Everything you ever wanted to know about HMA in 30 minutes

John D'Angelo
The mouth


Are they all the same?

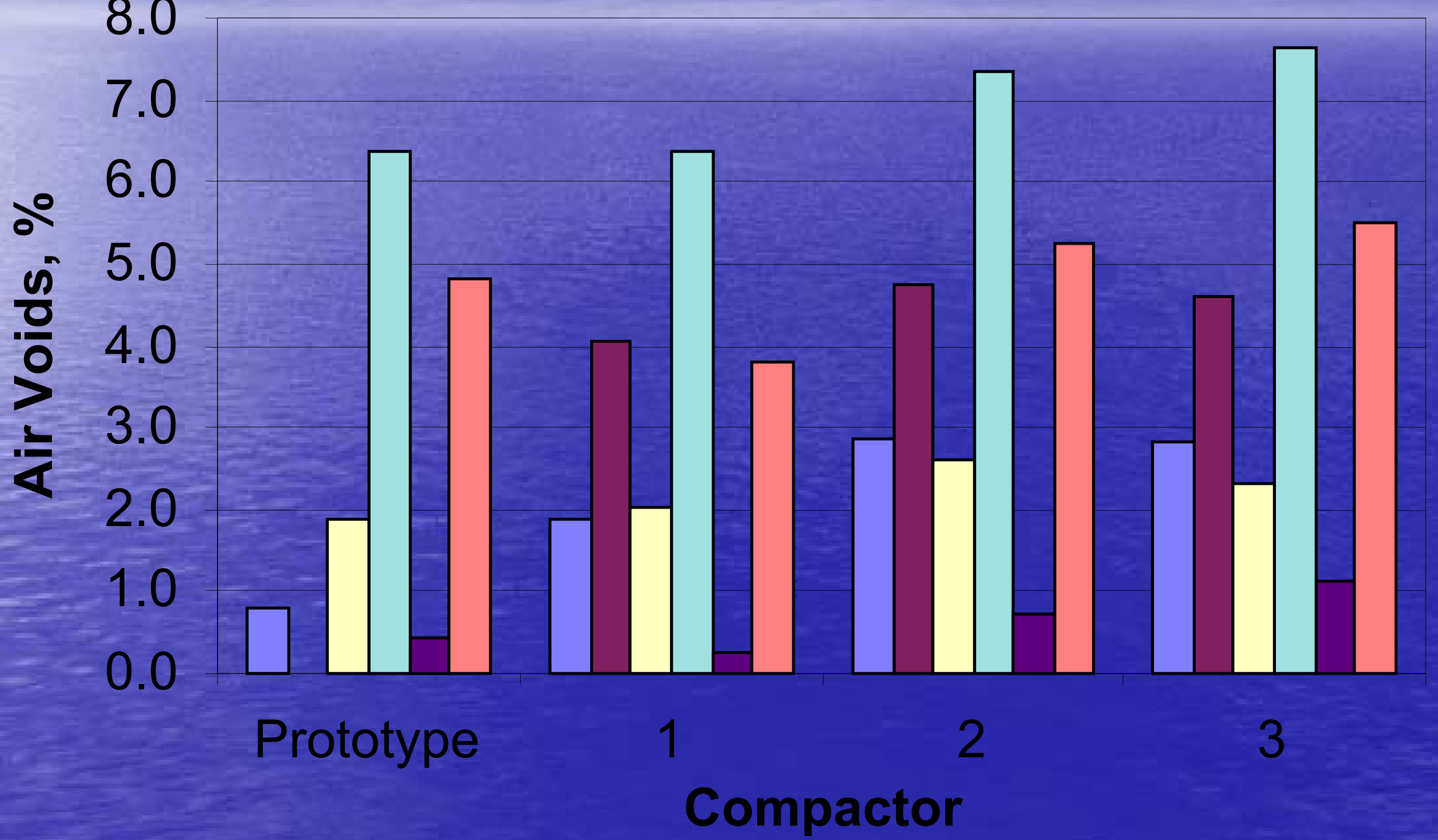



Background

- SHRP A-001 Contract
  - Development of Superpave Mix Design Procedure
    - Gyratory Compactor Experiments
      - Conducted at Asphalt Institute
      - Included rotational speed, N_{design}, sensitivity experiments
      - Comparison between prototype and production SGC
        - Led to discovery of angle sensitivity
        - Tolerance of ±0.02 degrees


2400
2700
3000
50
300

Differences in SGCs – NATC Mixtures



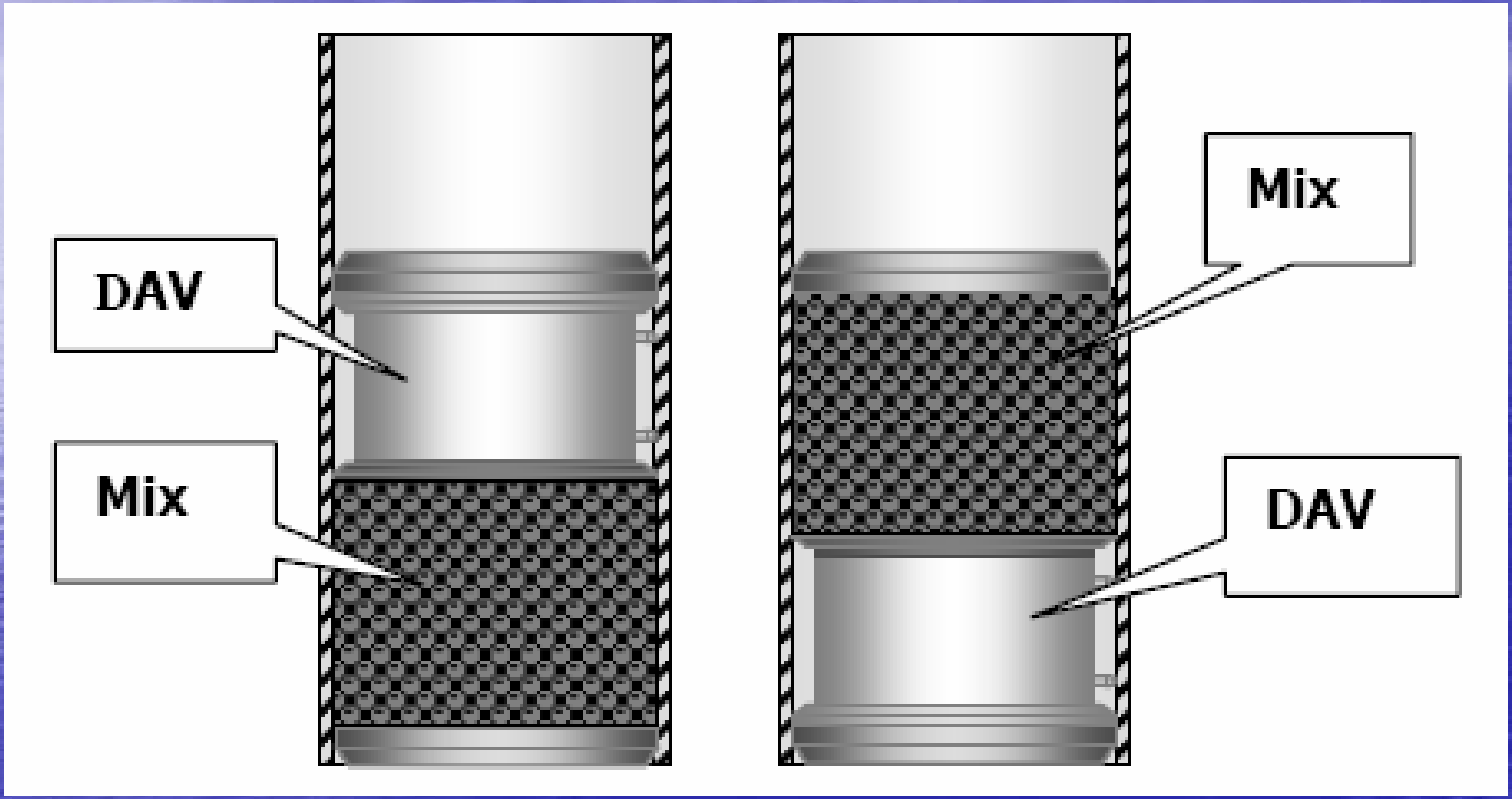
Measurement of the Internal Angle of Gyration

- Significant Differences in Air Voids
  - Difference in Design AC Could be as Much as 0.8% Asphalt Content
- Angle of Gyration
  - All Compactors set to 1.25° Externally
  - What is the Internal Angle of Gyration?
    - Frame compliance?

Internal Angle of Gyration

- Internal Angle of Gyration
  - – Development of the Dynamic Angle Validator (DAV) or Angle Validation Kit (AVK)
    - Wireless Unit
    - Drop into mold either before or after adding mix

Dynamic Angle Validator

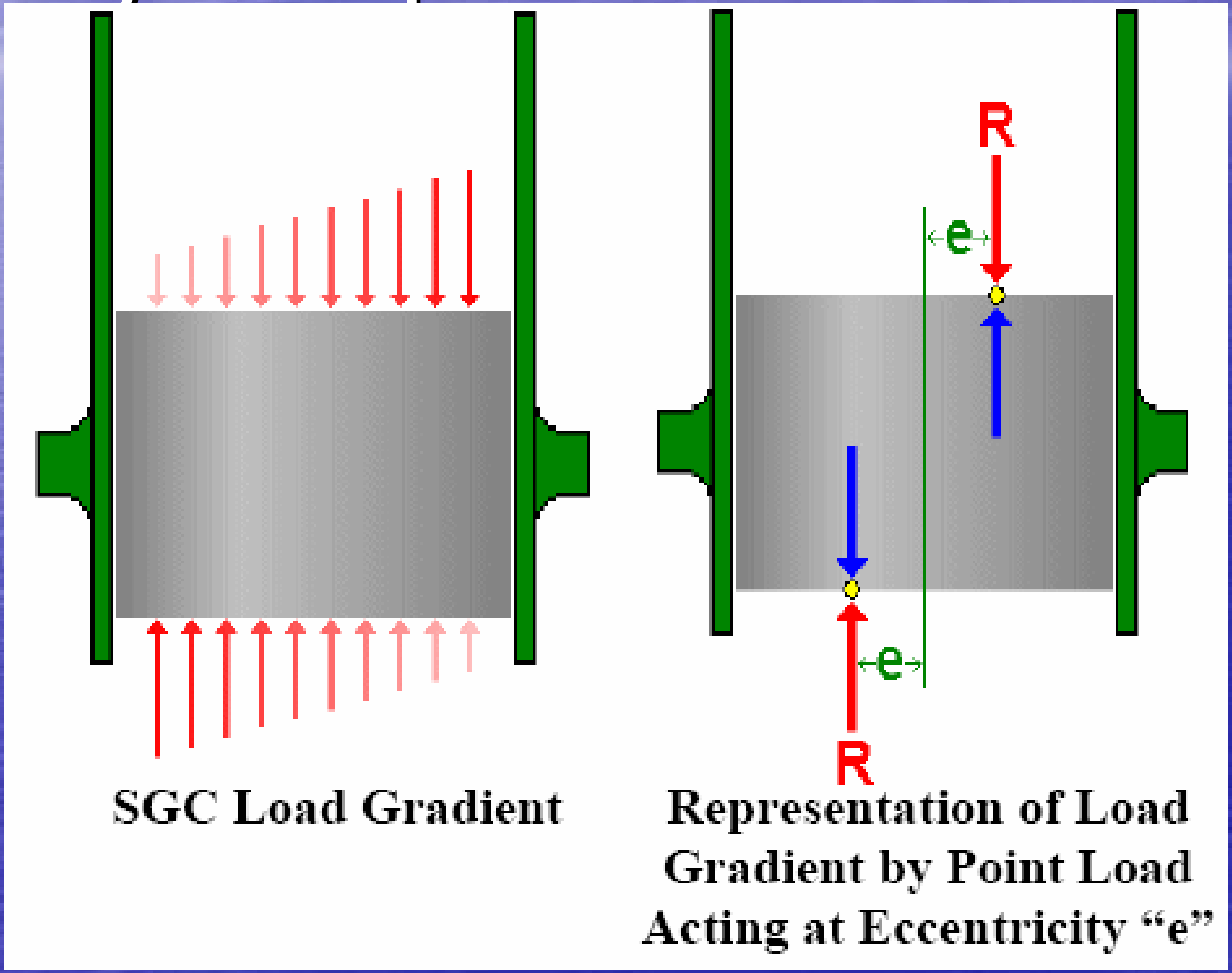


Dr. Kevin Hall, “Evaluating the Superpave Gyratory Compactor Internal Angle of Gyration Using Simulated Loading”, submitted to AAPT2005

Internal Angle of Gyration

- DAV
  - Validate Differences in SGCs
    - Demonstrated that internal angle of gyration could be different even though external angle was the same.
  - Calibration
    - Potentially time-intensive
      - Up to 1 day for a calibration
    - Affected by mixture stiffness?
      - Requiring recalibration for different mix types

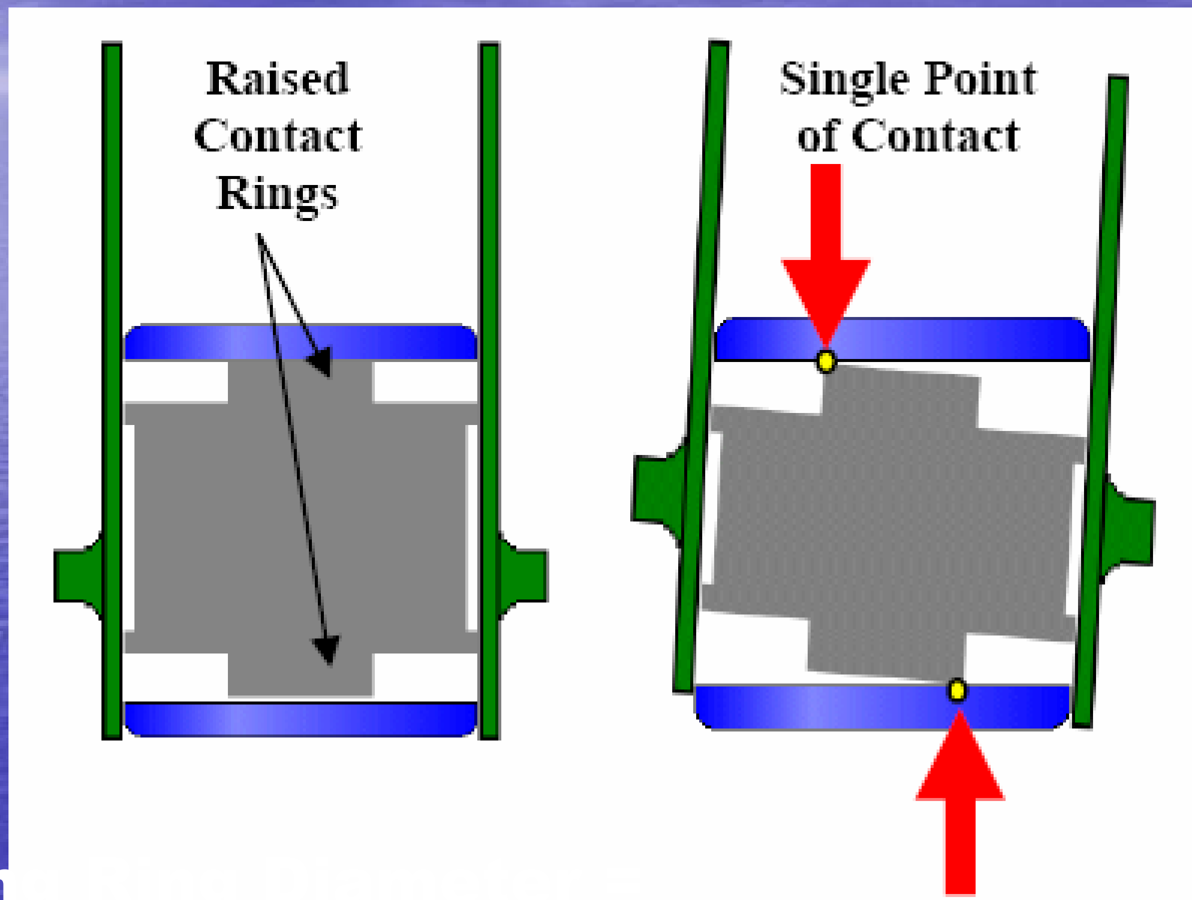
Forces Acting in a Mold During Gyratory Compaction



Mechanical Simulation of an Asphalt Mixture – RAM

RAM – Rapid Angle Measurement Device (Pine)

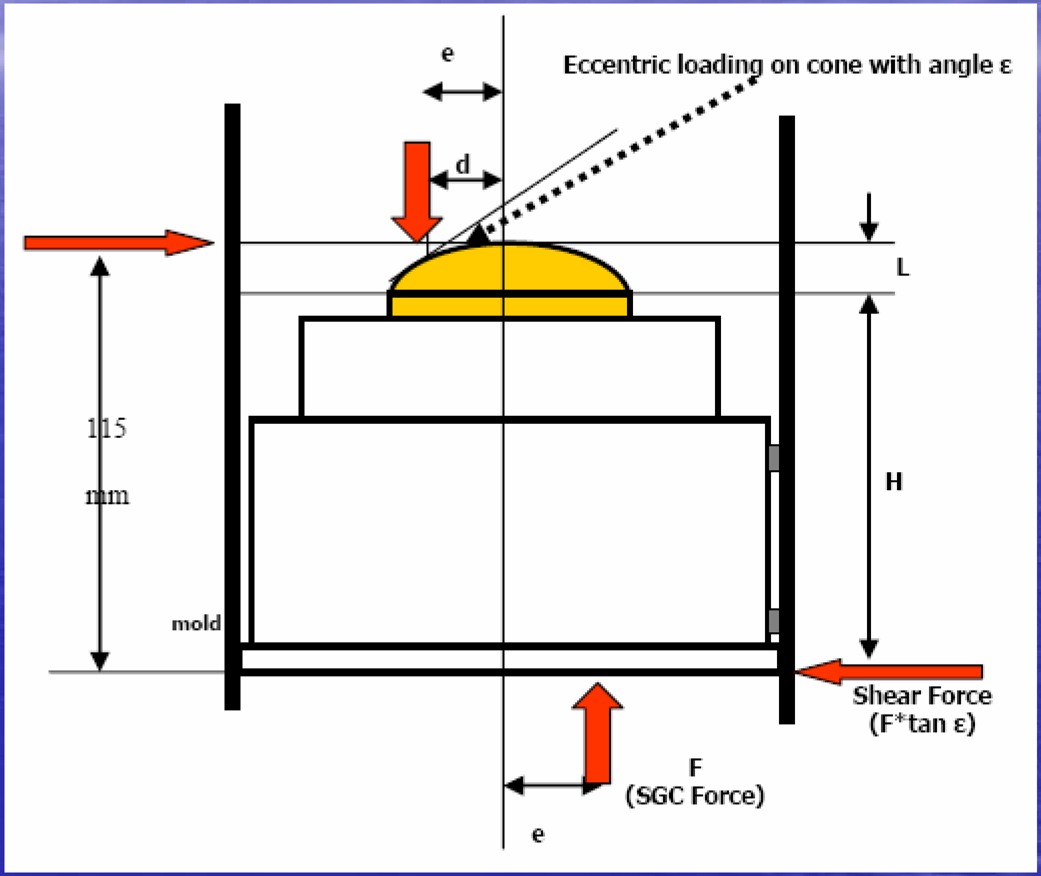
RAM Operations



Increasin

Increasing Mix Eccentricity

Mechanical Simulation of an Asphalt Mixture – HMS



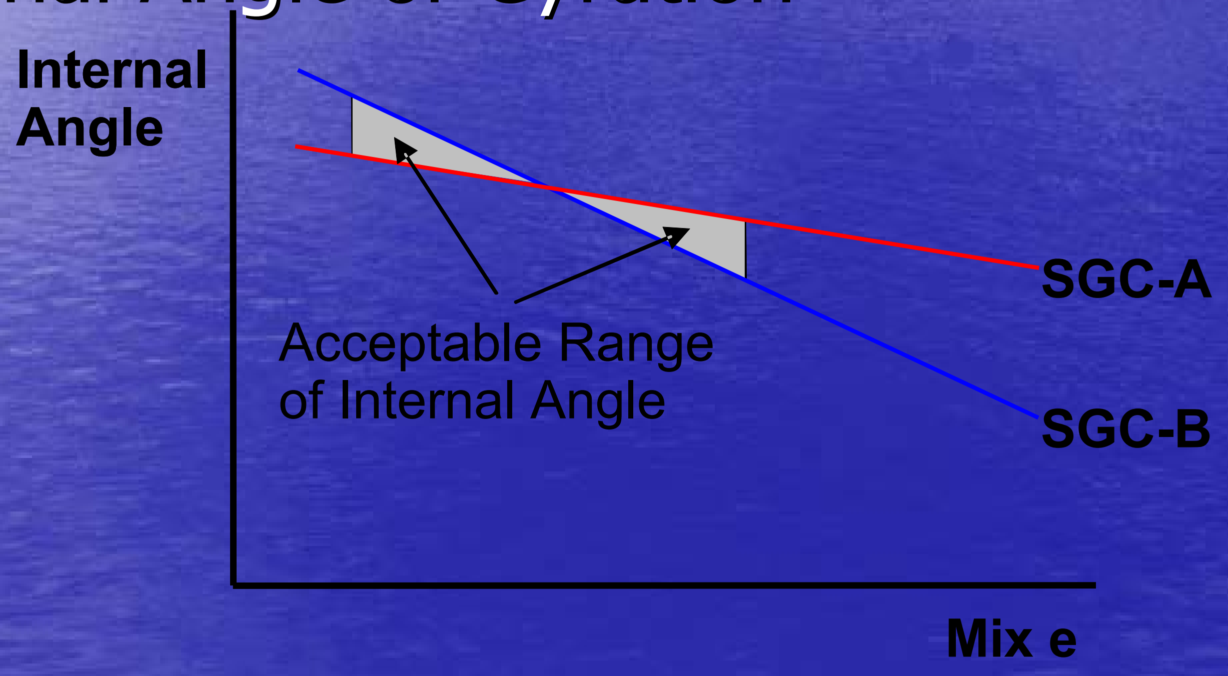
HMS – Hot-Mix Simulator (TestQuip)

Purpose of Research

- Objectives
  - Improve the determination and calibration of the dynamic internal angle of gyration for the Superpave gyratory compactor using mechanical mixture simulation devices
    - Reduce time for calibration
    - Improve reproducibility between different labs
    - Recommend revisions to AASHTO T312

Research Plan – Task 1

- Determine the Effect of Mix Eccentricity on Internal Angle of Gyration



Research Plan – Task 2

- Using a Wide Variety of Mixtures…
  - What is the relationship between mixture eccentricity and stiffness?
  - What is an “average” or representative mixture eccentricity?
  - Is there a standard mixture eccentricity that can be used to minimize variation in the percentage of air voids in specimens produced by different SGCs?

Research Plan – Task 3

- Using Mechanical Simulation Devices in the Calibration Process
  - Issues
    - Necessity of heated molds?

Frame Stiffness Measures – RAM only

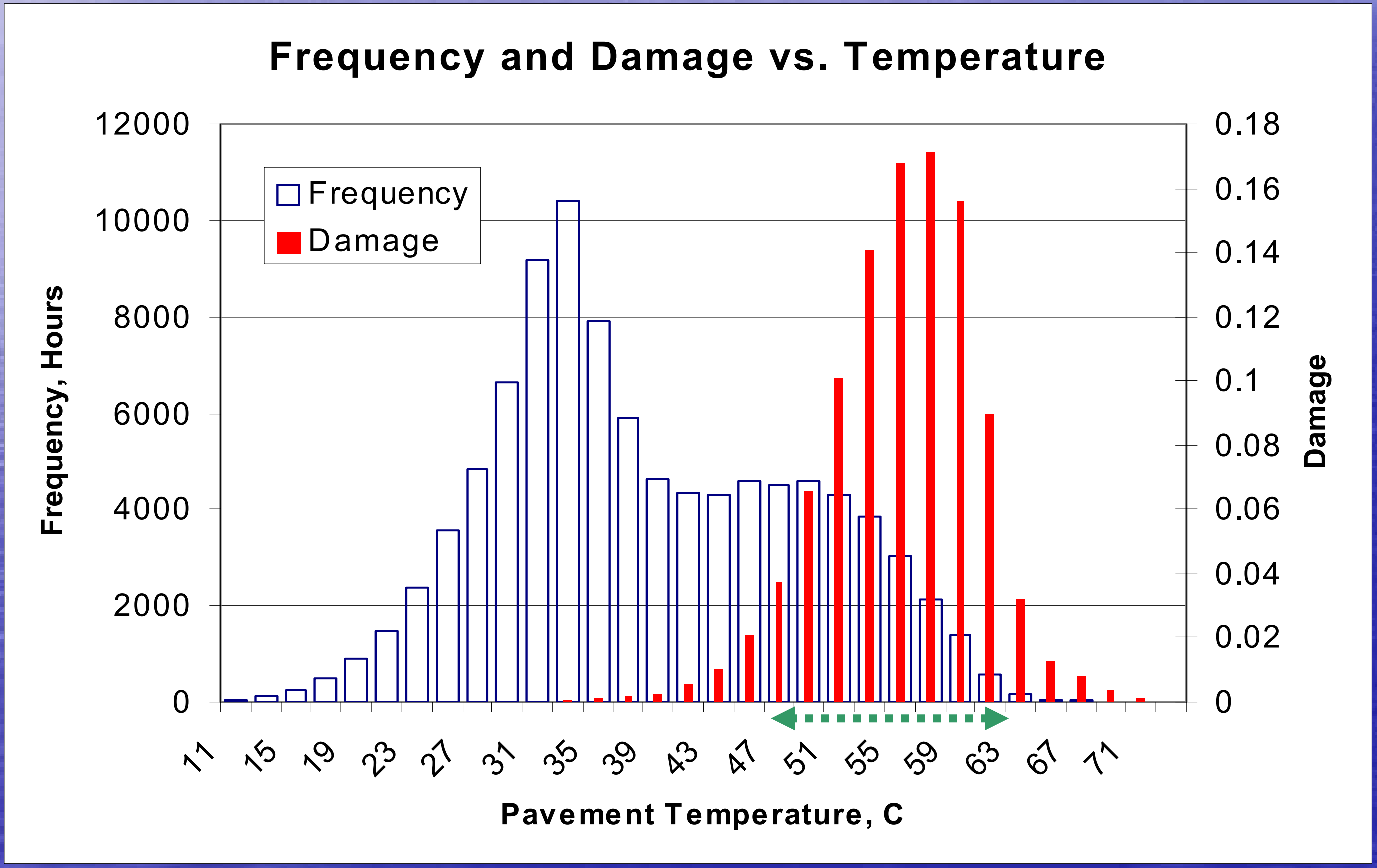
Testing Agency	Frame Stiffness (Deg / N-m)					
	Superpave Gyratory Compactor (SGC) Model					
	Pine AFG125x	Pine AFG1	Pine AFGB1 (Brovold)	Troxler 4140	Troxler 4141	ServoPac
Univ. of Arkansas *(Stiffness Study)*	0.00031	0.00034	0.00036	0.00109	0.00063	
Univ. of Arkansas *(RAM ILS)*	0.00046		0.00025	0.00139	0.00058	
Univ. of Arkansas *(RAM-DAV/HMS Study)*	0.00037	0.00047	0.00031	0.00127	0.00054	
Florida DOT *(used by permission)*	0.00033		0.00041	0.00172		0.00041
InstroTek *(used by permission)*	0.00047	0.00050	0.00055	0.00176	0.00180	
				0.00136	0.00122	
				0.00132		
Mean Value	0.00039	0.00044	0.00038	0.00142	0.00095	0.00041
Standard Deviation	0.000074	0.000085	0.000114	0.000242	0.000548	N/A
Coefficient of Variation (%)	19.0	19.5	30.3	17.1	57.5	N/A

Binders

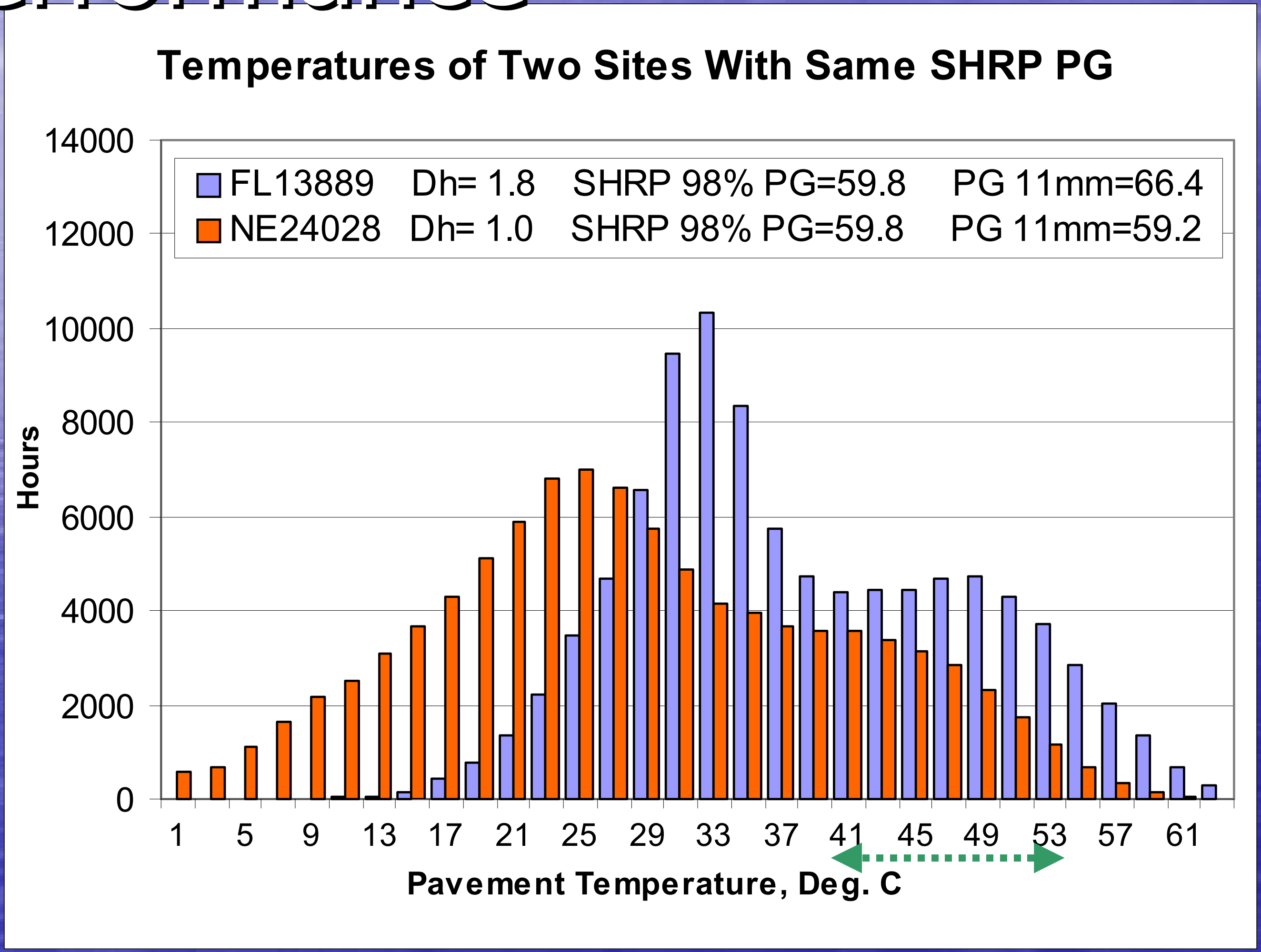
Is the current binder selection based on pavement temp. correct?

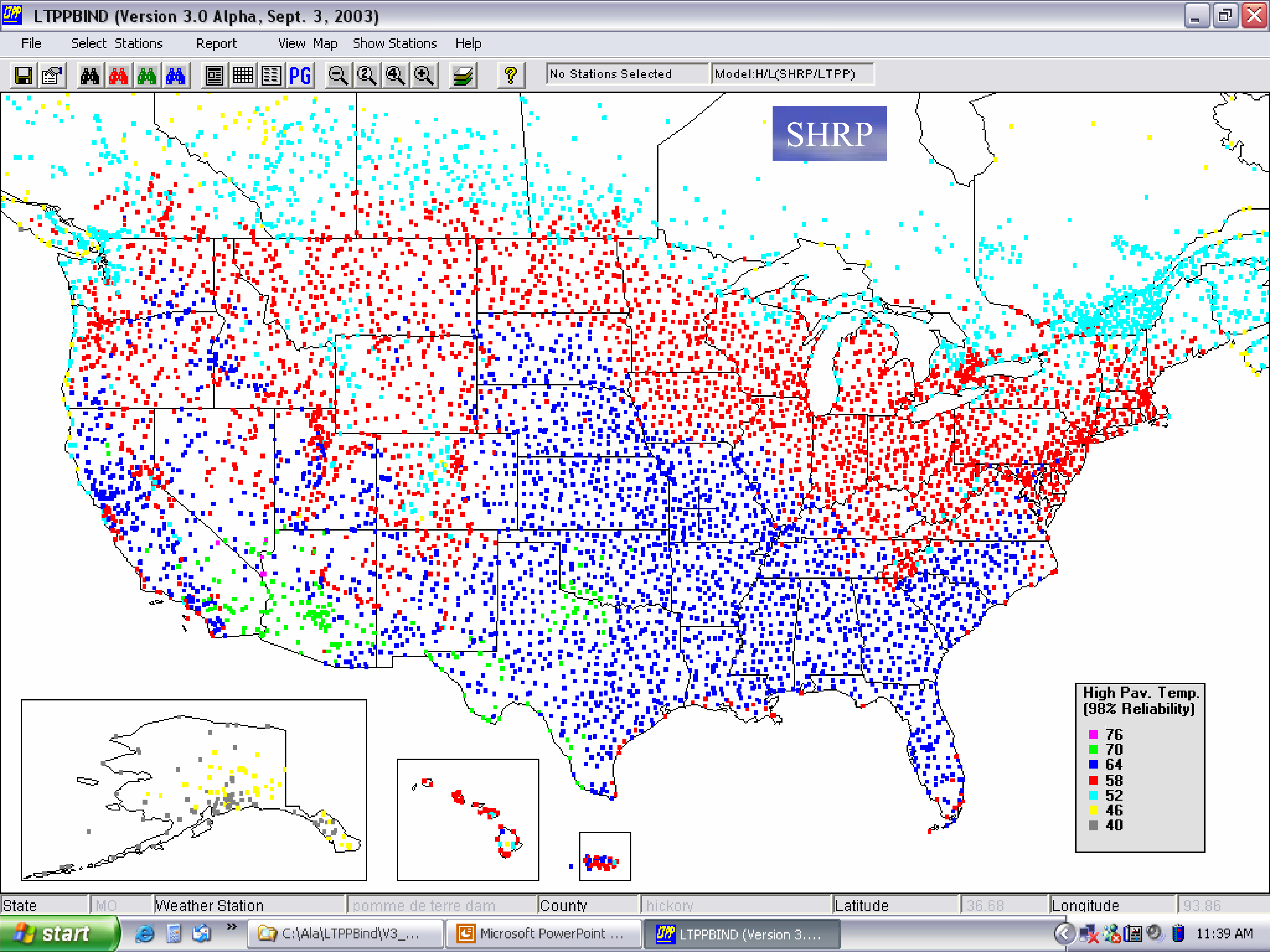
- Is a PG 58 in Florida the same as a PG 58 in Idaho?
- Is the average 7 day high temp the best measure of pavement rutting?

Most Damage is at Many Hours of High Temperatures, not Highest Temperatures



Same SHRP PG, Different Performance




LTPPBIND (Version 3.0 Alpha, Sept. 3, 2003)
File
Select Stations
Report
View Map
Show Stations
Help
PG
No Stations Selected
Model:H/L(SHRP/LTPP)
SHRP
High Pav. Temp.
(98% Reliability)
76
70
64
58
52
46
40
State
MO
Weather Station
pomme de terre dam
County
hickory
Latitude
36.68
Longitude
93.86
start
C:\Ala\LTPPBind\V3_...
Microsoft PowerPoint ...
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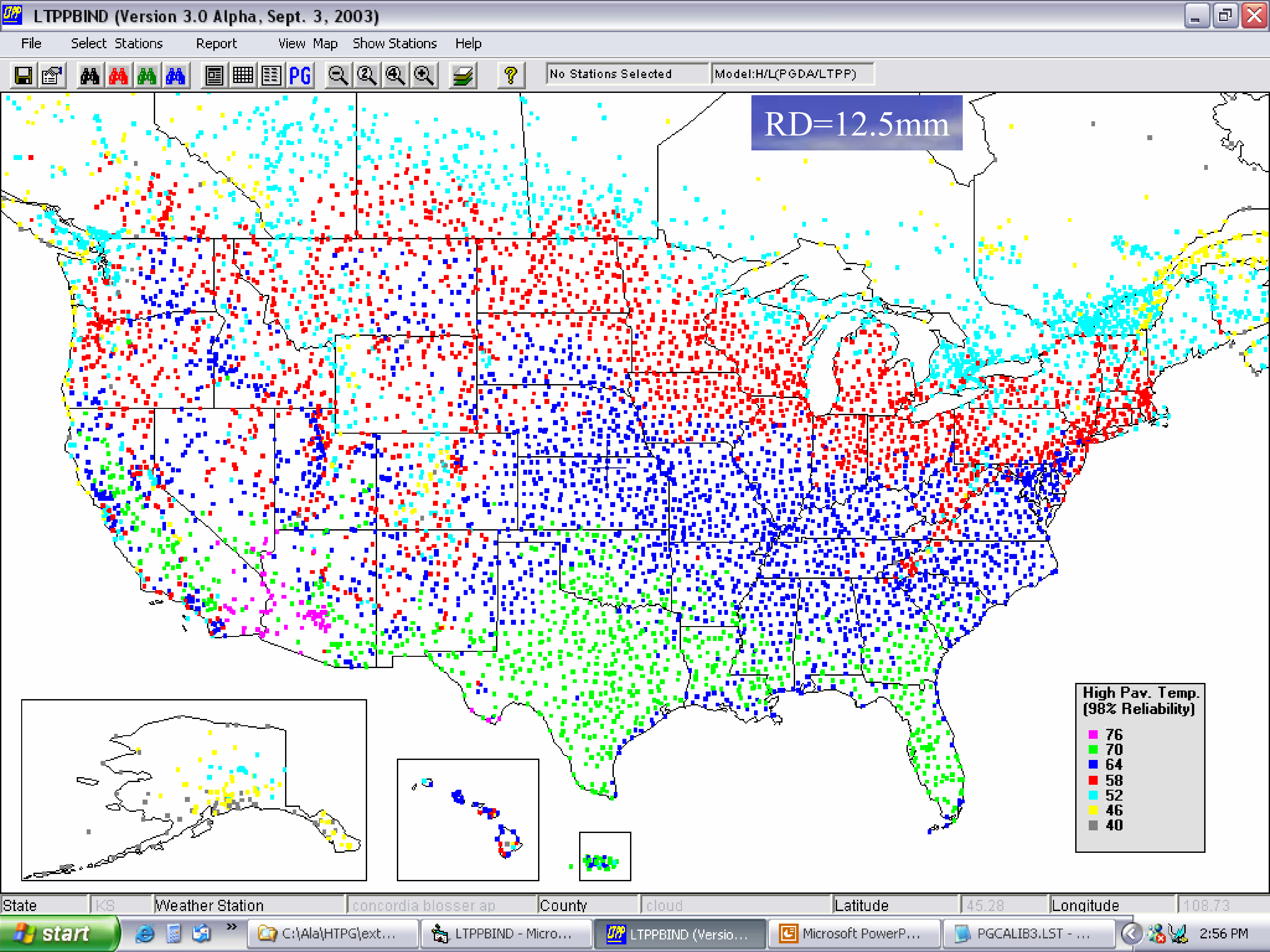
11:39 AM


LTPPBIND (Version 3.0 Alpha, Sept. 3, 2003)
File
Select Stations
Report
View Map
Show Stations
Help
No Stations Selected
Model:H/L(PGDA/LTPP)
RD=12.5mm
High Pav. Temp.
(98% Reliability)
76
70
64
58
52
46
40
State
KS
Weather Station
concordia blosser ap
County
cloud
Latitude
45.28
Longitude
108.73
start
C:\Ala\HTPG\ext...
LTPPBIND - Micro...
LTPPBIND (Versio...
Microsoft PowerP...
PGCALIB3.LST - ...
2:56 PM

Grade Bumping by Base PG and Speed for All Rut Depths

		ESAL, Millions			
Speed	**Base Grade**	**<3**	**3-10**	**10-30**	**30+**
Fast	**52**	0	10.3	16.8	19.3
	58	0	8.7	14.5	16.8
	64	0	7.4	12.7	14.9
	70	0	6.1	10.8	12.9
Slow	**52**	3.1	13	19.2	21.6
	58	2.9	11.2	16.8	19
	64	2.7	9.8	14.9	17
	70	2.5	8.4	12.9	14.9

LTPPBind 3 new software

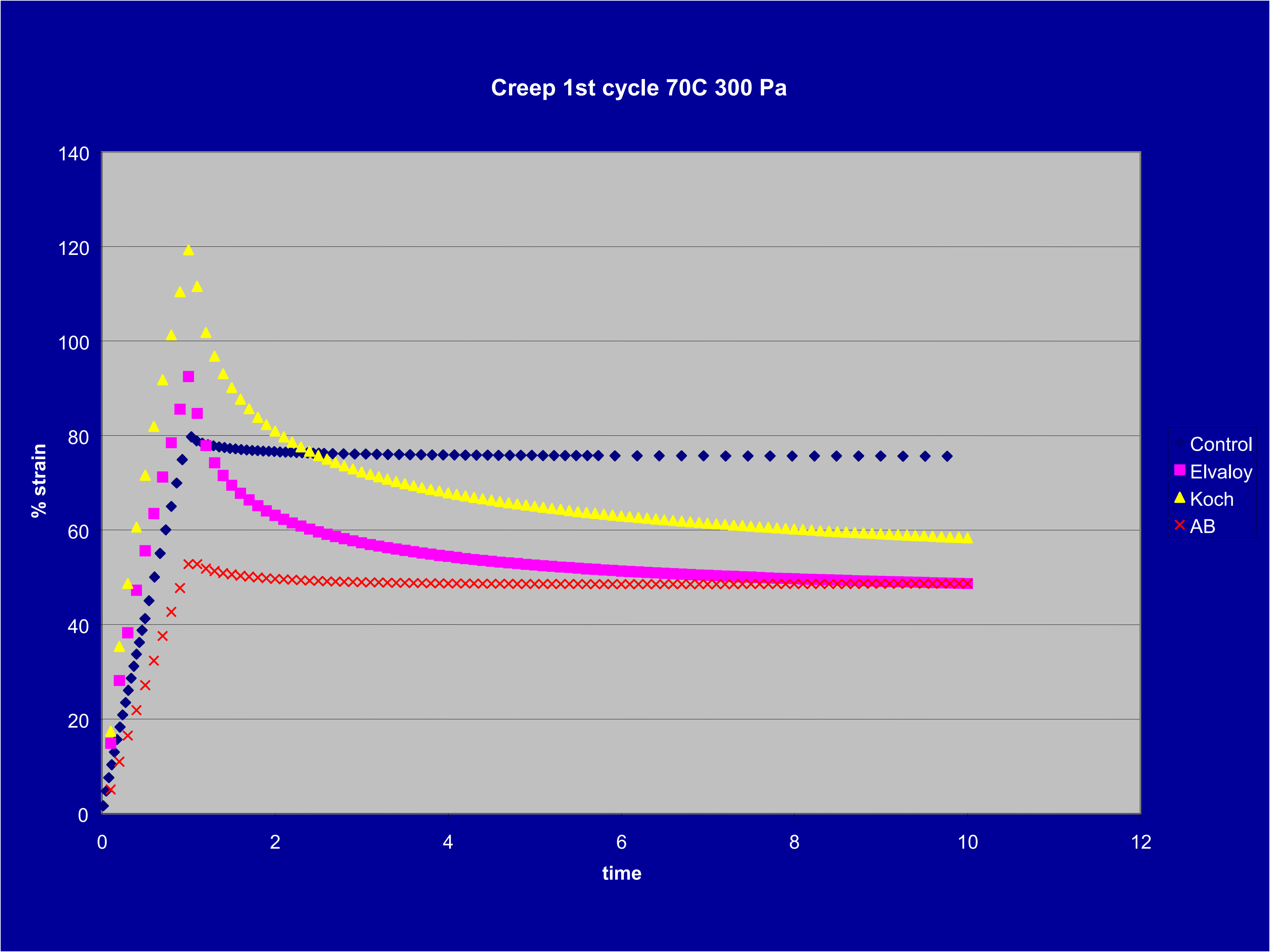
- Web site
- http://ltppbind.com/

Modified Binders Affect Performance

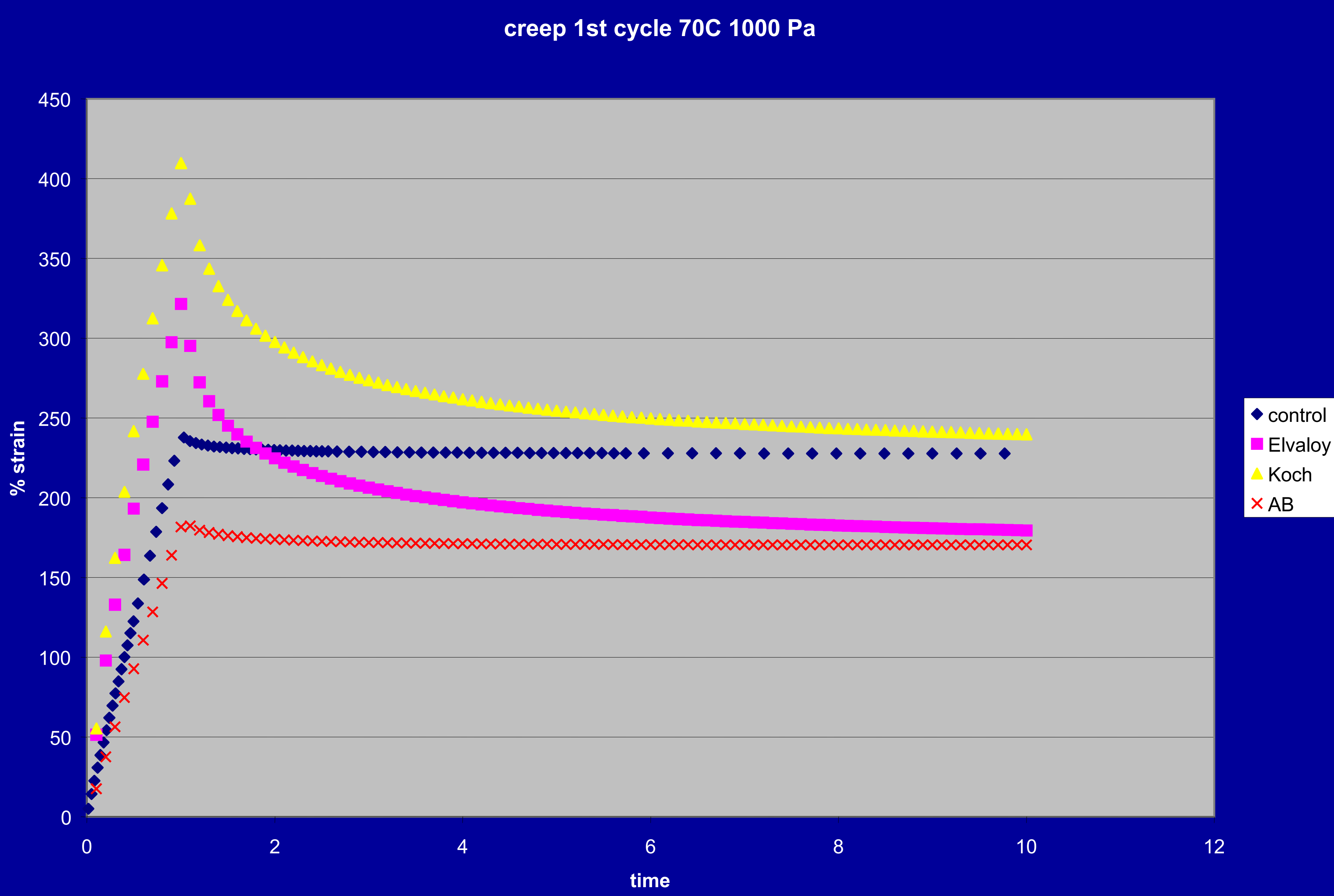
- Study same mix different binders.

PG 63-22 mod. no rutting

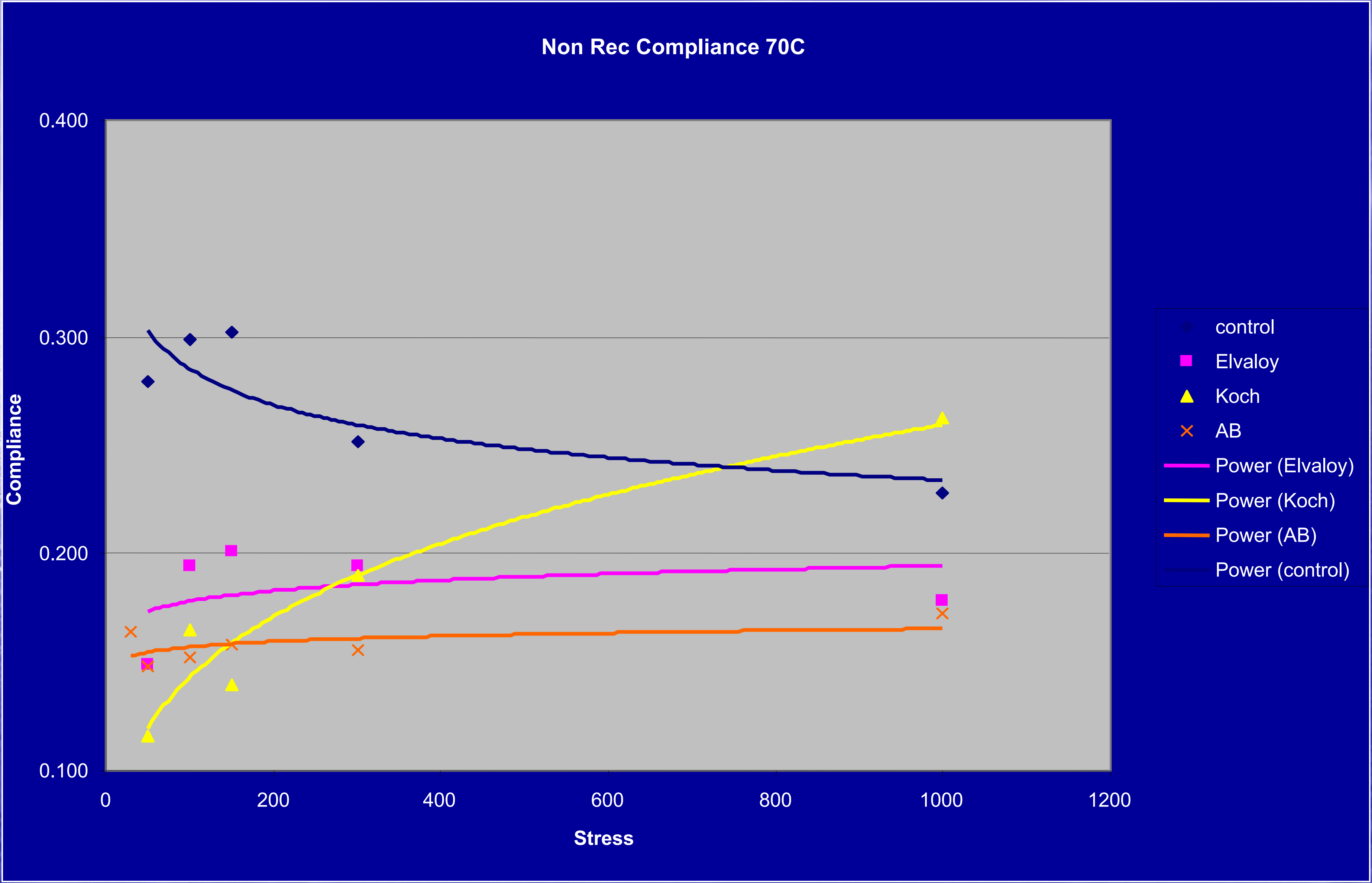
PG 67-22 unmod. 15mm rutting



Creep 1st cycle 70C 300 Pa
% strain
time
0
20
40
60
80
100
120
140
0
2
4
6
8
10
12
Control
Elvaloy
Koch
AB

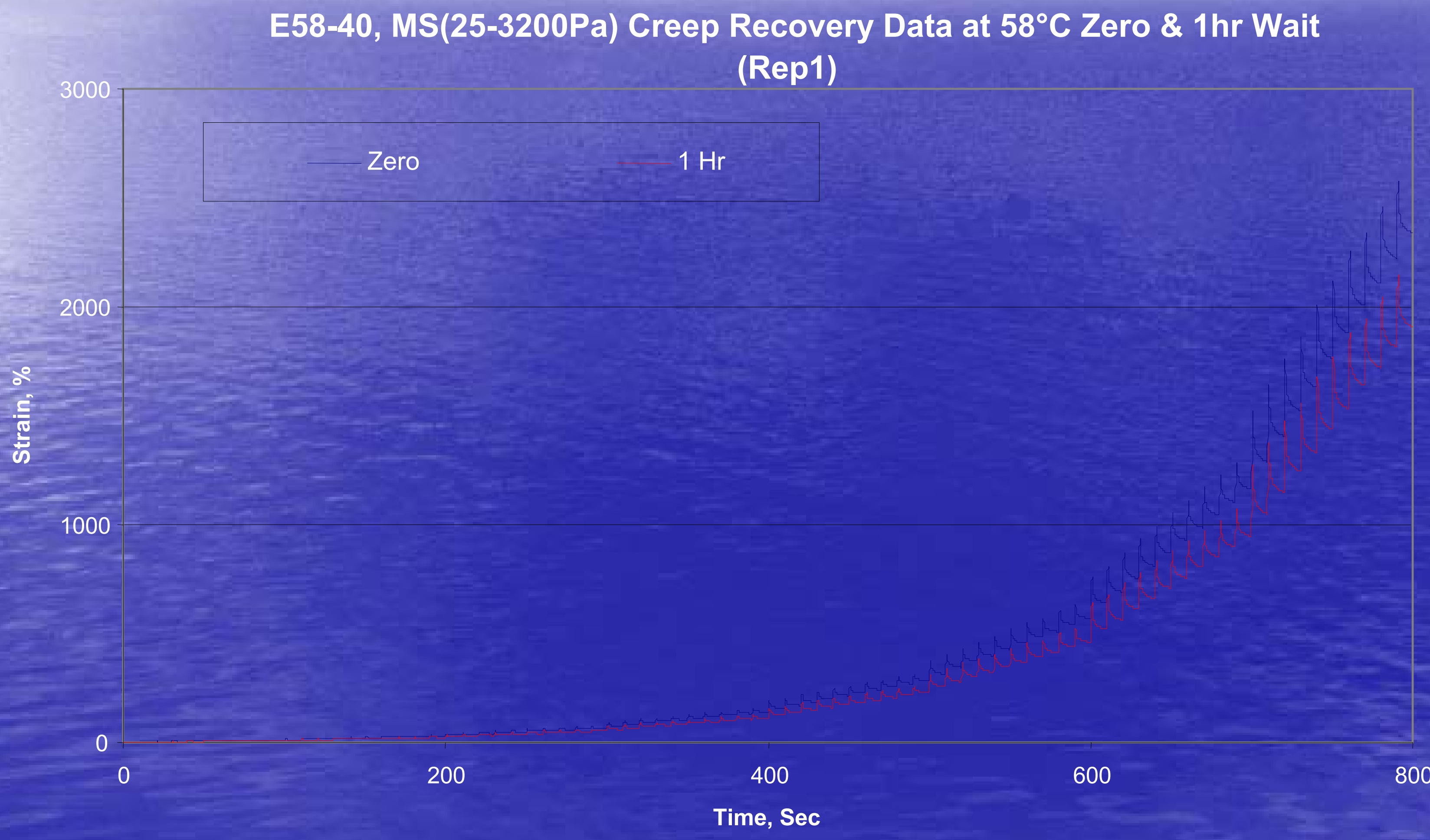


creep 1st cycle 70C 1000 Pa
% strain
time
0
50
100
150
200
250
300
350
400
450
0
2
4
6
8
10
12
control
Elvaloy
Koch
AB

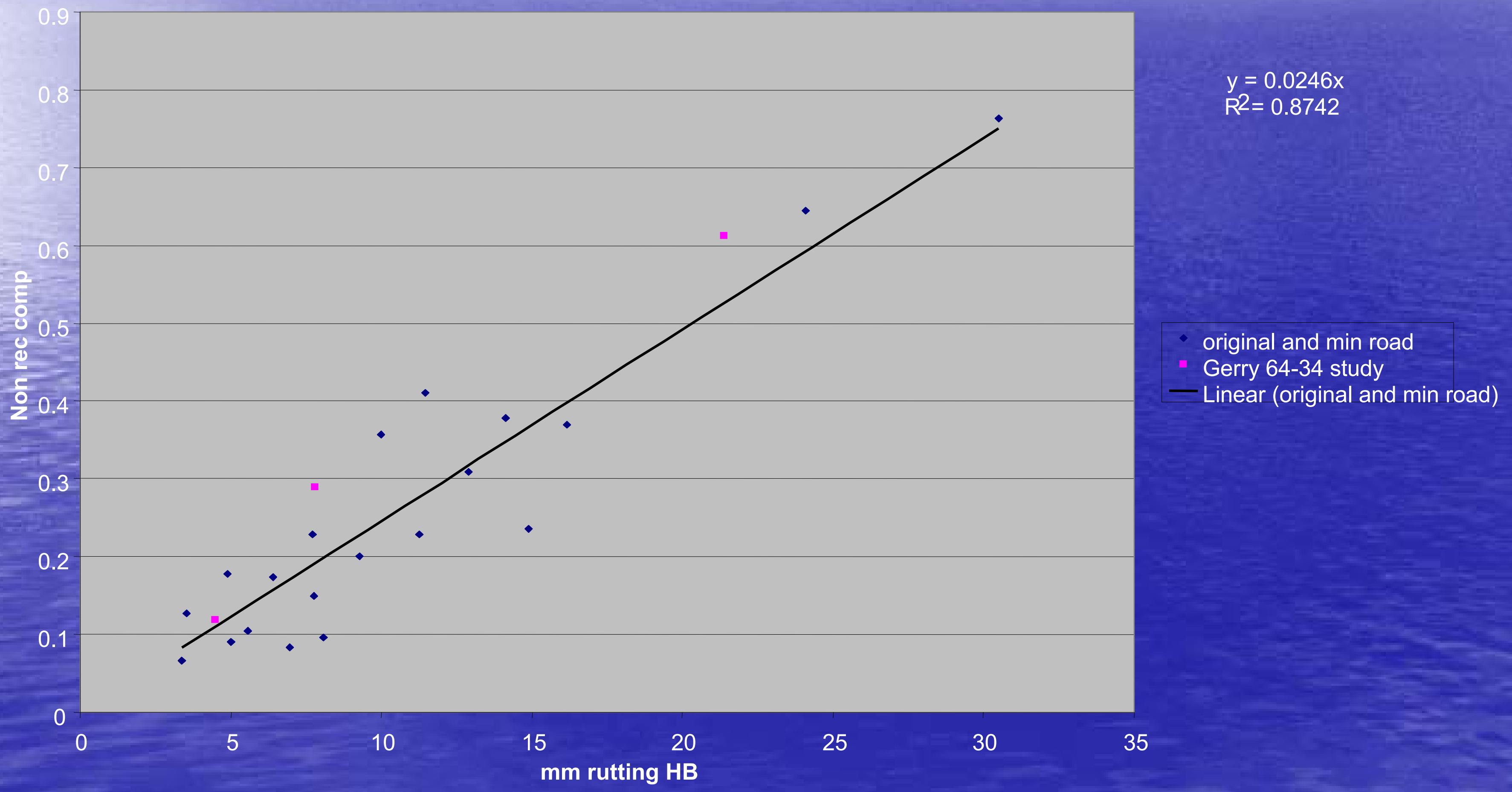


Non Rec Compliance 70C
0.400
0.300
0.200
0.100
Compliance
0
200
400
600
800
1000
1200
Stress
control
Elvaloy
Koch
AB
Power (Elvaloy)
Power (Koch)
Power (AB)
Power (control)

Retest of binder after 1 hr rest



Mix testing multiple studies



***N*ational**

***C*ooperative**

***H*ighway**

***R*esearch**

***P*rogram**

9-29: *Simple Performance Tester for Superpave Mix Design*

- Evaluation of 1st-article SPTs from Shedworks/IPC and Interlaken complete.
- Single-replicate measurement COV: dynamic modulus 13%, flow time 33%.

Advanced Asphalt Technologies (November 2005)

9-27: *Relationships of HMA In-Place Air Voids, Lift Thickness and Permeability*

Determine in-place air voids and minimum lift thicknesses needed to achieve durable, impermeable HMA pavements.

NCAT (April 2004)

Factors Affecting In-Place Air Voids

- Recommended thickness/NMAS ratios for adequate in-place density:
  - $\geq$ 3 for fine-graded mixes
  - $\geq$ 4 for coarse-graded mixes
- Lower ratios will require more field compactive effort to achieve adequate density.

Factors Affecting HMA Permeability

- No significant difference in lab permeability between fine- and coarse-graded mixes.
- Satisfactory permeability at 7±1% AVC at t/NMAS = 2, 3, or 4.
- Permeability increases as air voids and coarse aggregate ratio increase, decreases as VMA increases.

9-33: *A Mix Design Manual for Hot Mix Asphalt*

Update method in AI Manual SP-02:

- **Simple performance test(s).**
- **As-delivered M-E design guide performance models and software.**
- **New volumetric criteria.**
- **Framework for integrated mix and structural design.**

Advanced Asphalt Technologies, LLC (August 2006)

9-39: *Determining the Mixing and Compaction Temperatures of Superpave Asphalt Binders in HMA*

- Reliable, user-friendly method.
- Equally applicable to modified and unmodified binders.
- Simple and quick to use.
- Suitable for routine specification use.

(RFP anticipated December 2004)

1-40:Facilitating the Implementation of the Guide for the Design of New and Rehabilitated Pavement Structures

- Conduct a thorough review of the Guide
- Organize and convene workshops
- Develop a concise user's guide
- Provide technical support

Thanks!