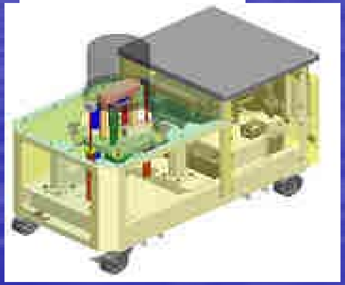


Understanding the Performance of Modified Asphalts in Mixtures

NCHRP 90-07, TPF 5(019)

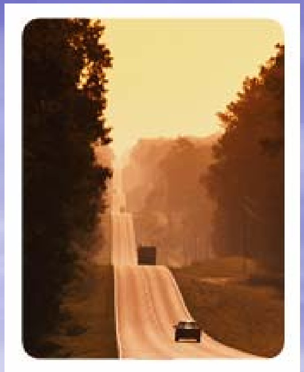
Thomas Harman

Materials & Construction Team Leader, R&D

Federal Highway Administration

www.TFHRC.gov

MATERIALS & CONSTRUCTION TEAM, R&D



United States
National **H**ighway **S**ystem

- A **$1 trillion** investment/priceless national asset
- The way nearly all products move
- Inter-modal link to sea→air →rail
- Permits our high quality of life & economic growth

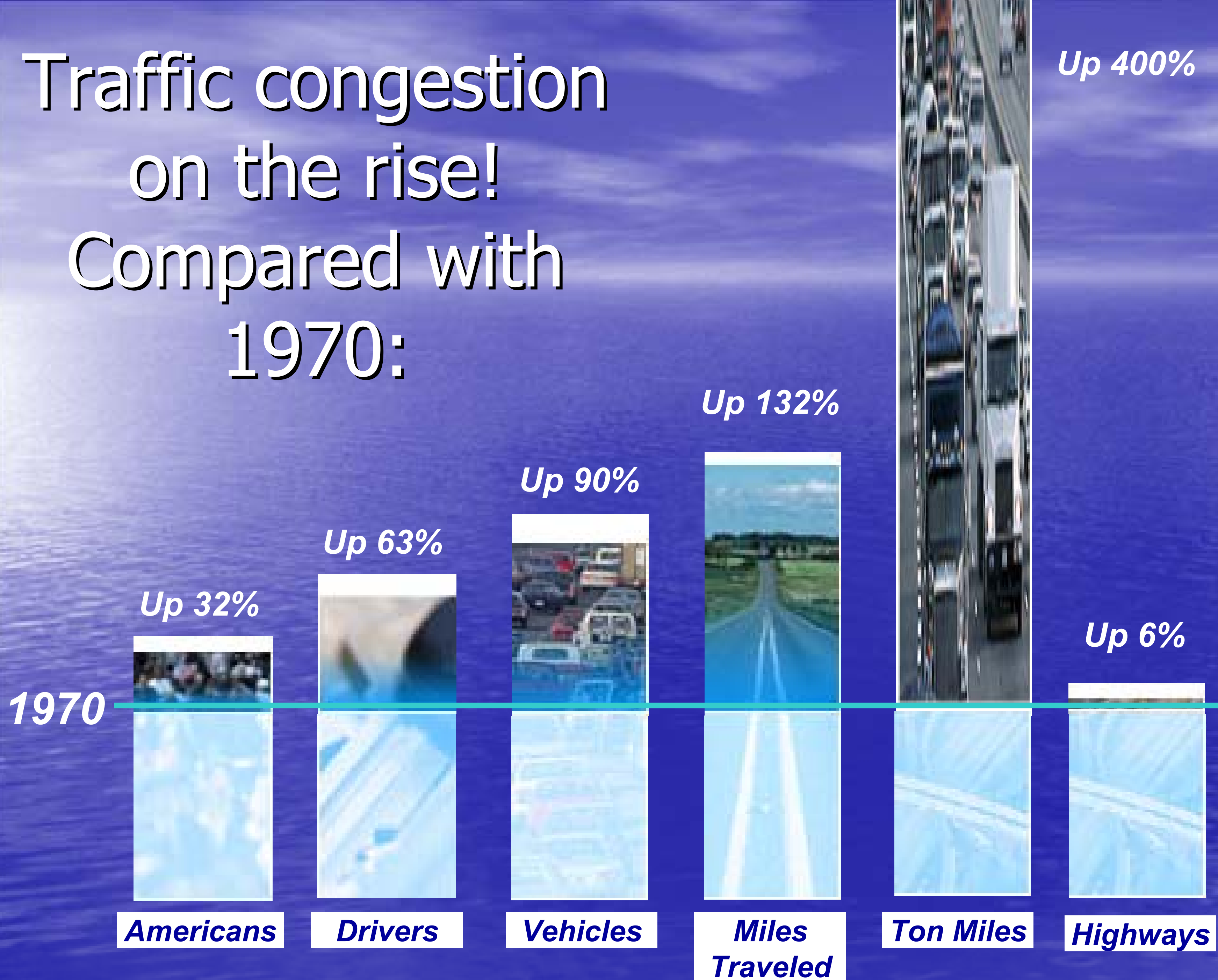
United States National Highway System

- NHS is over 160,000 miles of pavement
  - most over 35 years old
  - $59 billion shortfall to maintain condition
- ***Safety*** tied to pavement condition
- Customer/User expectations
  - Safer pavements
  - Smoother ride
  - Quieter pavements
  - Reduced delay & congestion

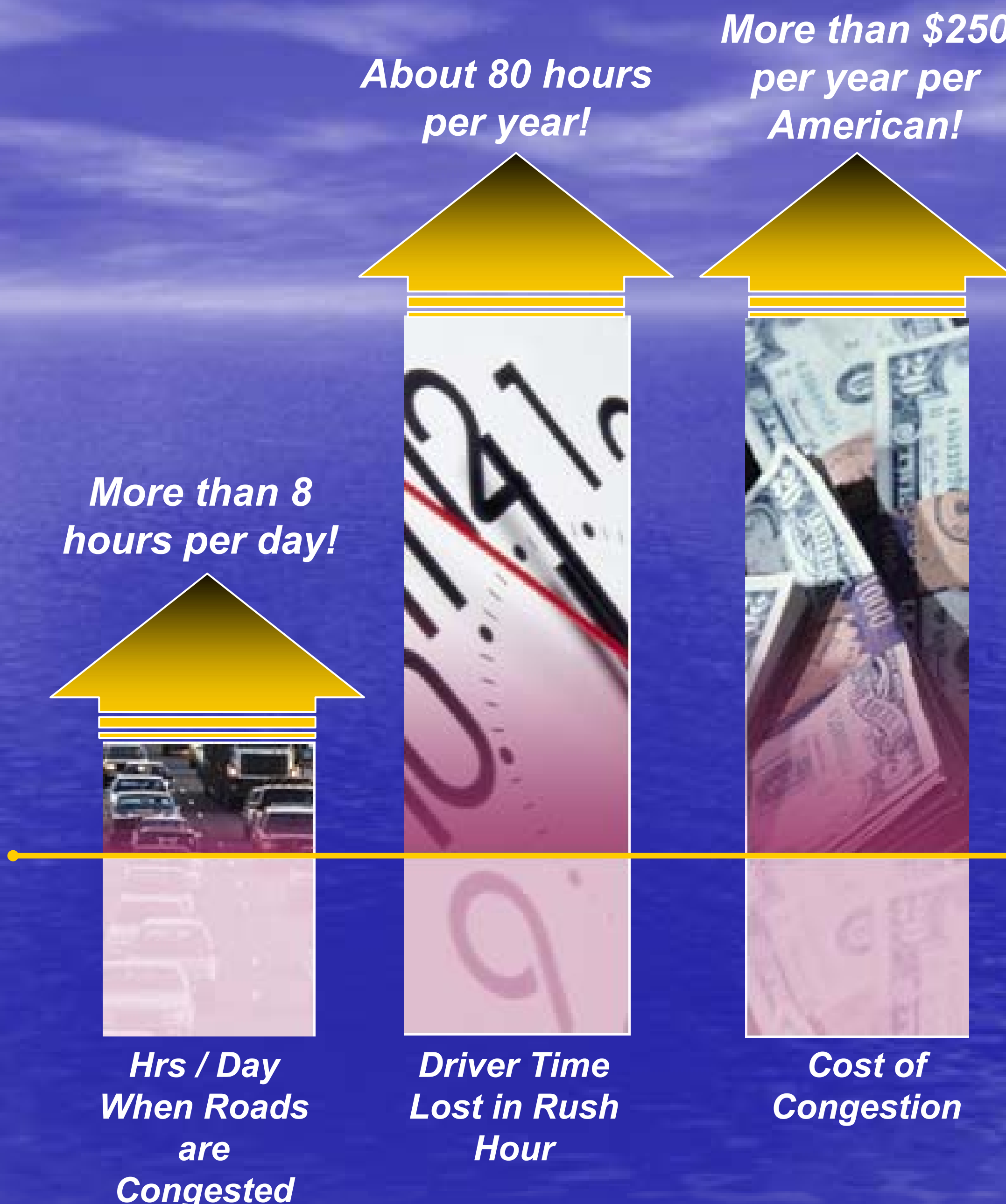
Annual HMA Investment

- $15 Billion
- 500 M tons of HMA
- 30 M tons of binder

Traffic congestion on the rise! Compared with 1970:

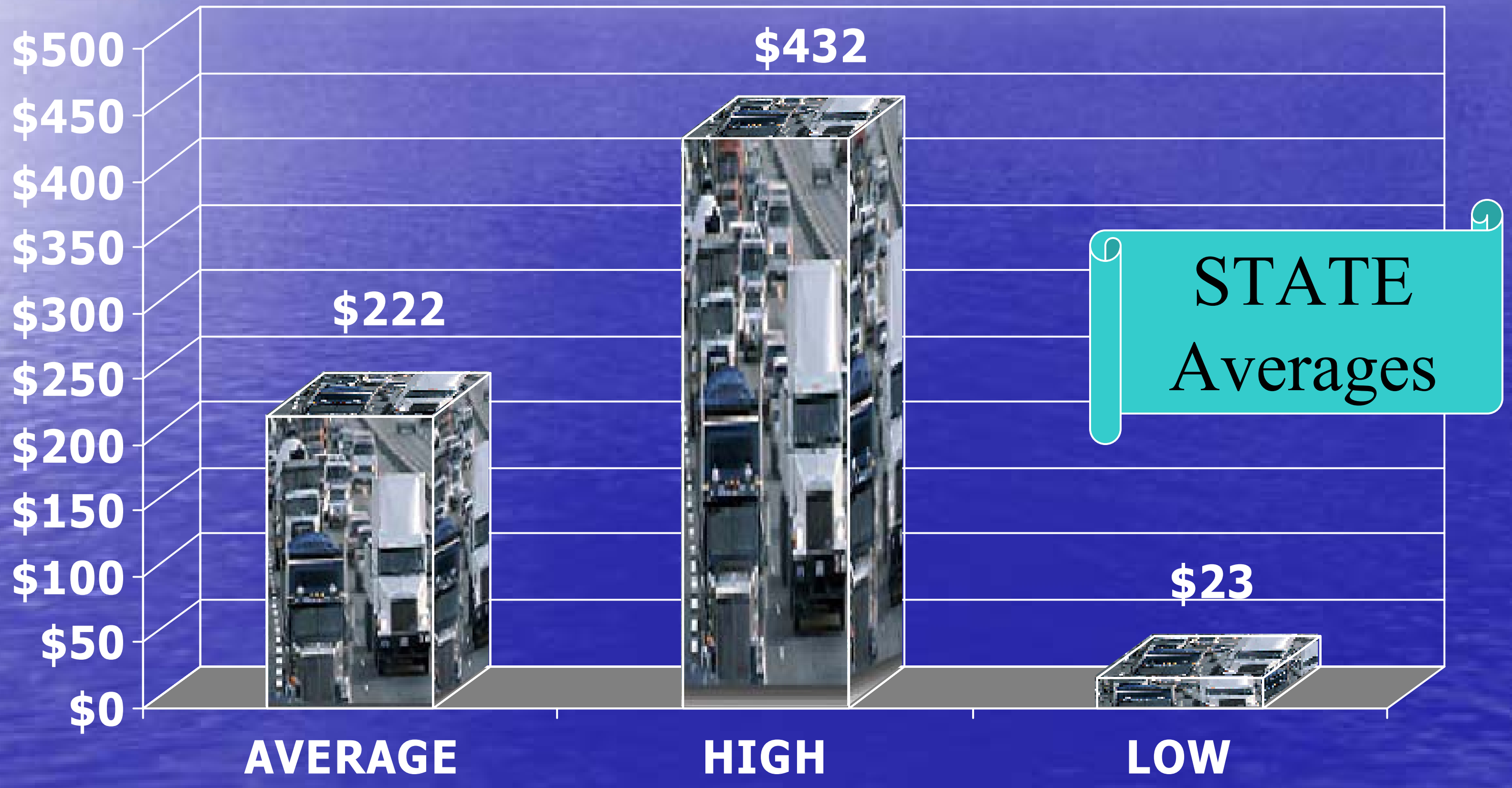


Following current congestion trends:



Extra Vehicle Operating Cost per Year Due to **Poor** Pavement Condition

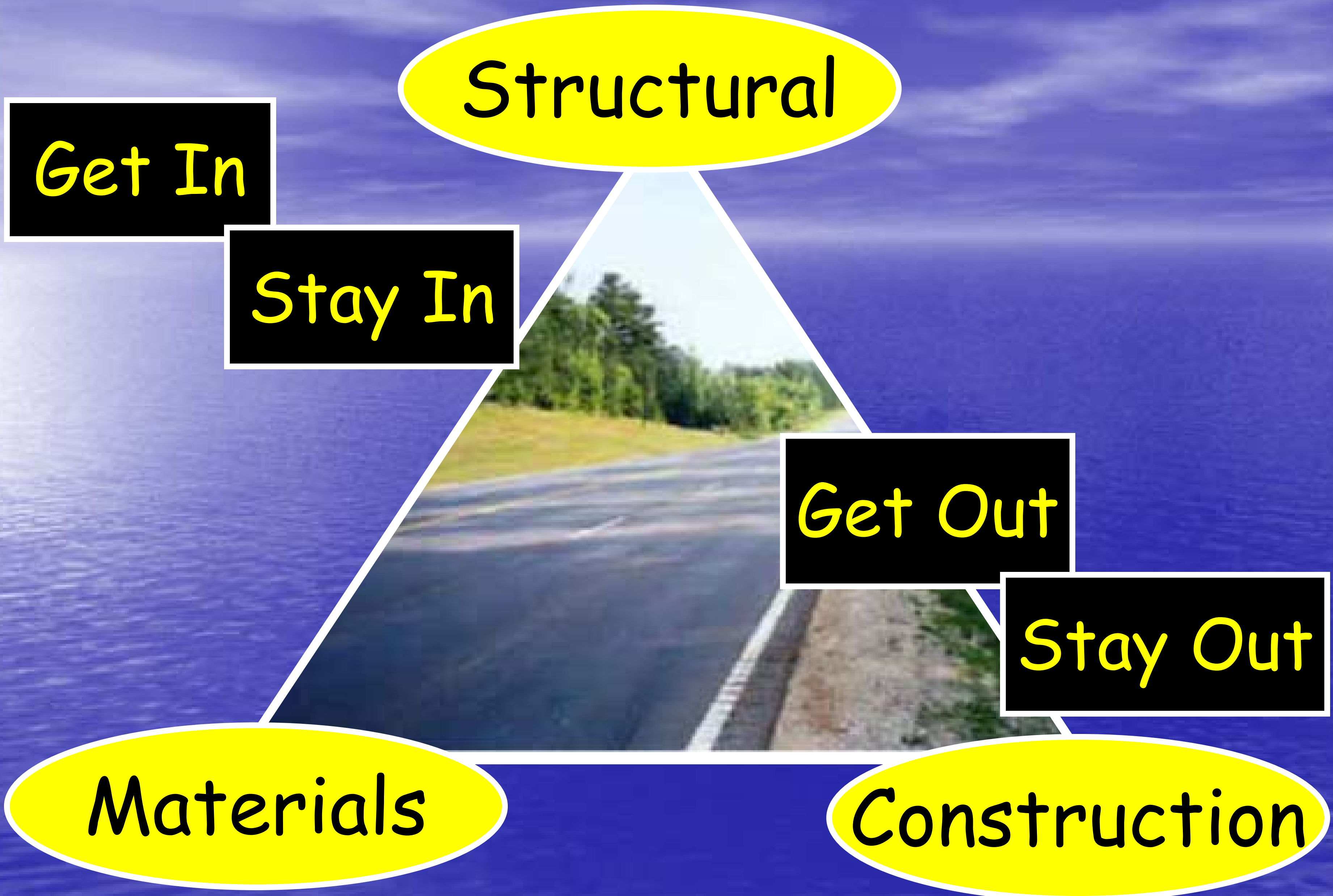
$ 41.5 Billion / year !



The Road Information Program (TRIP)
April 2001

But Things are Improving

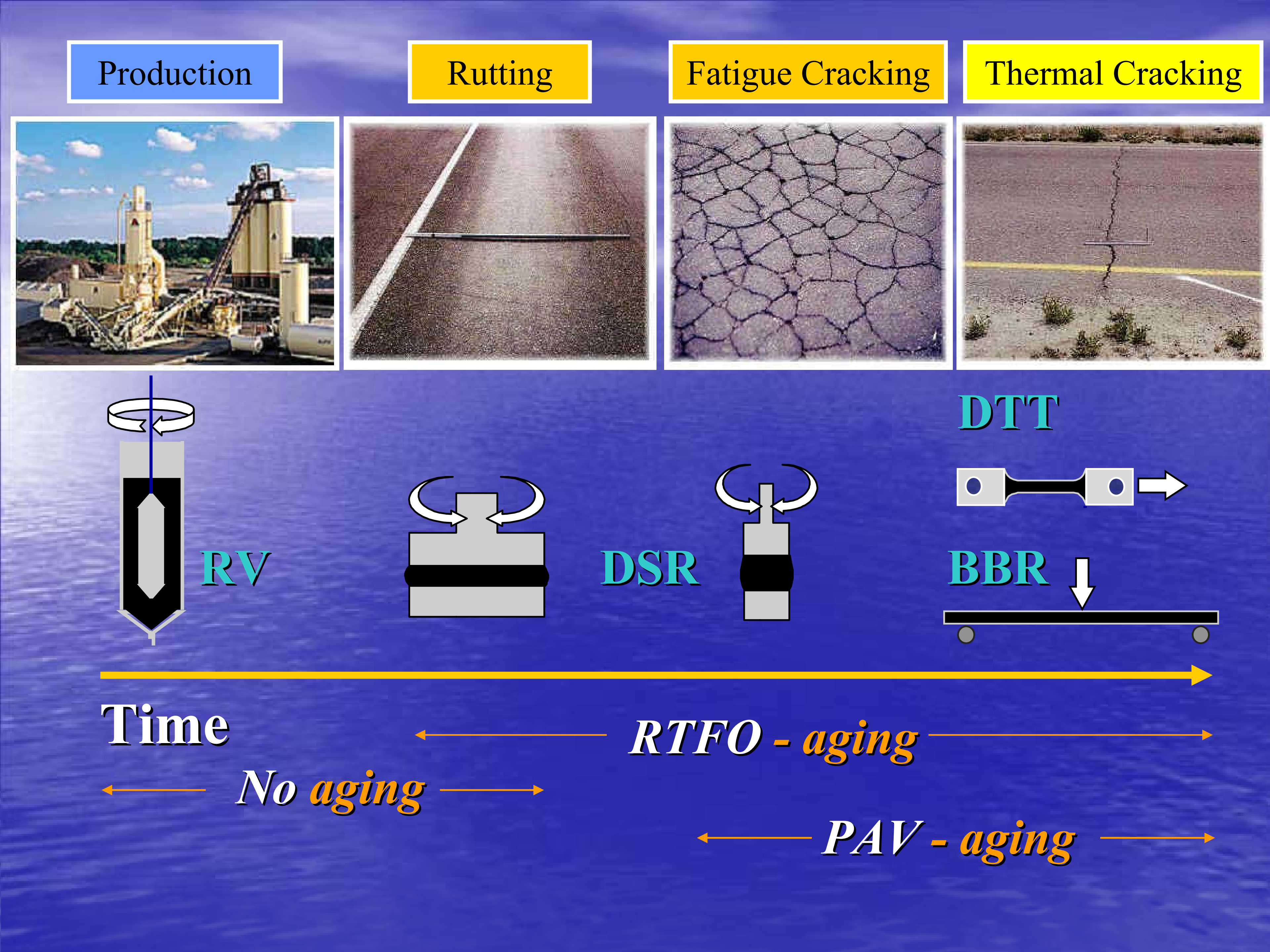
- 2002 Report on Conditions and Performance of the NHS
  - 86.0% with acceptable ride quality
  - Up from 82.5% in 1993
  - A trend reversal
  - Most of the improvement on higher order highways
  - What we are doing – we are doing better!


Structural
Get In
Stay In
Get Out
Stay Out
Materials
Construction

Outline

- Superpave® Binder ETG Direction
- Preliminary FHWA ALF Results
- Next Steps

- Goal - Right materials provide the best performance!


Production
Rutting
Fatigue Cracking
Thermal Cracking
RV
DSR
DTT
BBR
Time
RTFO - aging
No aging
PAV - aging

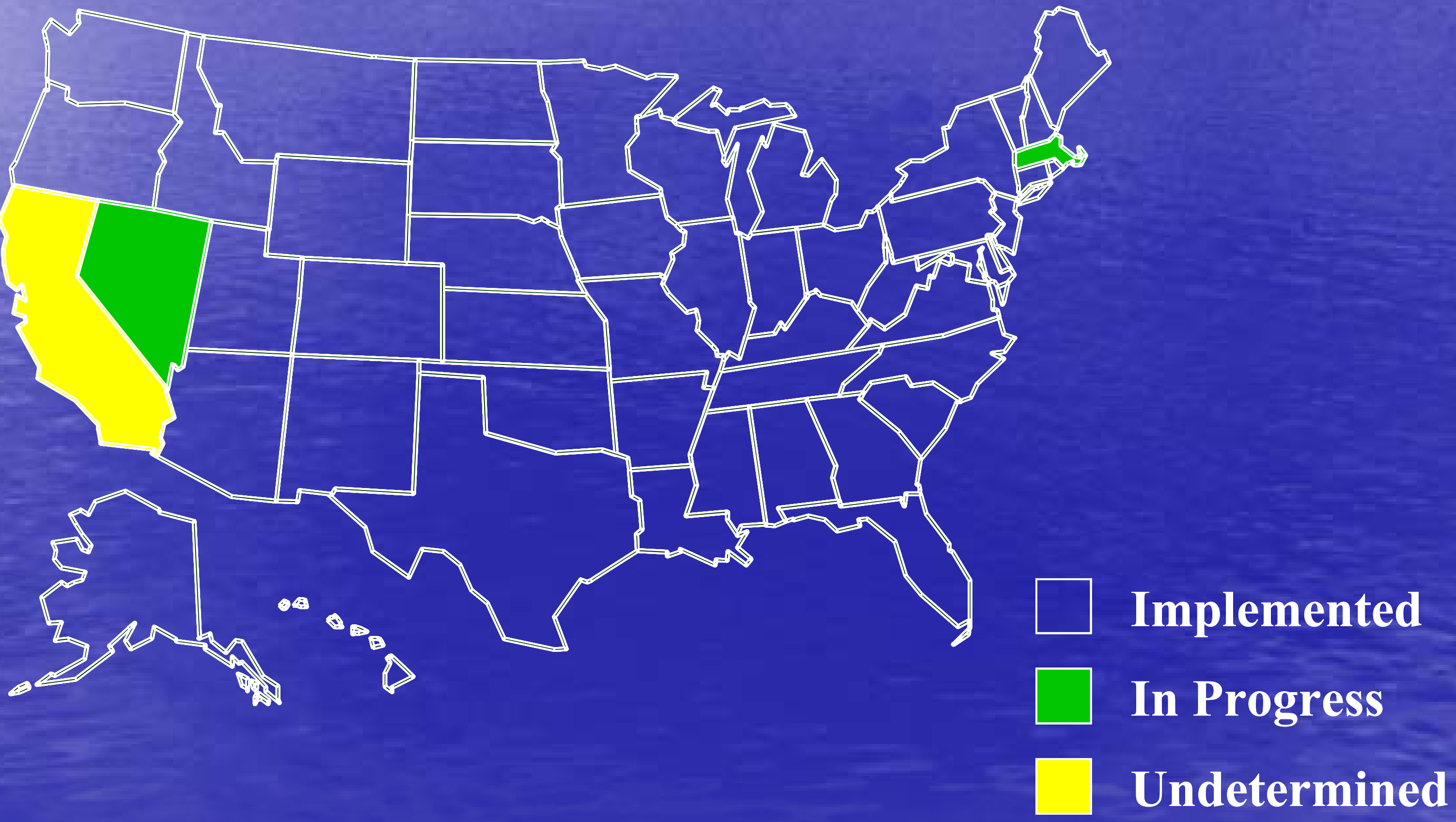
Superpave® Binder Specification

Rutting, Fatigue, and Low-Temp. Cracking

WHEN	WHAT	HOW	WHERE
Construction	Safety Pumpability Rutting	Flash Point Rot Visc $G^* / \sin \delta$	230 min 3 Pa-s max T(high)
Early *(RTFO)*	Rutting	$G^* / \sin \delta$	T(high)
Late *(+PAV)*	Fatigue Low Temp	$G^* \sin \delta$ BBR/DTT	T(inter) T_{CR}

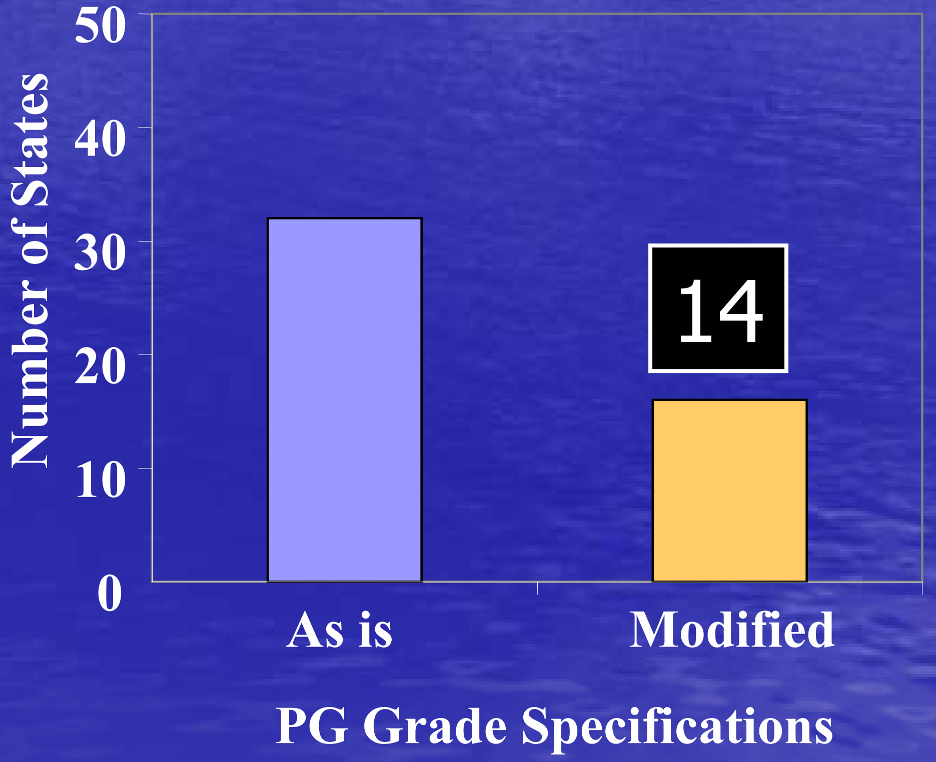
Superpave® 2002

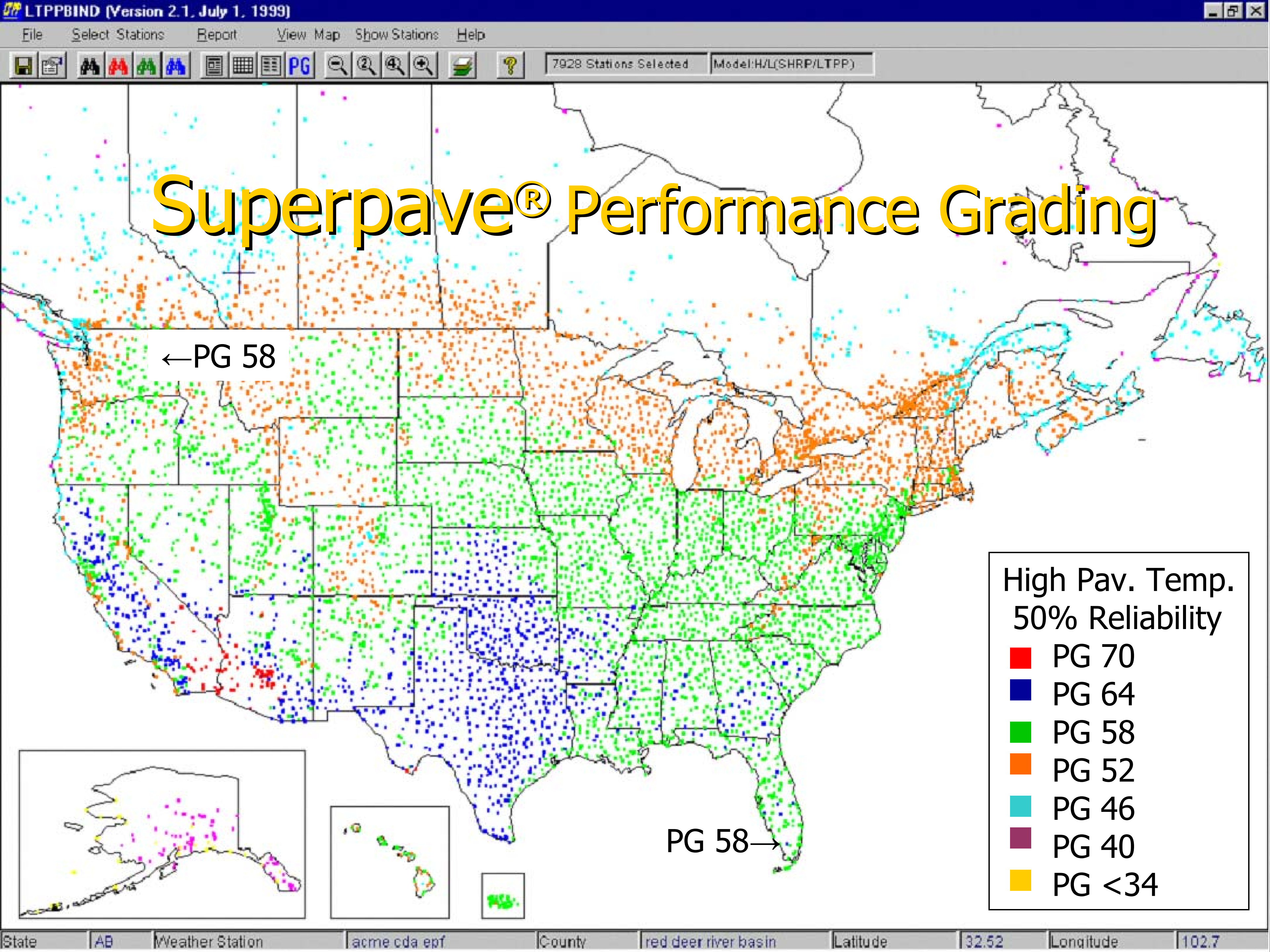
- Asphalt Binder Implementation Status



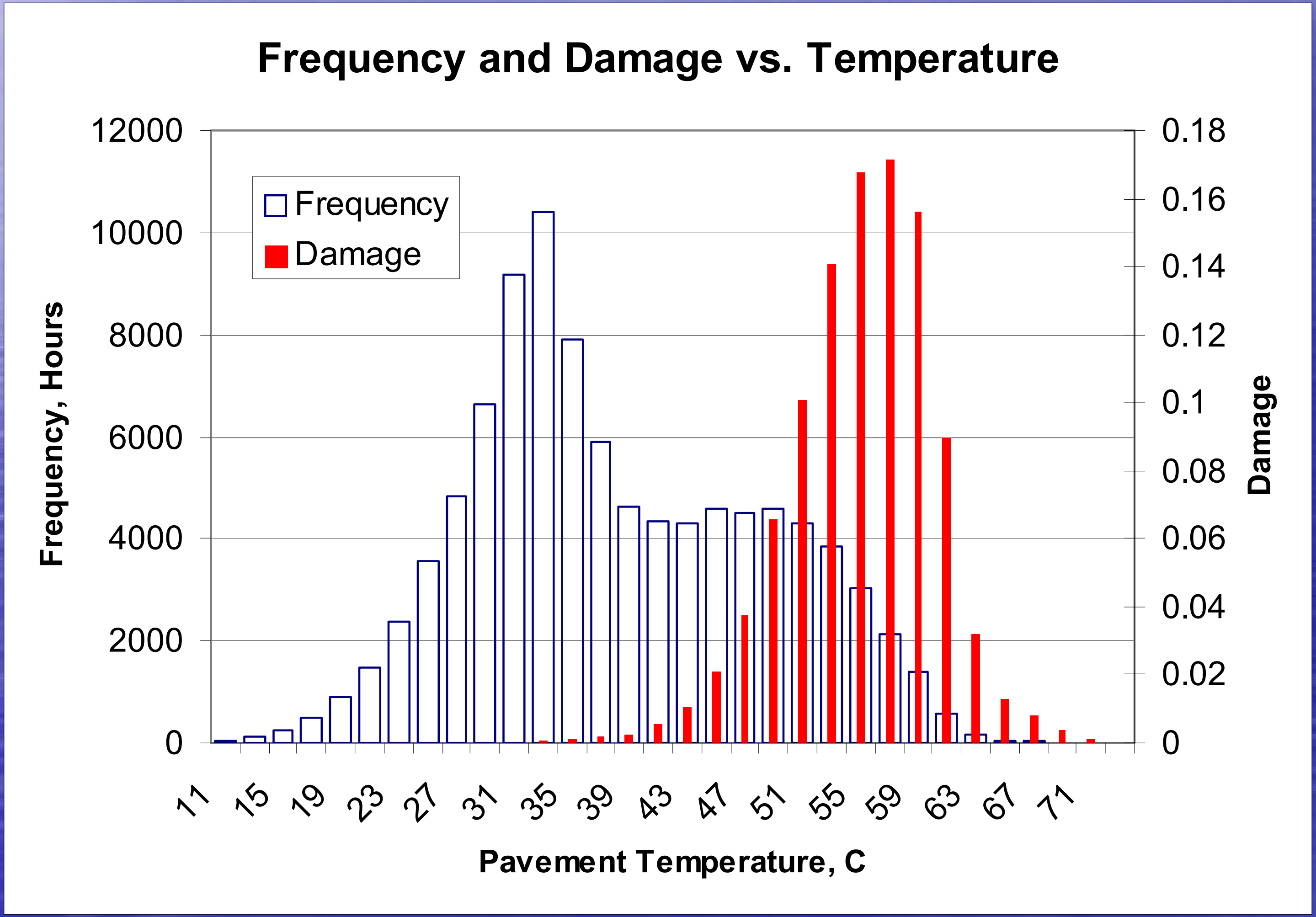
Superpave® Plus

- Elastic recovery
- Forced ductility
- Toughness and tenacity
- Phase angle
- Method
  (mode and dose)
- Combinations




LTPPBIND (Version 2.1, July 1, 1999)
File
Select Stations
Report
View Map
Show Stations
Help
PG
7928 Stations Selected
Model:H/L(SHRP/LTPP)
Superpave® Performance Grading
←PG 58
PG 58→
High Pav. Temp.
50% Reliability
PG 70
PG 64
PG 58
PG 52
PG 46
PG 40
PG <34
State
AB
Weather Station
acme cda epf
County
red deer river basin
Latitude
32.52
Longitude
102.7

Adjusting Model for Performance "Degree Days"



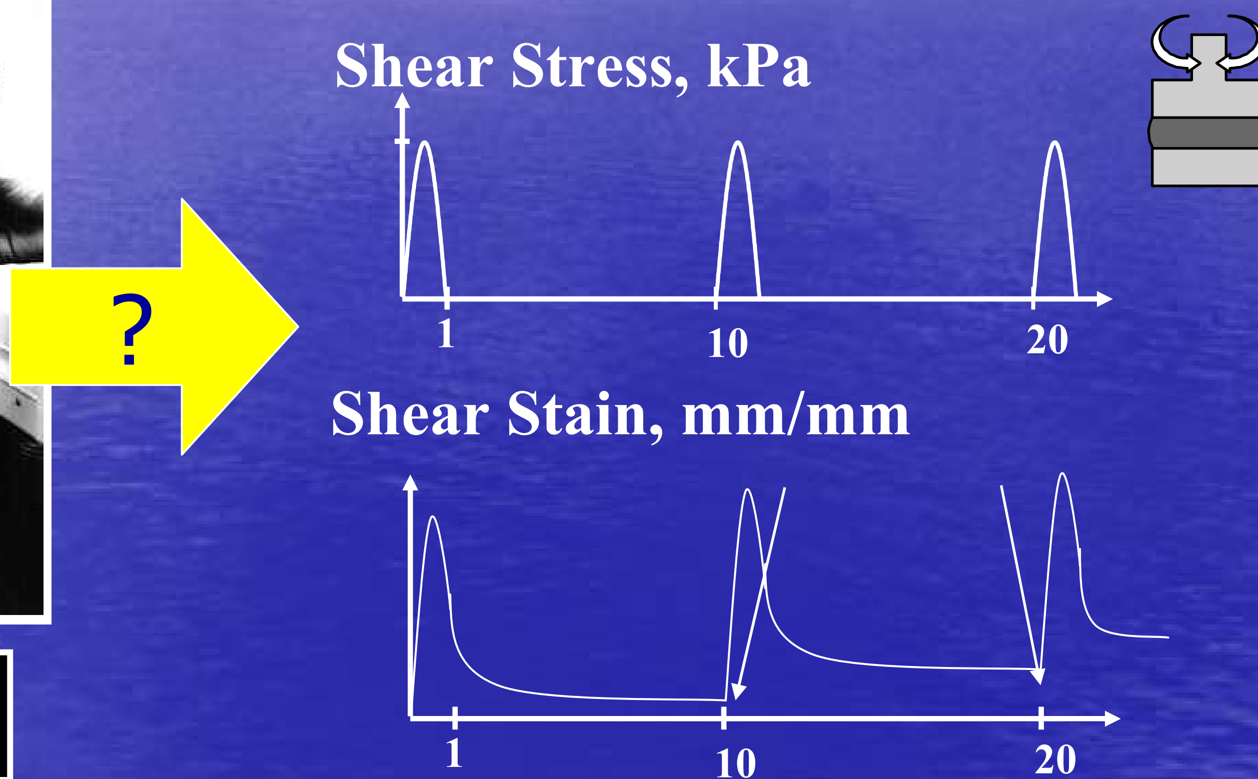
Superpave® Binder Specification

Short Term Aging - NCHRP

?

Superpave® Binder Specification

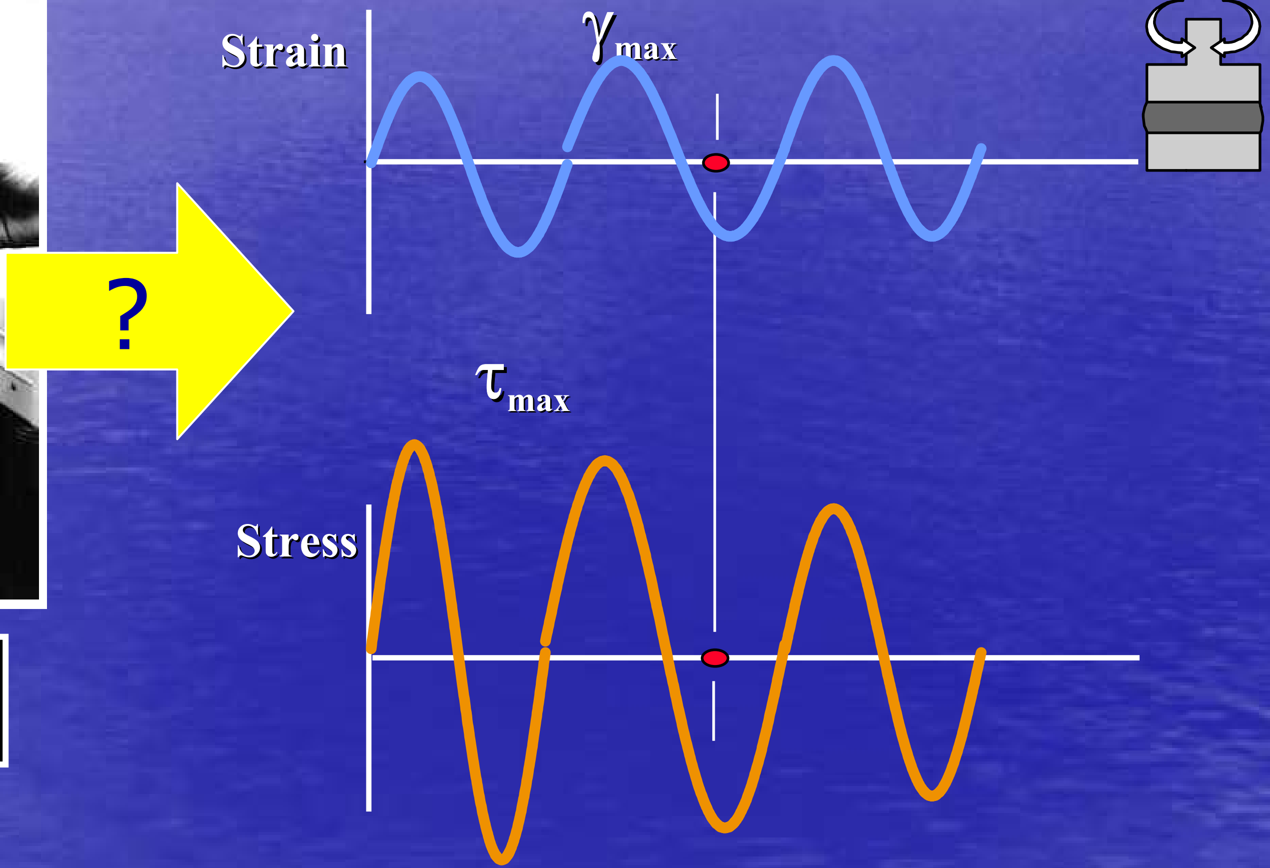
Rutting



$G^* / \sin \delta$

Superpave® Binder Specification

Fatigue



$G^* \sin \delta$

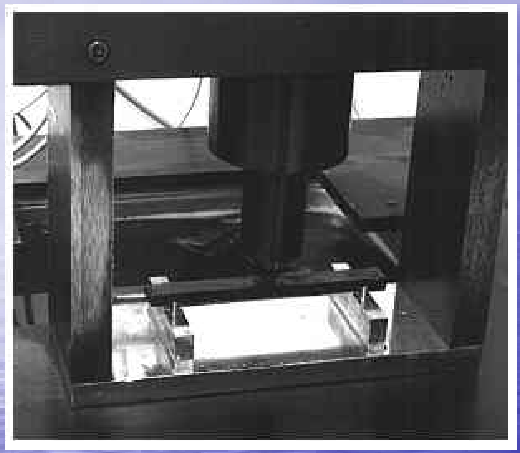
Superpave® Binder Specification
Long Term Aging

?

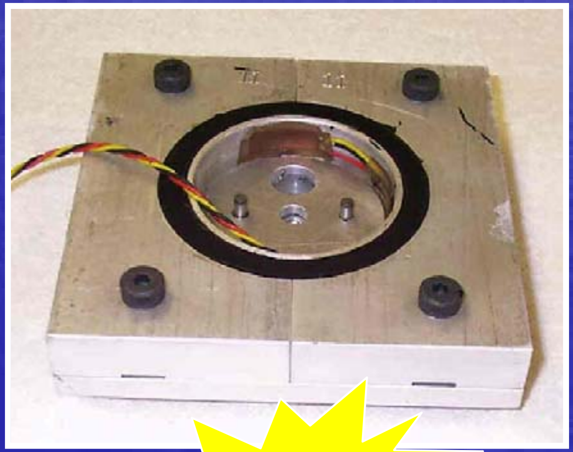
Little Research
Using
Microwave Technology

Superpave® Binder Specification

Low Temperature Cracking (Thermal Fatigue)



?



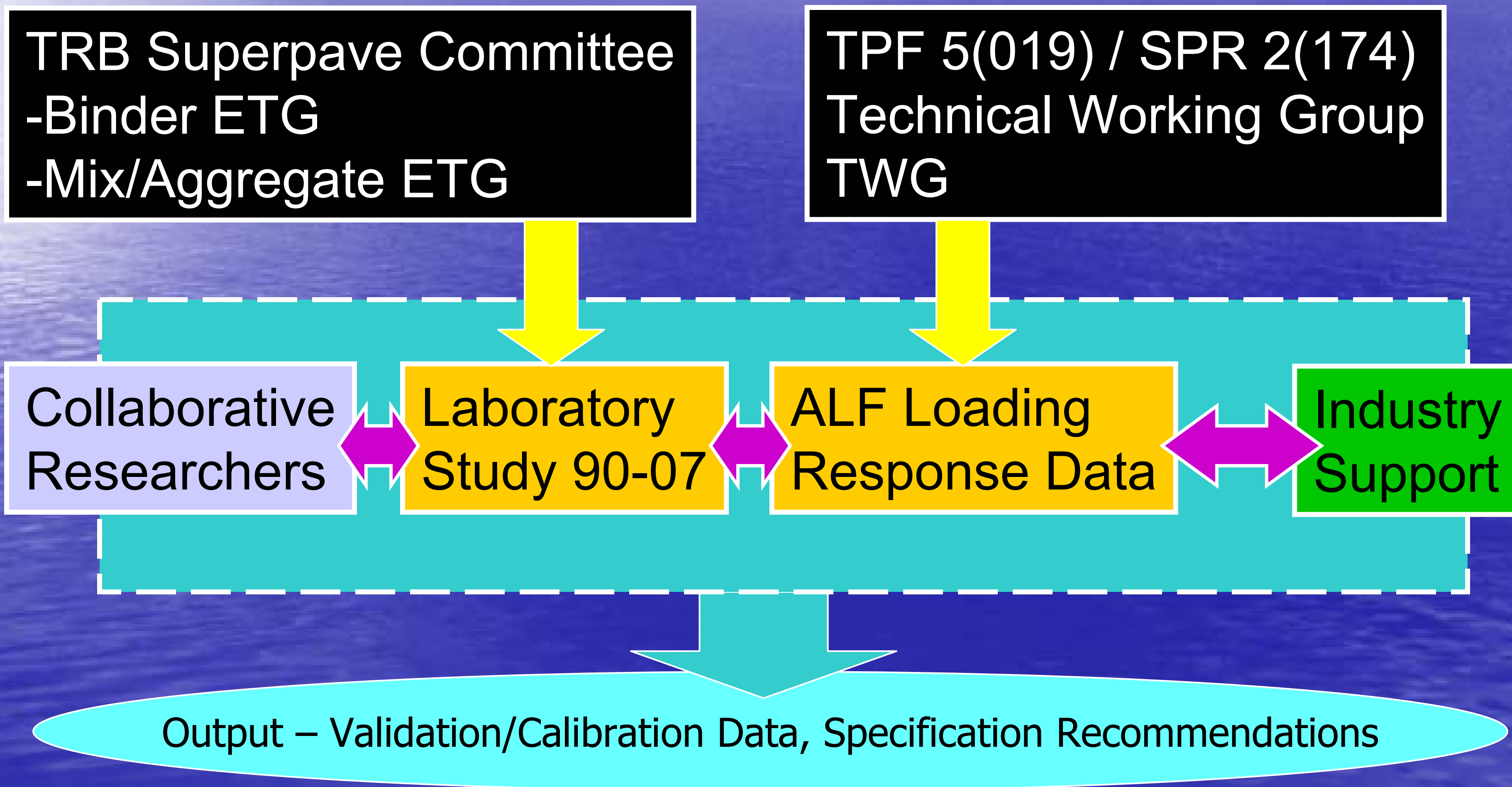
R&D

Superpave® II

PG based on Degree Days

WHEN	WHAT	HOW	WHERE
Construction	Safety Pumpability Rutting	Flash Point Rot Visc $f'(G^* \delta)$	230 min 3 Pa-s max T(high)
Early *(GRF, TX)*	Rutting	$f'(G^* \delta)$	T(high)
Late *(PAV)*	Fatigue Low Temp	$f''(G^*\delta)DT$ DT *ABCD*	T(inter) T_{CR}

Relationships



Technical Working Group (TWG) Meeting December 5-6, 2002
(17 States, 29 Industry Partners/Collaborative Researchers)

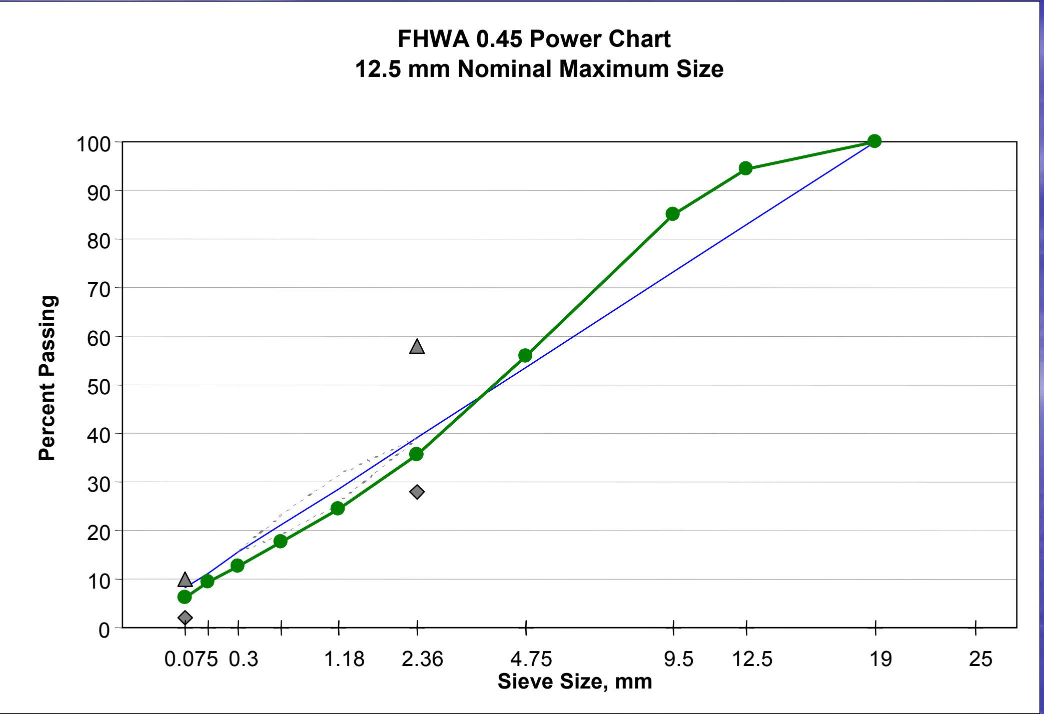
Final Test Matrix…

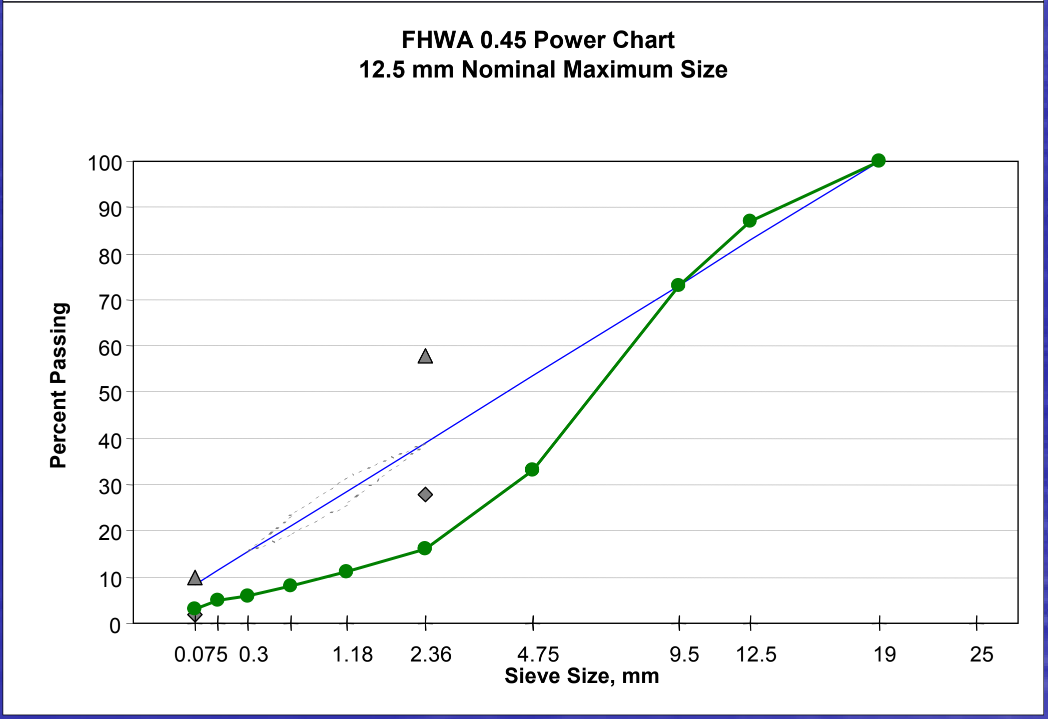
1	2	3	4	5	6	7	8	9	10	11	12
AZ CRM ---- 70-22	PG 70-22 Control	Air Blown	SBS	TX TBCR	T-P	PG 70-22 + Fibers	PG 70-22	SBS 64-40	Air Blown	SBS	T-P

Mix Designs

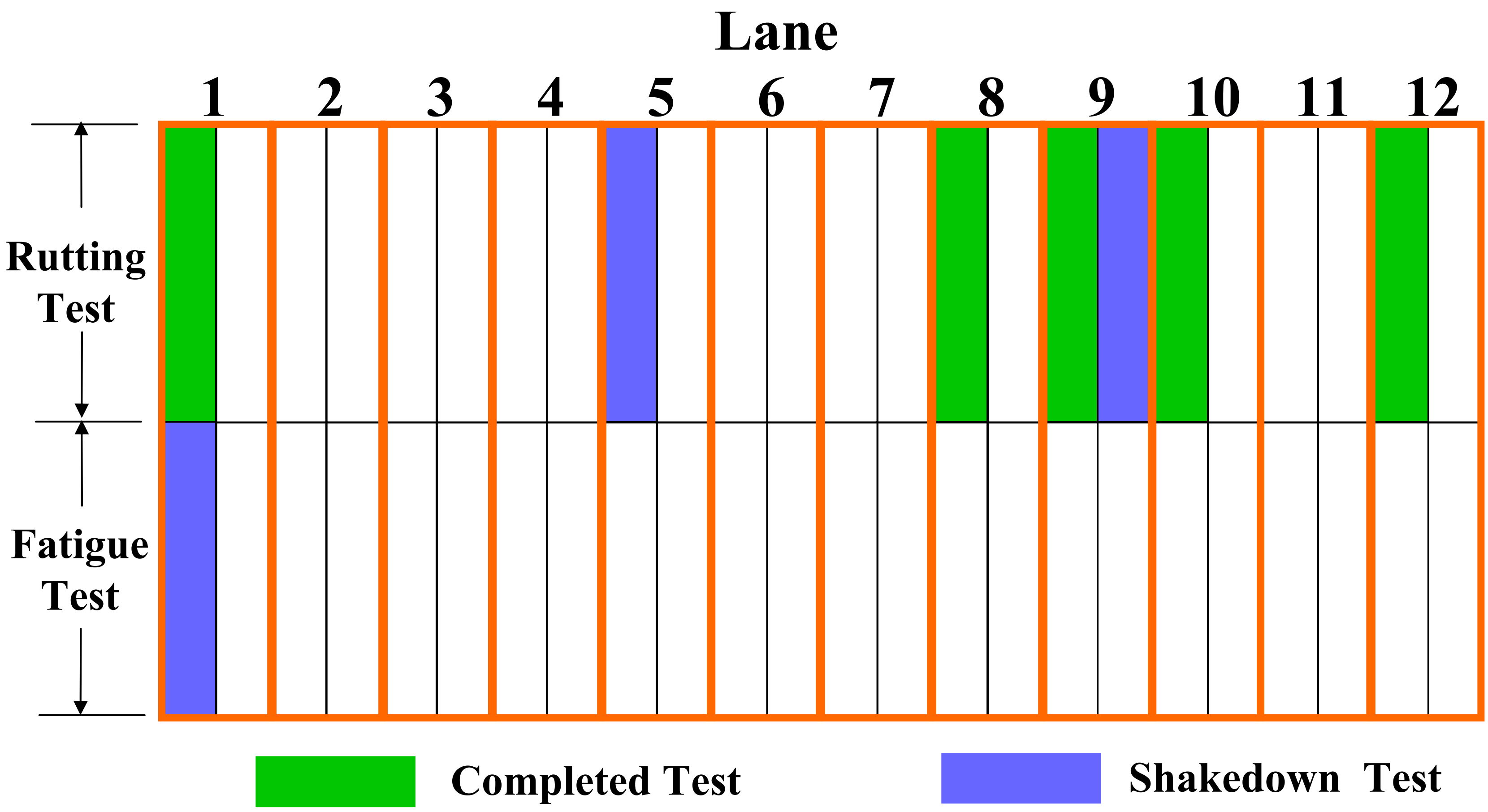
Superpave
12.5mm NMS
Coarse Graded
Pb = 5.3 %
PG 74-28
Ndes = 75

Arizona CRM
12.5mm NMS
Coarse Graded
Pb = 7.1 %
PG 58-22 with
17% CRM





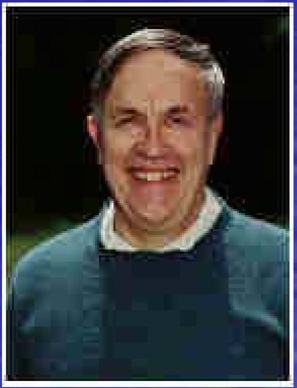
ALF Testing Status

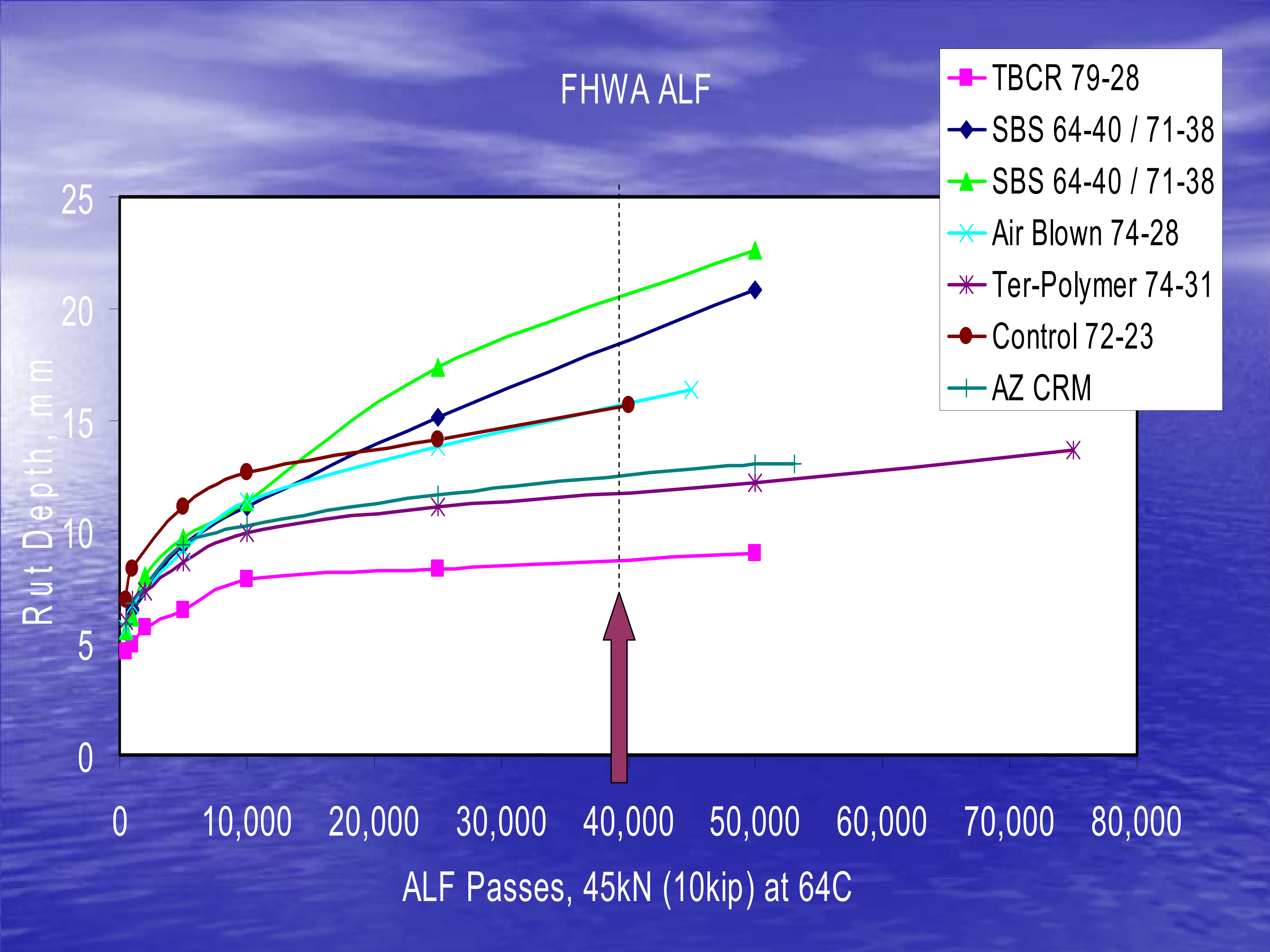


***Initial Strain Measurements: 100% Complete**
***Rutting Tests: Shakedown Tests Complete (5, 9)**
***Rutting Tests: 5 of 12 Lanes Complete**
***Fatigue Tests: Shakedown Test Complete (1)**

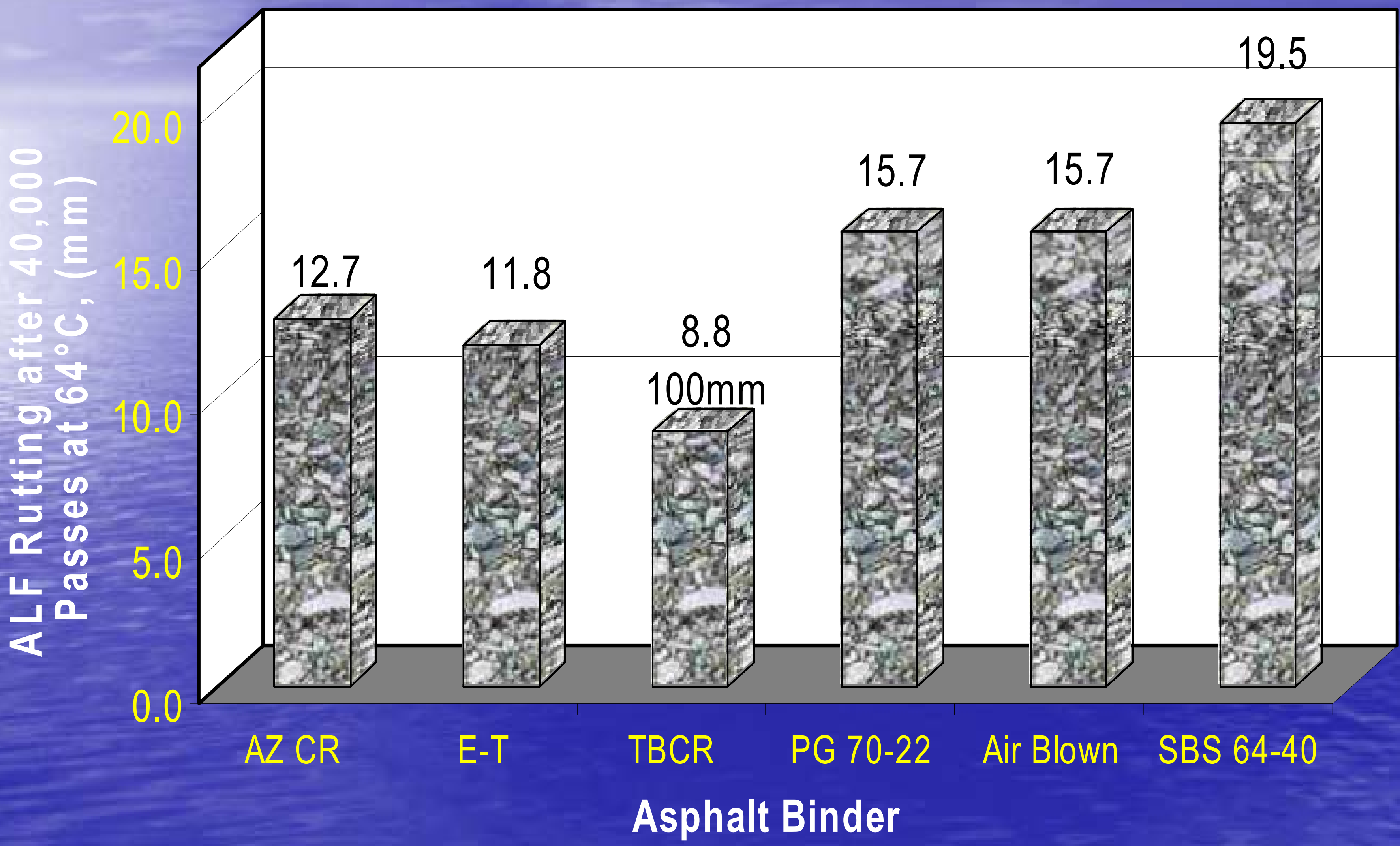
ALF - Laboratory

Preliminary Results

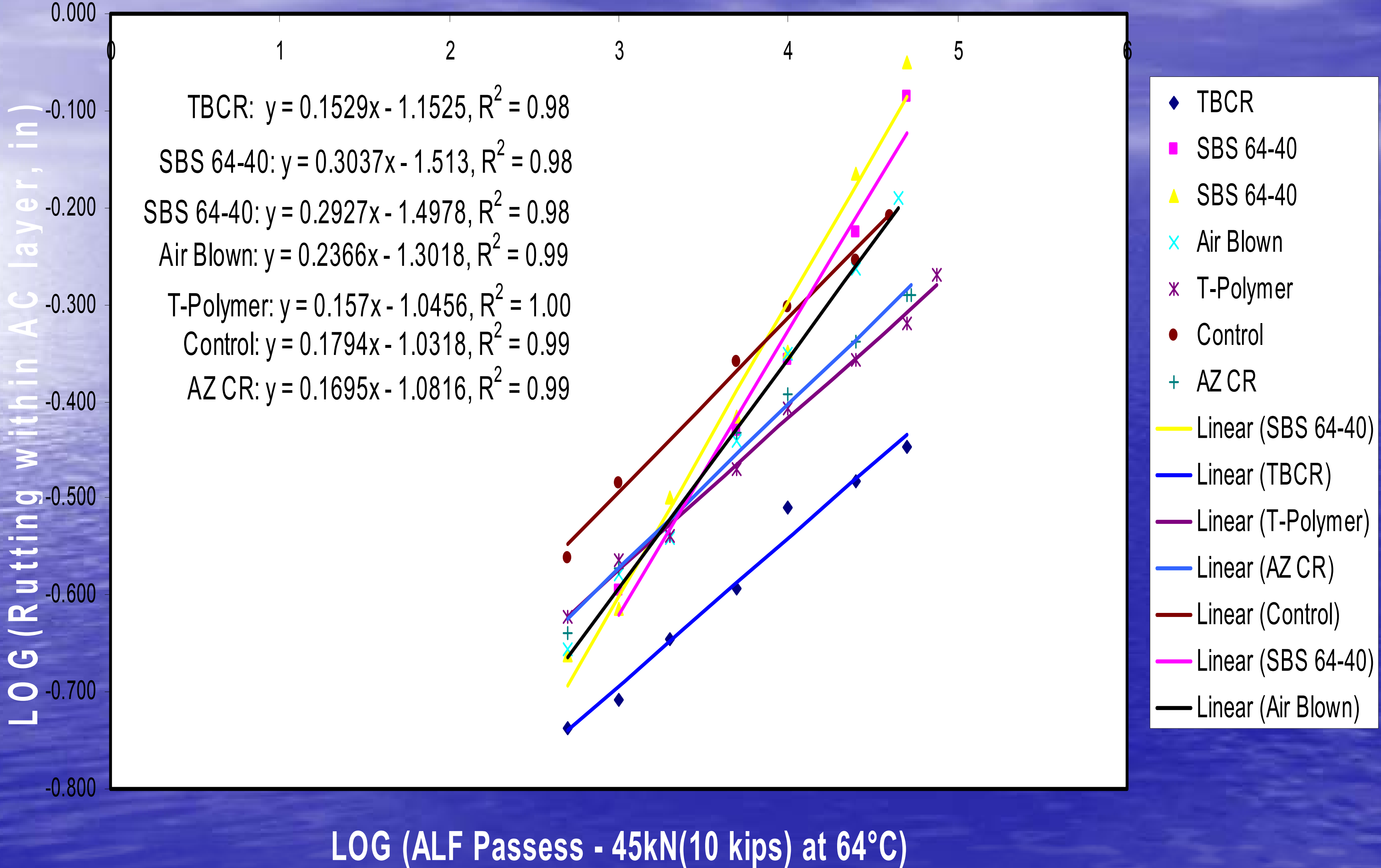



FHWA ALF
TBCR 79-28
SBS 64-40 / 71-38
SBS 64-40 / 71-38
Air Blown 74-28
Ter-Polymer 74-31
Control 72-23
AZ CRM
Rut Depth, mm
0
5
10
15
20
25
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
ALF Passes, 45kN (10kip) at 64C

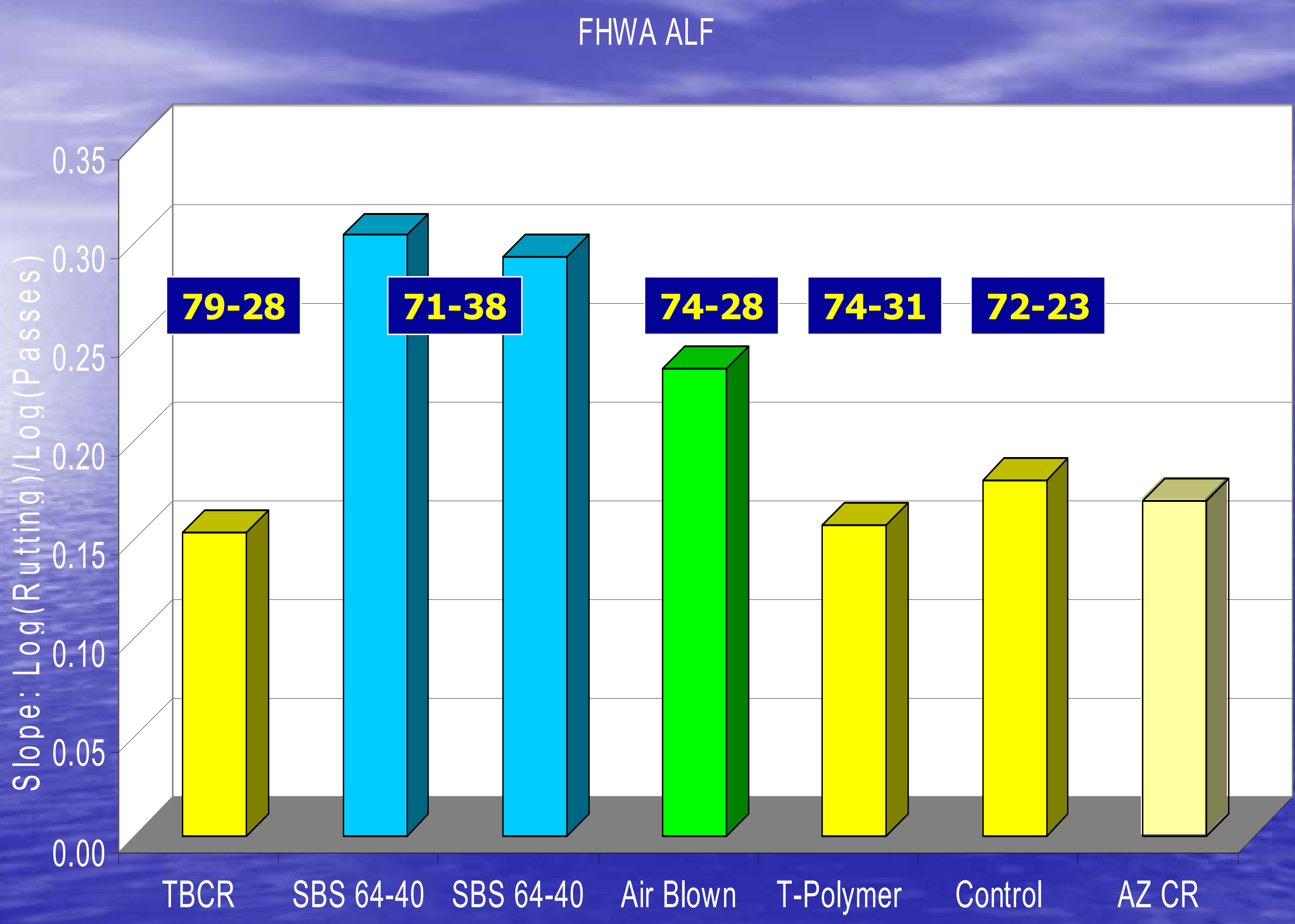
Preliminary ALF Results



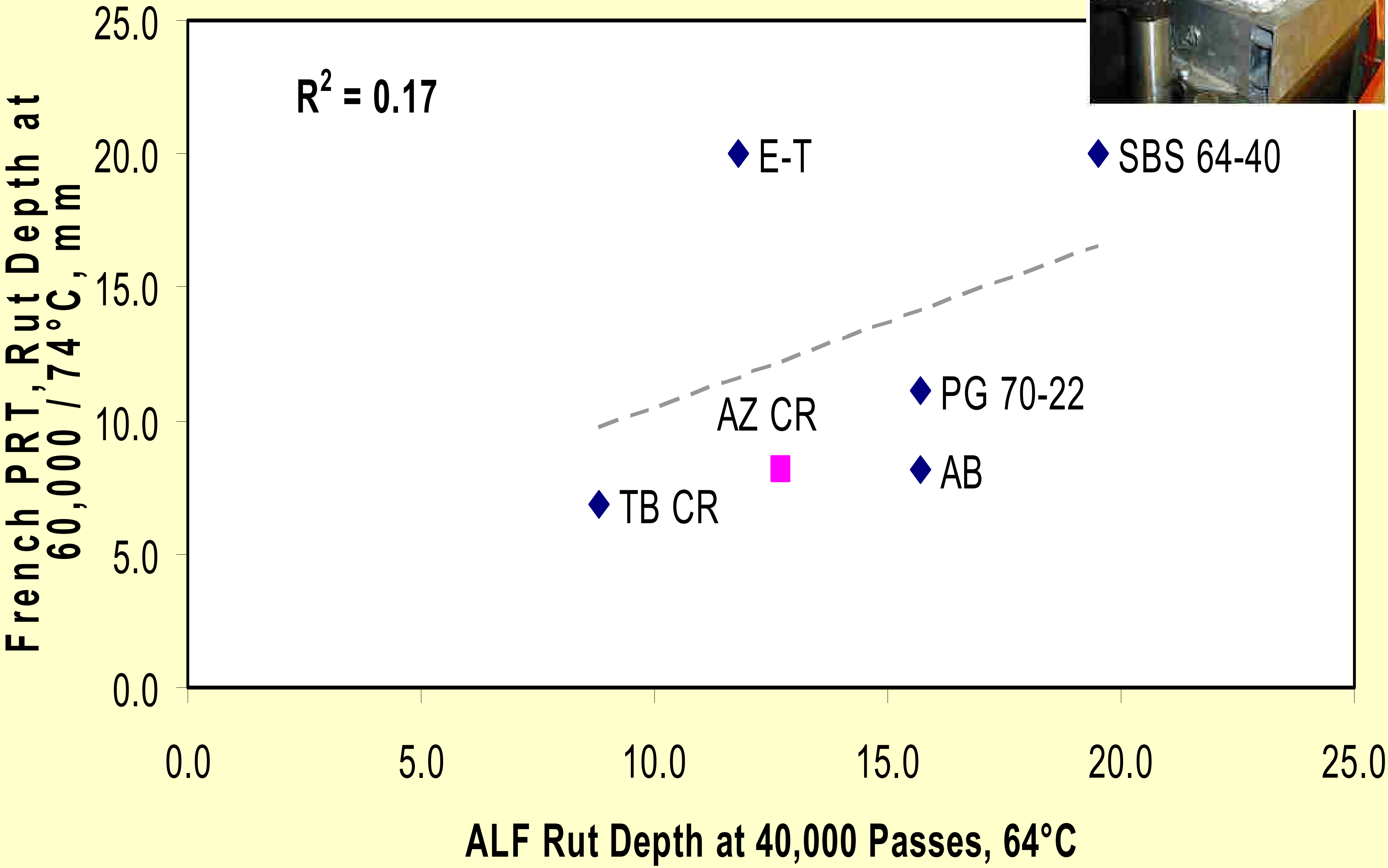
FHWA ALF



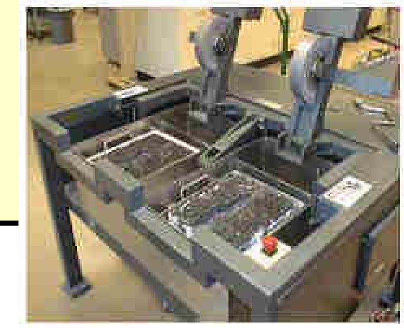
TBCR: y = 0.1529x - 1.1525, R2 = 0.98
SBS 64-40: y = 0.3037x - 1.513, R2 = 0.98
SBS 64-40: y = 0.2927x - 1.4978, R2 = 0.98
Air Blown: y = 0.2366x - 1.3018, R2 = 0.99
T-Polymer: y = 0.157x - 1.0456, R2 = 1.00
Control: y = 0.1794x - 1.0318, R2 = 0.99
AZ CR: y = 0.1695x - 1.0816, R2 = 0.99
LOG (Rutting within AC layer, in)
LOG (ALF Passess - 45kN(10 kips) at 64°C)
0.000
-0.100
-0.200
-0.300
-0.400
-0.500
-0.600
-0.700
-0.800
0
1
2
3
4
5
6
TBCR
SBS 64-40
SBS 64-40
Air Blown
T-Polymer
Control
AZ CR
Linear (SBS 64-40)
Linear (TBCR)
Linear (T-Polymer)
Linear (AZ CR)
Linear (Control)
Linear (SBS 64-40)
Linear (Air Blown)

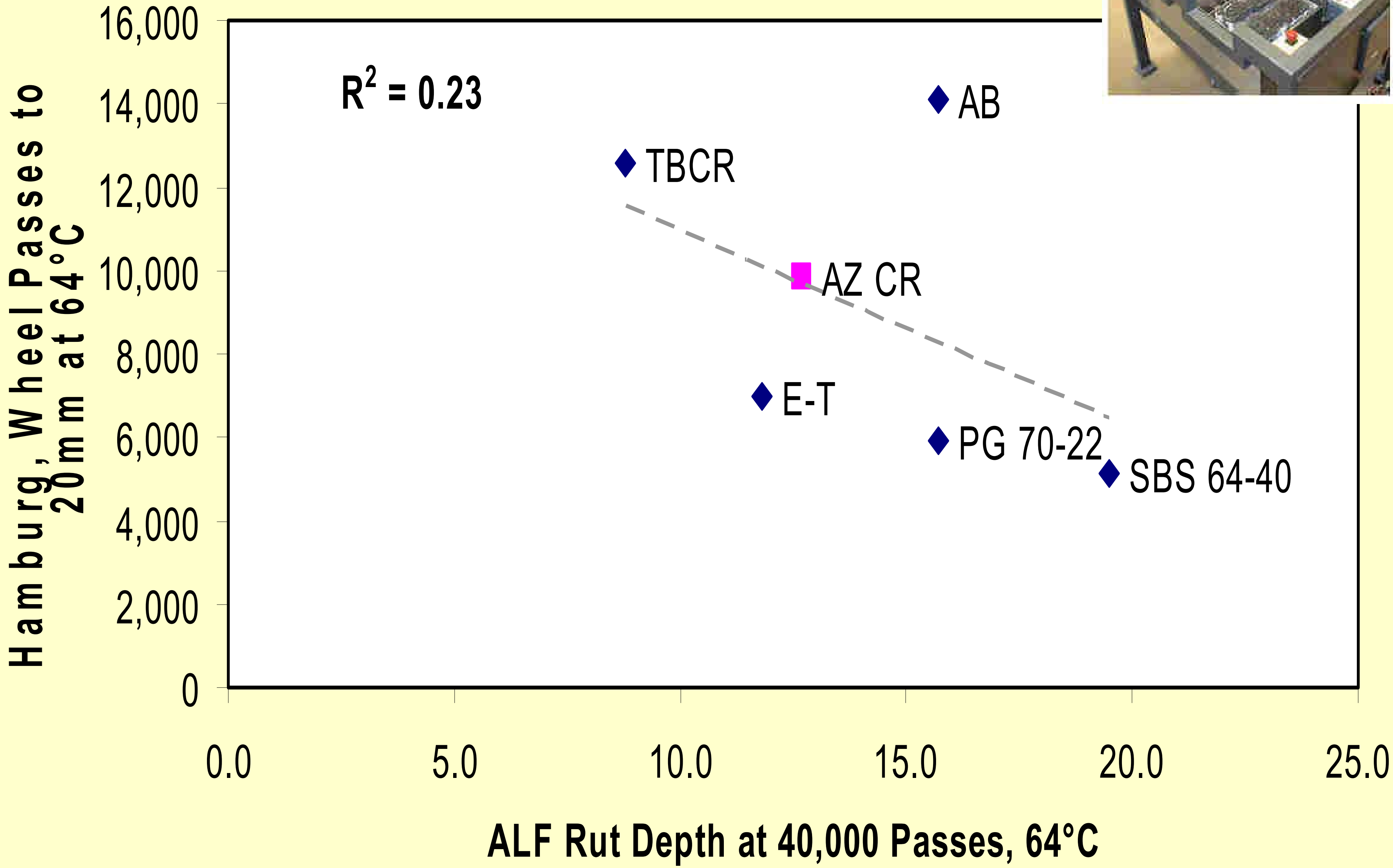

FHWA ALF
Slope: Log(Rutting)/Log(Passes)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
79-28
71-38
74-28
74-31
72-23
TBCR
SBS 64-40
SBS 64-40
Air Blown
T-Polymer
Control
AZ CR

Preliminary ALF Data

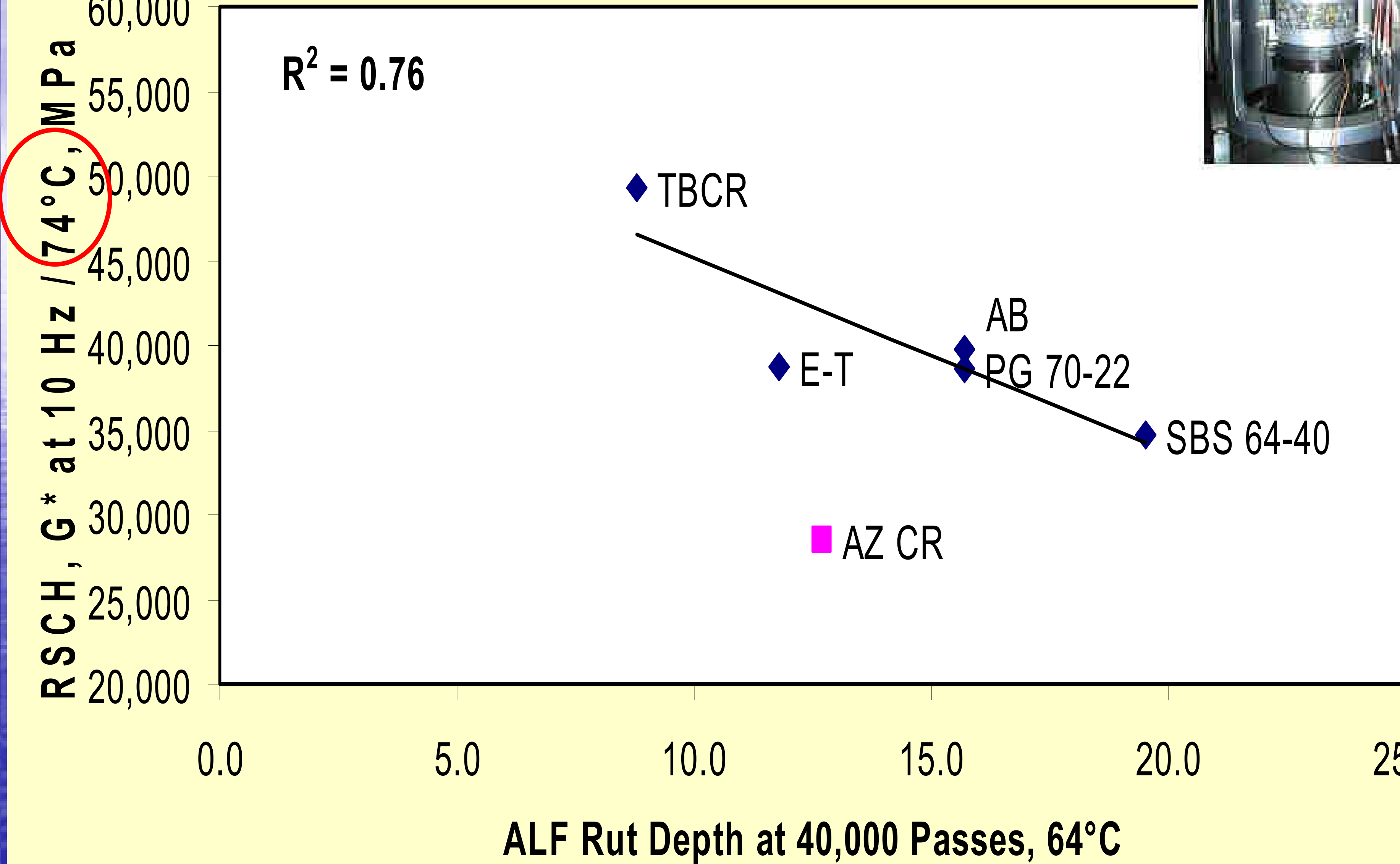


Preliminary ALF Data

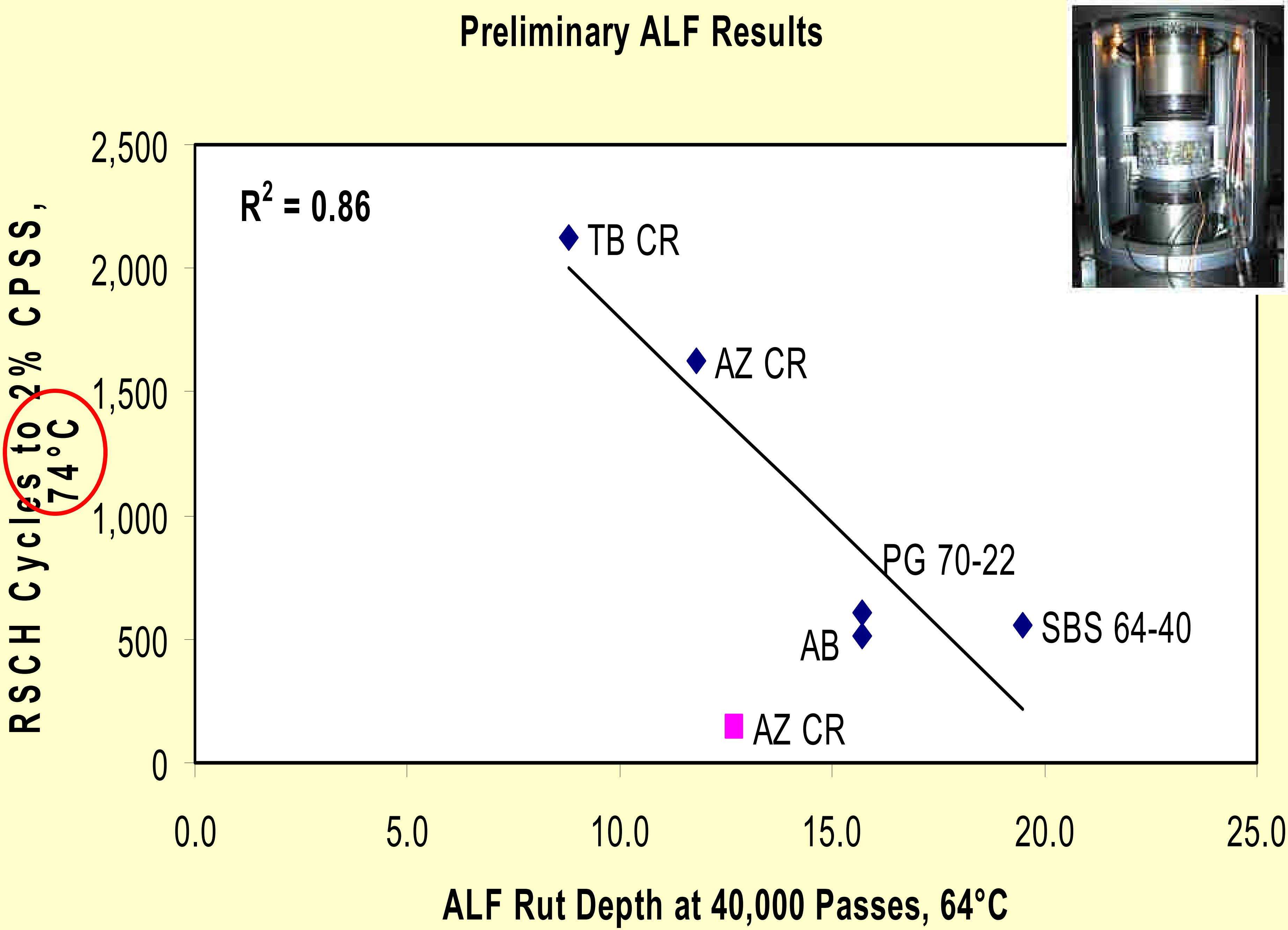




Preliminary ALF Data

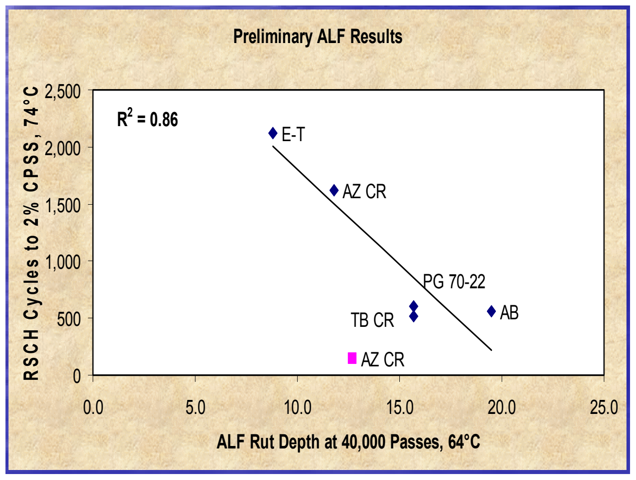


Preliminary ALF Results



Significance

- Superpave Shear Tester
  Repeated Shear at Constant Height to 2% Cumulative Permanent Shear Strain
  Tracks ALF Rutting Performance

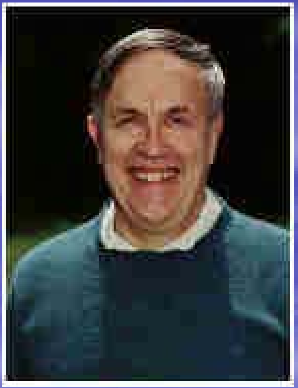


Superpave Performance Tests

- Dynamic Modulus, |E*|
- Flow Time
- Flow Number – Repeated Creep

- Ongoing Testing…



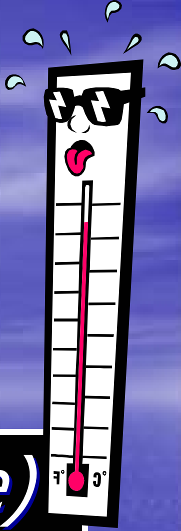


Binder Specification Parameters

Preliminary Results

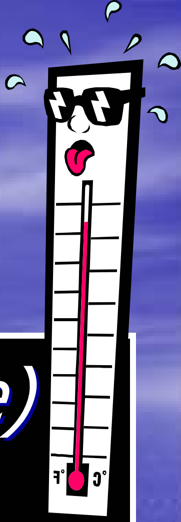


High Temperature Parameters



- $|G^*|/\sin\delta$ @10 radians *(Superpave)*
- $|G^*|/(1-(1/\tan\delta \sin\delta))$ @0.25 radians *(Shenoy)*
- % γ_{acc} Repeated Creep @ 300 Pa *(Bahia)*
- η' @ 0.01 radians/s, LSV *(Dongre'/D'Angelo)*
- η_0 @ ~0 radians/s, ZSV *(Rowe)*
- MVR, 1.225kg load, cc/10min *(Shenoy)*

High Spec. Temperature, T_{HS}



- $|G^*|/\sin\delta = 2200$ Pa *(Superpave)*
- $|G^*|/(1-(1/\tan\delta \sin\delta)) = 50$ Pa *(Shenoy)*
- $\% \gamma_{acc}$ No Criterion *(Bahia)*
- $\eta' = 250$ Pa-s, LSV *(Dongre'/D'Angelo)*
- $\eta_0 = 250$ Pa-s, ZSV *(Rowe)*
- *MRV = 50 cc/10min* *(Shenoy)*

High-Temperature Performance
I-80, Nevada

Same gradation - different binders.

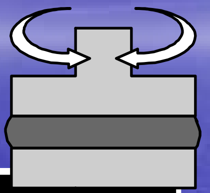
PG 63-22 modified
No rutting

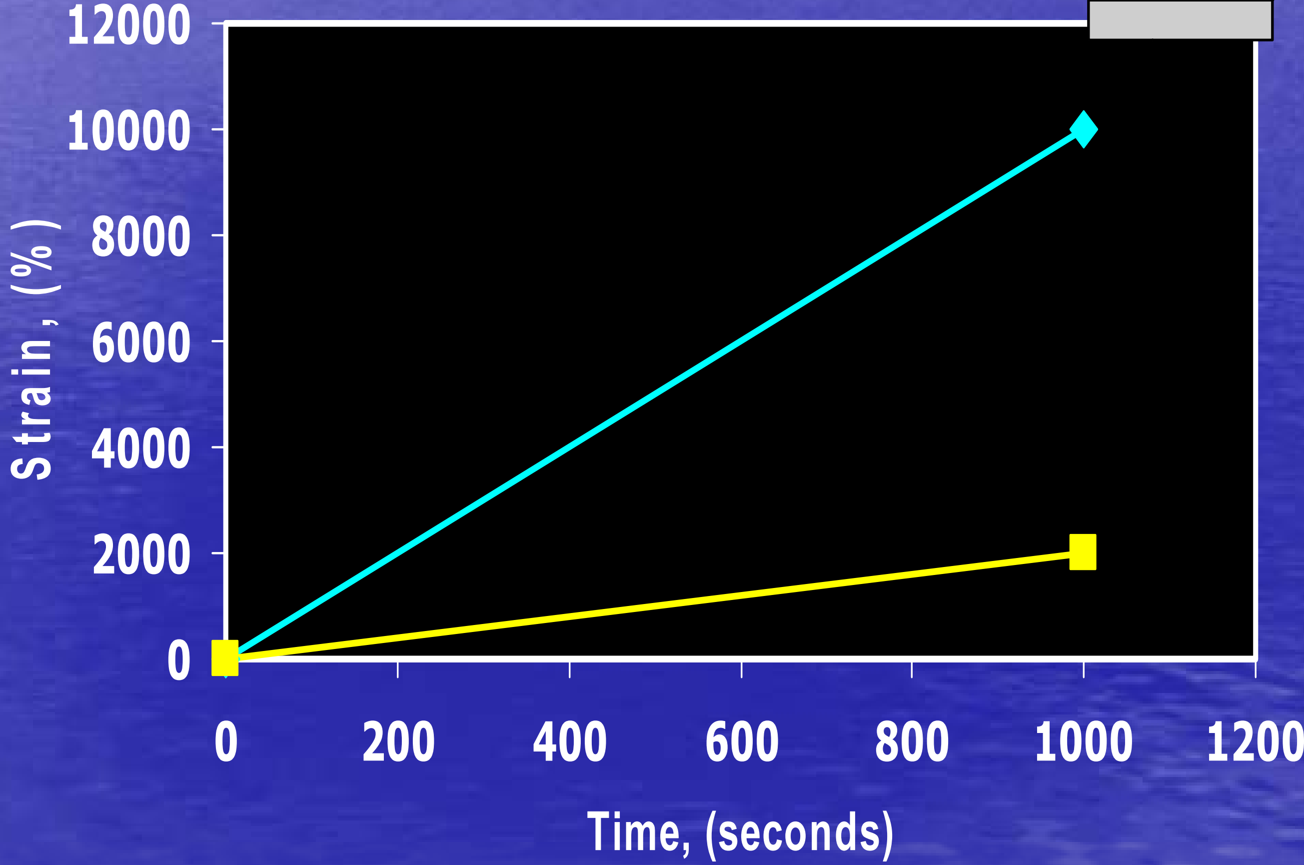
PG 67-22 unmodified
15mm of rutting

High Temperature (Rutting) Repeated Creep Recovery Test

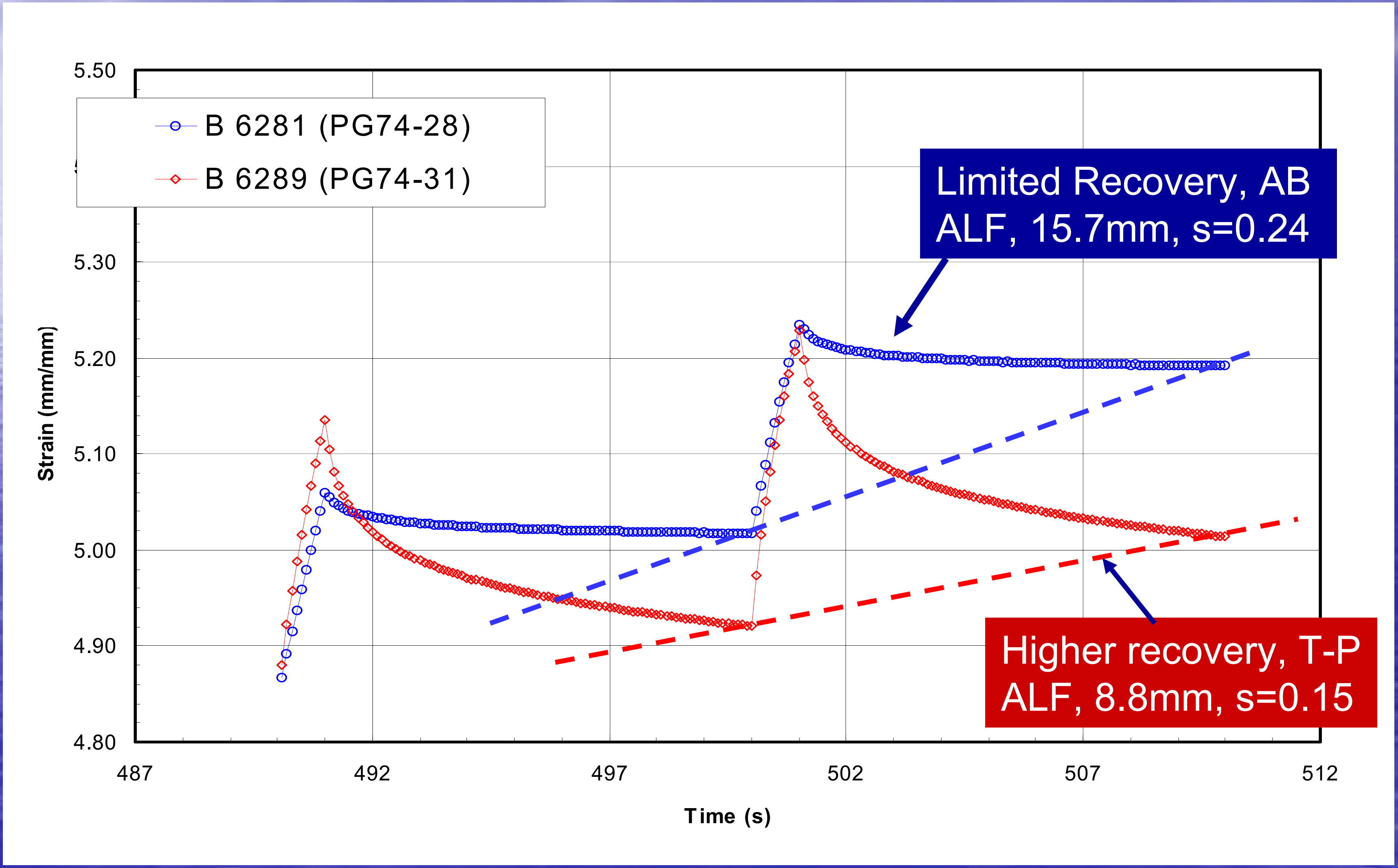
PG 67-22 Neat AC

PG 63-22 Modified

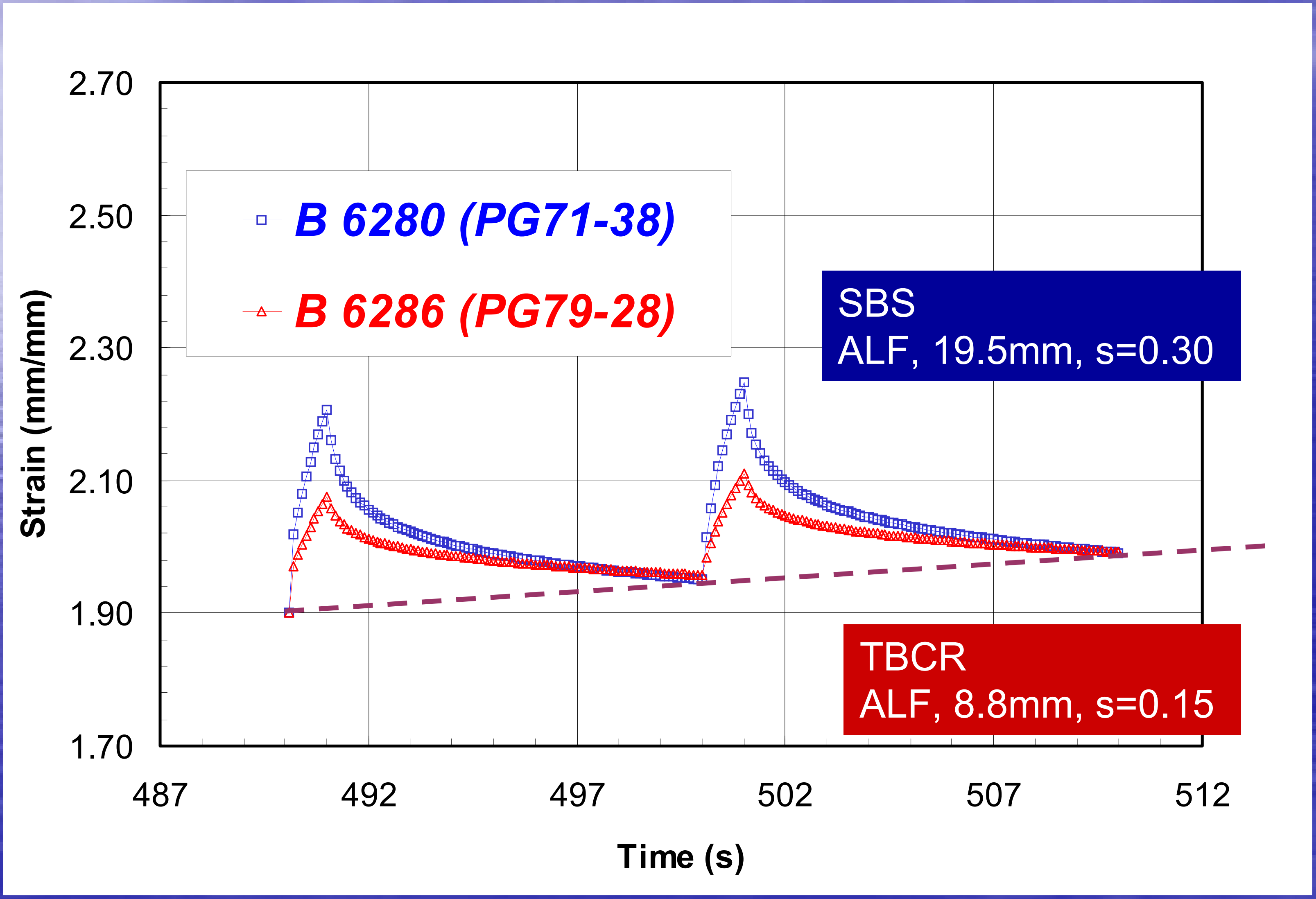




Repeated Creep Test Results
Two binders of Same PG-Grade



Repeated Creep Test Results
Two binders of Different PG-Grades



Summary of Findings To Date

Preliminary Results

- Current specification does not adequately identify the benefits of modifiers
- RSCH tracks ALF rutting performance
- A wide range of high specification temperature parameters are being evaluated

What's Next

- Fatigue Testing
  - Two Temperatures
- Rutting Testing
  - 7 Lanes
- Additional Sections
  - TBD
- Superpave SPT
  - |E*|, Creep
- Beam Fatigue
- Low-Temp Study
  - ABCD, DT, T_{CR}

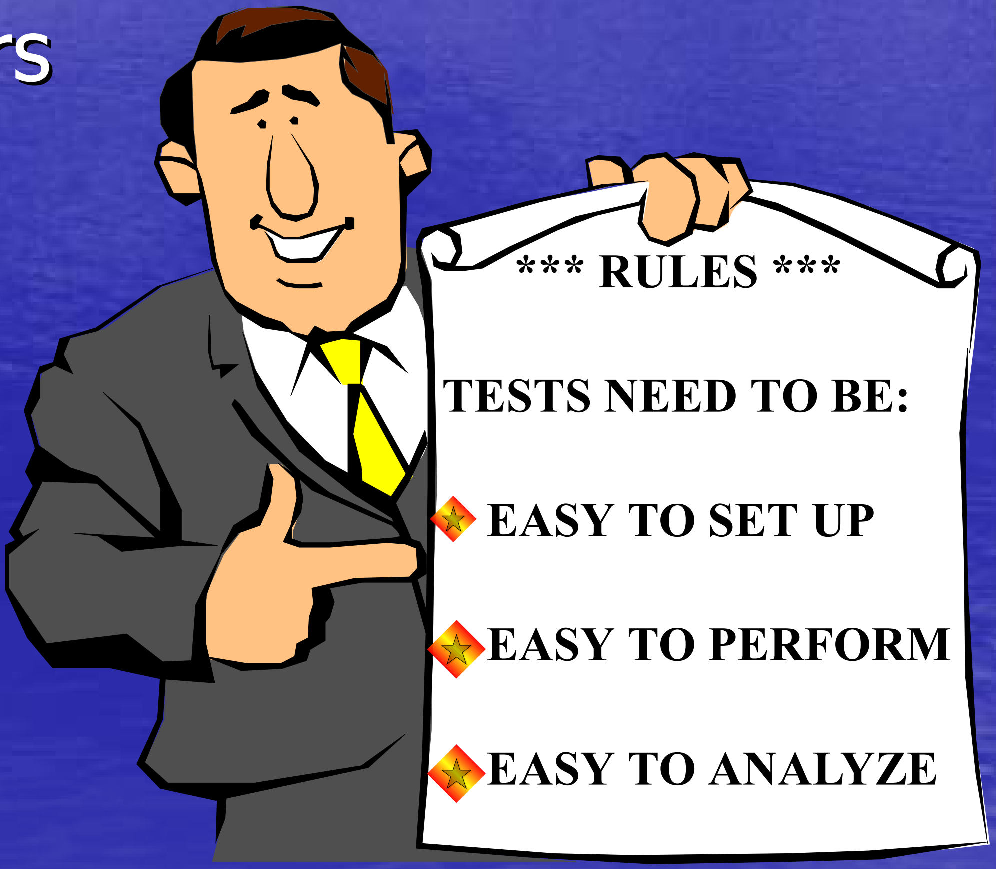
Superpave® II – 2005/6

PG based on Degree Days

WHEN	WHAT	HOW	WHERE
Construction	Safety Pumpability Rutting	Flash Point Rot Visc $f'(G^* \delta)$	230 min 3 Pa-s max T(high)
Early *(GRF, TX)*	Rutting	$f'(G^* \delta)$	T(high)
Late *(PAV)*	Fatigue Low Temp	$f''(G^*\delta)DT$ DT *ABCD*	T(inter) T_{CR}

Binder Specification Direction

- To better handle neat asphalts
- To address modifiers
- To do it faster,
  better, and
  more economical!




PRO GOLF


Smooth
Roads Ahead