# FHWA Pavements program What's Happening

John D'Angelo

Office of Pavement Technology


# Pavement Design

tiffness

Mechanistic Analysis

Layered Elastic Analysis

ations at Critical Locations

$E = \sigma/\varepsilon$

# Current Status of MEPDG

## MEPDG Software Version 1.0

- Downloadable, must be connected to Internet to use
- Updated on NCHRP website: www.trb.org/mepdg
- Voted on by the SOM and SOD
- Next step AASHTO SCOH
- AASHTO to develop actual design software in 2010

# FHWA DGIT Workshops

*Webcast available

## Upcoming

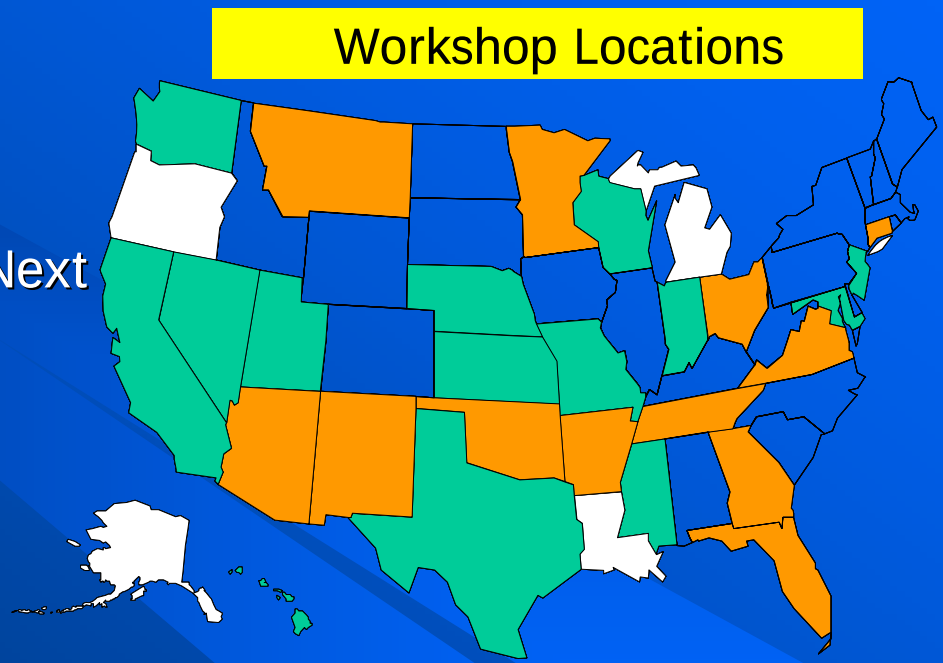
- Traffic – 3
- PMS Database Inputs - 1

## Future

- Local Calibration
- Weighing Impacts of MEPD for Next Generation Traffic Data

## Past Workshops

- Introduction to the DG – 8*
- Traffic – 2
- Materials – 11*
- Climatic Inputs – 12*



# FHWA Other Activities

## DGIT & Office of Freight Management / Operations

Contract with Auburn University

- Models in M-E PD that deal with truck size & weight
- Assessing impacts of raising weight limits

FHWA cross-disciplinary cooperation team

- Identify methods to assign cost to infrastructure damaged by increased highway load limits
- Strive for official FHWA position on this topic

# Future FHWA Workshops

National Highway Institute
NHI Course #131109
Pilot: April 2007

**Analysis of New and Rehabilitated Pavement Performance with Mechanistic-Empirical Pavement Design Software**

- Hands-on format with computers loaded with software
- Focus on user, not theory
- Objective is for audience to be capable of performing flexible, rigid, rehab designs

# Future FHWA Workshops

- Local Calibration for M-E PDG models
  - Awaiting deliverables from NCHRP 1-40 B
  - Pilot planned for Fall 2007
  - Purpose: discuss Sensitivity of inputs & calibration, educate Pavt Designers & Pavement Managers

# Asphalt Mix Performance Tester


The test can evaluate the rutting and fatigue response of the mix.

The equipment is relatively inexpensive and easy to use.

Provides input data for MEPDG

Can be used for Construction acceptance.

# Asphalt Mix Performance Tester

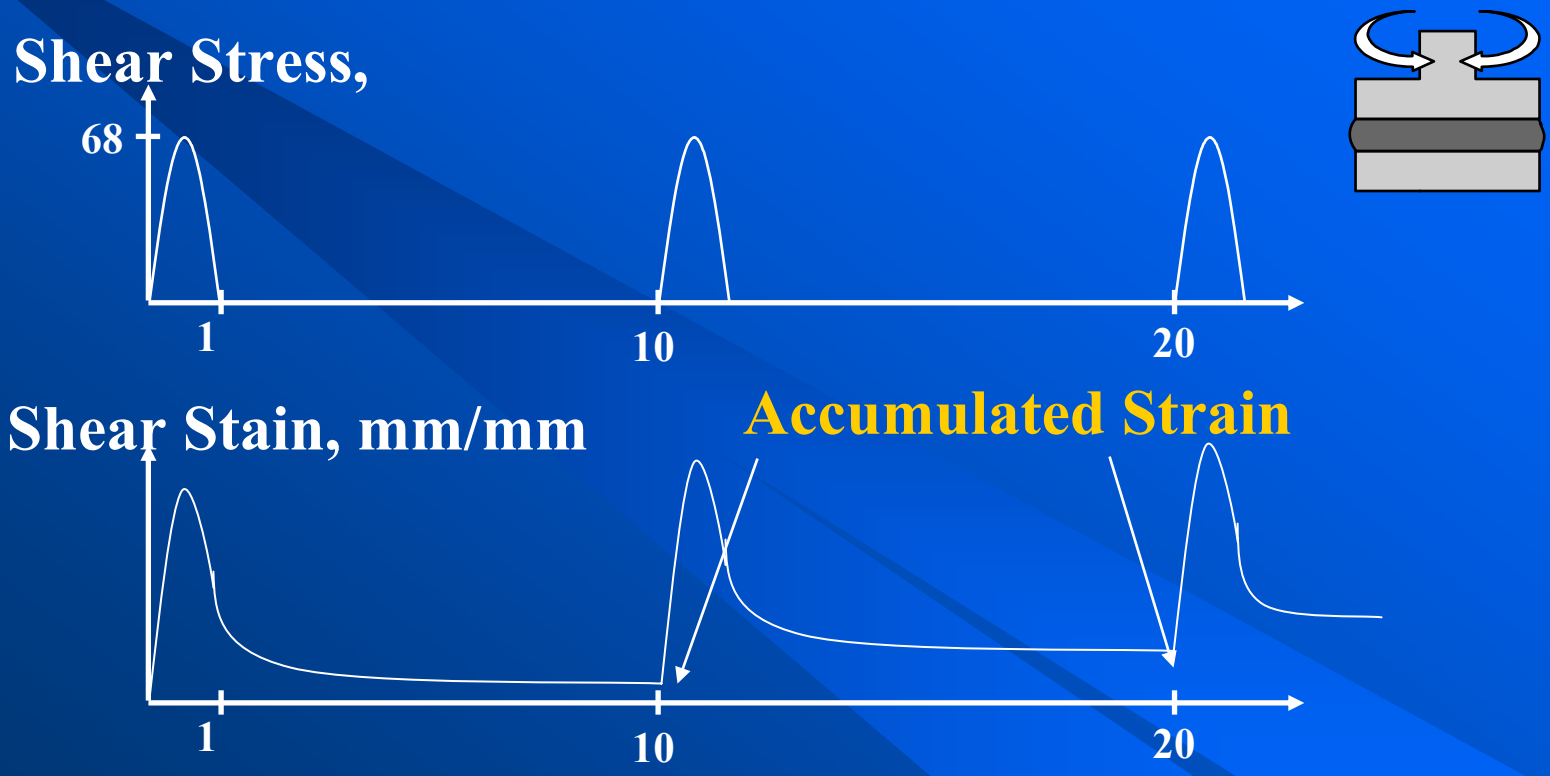
- Develop new pooled fund for purchase of the equipment.
- Establishment of a technician training school for operation of the equipment.
- Develop precision and bias for test procedure.


Binders

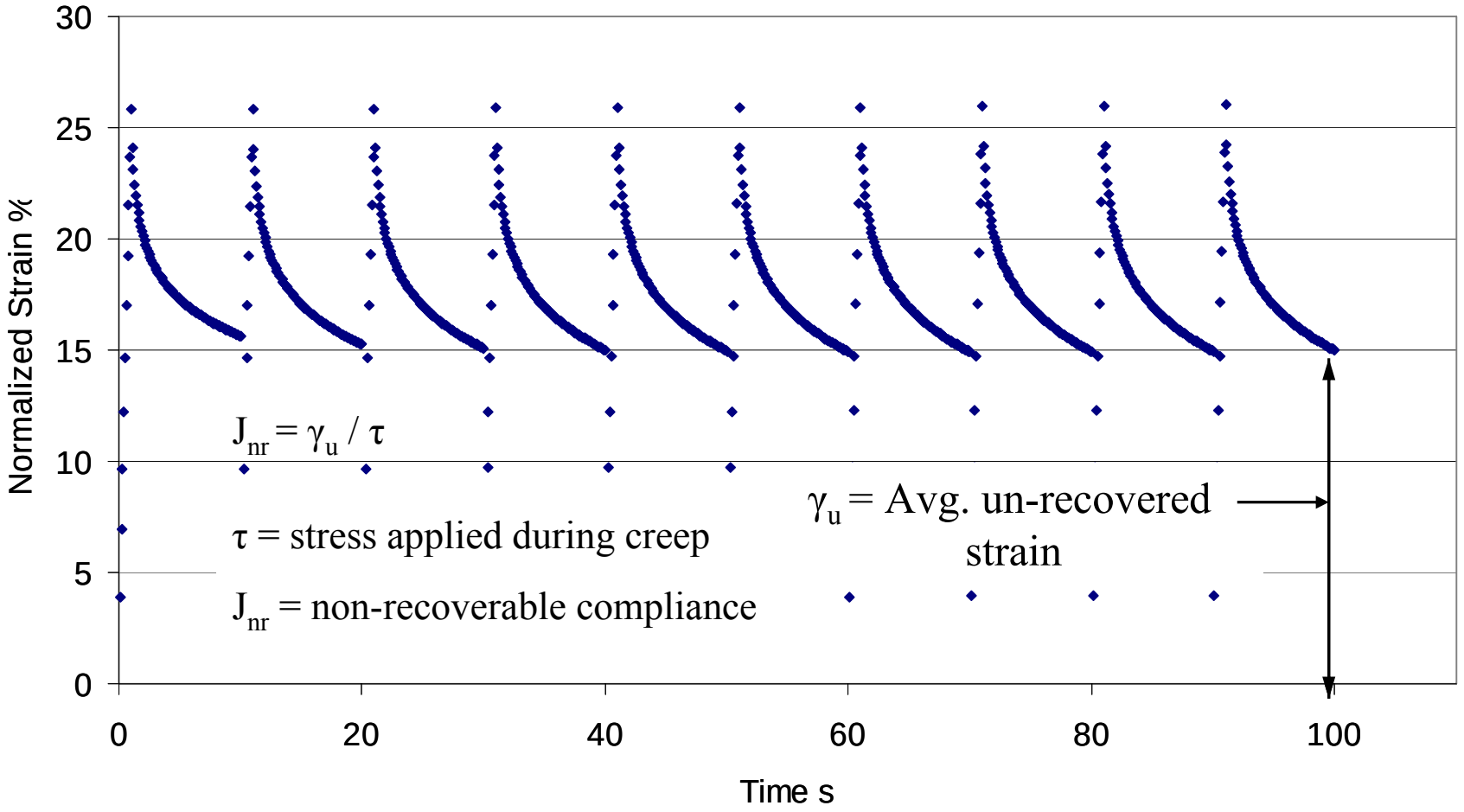
# Problem-High Temperature Binder Criteria

- Does G*/sinδ reflect rutting performance of modified binders.
  - General anecdotal data says no.
- What are the alternatives?
  - ZSV, LSV, Creep & Recovery testing

# NCHRP 9-10 Rutting Test Repeated Creep Recovery Test

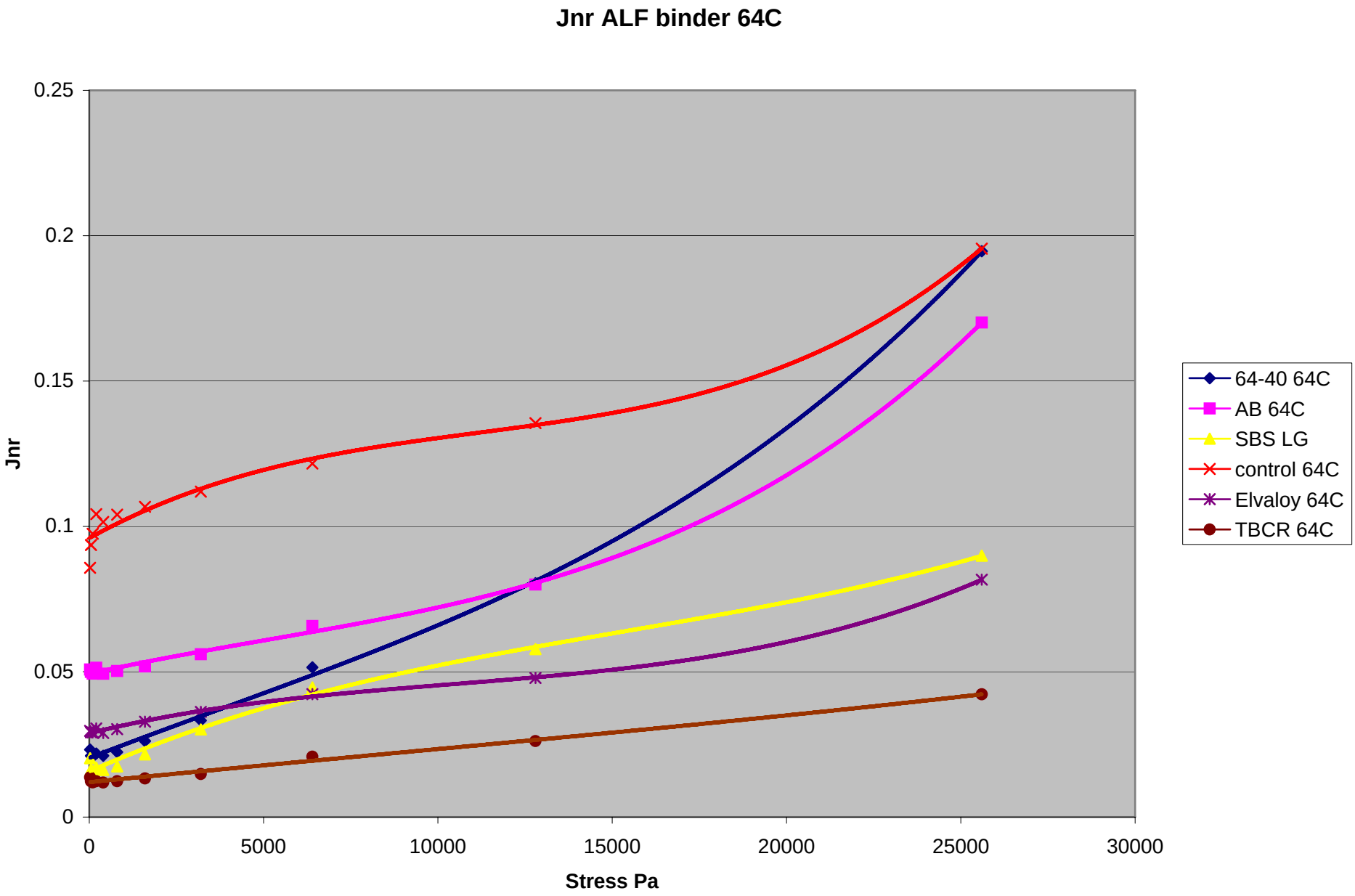


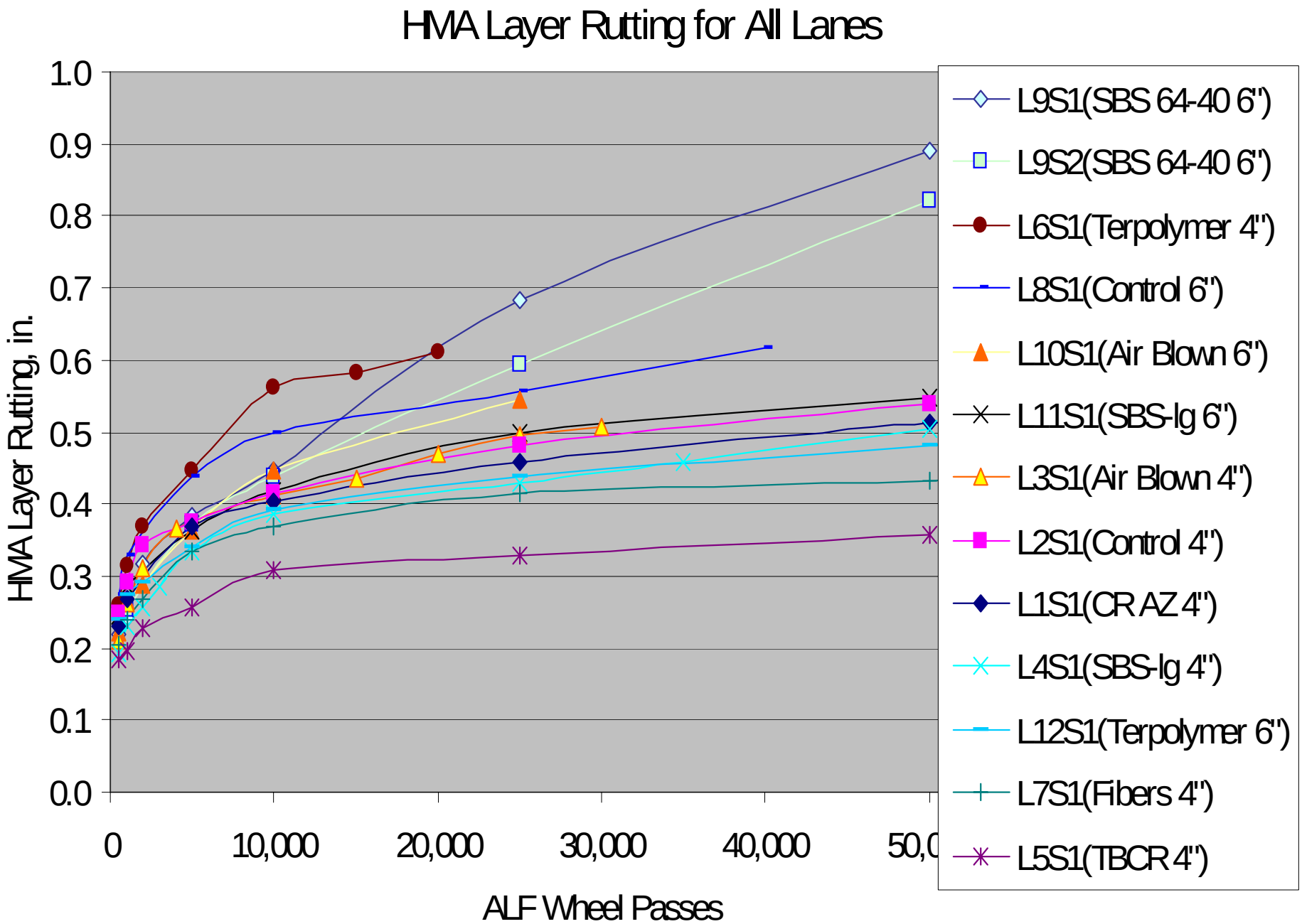
# New High Temp Criteria Jnr

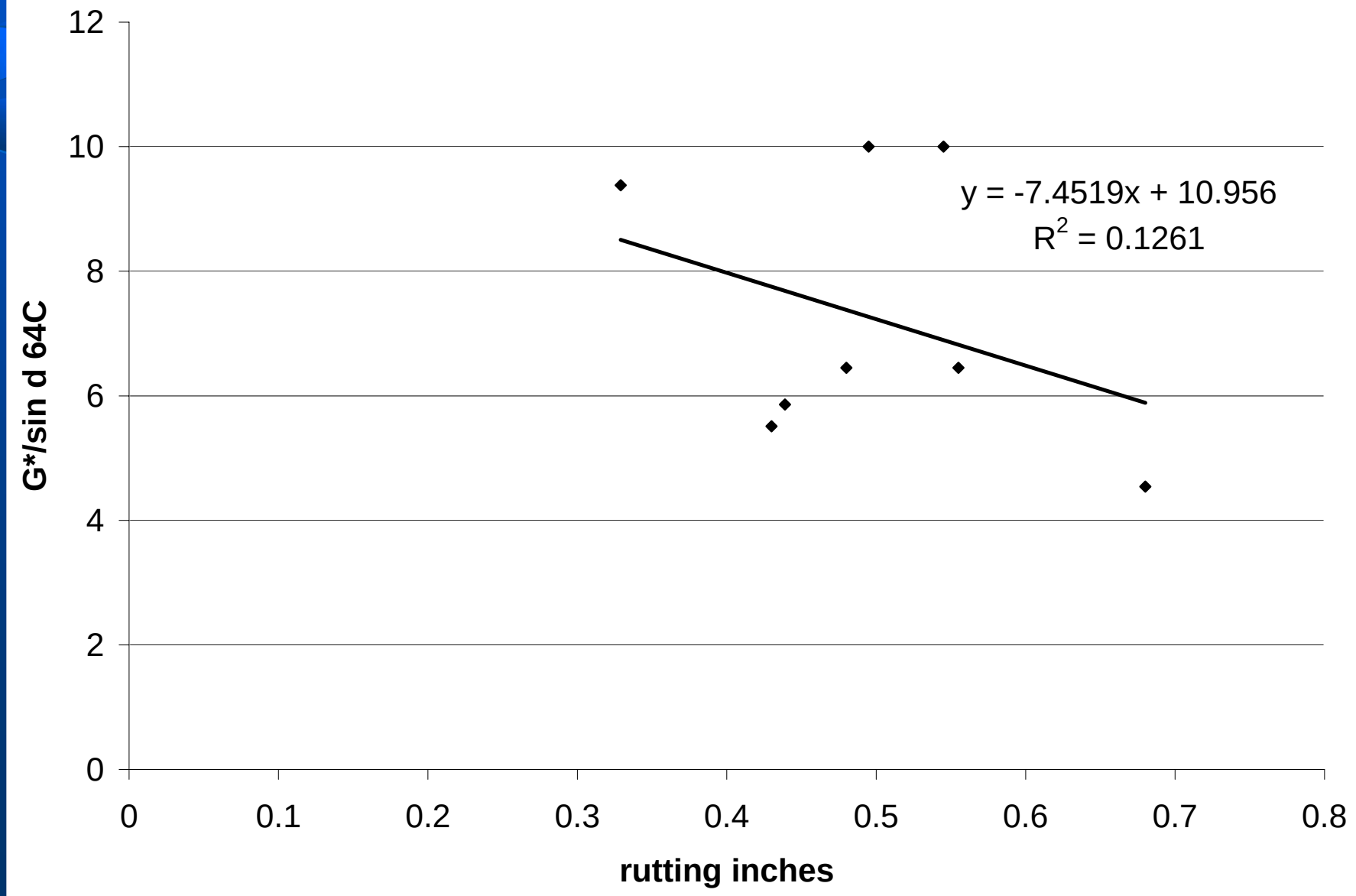


# As-Built Pavement Lanes

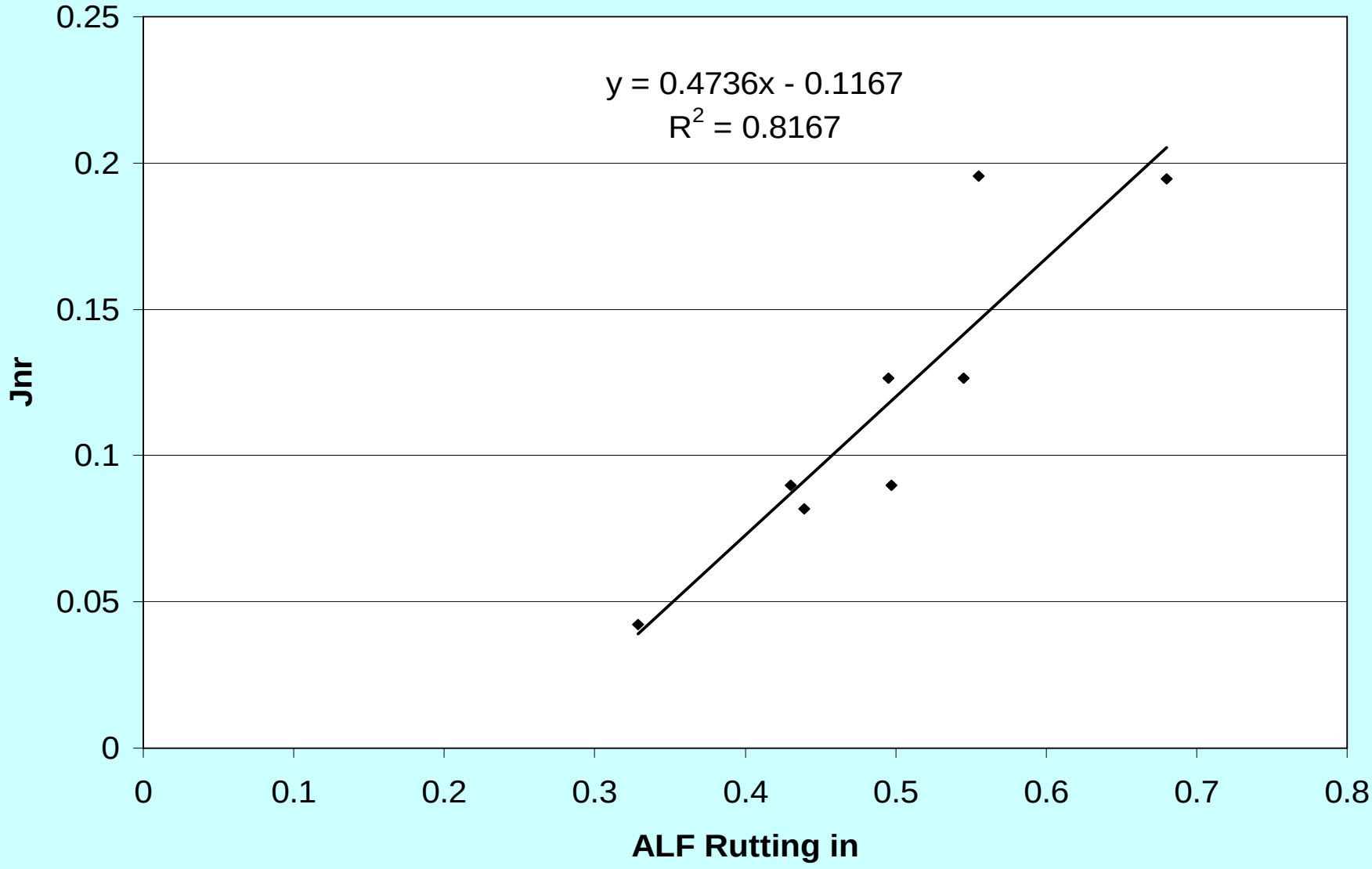
| CR-AZ ---- 70-22 | PG 70-22 Control | Air Blown | SBS LG | CR-TB | TP | PG 70-22 + Fibers | PG 70-22 | SBS 64-40 | Air Blown | SBS LG | TP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |


Jnr ALF binder 64C
0.25
0.2
0.15
0.1
0.05
0
Jnr
0
5000
10000
15000
20000
25000
30000
Stress Pa
64-40 64C
AB 64C
SBS LG
control 64C
Elvaloy 64C
TBCR 64C

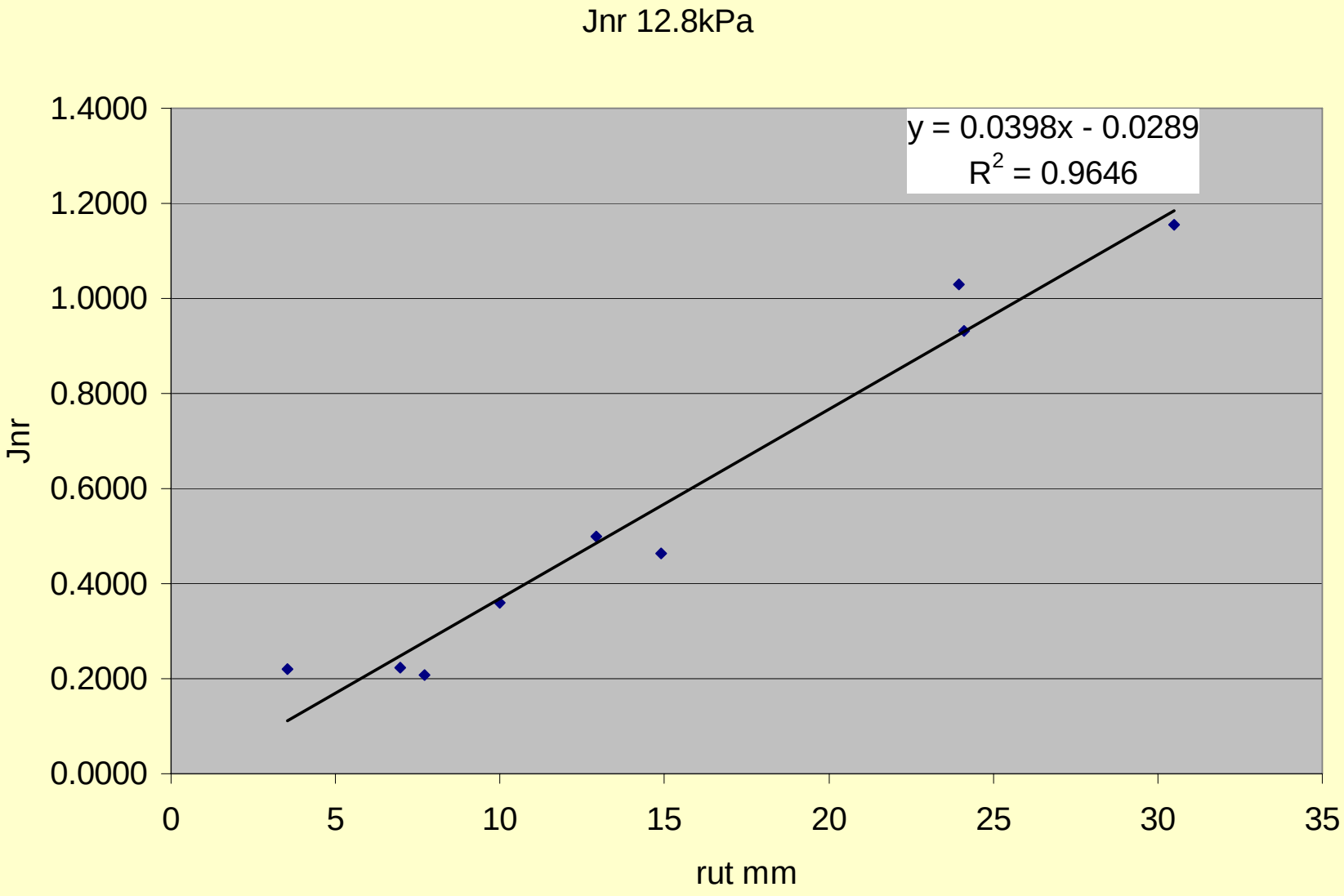

HMA Layer Rutting for All Lanes
HMA Layer Rutting, in.
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10,000
20,000
30,000
40,000
50,0
ALF Wheel Passes
L9S1(SBS 64-40 6")
L9S2(SBS 64-40 6")
L6S1(Terpolymer 4")
L8S1(Control 6")
L10S1(Air Blown 6")
L11S1(SBS-lg 6")
L3S1(Air Blown 4")
L2S1(Control 4")
L1S1(CR AZ 4")
L4S1(SBS-lg 4")
L12S1(Terpolymer 6")
L7S1(Fibers 4")
L5S1(TBCR 4")


12
10
8
6
4
2
0
G*/sin d 64C
y = -7.4519x + 10.956
R2 = 0.1261
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
rutting inches

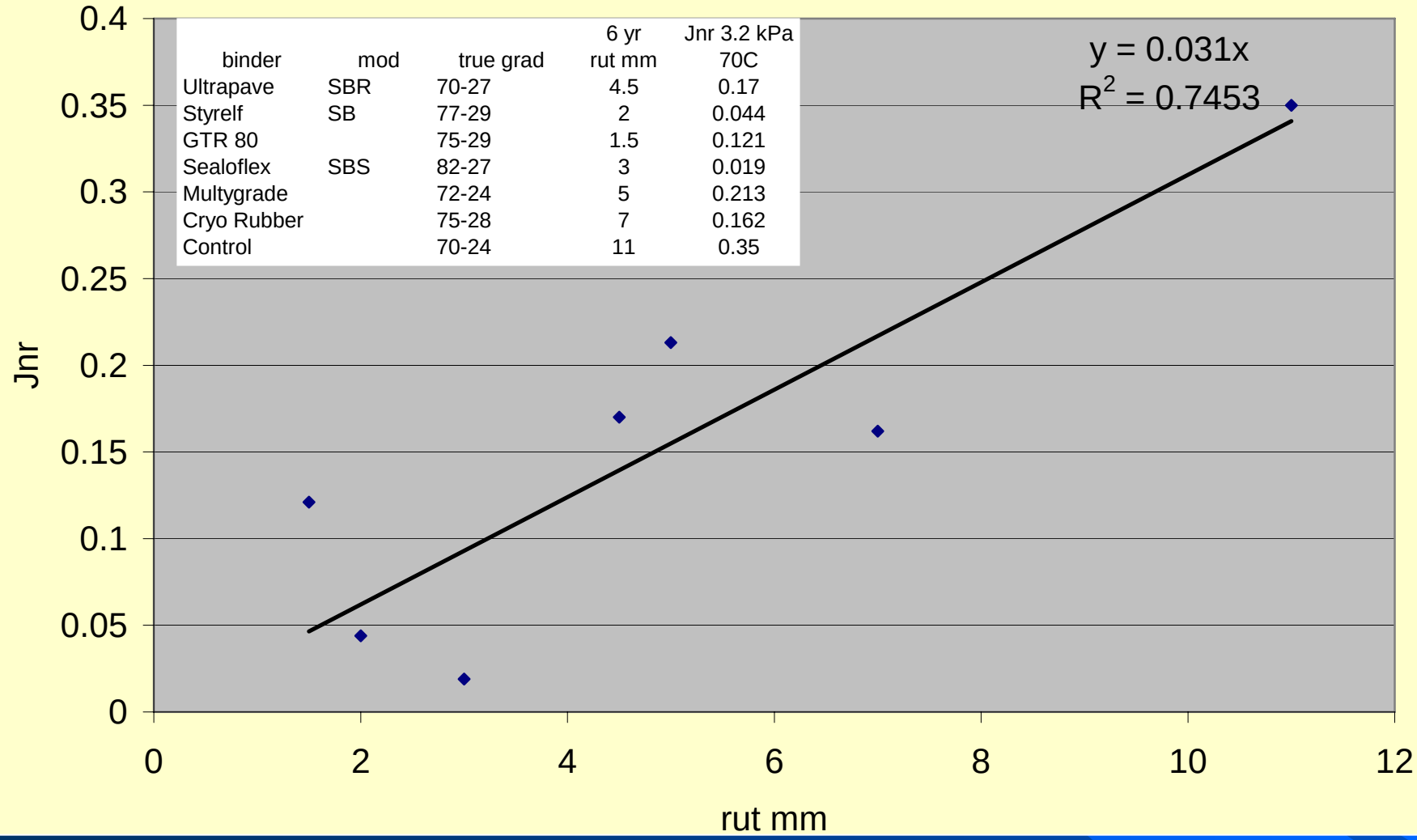
# Relationship between Jnr and ALF rutting



# Hamburg Rut testing  MINN Road mixes



# Miss I55 6yr rut Jnr 3.2 kPa




| binder | mod | true grad | 6 yr rut mm | Jnr 3.2 kPa 70C |
|---|---|---|---|---|
| Ultrapave | SBR | 70-27 | 4.5 | 0.17 |
| Styrelf | SB | 77-29 | 2 | 0.044 |
| GTR 80 | | 75-29 | 1.5 | 0.121 |
| Sealoflex | SBS | 82-27 | 3 | 0.019 |
| Multygrade | | 72-24 | 5 | 0.213 |
| Cryo Rubber | | 75-28 | 7 | 0.162 |
| Control | | 70-24 | 11 | 0.35 |

# High Temperature Binder Criteria

- Non-recoverable compliance of the binder describes the stress dependency of the binder.
- Creep and recovery testing done at multiple stress levels on one sample can be run to describe the stress dependency of the binder.
- Creep and recovery non-recoverable compliance can be correlated to mix testing done at different stress conditions and related to performance.

# Affect of Jnr on Rutting

- Reducing Jnr by half typically reduced rutting by half.
- This affect is seen on ALF sections and Hamburg Rut Testing
- But most importantly this is seen on the Mississippi I 55 sections.

# Determination of a Specification criteria.

- The existing binder specification works very well for neat binders.
- The grading for neat binders should not change.
- Establish new Jnr criteria based on response of neat binders at their continuous grade temp.
- Evaluate the binders near the end of their linear range. Most neat binders remain

# Evaluation of Straight run binders

| Sample ID | Name | Grade | true grade | Temp | Jnr 3.2kPa |
|---|---|---|---|---|---|
| ALF 6727 | Control | 70-22 | 72.7-74.2 | 72.7 | 0.439122 |
| BBRS3 | straight | 64-22 | 66.1-27.3 | 66.1 | 0.418449 |
| MN county rd 112 | neat Valero | 58-28 | 60.8-33.4 | 60.8 | 0.368445 |
| MN county rd 112 | neat Citgo | 58-28 | 59.5-29.8 | 59.5 | 0.529647 |
| MN county rd 112 | AshlandM | 58-28 | 60.7-31.4 | 60.7 | 0.430165 |
| Minn Road | straight | 58-28 | 61.8-30.8 | 61.8 | 0.302951 |
| Miss I-55 | CSL | 67-22 | 68.3-25.1 | 68.3 | 0.266912 |
| Shandong | straight | 64-22 | 64.4-23.5 | 64.4 | 0.444057 |
| BBRS3 | straight | 70-22 | 71.4-24.8 | 71.4 | 0.480855 |
| BBRS3 | straight | 58-28 | 61.3-30 | 61.3 | 0.400345 |
| MD project | straight | 64-28 | 64.8-29.6 | 64.8 | 0.459335 |
| average | | | | | 0.412753 |

# Grade bumping recommendation

- All testing should be done at the environmental grade temp.
- The standard grade should be based on the Jnr value of existing neat binders 0.4 .
- For high traffic the Jnr value should be reduced by half at the grade temp to 0.2 .
- For standing traffic the Jnr value should be reduced by half again 0.1 .

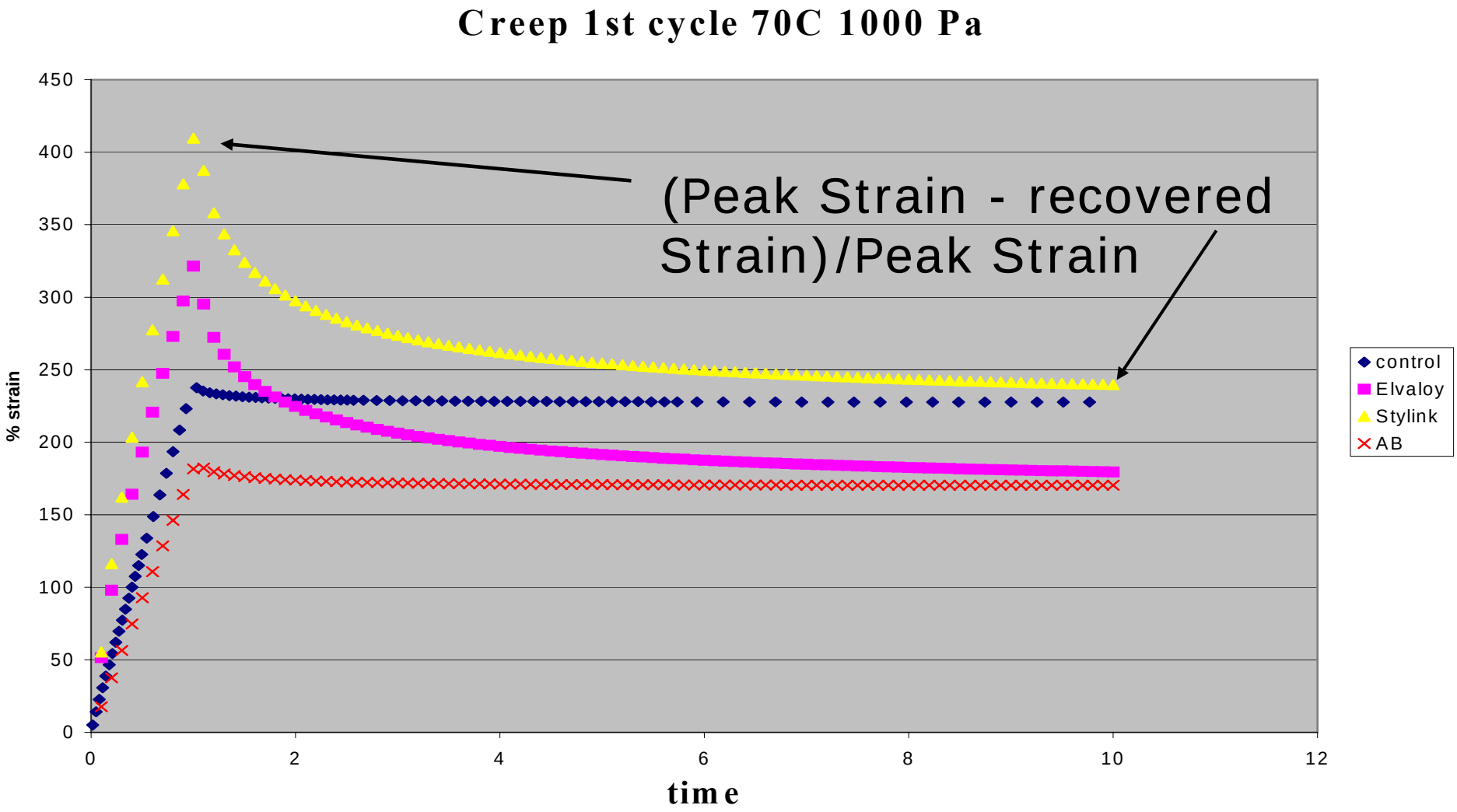
# New high Temp Spec

- PG 64 (Standard, Heavy, Very heavy) based on traffic.
  - PG 64S-XX $J_{nr}$ => 0.4
  - PG 64H-XX $J_{nr}$ => 0.2
  - PG 64V-XX $J_{nr}$ => 0.1

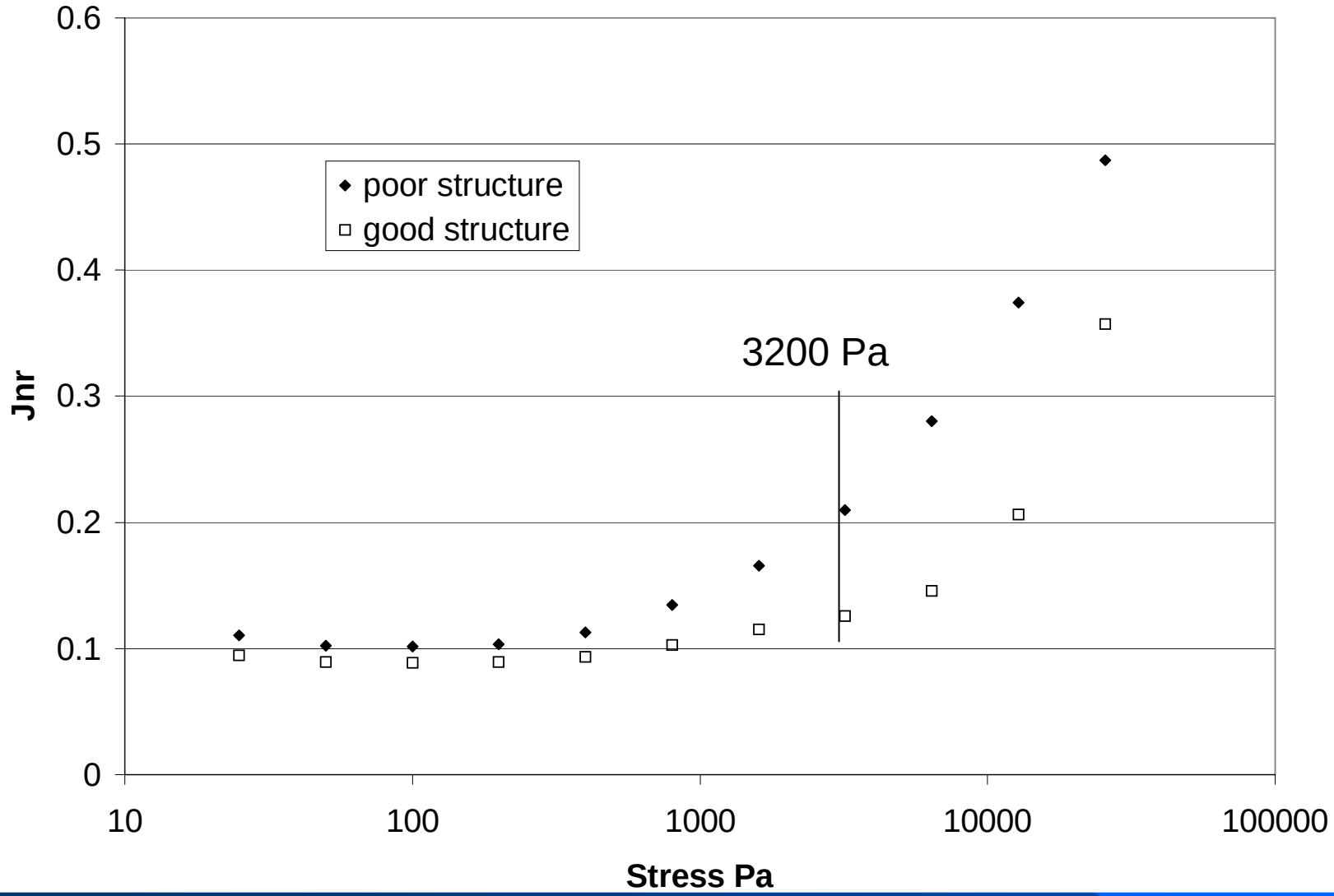
# How do we identify Polymers? Use DSR Approach

- Use DSR
  - Muti Stress Creep Recovery Test
    - Two creep stress levels
    - Ten cycles per stress level
    - For Elastomeric modifiers Specify:
      - % strain recovery 3200 Pa > 15% or 20%
      - Overall change between stress levels 100-3200 Pa < 75%
    - Run on the RTFOT
    - Run on the same sample as RTFOT grading

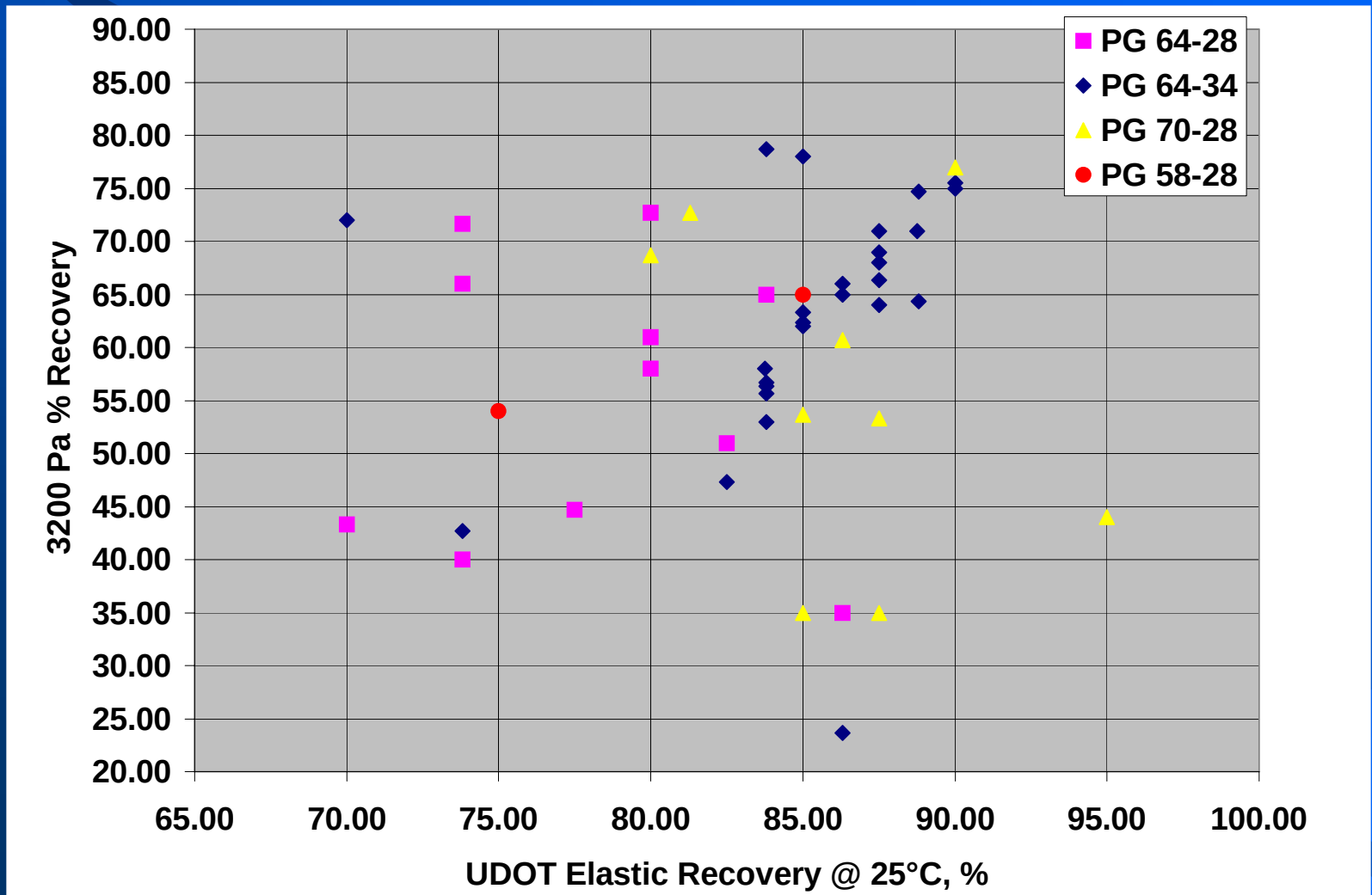
# What criteria? % recovered strain



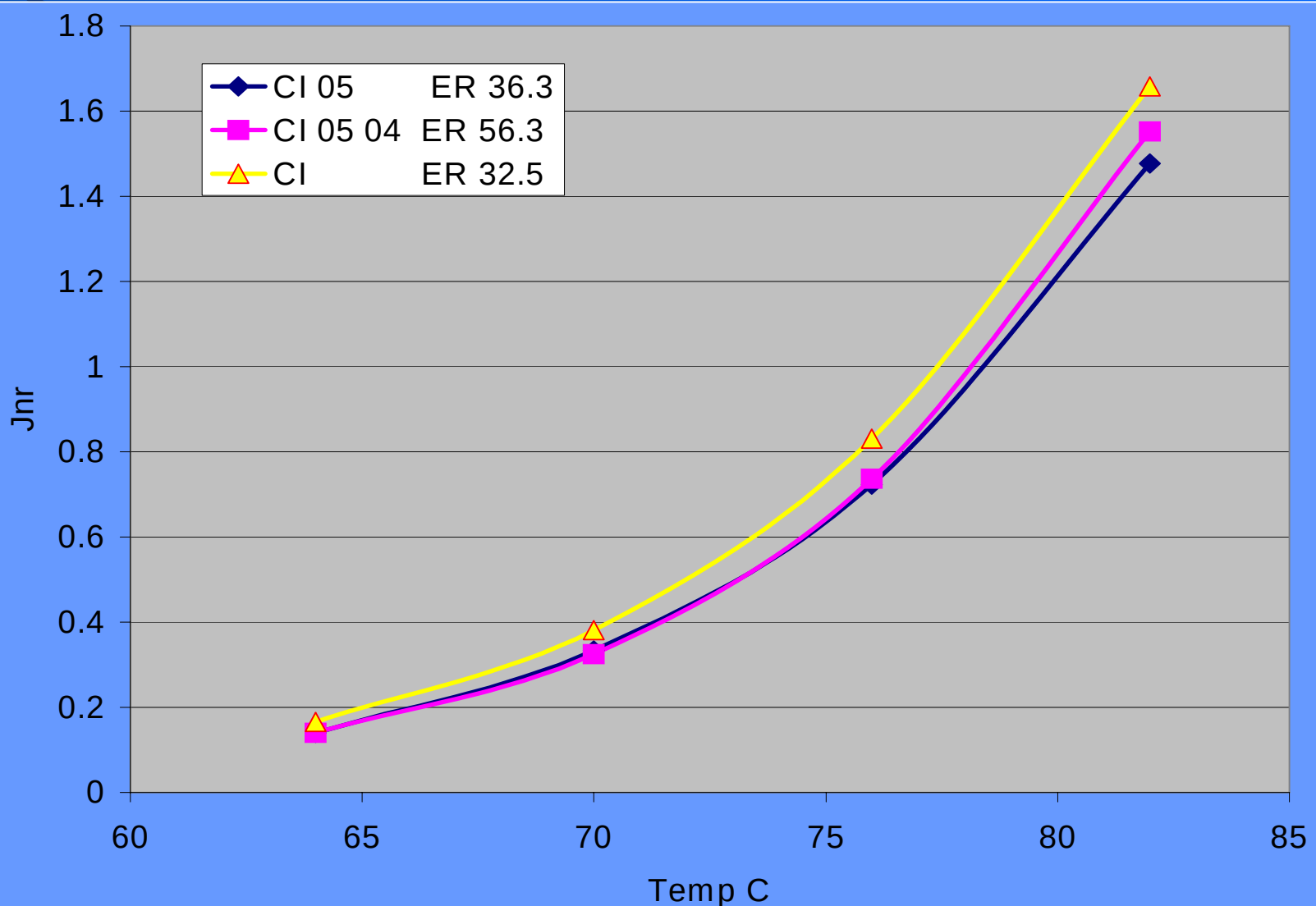
# MSCR selection of stress levels



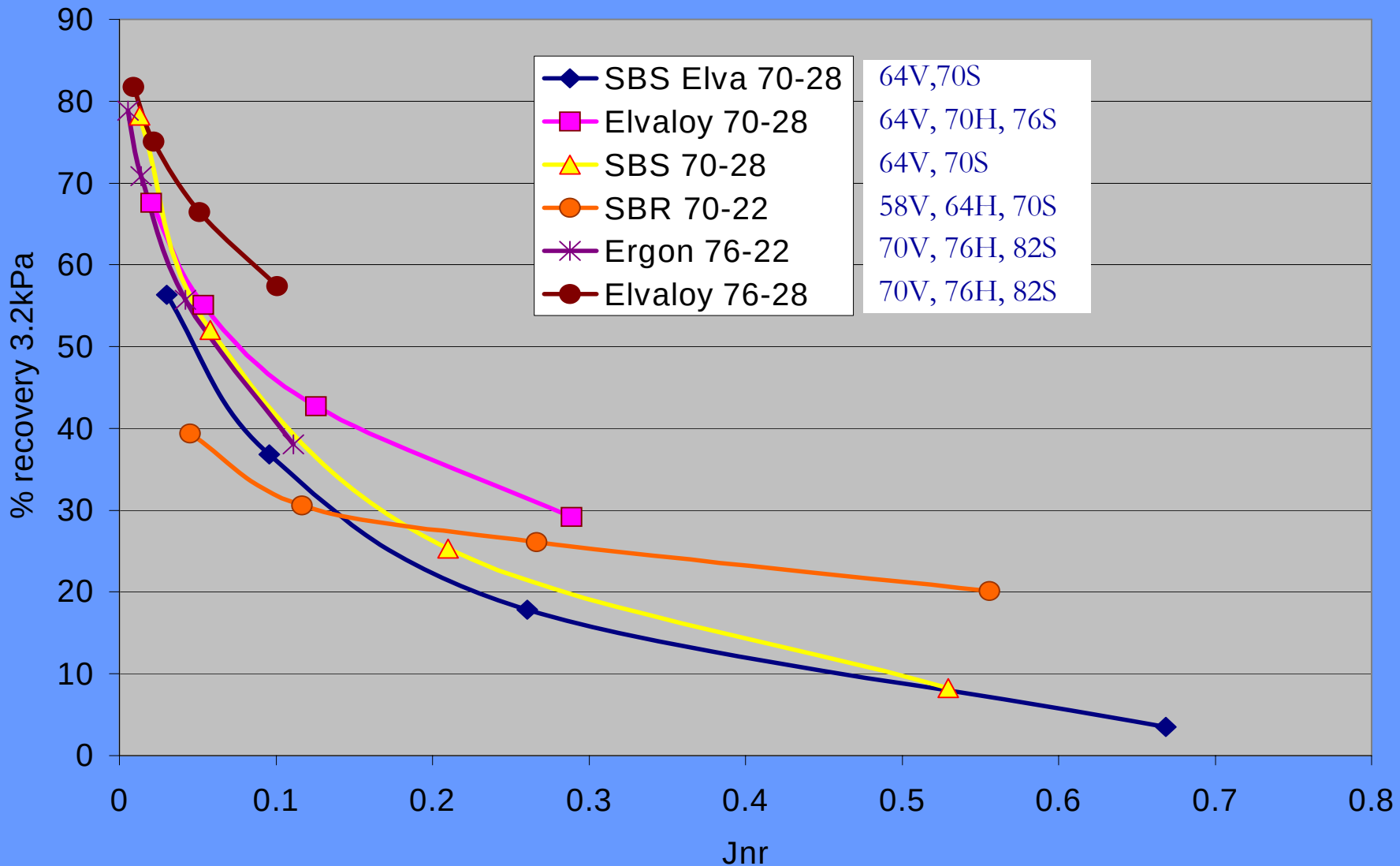
# General relationship between ER and MSCR



# Effect of X-linking on ER



# BBRS Study


90
80
70
60
50
40
30
20
10
0
% recovery 3.2kPa
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Jnr
SBS Elva 70-28
Elvaloy 70-28
SBS 70-28
SBR 70-22
Ergon 76-22
Elvaloy 76-28
64V,70S
64V, 70H, 76S
64V, 70S
58V, 64H, 70S
70V, 76H, 82S
70V, 76H, 82S

# Laboratory Evaluation: Warm-Mix Asphalt Binder Additives

Warm Mix Task Group:

Gaylon Baumgardner

Gayle King

Gerald Reinke

Matt Corrigan

Chris Abadie

# Experimental – Binder Testing

– Question:  (RTFO , PAV or both?)

- Master Curve Development (DSR) – PTSi
- SuperPave™ True Grade (Through DTT) – PTSi
- Physical Hardening (30 days saturation at -12°C) Bending Beam Rheometry (BBR) - PTSi
- Multi-Step Creep Recovery (MSCR) – FHWA
- Glass Transition Tg (MDSC) – WRI/MTE
- Atomic Force Microscopy (AFM) –WRI

# Mixture Issues

# Superpave Gyratory Compactor Calibration

Making Superpave Mixtures Consistent

# AASHTO Designation: T 312-03 Preparing ... Specimens by ... SGC

4.1

*Superpave Gyratory Compactor* – ... an average internal angle of 1.16° ± 0.02°

.....

(only internal angle with simulated mix measurement)

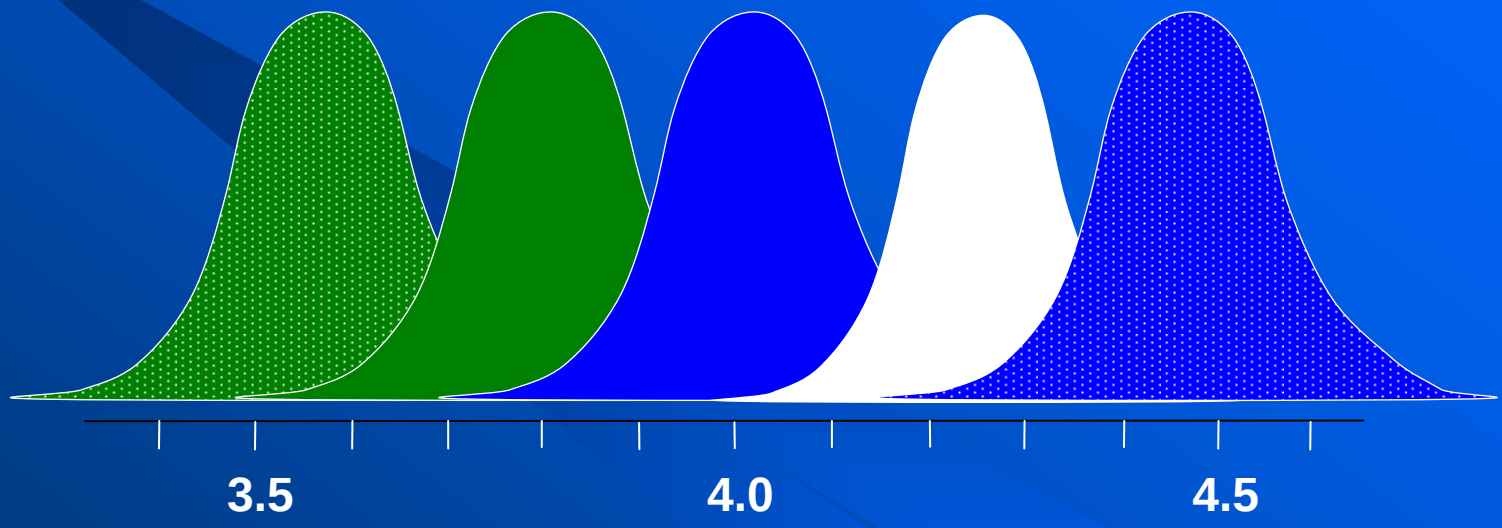
# Internal Angle Measurement
## with Hot Mix Asphalt

**DAV on Top to measure $\alpha_T$**

**DAV on Bottom to measure $\alpha_B$**

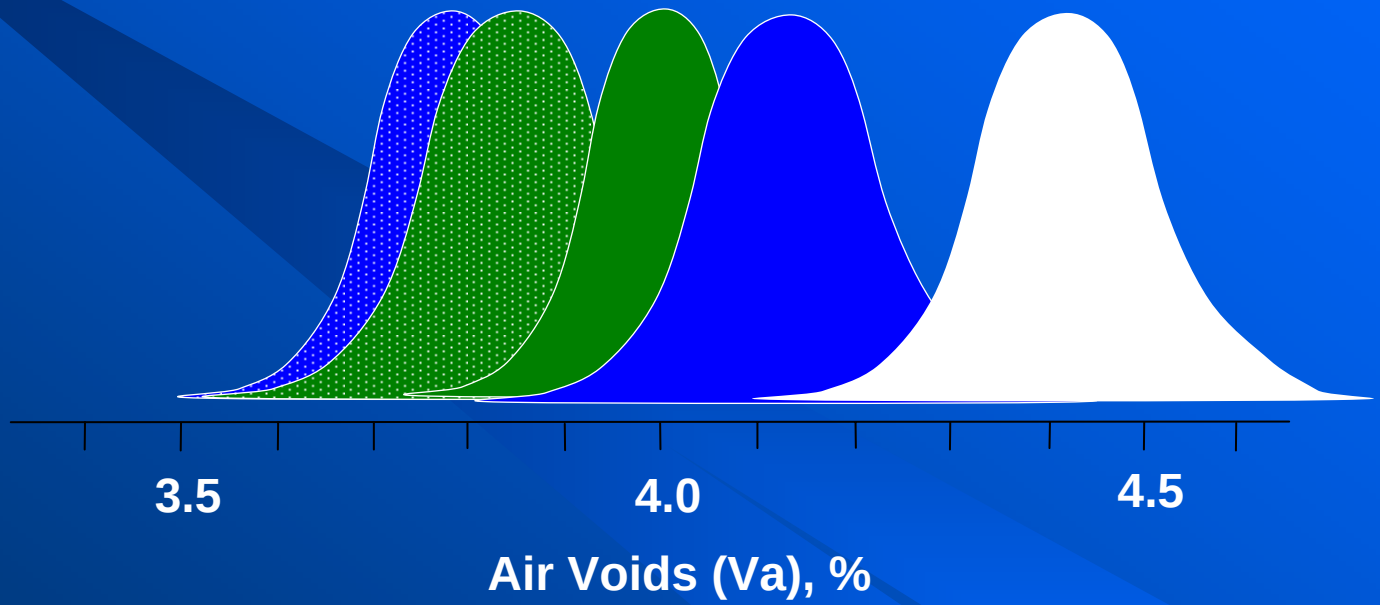
# APAC

## Calibrated to 1.25 degrees External



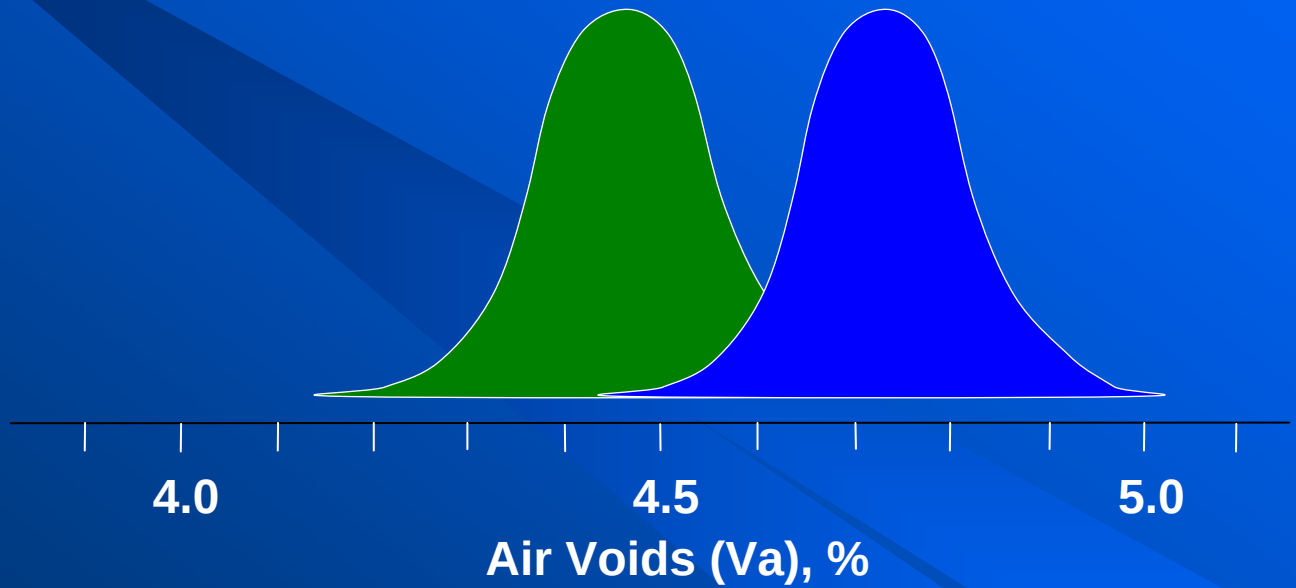
# APAC

## Calibrated to 1.16 degrees Internal



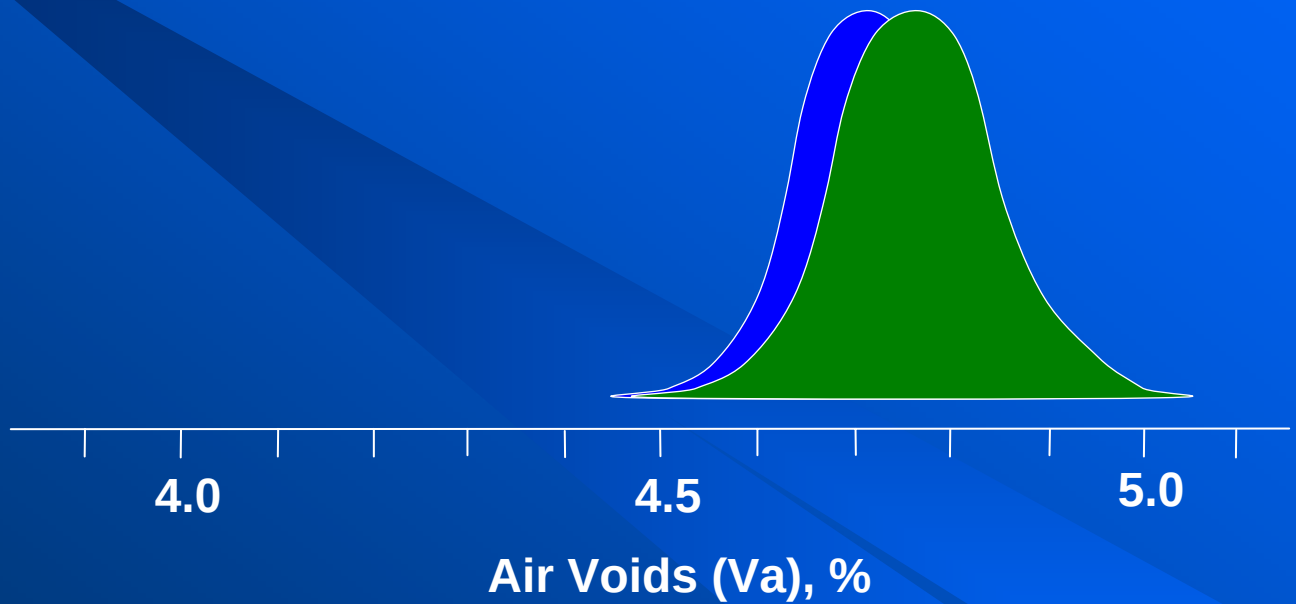
# Asphalt Institute

## Calibrated Externally at 1.25°



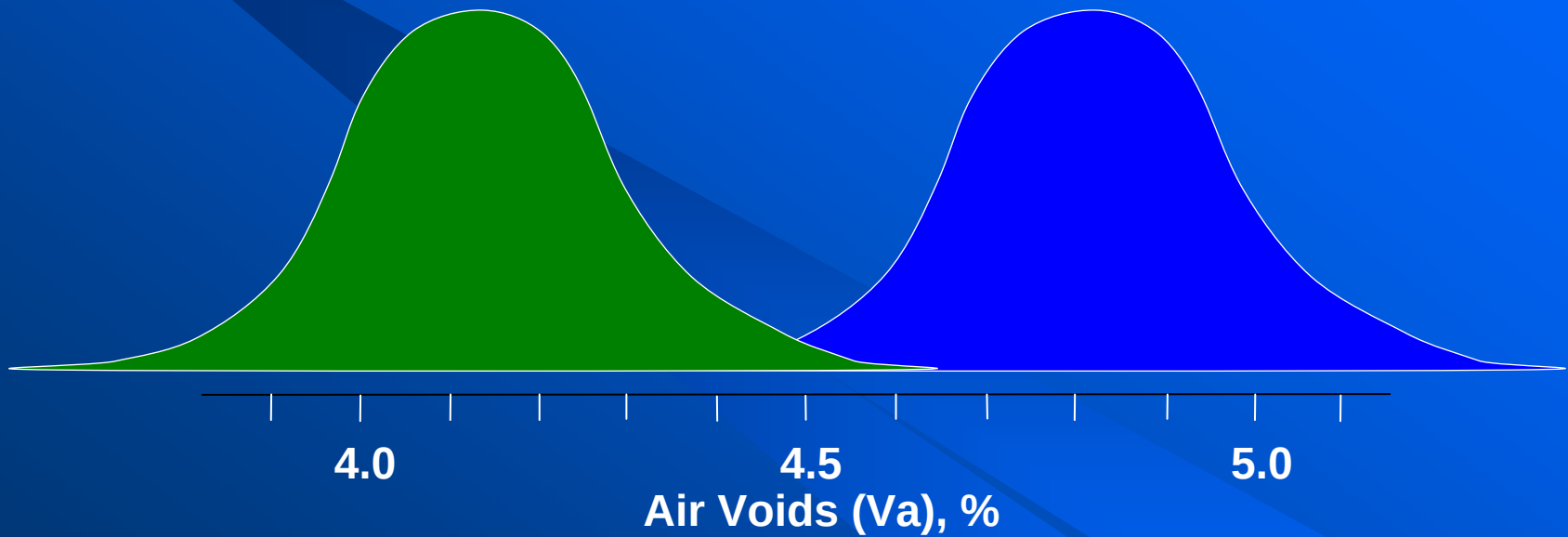
# Asphalt Institute

## Calibrated Internally at 1.16°



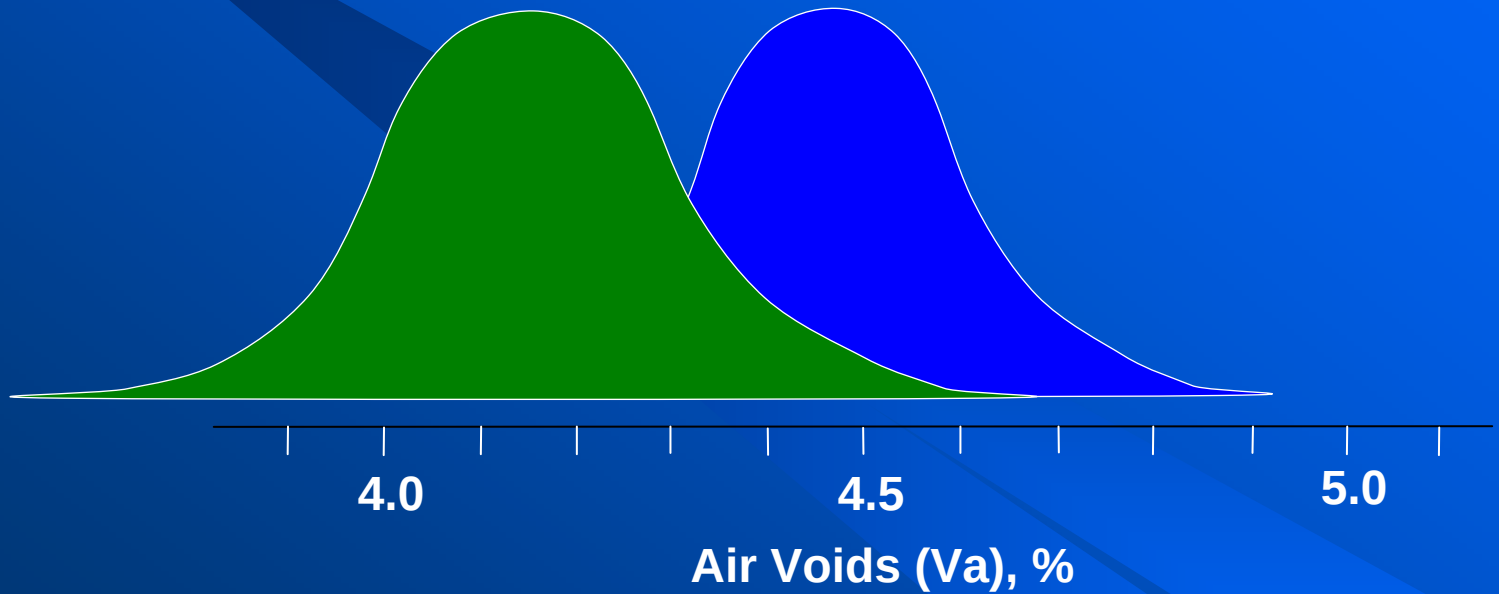
# University of Arkansas

## Calibrated Externally at 1.25°



# University of Arkansas

## Calibrated Internally at 1.16°



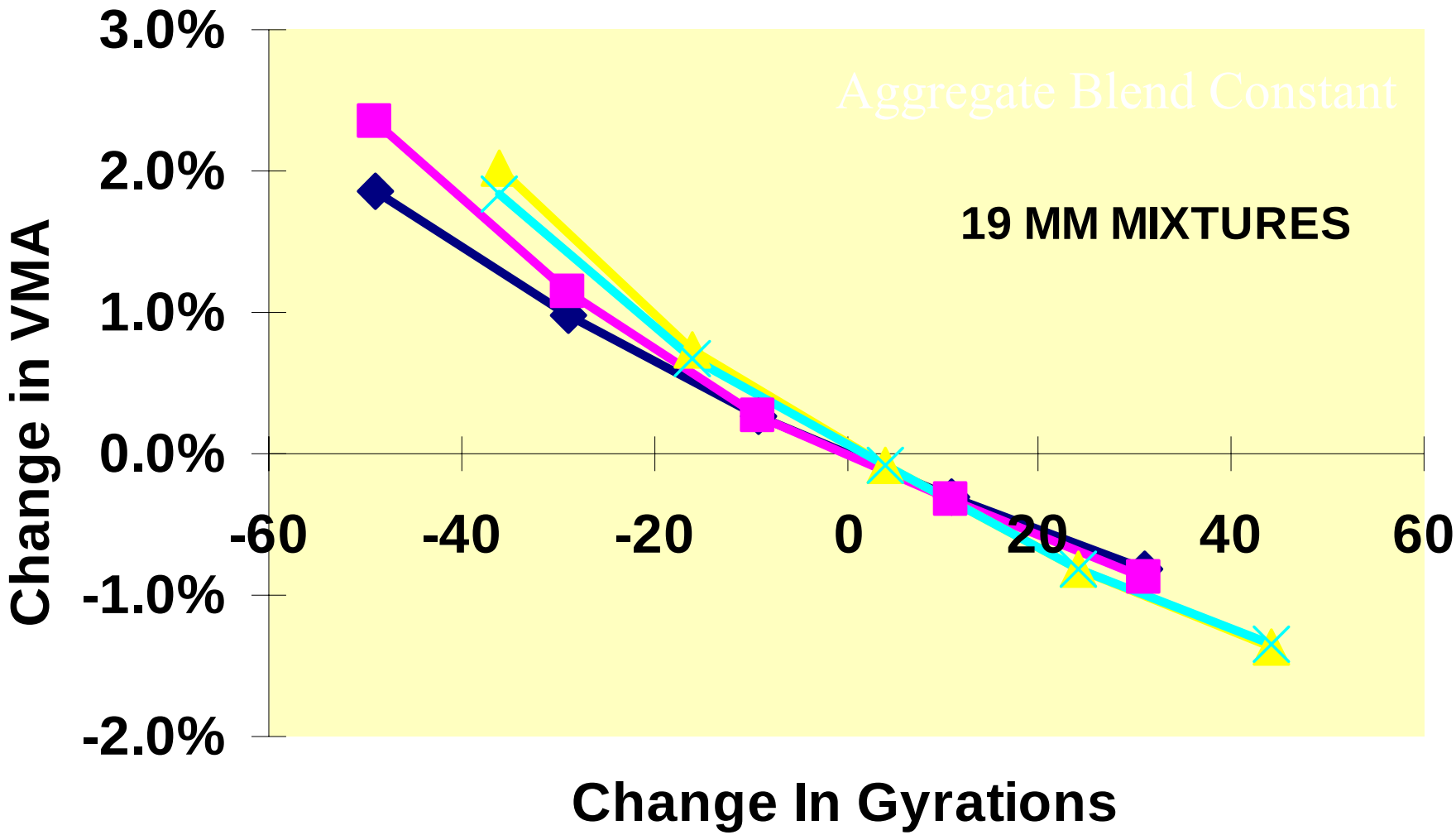
# HMS & RAM

# Specification Recommendations

- Drop procedures related to use of HMA
  - drop reference in T312; eliminate TP48
- Implement new TP for simulated loading
  - add reference in T312
  - Precision:  Troxler 4140 NOT INCLUDED
  - Refer to “manufacturers’ recommendations”
    - Applies to specific procedures for using various devices
    - Applies to hot-versus-cold question(s).
  - Inform users that RAM ~ DAV2/HMS
- Angle tolerance:  move to +/- 0.03 deg

# EFFECT OF DESIGN COMPACTION

# Effect on VMA

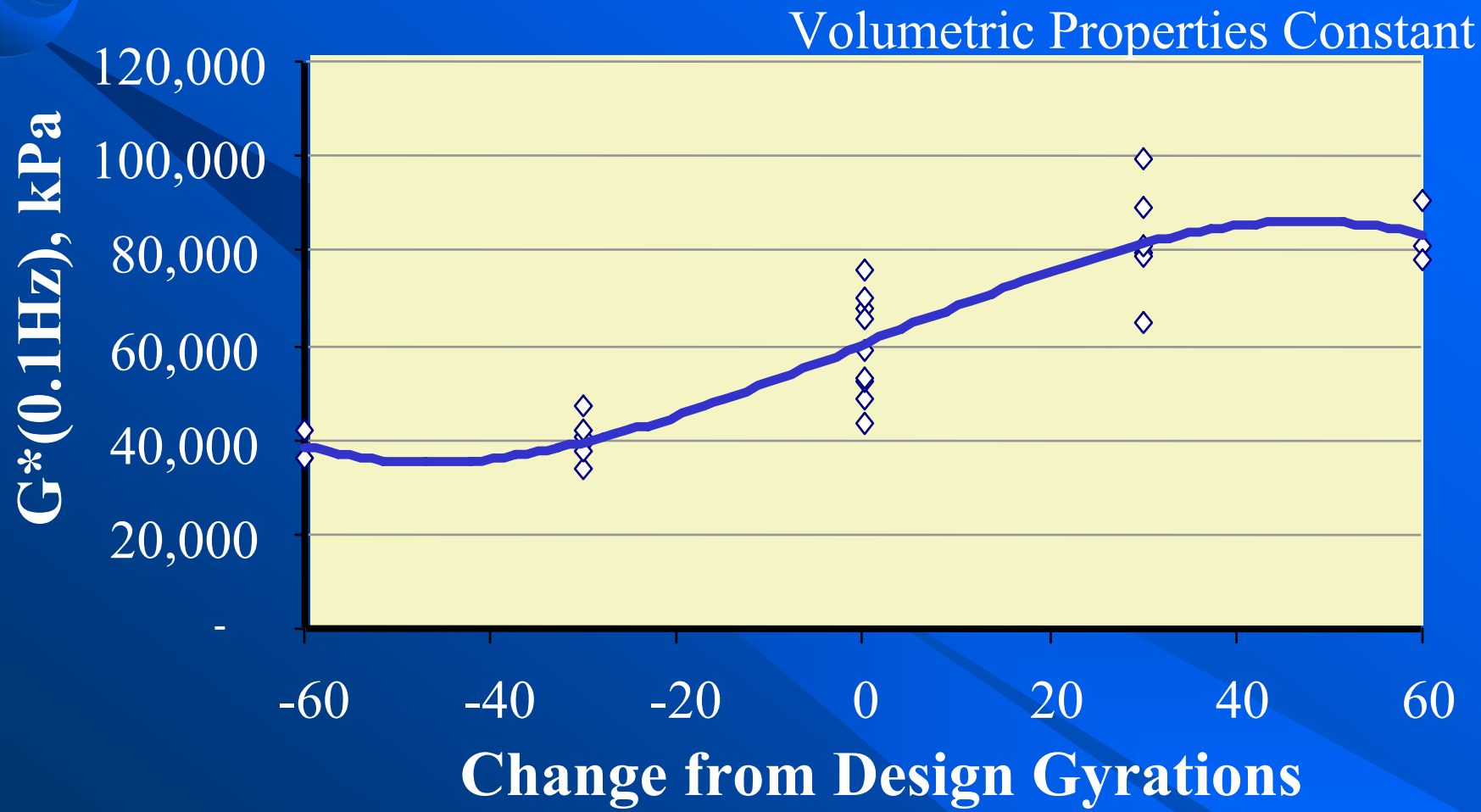


# Effect of Design Gyrations

Aggregate Properties Constant (gradation, CAA, FAA)

| LAB | | ROAD |
|---|---|---|
| N design | | % Asphalt |
| high | | low |
| low | | high |

# Effect on Stiffness



# Effect of Design Gyrations

## Volumetric Properties Constant (air voids, VMA, VFA)

LAB

N design

high

low


ROAD

Skeleton

strong

weak

# What Should Design Gyrations Be?

- 20-30 gyrations changes
  - VMA by 1%
    0.4% asphalt content
  - Mixture stiffness by 25 to 30%
    about one PG high temp grade difference
  - SO . . . . . .

# Original Design Table

| Design ESALs Millions | Average Design High Air Temperature | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <39 C | | | 39 – 40 C | | | 41 - 42 C | | | 43 – 44 C | | |
| | $N_{ini}$ | $N_{des}$ | $N_{max}$ | $N_{ini}$ | $N_{des}$ | $N_{max}$ | $N_{ini}$ | $N_{des}$ | $N_{max}$ | $N_{ini}$ | $N_{des}$ | $N_{max}$ |
| < 0.3 | [illegible] | | | 7 | | | 8 | 1[illegible] | | | | 127 |
| < 1 | | | | 7 | | | 8 | 3[illegible] | | | | 46 |
| < [illegible] | | | | 8 | | | 0 | 5[illegible] | | 8 | 1[illegible] | 67 |
| < [illegible] | | | | 8 | | | | 113 | 181 | 9 | 119 | 192 |
| < [illegible] | 109 | 174 | 9 | 121 | 195 | 9 | 128 | 208 | 9 | 135 | 220 | |
| < 100 | 9 | 126 | 204 | 9 | 139 | 228 | 9 | 146 | 240 | 10 | 153 | 253 |
| > 100 | 9 | 142 | 233 | 10 | 158 | 262 | 10 | 165 | 275 | 10 | 172 | 288 |

| Estimated Design Traffic Level (Millions[1] ESALs) | Compaction Parameters | | |
|---|---|---|---|
| | $N_{ini}$ | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | 9 | 125 | 205 |

# Revised Table

# In Superpave (Marshall too)

- Air voids and VMA specified
  - Controls asphalt content
- Gradation is not
  - SO . . . . to change asphalt content, change VMA requirement

# Effect of Design Gyrations

## Volumetric Properties Constant (air voids, VMA, VFA)

LAB

N design

high

low


ROAD

Skeleton

strong

weak

# CONCLUSIONS

- Density at end of service life not appropriate to define N design
- N-design does not influence asphalt content
- N-design in Superpave is “in the ball park”

# Recommended Ndesign Table

## 9-9 (1) Proposed Ndesign Levels

| 20-Year Design Traffic, ESALs | 2-Year Design Traffic, ESALs | Ndesign Unmodified | Ndesign PG 76-22 |
|---|---|---|---|
| < 300,000 | < 30,000 | 50 | NA |
| 300,000 to 3,000,000 | 30,000 to 230,000 | 65 | 50 |
| 3,000,000 to 10,000,000 | 230,000 to 925,000 | 80 | 65 |
| 10,000,000 to 30,000,000 | 925,000 to 2,500,000 | 80 | 65 |
| > 30,000,000 | > 2,500,000 | 100 | 80 |

# Fine Aggregate Specific Gravity Issues

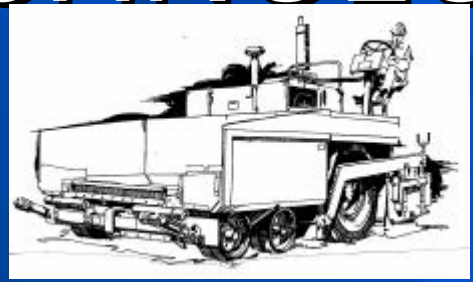
Task Group Objectives:

- Identify problems/issues with current standard AASHTO T 84
- Evaluate alternate methods
- Make recommendations regarding changes and/or new methods
- Additional scope -- Mixture gravity determination issues T 209

# Other NCHRP Projects

- 9-34: Improved Conditioning Procedure for Moisture Susceptibility
- 9-38: Endurance Limit of HMA Mixtures to Prevent Fatigue Cracking
- 9-39: Determining Mixing and Compaction Temperatures of PG Binders in HMA
- 9-45: Development of Specification Criteria for Mineral Fines Used in HMA

# WARM MIX ASPHALT TECHNOLOGY



## 44th Annual Idaho Asphalt Conference

October 21, 2004

Moscow, Idaho

U.S. Department of Transportation
Federal Highway Administration

# Thank You.....

http://www.fhwa.dot.gov/pavements