Fatigue of Polymer Modified Asphalt Mixes

by

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Why Polymers in Asphalt Mixes?

Distresses in Hot Mix Asphalt Surfaces:

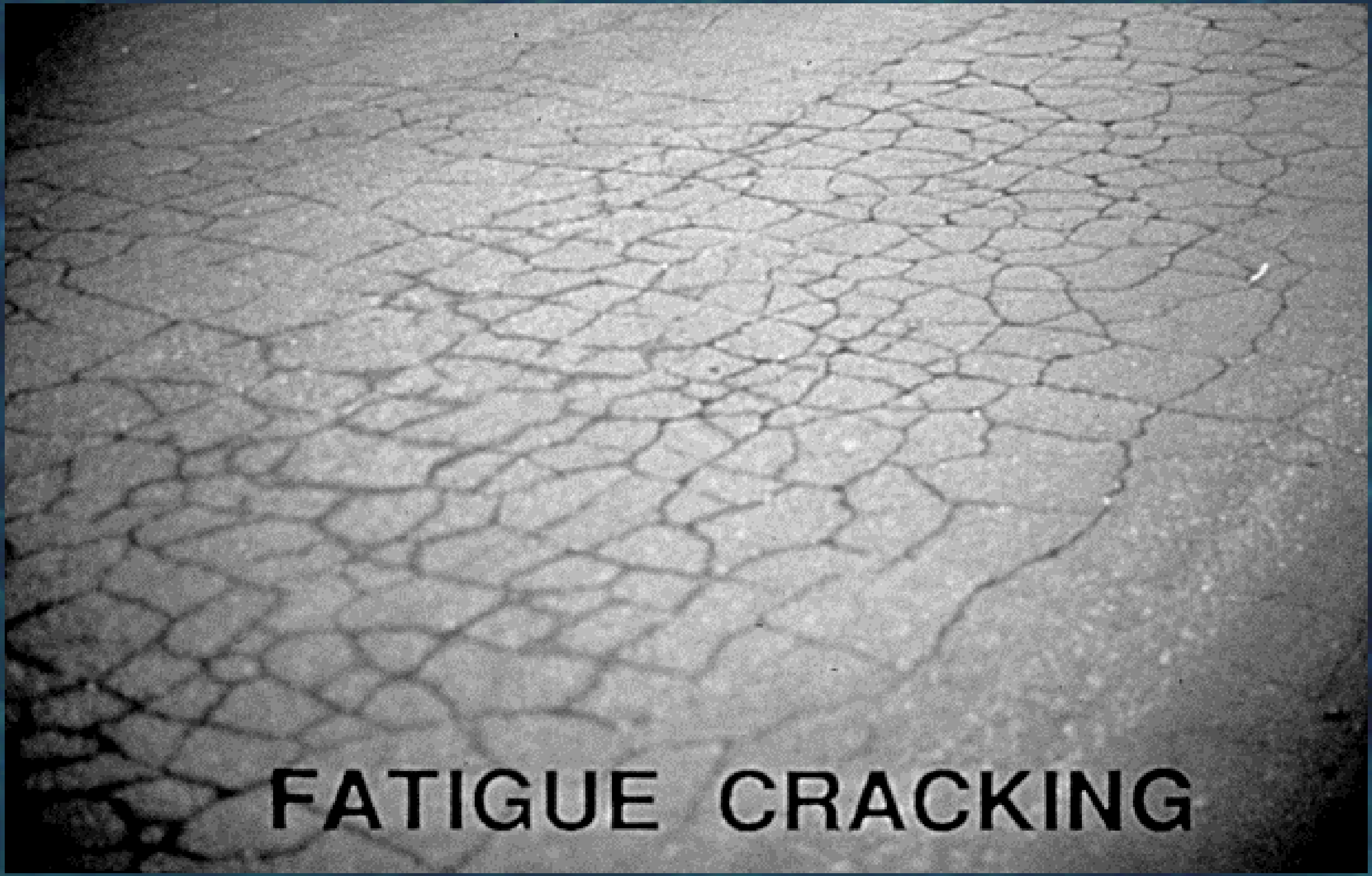
- Deformation >>> Rutting

- Cracking >>> Fatigue

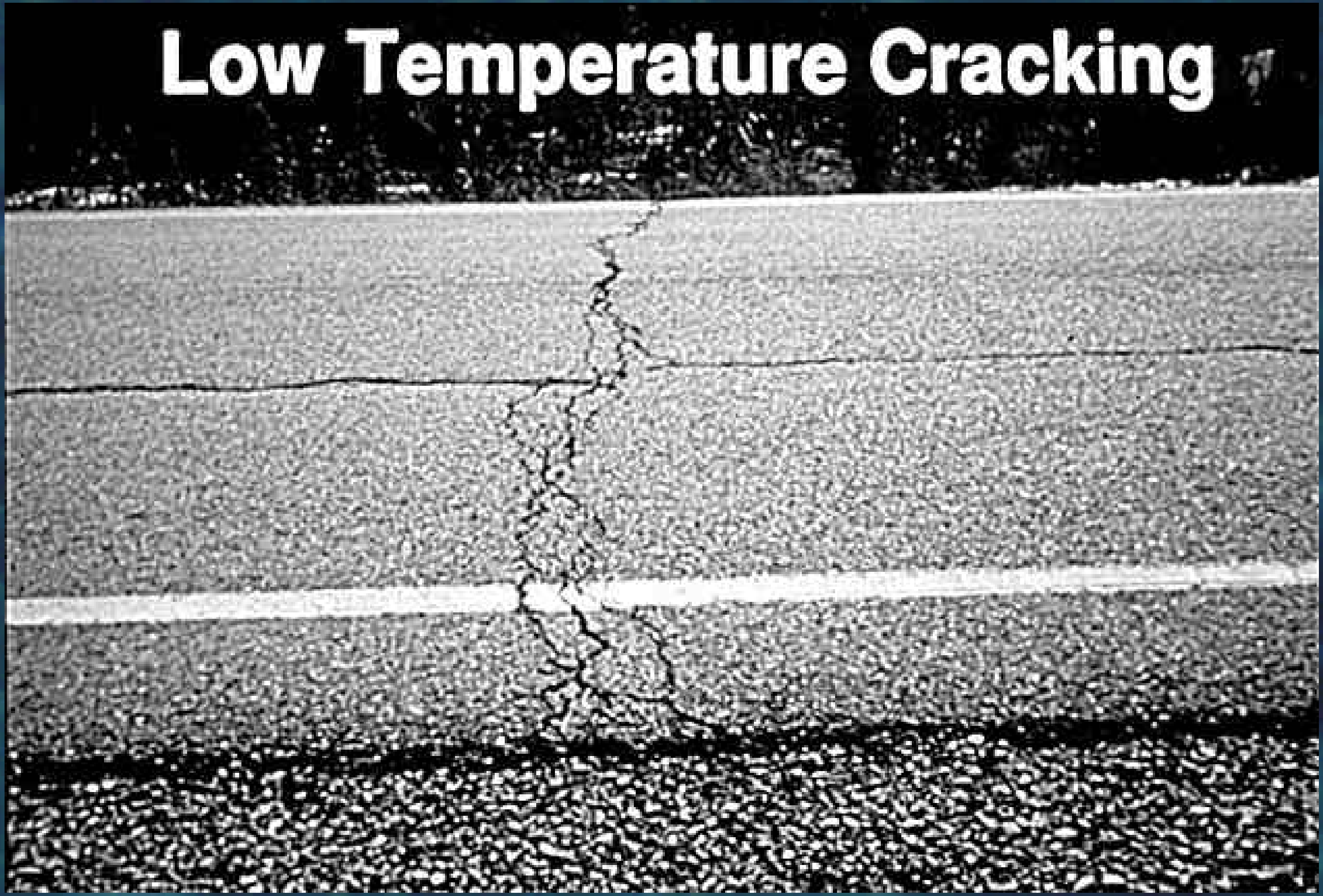
- Cracking >>> Low Temperature Shrinkage

High Temperature Phenomenon

Intermediate Temperature Phenomenon

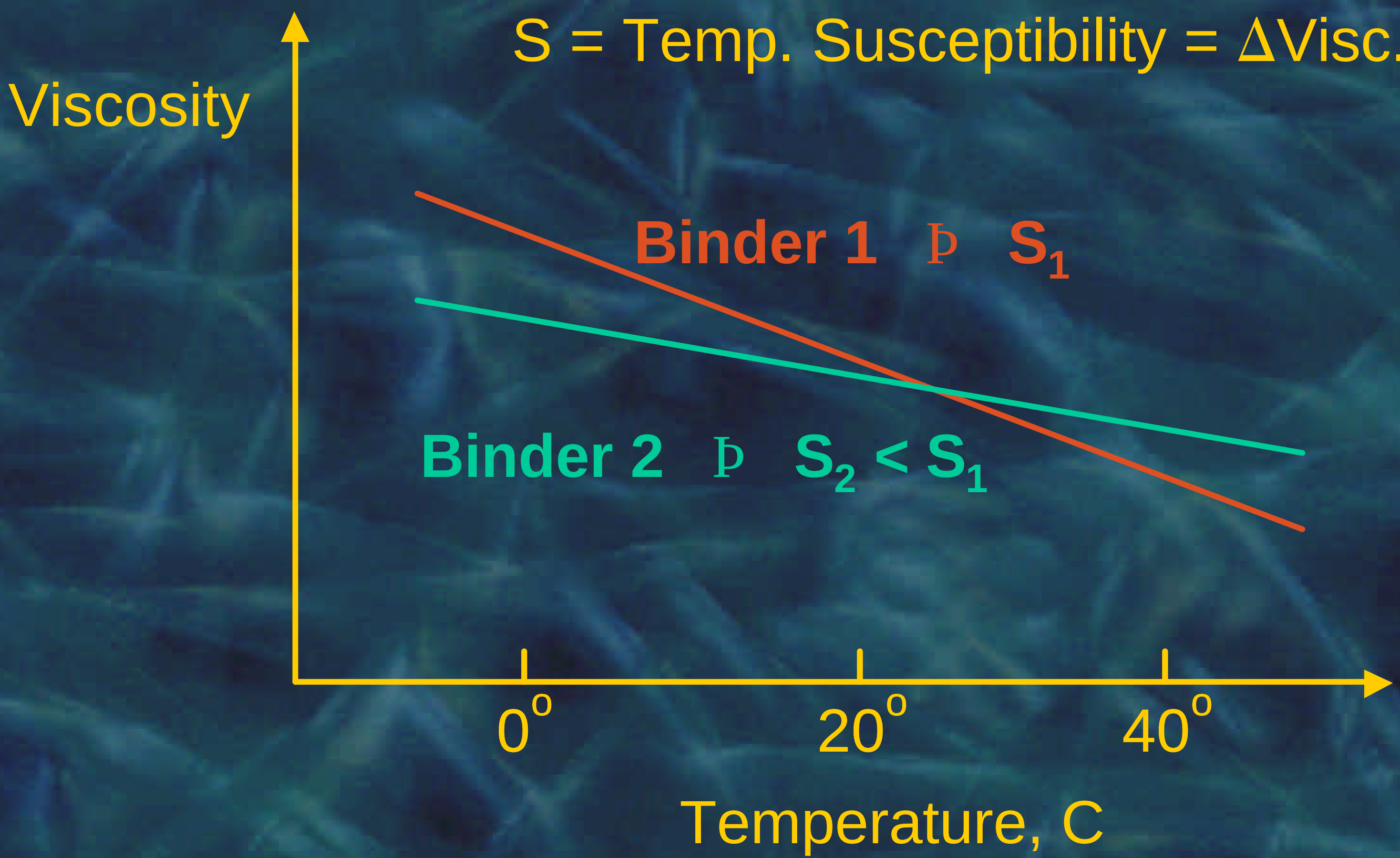


Low Temperature Phenomenon



Why Polymers in Asphalt Mixes?

S = Temp. Susceptibility = ΔVisc. / ΔTemp.



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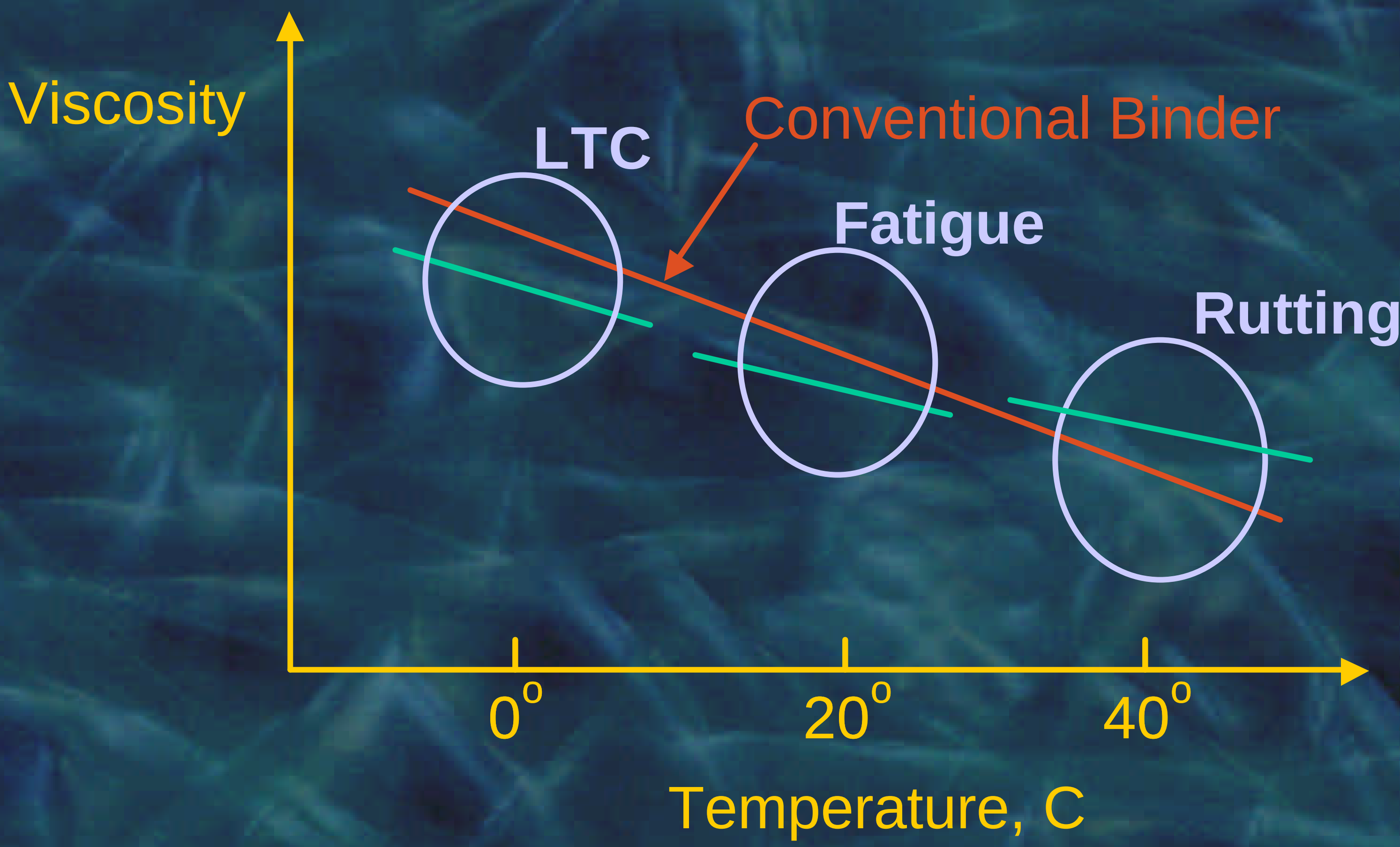

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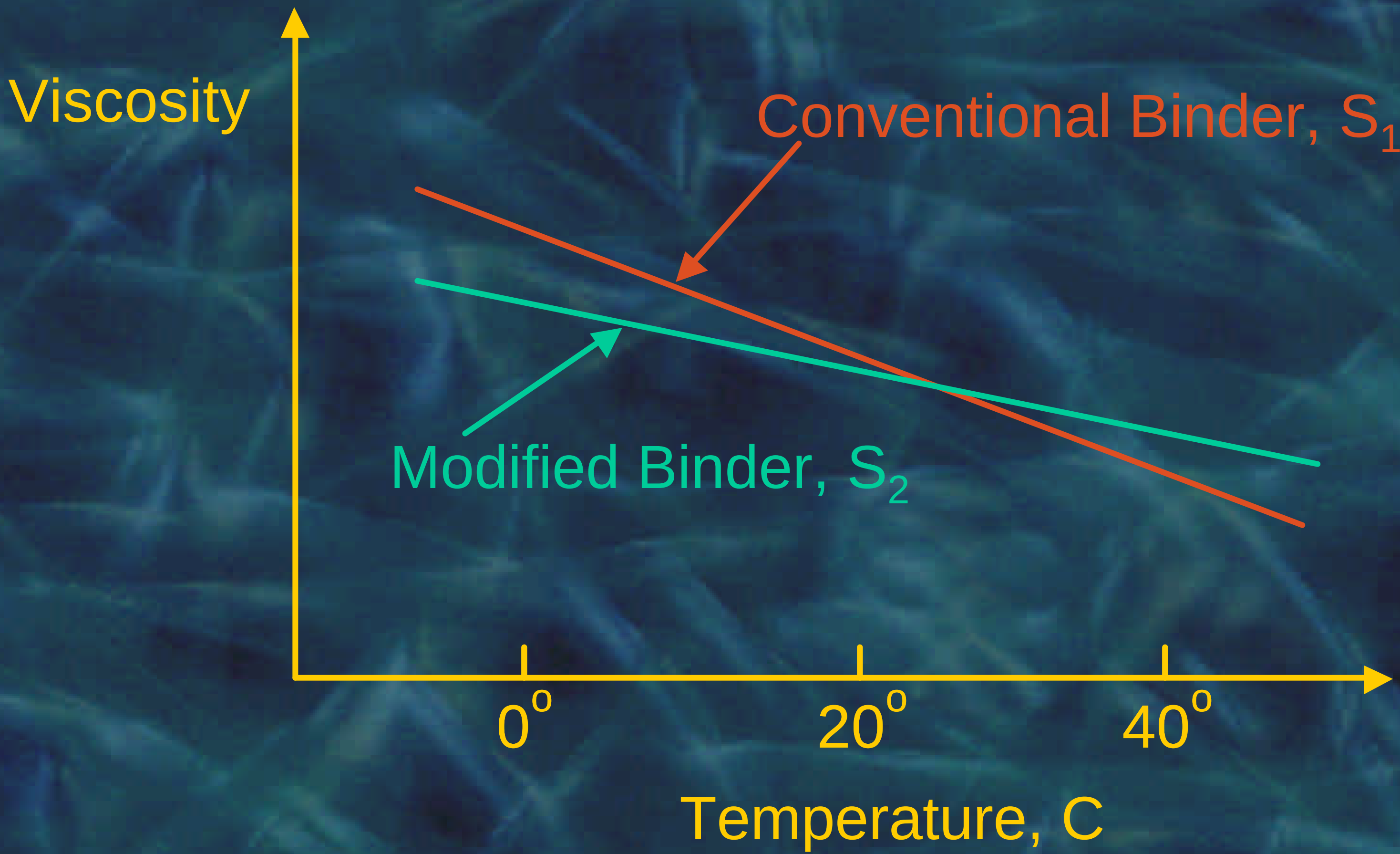


Benefits of PMA

- Rutting Resistance

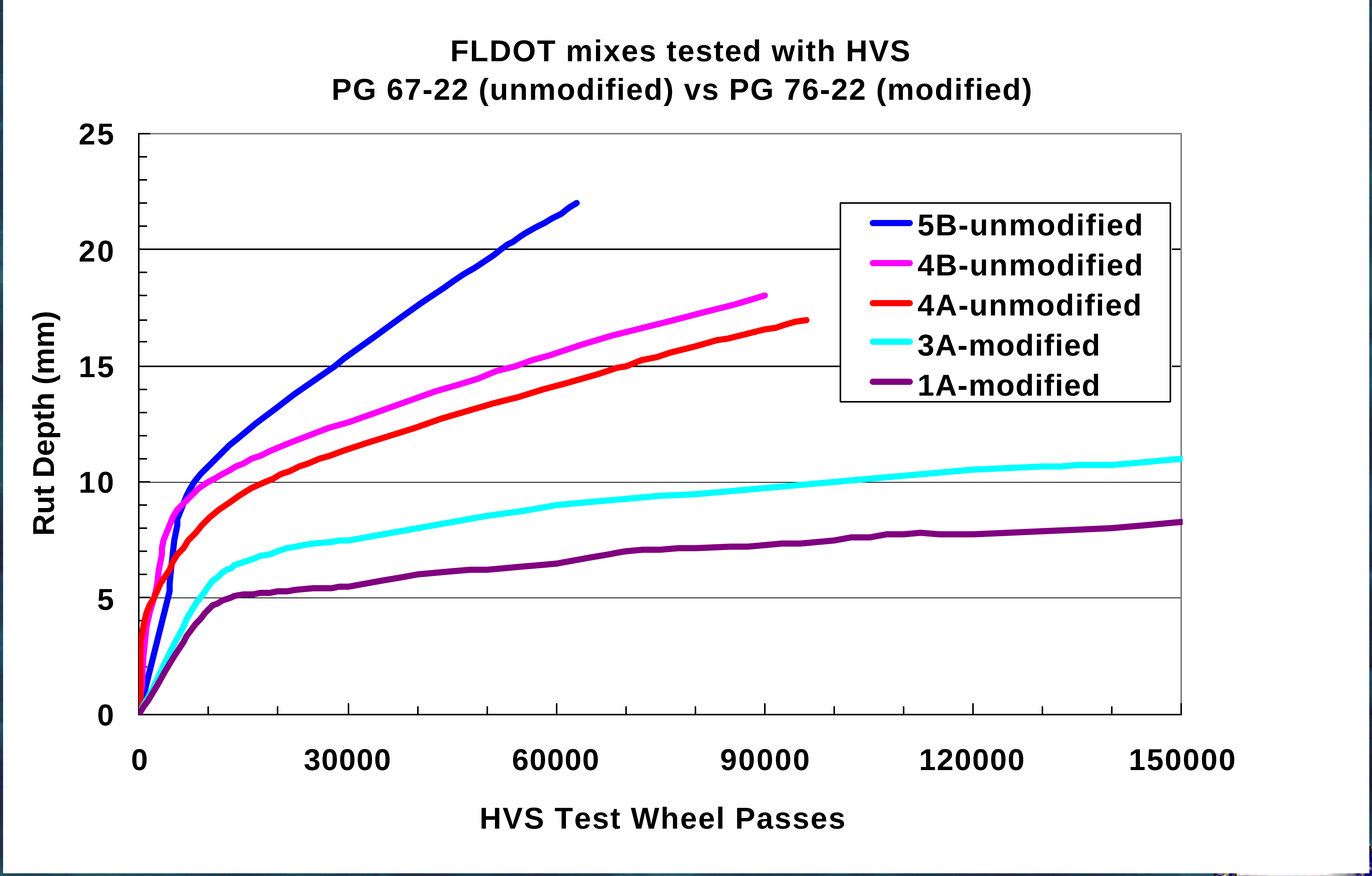
Florida DOT:

Superpave mixes PG 67-22 & PG 76-22 (~4%SBS)

1- Lab Asphalt Pavement Analyzer:

   Greater rut resistance with the PMA mix

2- Test track HVS: PMA mix showed less rutting


FLDOT mixes tested with HVS
PG 67-22 (unmodified) vs PG 76-22 (modified)
Rut Depth (mm)
25
20
15
10
5
0
0
30000
60000
90000
120000
150000
HVS Test Wheel Passes
5B-unmodified
4B-unmodified
4A-unmodified
3A-modified
1A-modified

Benefits of PMA

- Studded Tire Wear: PRALL Test Results

Anchorage Mixes	Binder	PRALL Abrasion Value	Average
1996 New Seward Hwy SB, Huffman-Dearmoun	AC-5	46	47
1982 New Seward Hwy SB, Rabbit Crk	AC-5	45	
1993 Muldoon Rd SMA	AC-5	50	
2003 N. Seward Hwy Superpave Dense Graded	PG 58-28	26	28
2003 N. Seward Hwy SMA SB , Fireweed-Benson	PG 64-28	23	
2003 N. Seward Hwy SMA NB , 36th-Benson	PG 64-28	32	
2003 N. Seward Hwy SMA SB , Tudor-Dowling	PG 58-28	30	

Benefits of PMA

- Low-Temperature Cracking Resistance

UAF-1997 study (Report No. INE/TRC 97.05)

- Lab testing of binders and field mix samples
- Field crack survey

- Main findings:

- Significant Improvement in LTC resistance with PMA
- Estimated 30%-40% reduction in crack sealing cost when PMA are used instead of neat asphalt

Benefits of PMA

- Fatigue cracking:
  - Research and field observations show the enhancement imparted by polymers
  - Magnitude of improvement unknown
  - Research project initiated
- Objectives:
  - Fatigue testing of Alaskan Mixes in the Lab
  - Inclusion of fatigue equations into the AK pavement design software (AKFPD)

Materials from the 3 Regions

- Northern Region:

  PG 52-28 & PG 58-28 PMA (EPA)

  Aggregate: Elliott Hwy Material source

- Central Region:

  PG 52-28 & PG58-28 PMA (EPA)

  Aggregate: Central Paving Products source

- South Eastern Region:

  PG58-28 & PG 64-28 PMA (US Oil&Refining)

  Aggregate: DuPont, WA Material source

Materials used in Mixes

Mix Design


SOILTEST
OmniScribe recorder

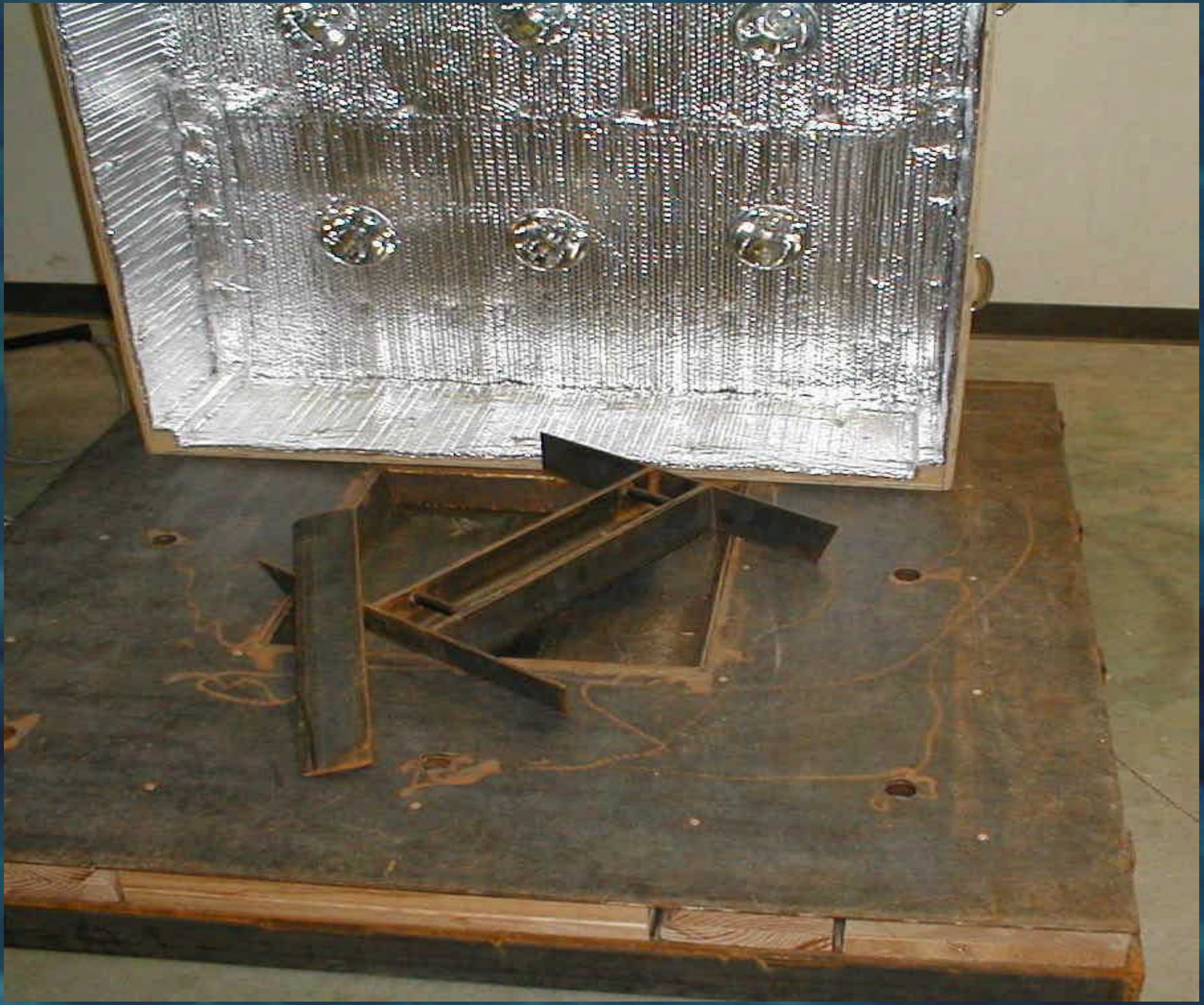

InstroTek
CORELOK
InstroTek, Inc.

Mixing

Roller Compaction

Steel Mold with 2 Ingots Slabs

Mold & Heating Device



Mold Heating Device

Mold Heater

Slab Sawing

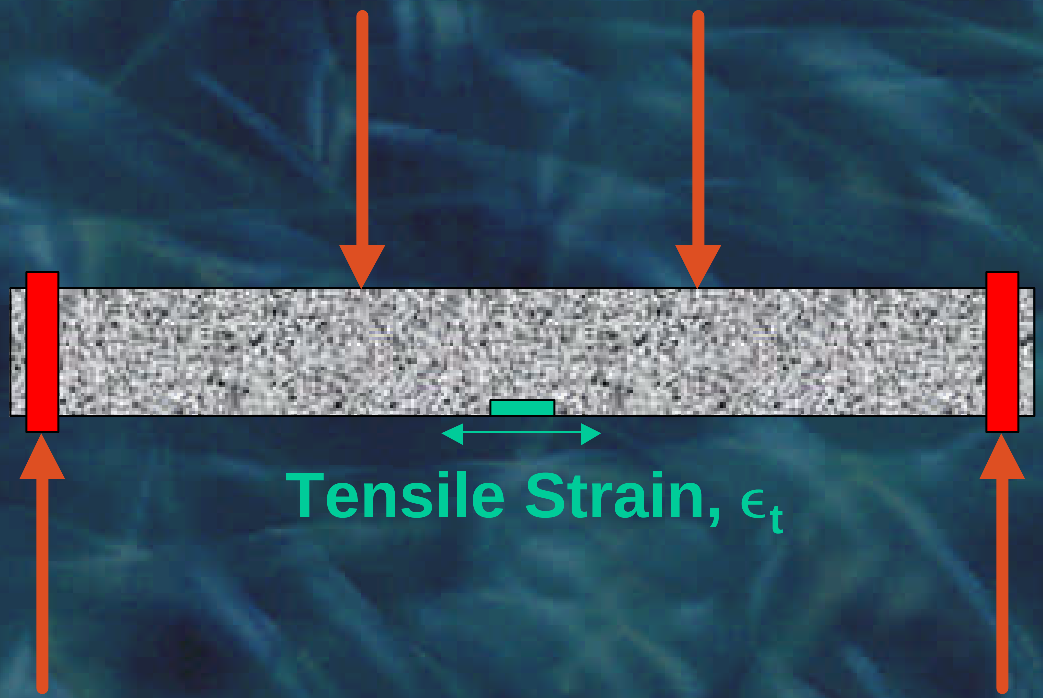
Beam Specimens from Slabs

Fatigue Testing

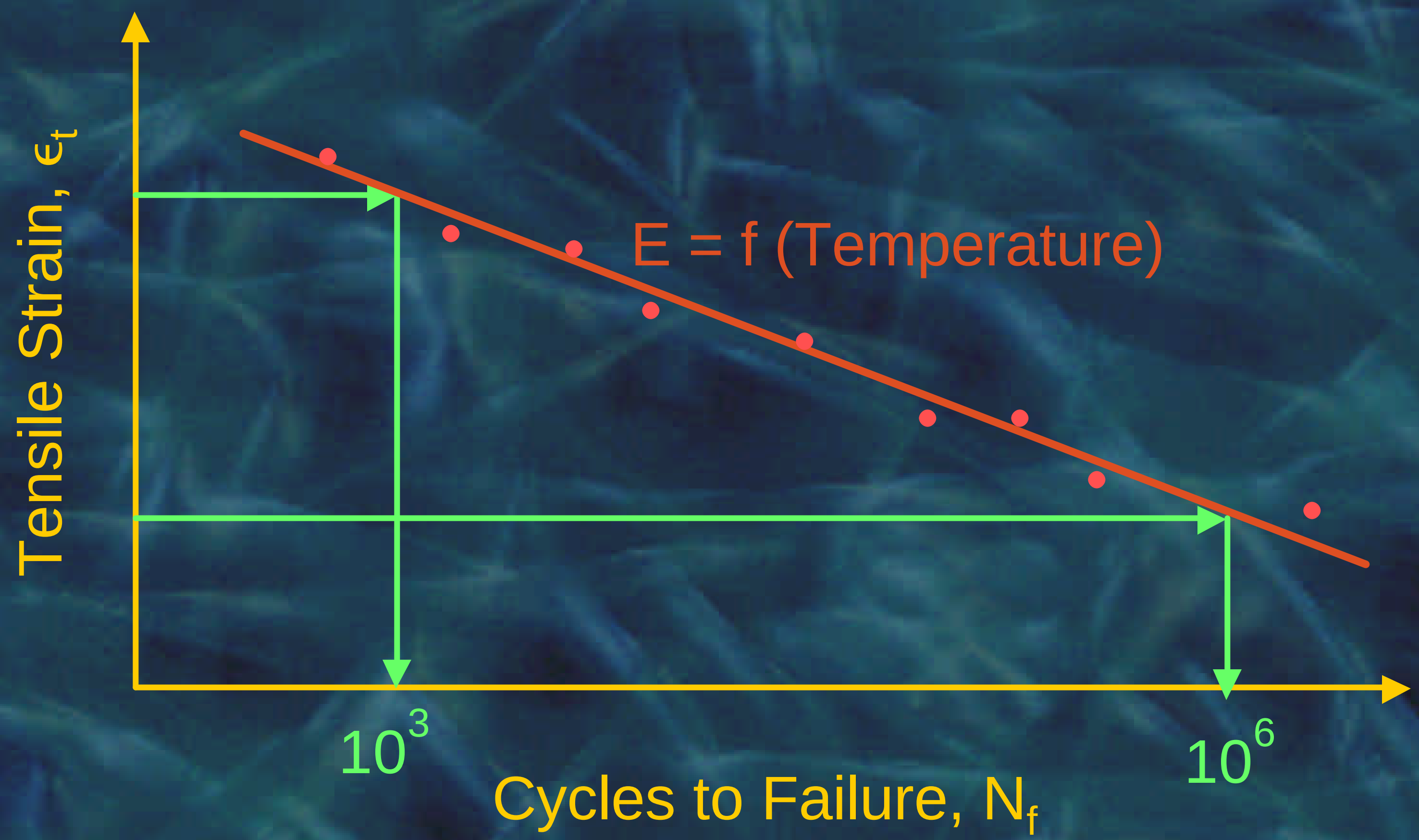
Four-point bending beam test (SHRP M009 protocol) at 3 Temperatures

Four-Point Bending Beam Fatigue

Beam Testing



Mix Fatigue



E = f (Temperature)
Tensile Strain, ϵ_t
10^3
10^6
Cycles to Failure, N_f

Mix Fatigue

TAI Fatigue Eq. for Conventional Dense Graded Mixes

$$N_f = 0.116 \times e_t^{-3.291} \times \left|E^*\right|^{-0.854}$$

Tensile Strain

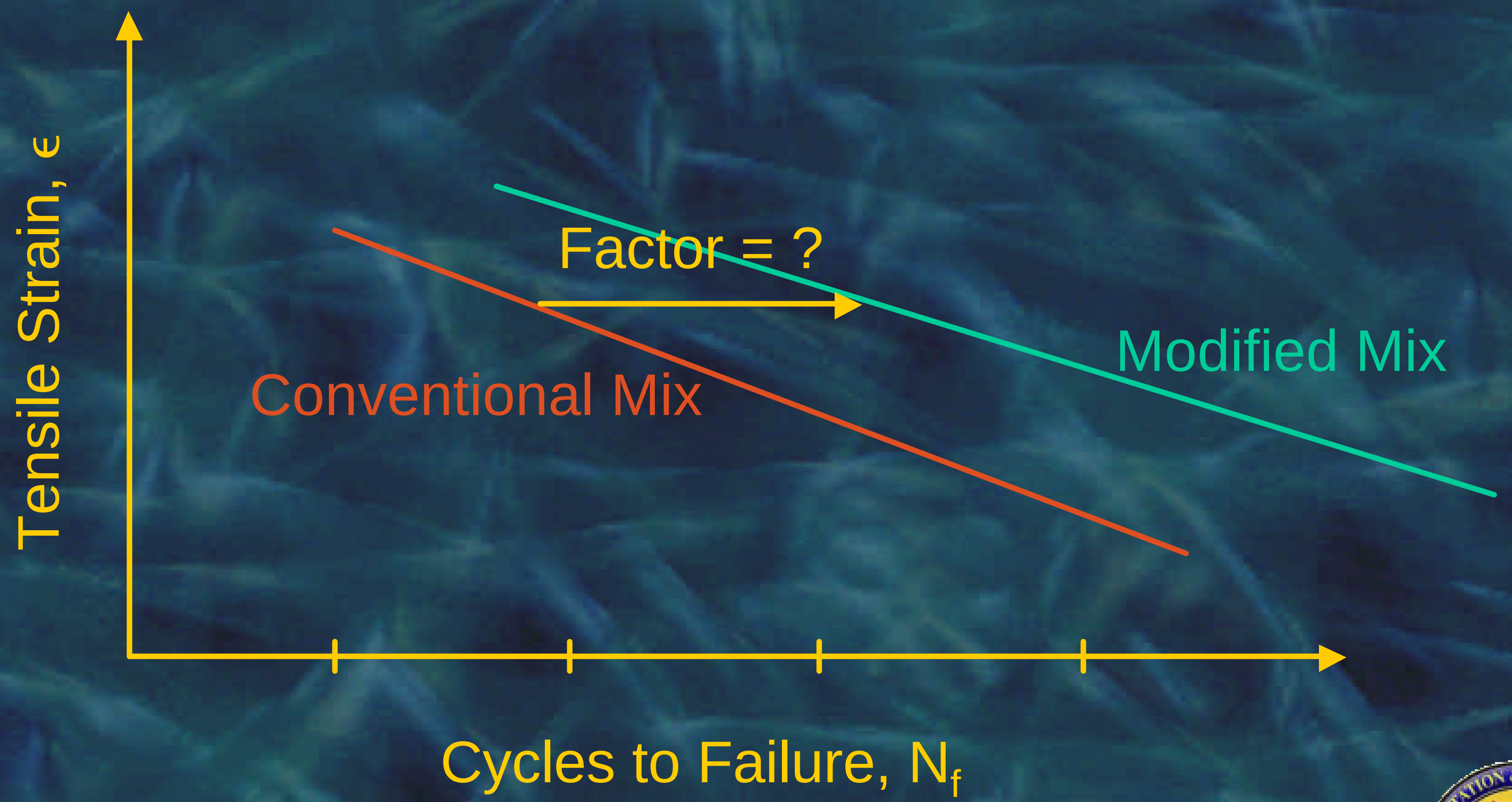
Mix Stiffness

Cycles to Failure

or

Fatigue Life

PMA Mix Fatigue



PMA Mix Fatigue

Fatigue Equation for PMA Mixes

Multiplication Factor

$$N_f^{PMA} = C \times \left[0.116 \times \varepsilon_t^{-3.291} \times |E^*|^{-0.854} \right]$$

$$N_f^{PMA} = C \times N_f^{Conv.HMA}$$

PMA Mix Fatigue

- Important Question:
  - Is “C” unique for all mixes or depends on the mix tested?

- Current Project Status:
  Slabs are being fabricated and saw-cut

Summary

- Use of PMA reduces mix Temperature Susceptibility

- Use of PMA in HMA improves mix resistance to:
  - Rutting and studded tire wear
  - Low temperature cracking
  - Fatigue cracking - ADOT&PF research
    - new *Transfer Function* in AKFPD software

- Economics of PMA:
  - Higher initial cost
  - LCCA >>> lower annual cost