Performance: Neat & Modified Asphalt Mixtures

Follow up to "All PG 70-22s the Same?", AAPT 1998

Phil Blankenship

Koch Pavement Solutions

We Are Going to Discuss...

- ***Project Description***
- ***Mixture Results***
  - ***Potential Rutting & Moisture Damage***
- ***Project Performance as of November 2001***

Cooperative Research

- *Asphalt Institute*
- *Kentucky Transportation Cabinet*
- *Kentucky Transportation Center*
- *Various asphalt suppliers*
- *The Walker Company*
- *Koch Pavement Solutions*

Question?

- ***Do all asphalt modification methods produce HMA mixtures that perform equally?***

Research Goals

- ***Accomplish by…***
  - ***Comparing the various mixtures according to potential performance***
    - ***Rutting***
    - ***Moisture damage***
    - ***Low temperature (Asphalt Institute, TRR #1661)***
  - ***Lab testing of asphalt binder & mix***
  - ***Monitoring yearly performance***

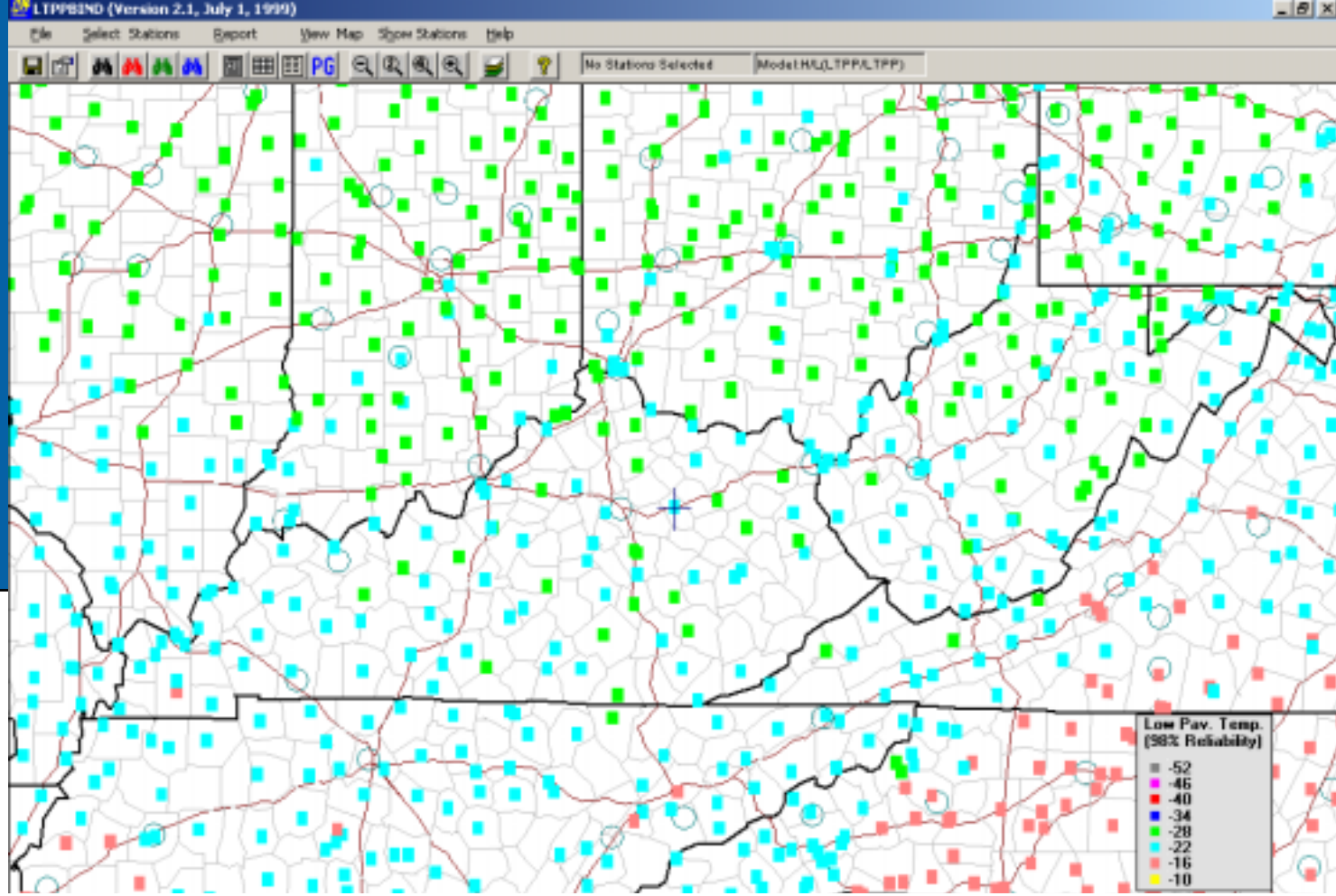
Project Description

- *I-64 near Mount Sterling, KY*
- *33 million ESAL's (20-year design)*

Project Description

- ***Milled & placed 38 mm (1.5 in.) dense-graded (coarse) HMA surface***
- ***One variable (binder type)***
  - ***PG 70-22's with different modification methods with 64-22 (AC-20) control***

98% Reliable PG at Surface



- *Weather stations near project have these surface pavement temperatures:*
  - *58.6 -20.8 (-20.1 air) → PG 76-22*
  - *58.7 -22.9 (-21.5 air) → PG 76-28*
- *KY is in -22/-28 transition climate*

Five Test Sections Placed in 1996

- The Walker Company constructed five, 1.5-mile PG 70-22 test sections
  - Straight-run (unmodified)
  - Chemically modified
  - SBR
  - SBS 1
  - SBS 2
- AC-20 (PG 64-22) control

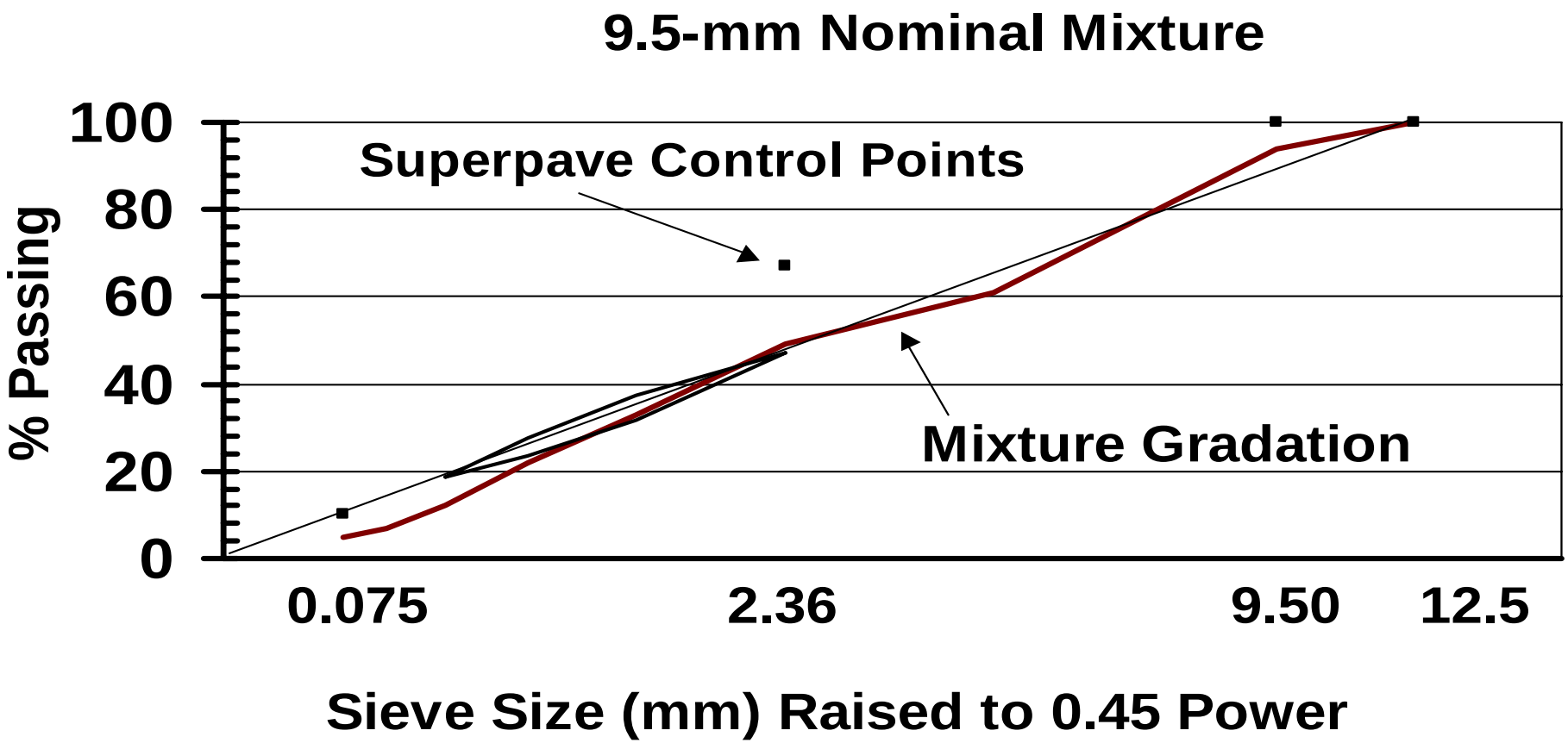
Samples & Testing

- ***Sampled from contractor's plant by Kentucky Transportation Cabinet***
- ***Testing performed "blind" by:***
  - ***Kentucky Transportation Cabinet***
  - ***Asphalt Institute***
  - ***Koch Pavement Solutions***

Job-Mix Formula

- **Aggregate**
  - **45% Dolomite # 8's, 35% Limestone sand, 20% Natural sand**
- **Marshall design**
  - **5.5 % AC, 5.0 % voids at 75 blows**
  - **Similar to Superpave 9.5mm design with about 1% lower VMA**
- **Evaluated in SGC at N-design = 109**

Gradation


9.5-mm Nominal Mixture
100
80
60
40
20
0
% Passing
Superpave Control Points
Mixture Gradation
0.075
2.36
9.50
12.5
Sieve Size (mm) Raised to 0.45 Power

Identification Key

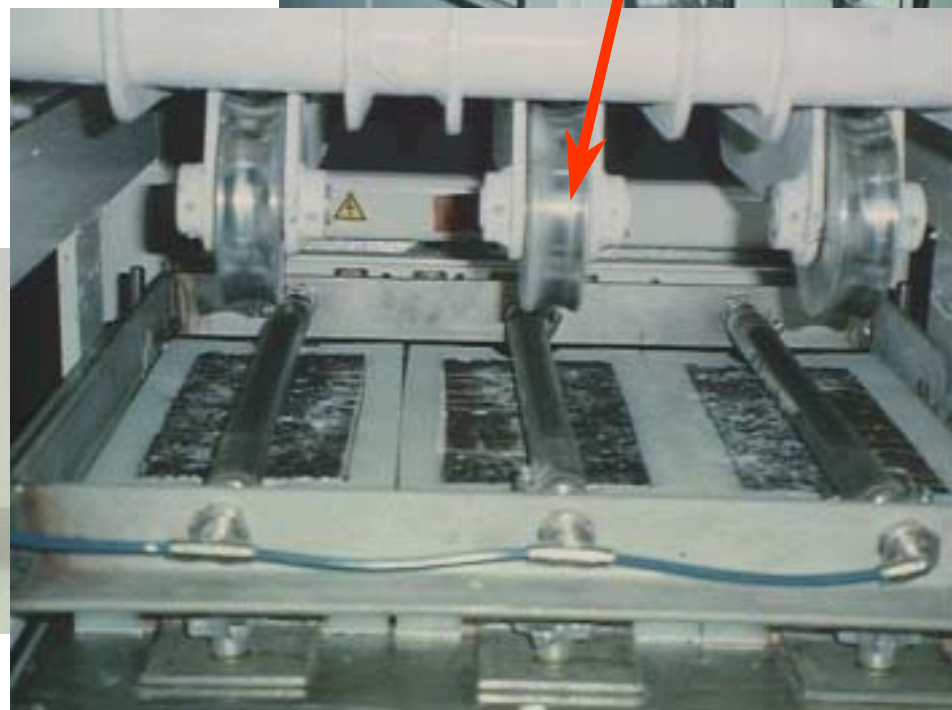
Sample Number	Product	PG
1	AC-20 (Control)	64-22
2 - 3	Straight-Run (Crude)	70-22
4 - 5	Chemically modified	70-22
6 - 7	SBR-Latex	70-22
8 - 9	SBS 1	76-22
11 - 12	SBS 2	70-22

KY I-64, April 1997

Lab Mixture Results

Modulus & Rutting

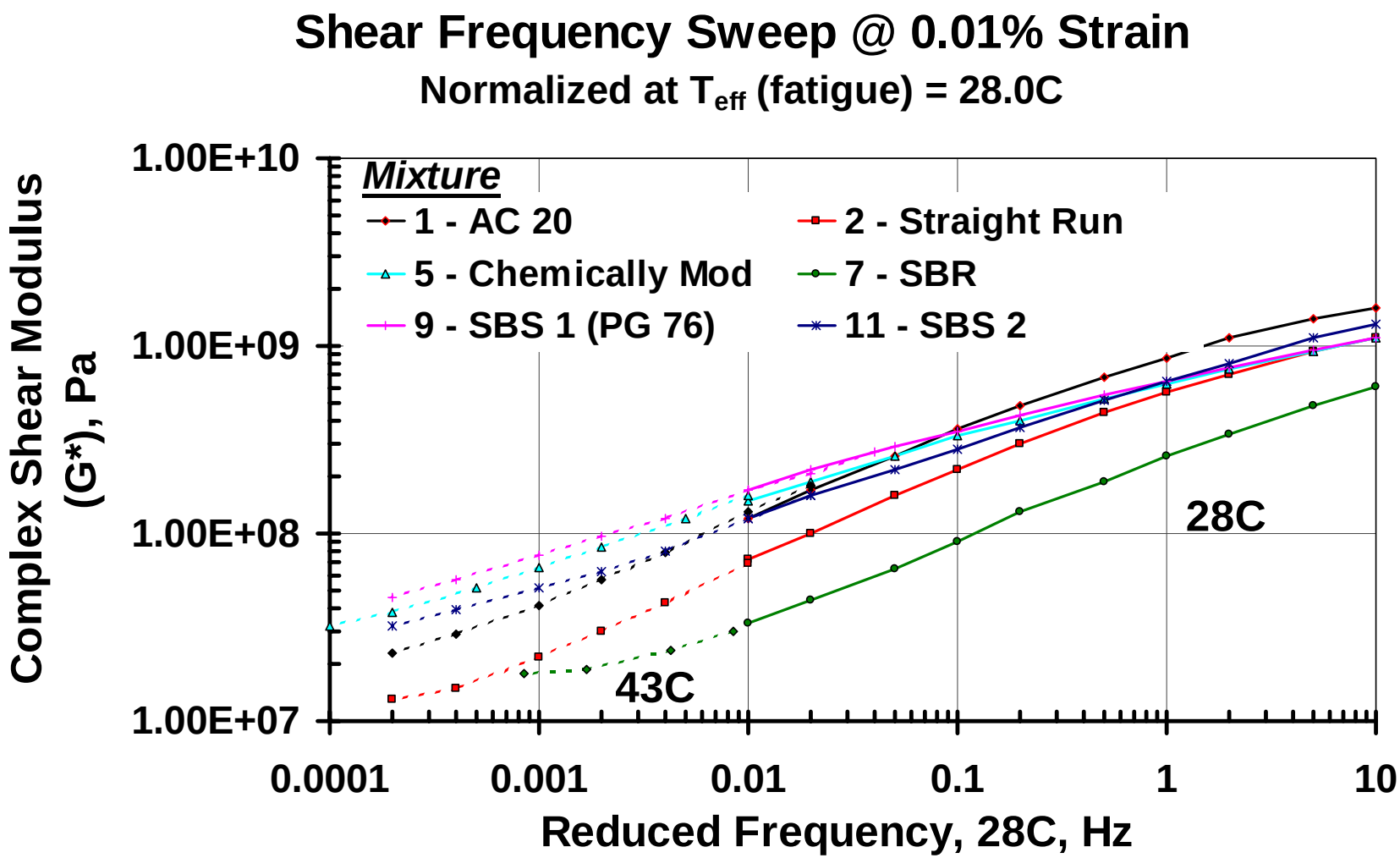
Modulus and Rutting Tests SST and APA



Repeated Shear Test - Frequency Sweep

Lab modulus testing

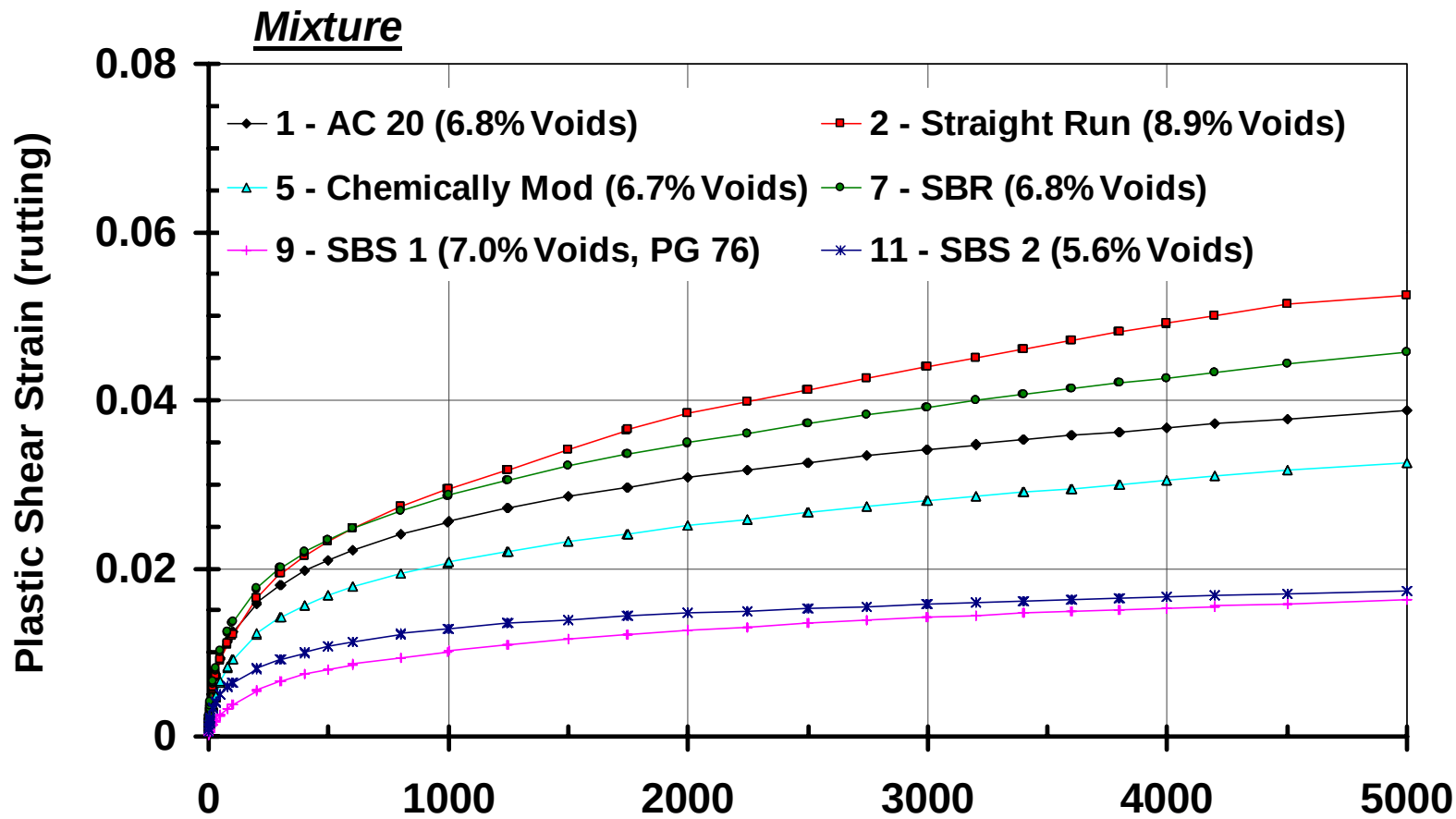
Repeated Shear Test - Frequency Sweep



Repeated Shear Test - Constant Height

Lab rut testing

Repeated Shear Test - Constant Height

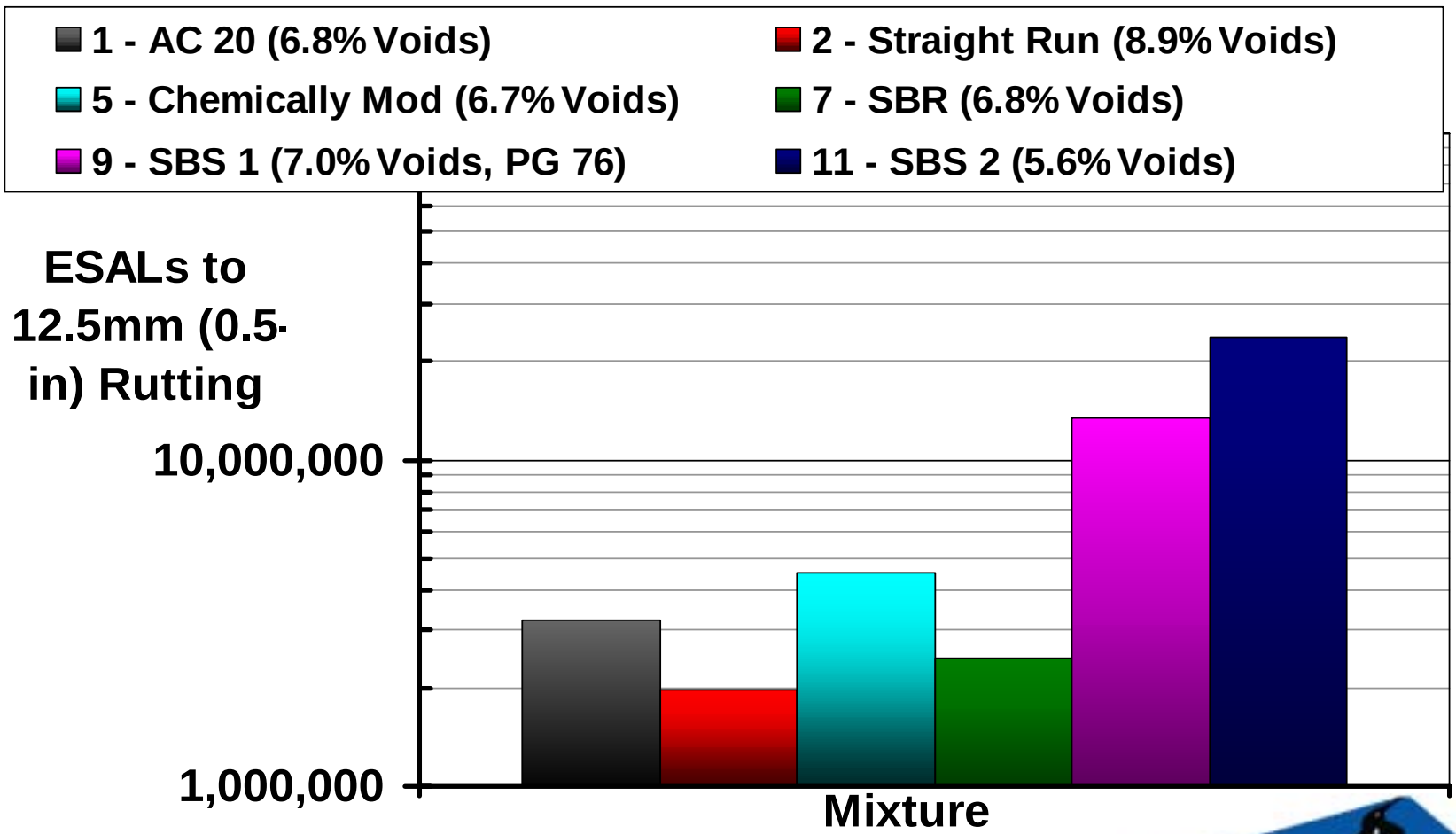


T-critical = 58C

Maximum shear stress of 68 kPa

Repeated Shear Test - Constant Height

ESALs to 12.5mm Rutting



Mixture Results

Summary of Lab Predicted Permanent Strain (Rutting)

Least Potential Rutting

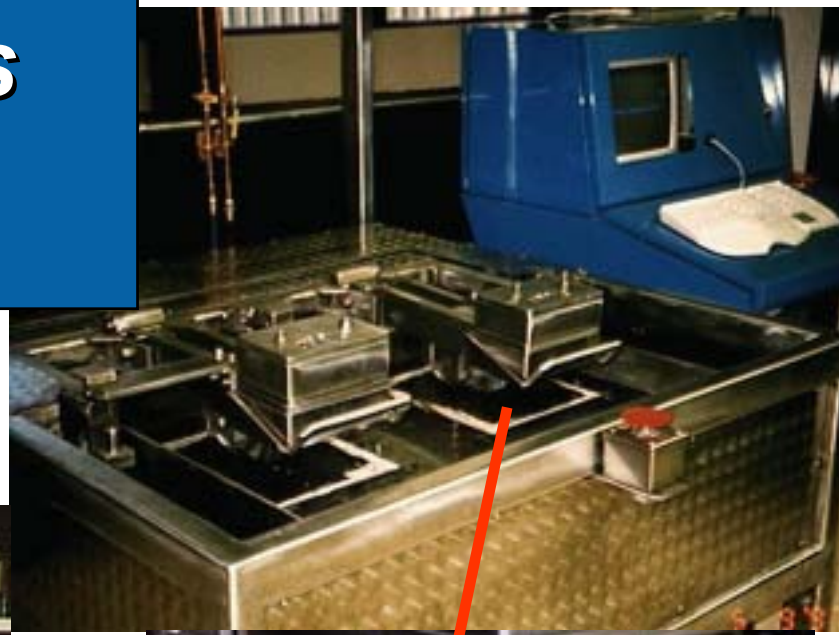
Most

Shear Frequency Sweep mix m-value, 43C	RST-Constant Height 58°C	RST-Constant Stress Ratio 58°C	GA Loaded Wheel dry at 49°C
SBS 1	SBS 2	SBS 2	SBS 1 - PASS
Chemically Modified	SBS 1	SBS 1	SBS 2 - PASS
SBS 2	Chemically Modified	Chemically Modified	Straight Run - PASS
SBR	AC 20	SBR	Chemically Mod. - PASS
AC 20	SBR	Straight Run	AC 20 -PASS
Straight Run	Straight Run	AC 20	SBR - *FAIL*

Lab Mixture Results

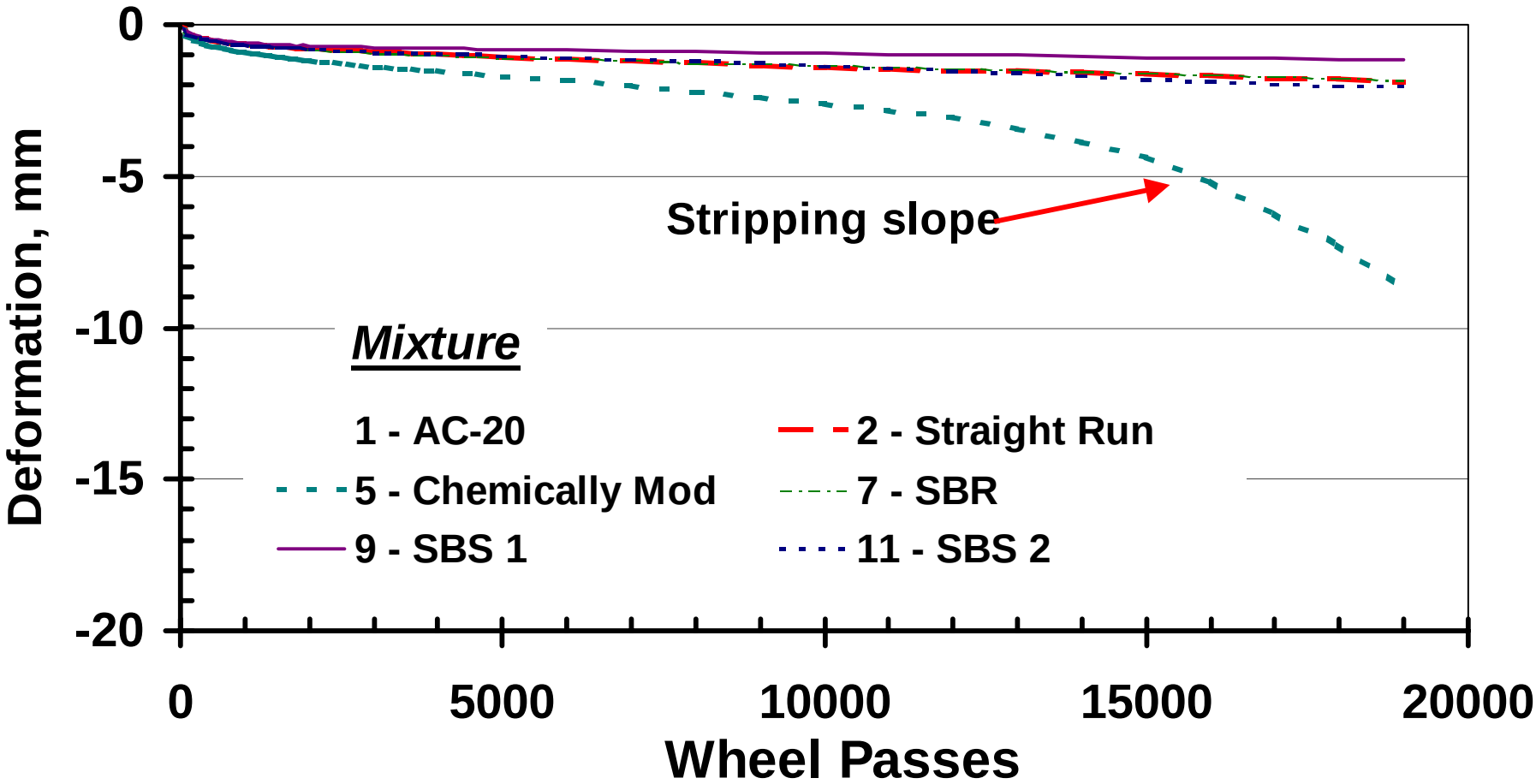
Moisture Damage

Moisture Damage Tests
APA, TSR, and HWT



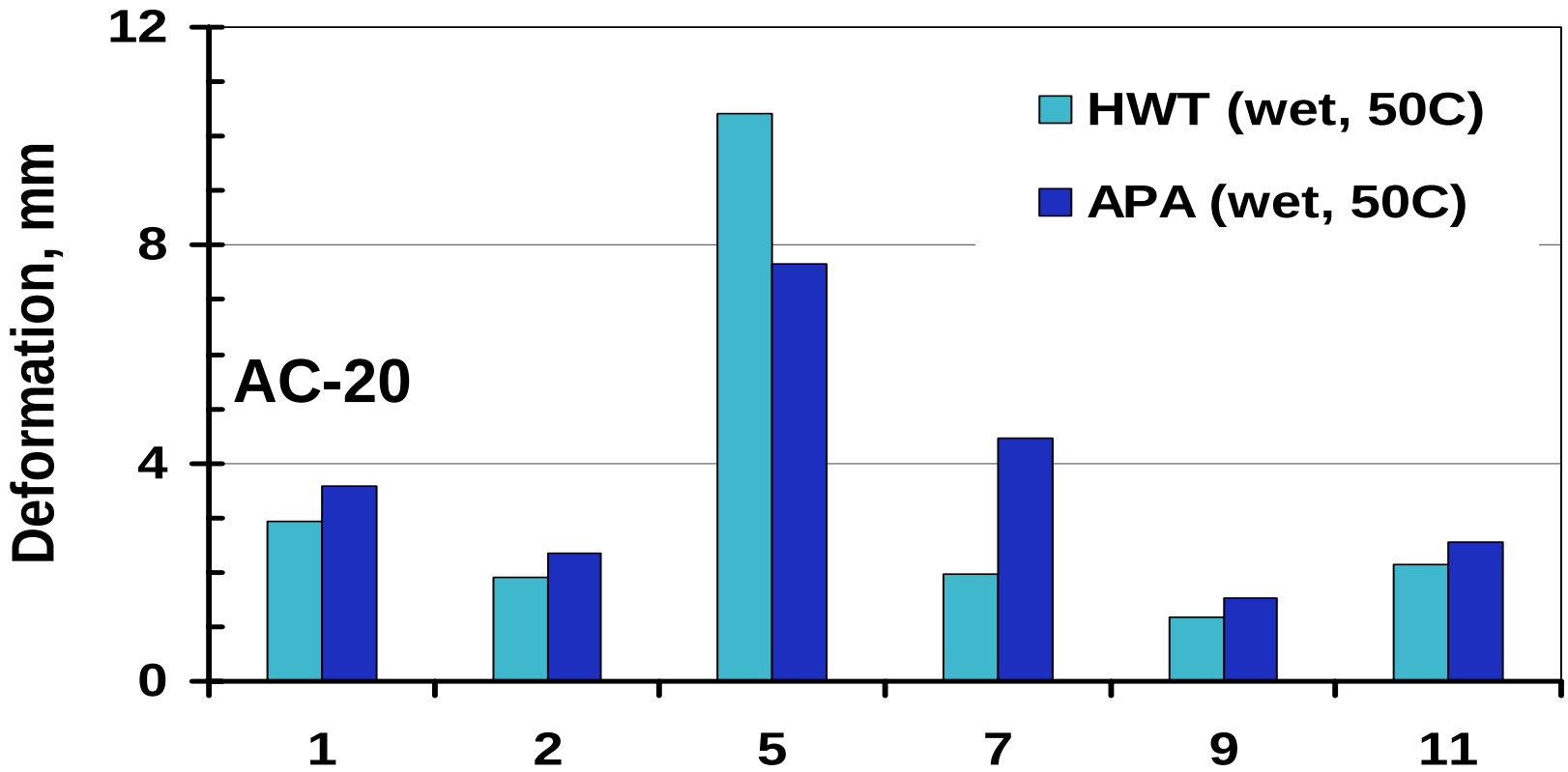
Mixture Results

Hamburg Wheel Track Test



Mixture Results

Hamburg and Asphalt Pavement Analyzer



Mixture Results

Summary of Lab Predicted Moisture Damage

Asphalt	TSR	HWT wet, 50C	HWT Stripping Performance (passes)*	APA wet, 50C
	70% min	*4-mm max*	*Visual Stripping (Inflection Point)*	*4-mm max*
AC20	Pass	Pass	Good	Pass
Straight Run		Pass	Good	Pass
Chemically Modified	Pass	*Fail*	Maintenance possible (14,764)	1 Pass & 1 Fail
SBR	Pass	Pass	Good	*Fail*
SBS 1	Pass	Pass	Good	Pass
SBS 2	*Fail*	Pass	Good	Pass

Conclusions in 1998

1998 Conclusions

- *Did we expect all PG 70-22's to perform the same? Not according to:*
  - *4 rutting indicators show slight differences*
  - *2 moisture damage tests show one mix with potential to strip*
- *Differences may take 5+ years to appear*

1998 Conclusions

- ***In addition to PG testing & volumetric testing, performance related & based testing should be used to verify higher ESAL mixtures***

I-64 Performance Update

I-64 Performance Update

- ***Project visited 1x per year***
  - ***No differences in August 2000***
  - ***No large <u>lab</u> performance differences in stripping & rutting (I.e. catastrophic failures) → no large <u>field</u> performance differences in stripping & rutting Last visit,***

I-64 Performance Update
Cracking

- ***Last visit, November 2001***
  - ***All sections but SBR has thermal cracks***
  - ***1 section with SBS has block & thermal cracking***
- ***Cracking performance differences are from PG low differences, rather than modifier type***

First…

Cracking Definitions

SHRP P-338 Distress Manual

What Is Transverse (Thermal) Cracking?

FIGURE 20
ACP 6. Moderate Severity Transverse Cracking

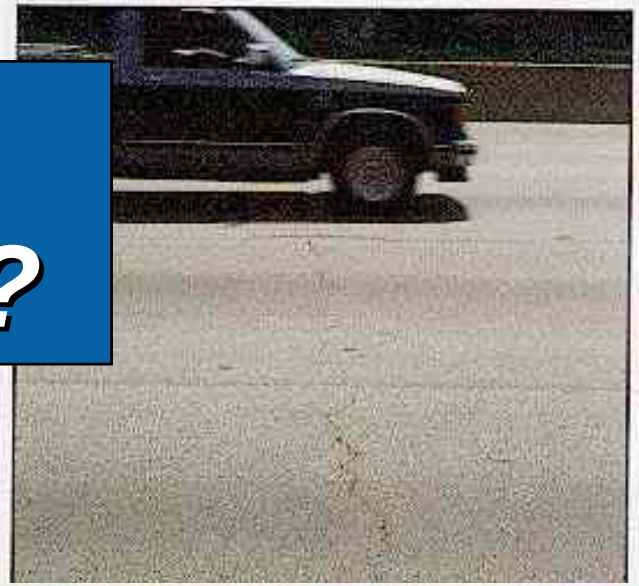


FIGURE 21
ACP 6. High Severity Transverse Cracking

From SHRP P-338 Distress Manual

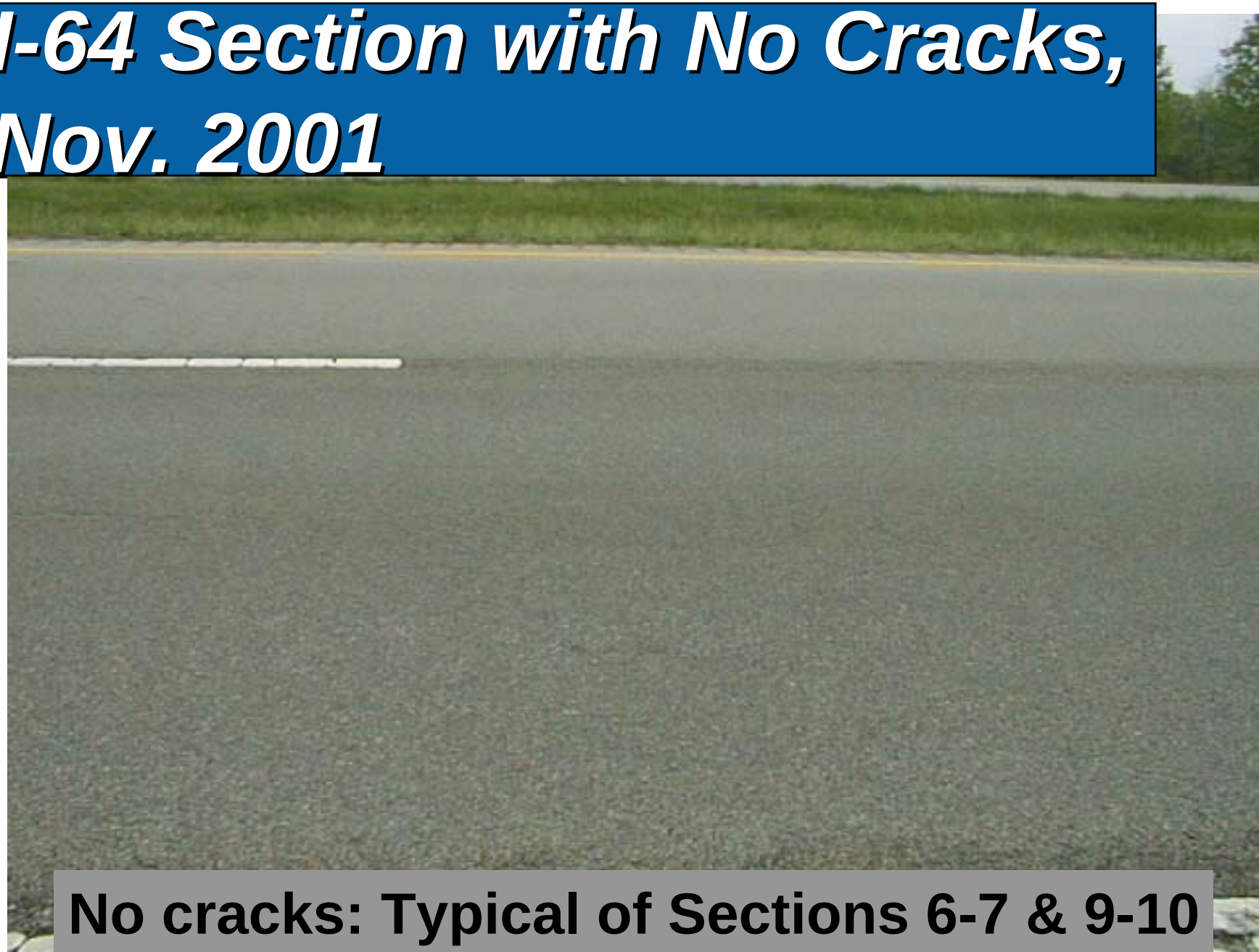
What Is Block Cracking?

FIGURE 10
ACP 2. High Severity Block Cracking

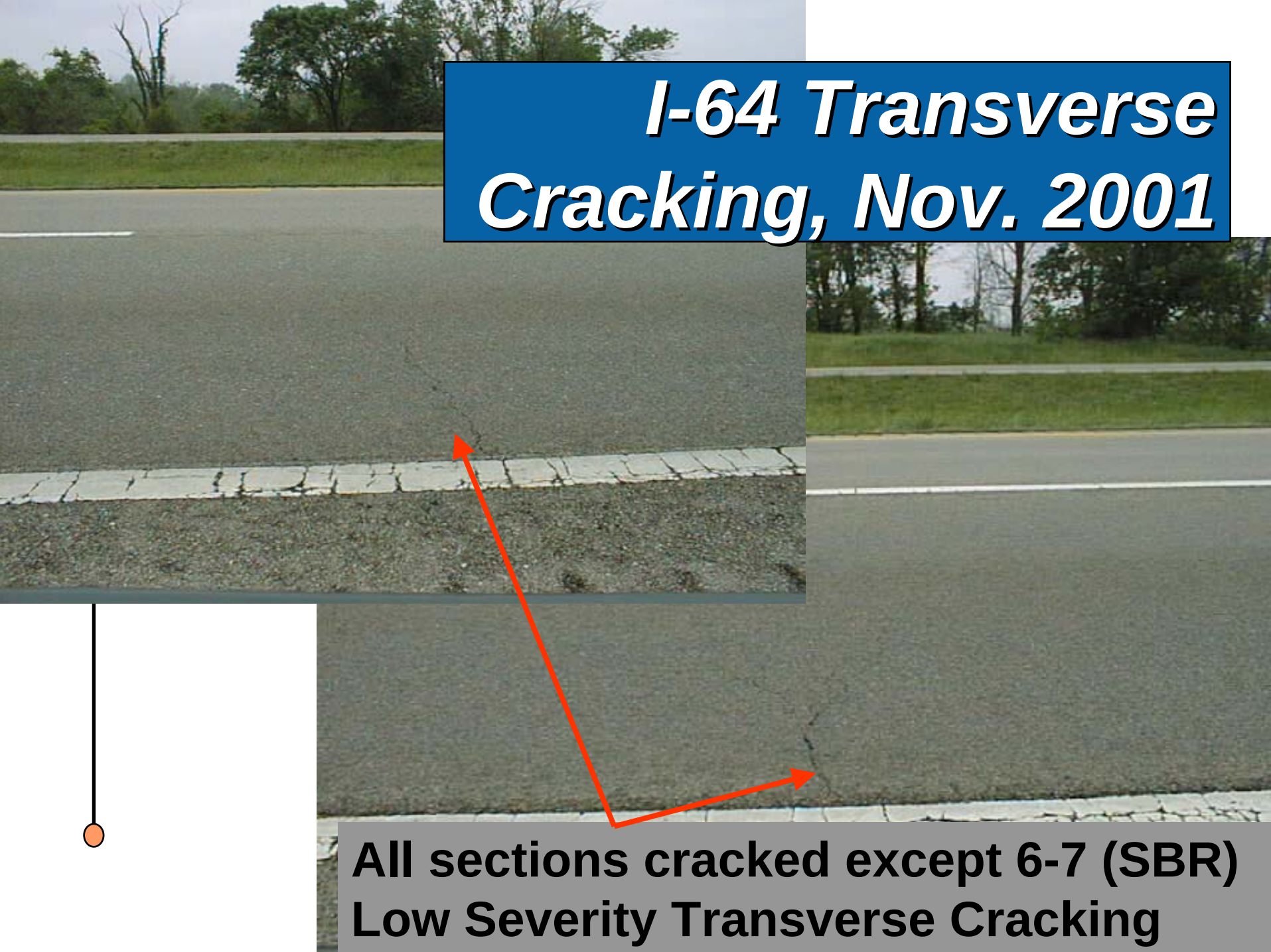
FIGURE 9
ACP 2. Moderate Severity Block Cracking

From SHRP P-338 Distress Manual

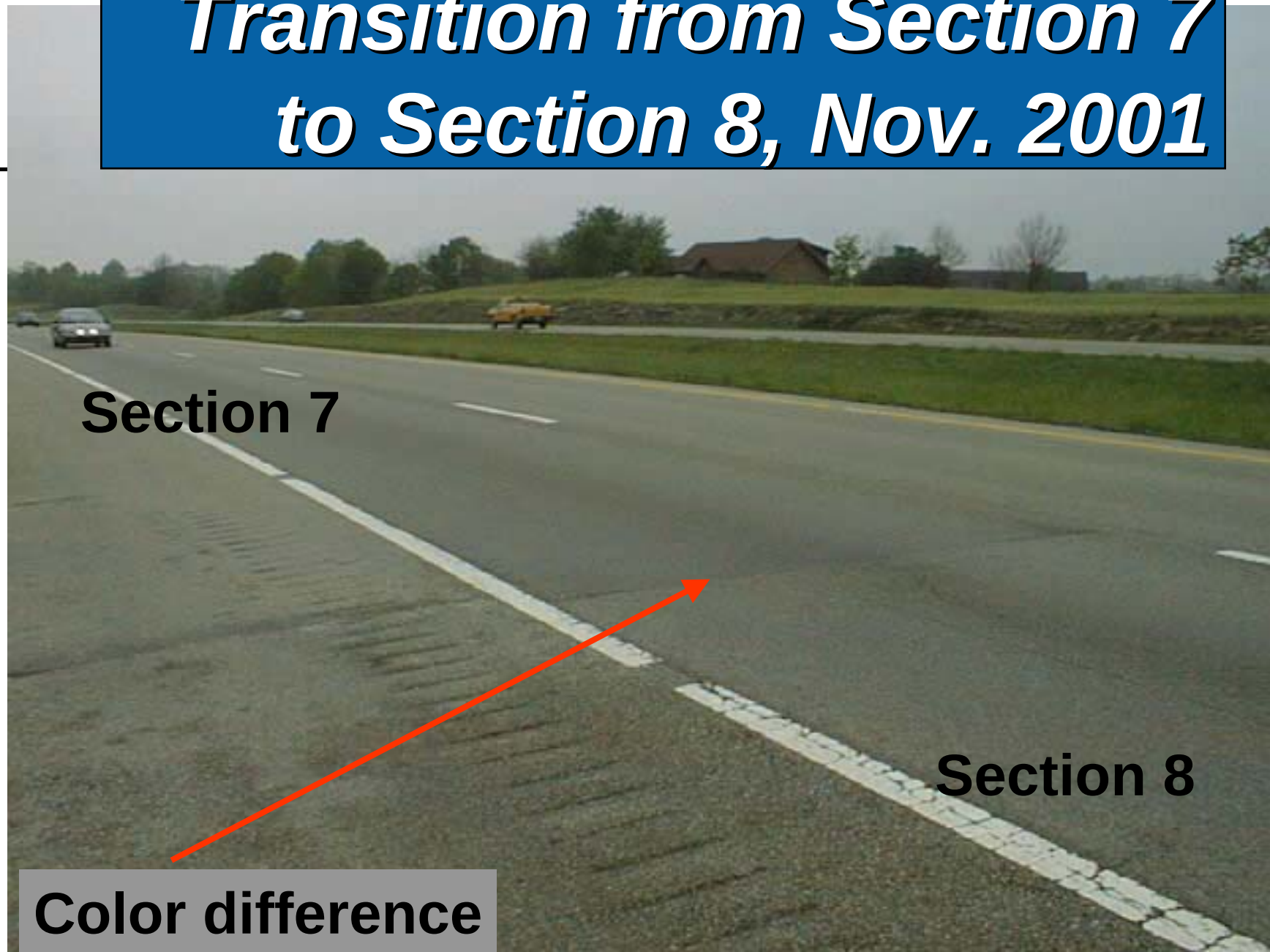
I-64 Section with No Cracks, Nov. 2001



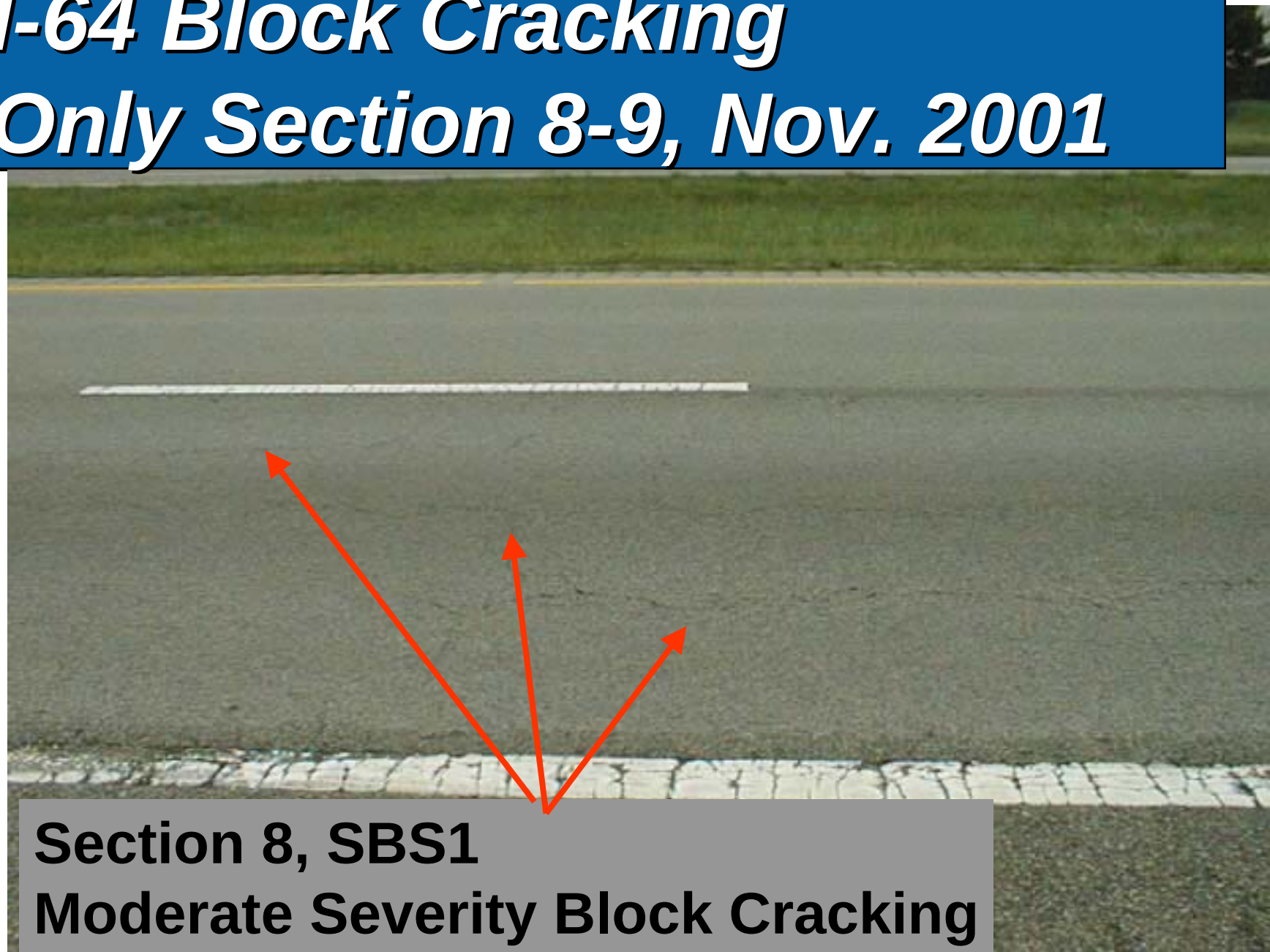
No cracks: Typical of Sections 6-7 & 9-10


I-64 Transverse Cracking, Nov. 2001
All sections cracked except 6-7 (SBR)
Low Severity Transverse Cracking

Transition from Section 7 to Section 8, Nov. 2001



I-64 Block Cracking Only Section 8-9, Nov. 2001



Section 8, SBS1
Moderate Severity Block Cracking

Why Cracking? Not expected & was not a major concern in KY...

The Cold & Snow of December 2000 in the Midwest

Midwest Climate Center Report

- ***"The Midwestern region of the United States experienced its 2nd coldest December in 106 year record..."***
- ***"The December 2000 average temperature was 14.3°F (-10C)"***
- ***"... stations broke all-time cold records for December including South Bend, IN; Chicago-Midway, IL; and Louisville & Paducah, KY."***

December 2000 Low Temperature

- On December 16, 2000 the low was -17.2C near I-64 PG 70-22 project

Results from AI Study
Asphalt Institute, TRR #1661

Section 8-9: This field section has most cracks. →

	Critical Pavement Temp, °C	
Sample	Mixture IDT	Binder (m-value)
A	-30.2	-25.4
B	-31.7	-22.2
C	-19.9	-15.1
D	-23.1	-22.2
E	-26.1	-28.3
F	-22.5	-26.2
G	-34.9	n/a
H	-29.9	-21.5
I	-30.6	n/a
J	-30.8	-21.8
K	-28.4	-24.6

BBR m-value was limiting value on all binders.

Observed Field Cracking

Least Cracking

Most

Section (Modifier)	Low Transverse (Thermal) Cracking	Moderate Blocking Cracking	*BBR Predictions
6-7 (SBR)	No cracking	None	NA
11-12 (SBS2)	Few, 1-2 cracks	None	NA
4-5 (Chemically Modified)	Less cracks	None	NA
1 PG (64-22)	Several cracks	None	NA
2-3 (Neat)	Several cracks	None	NA
8-9 (SBS1)	Most cracking	Moderate	-15.1C Sample C in AI Study

*AI data key is not available on all samples.

Comments from KYTC Materials Division

"The amount of cracking that occurred in the past year was very significant and highly undesirable on a 5-yr old project."

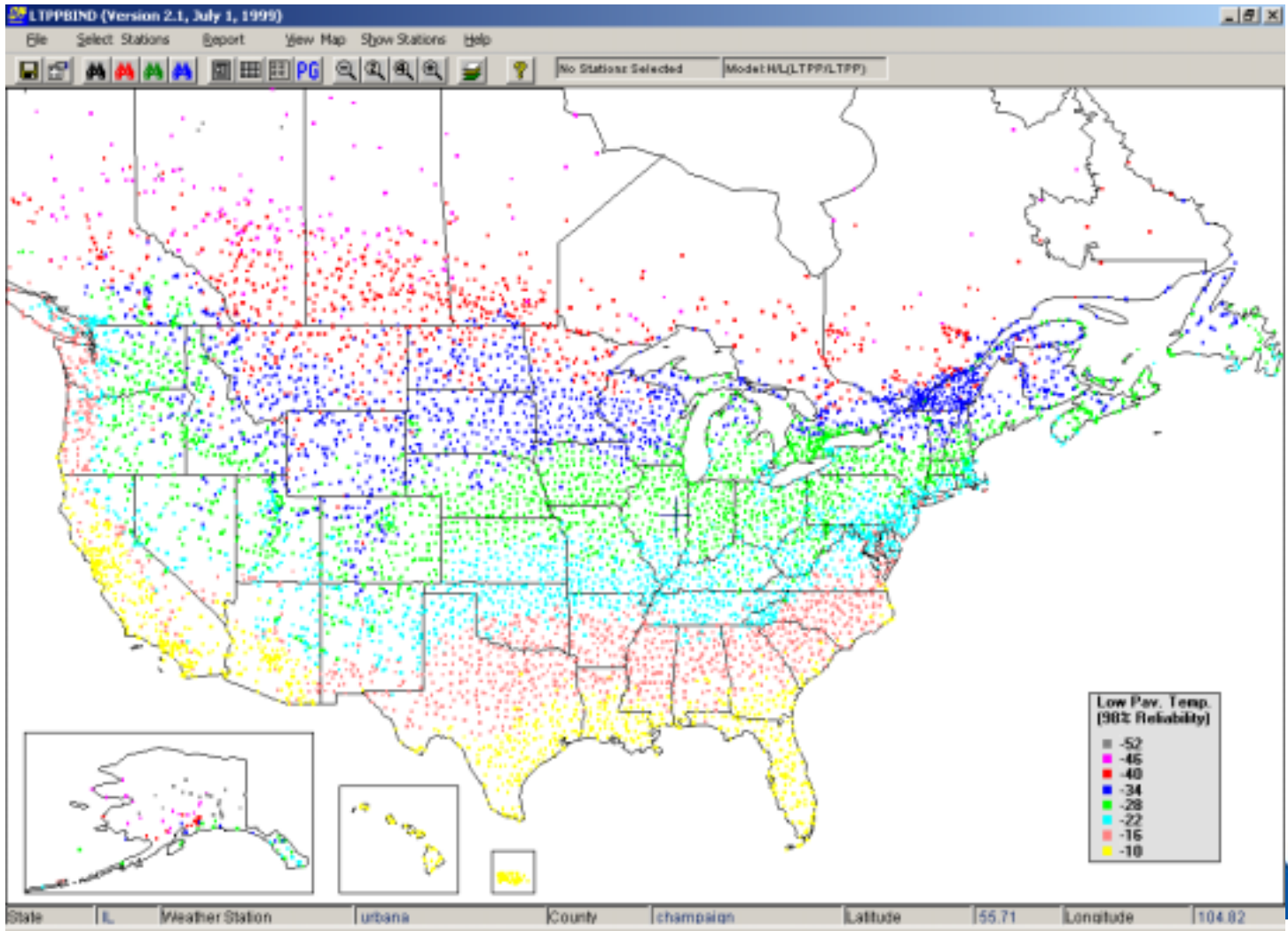
What should suppliers & agencies learn from this project as of Nov. 2001?

Conclusions

- ***The 98% algorithms in LTPPBind continue to prove their validity in field performance***
- ***Agencies should verify that they are specifying 98% reliable binders***

Verify You Are Using 98% LTPPBind PG Binders

http://tfhrc.gov/pavement/ltpp/ltppbind.htm



Conclusions

- ***98% temperatures occur less frequently than 50%, but can happen any year***
- ***Dear Suppliers:***
  - ***1st recommend 98% reliable binder according to LTPPBind***
  - ***…then discuss modifier advantages***

Conclusions

- ***When 98% reliable binders are used, do not expect immediate performance differences between modifiers***
  - ***Similar I-80 PennDOT study of 6 modifiers reported noticeable performance differences after 9-yrs (built 1989) when one section was removed***

Other Similar Projects

- **Review reports on similar field studies:**
  - **PennDOT I-80, CTAA 1996**
  - **TTI 187-22, Lewandowski's LCC study**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