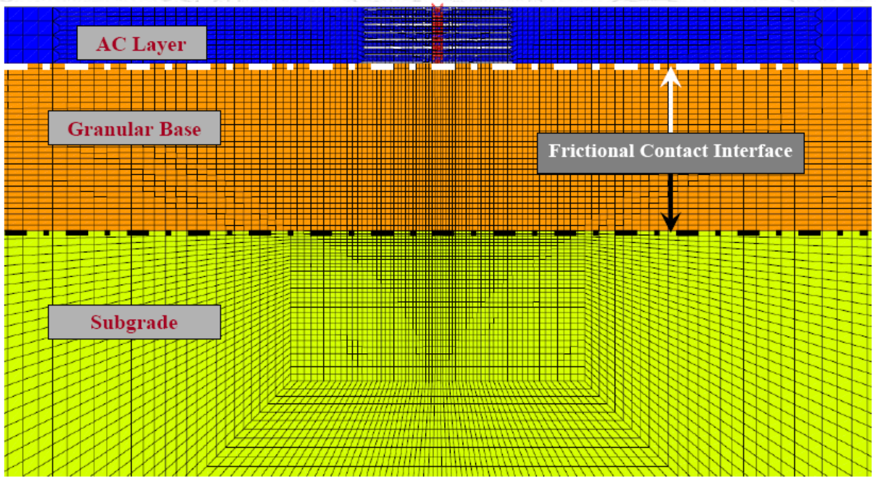
Contents	Project Criticality/ Traffic Level		
	High >30M ESALS	Moderate 10-30M ESALS	Low <10M ESALS
Fracture Energy, minimum (J/m^2), PGLT + 10ºC	690	460	400
Predicted Thermal Cracking using ILLI-TC(m/km)	< 4	< 64	Not required

Alternative Low-Temperature Cracking Specification for Loose Mix
SCB

Contents	Project Criticality/ Traffic Level		
	High >30M ESALS	Moderate 10-30M ESALS	Low <10M ESALS
Fracture Energy, minimum (J/m^2), PGLT + 10ºC	600	400	350
Optional fracture toughness (kPa×m$^{0.5}$)	800	800	Not required

Thermal Cracking Model

- Parameters also used in ILLI TC
- An executable code that can either be run standalone or in conjunction with the MEPDG
- User-friendly interfaces for data input and presentation of results
- User's guide with numerical examples that can be used to verify that the program is working properly



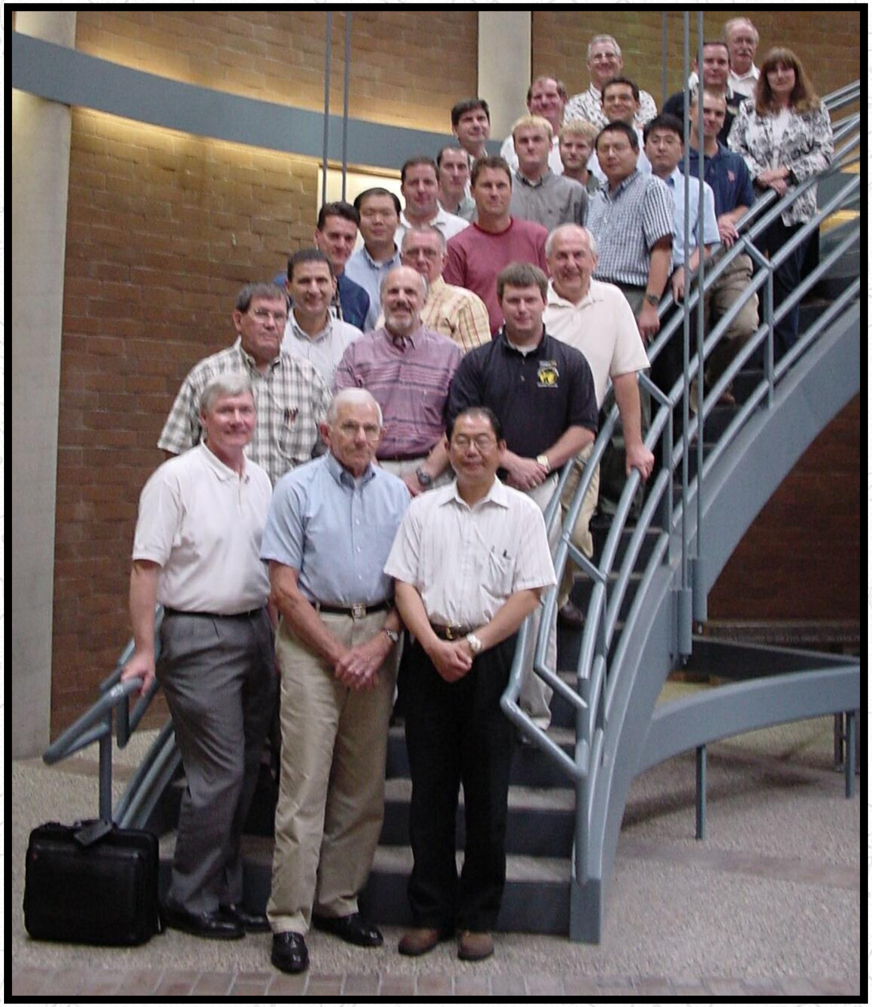
Significant Contributions

- Two fracture testing methods were proposed and specifications were developed for mixtures selection
    - Alternative methods were proposed to obtain mixture creep compliance needed to calculate thermal stresses
- Mixture dilatometric measurements resulted in a set of coefficients of thermal contraction that can be used to more accurately predict thermal stresses
- Physical hardening further evaluated and improved model proposed to take these effects into account

Significant Contributions

- Two methods for obtaining asphalt binder fracture properties were proposed and discussed
- New thermal cracking model, "ILLI-TC," was developed and validated
- The work performed on the cyclic behavior of asphalt mixtures may hold the key to developing cracking resistant mixtures under multiple cycles of temperature

Acknowledgments



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