ARC

Asphalt Research Consortium

Evaluation of PG Plus Testing Methods by the Asphalt Research Consortium

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Objective Statement in ARC Work Plan

- ARC Task: Continual Assessment of Specifications
- The objectives of this task are
  - To cooperate with state highway agencies to validate the findings of the research activities of the Consortium and,
  - To evaluate the models used in the MEPDG for possible revisions.

PG Plus Testing Methods Under Investigation

- High Temperature (Performance)
  - Multiple Stress Creep and Recovery (MSCR)
- Intermediate Temperature
  - Elastic Recovery
- Low Temperature
  - Single-Edge Notched Bending
  - Asphalt Binder Cracking Device

Proliferation of PG+ Tests in WCTG

- Elastic Recovery (AASHTO T301)
- MSCR (ASTM D7405)

} ARC

- Toughness and Tenacity (ASTM D 5801-95)
- Ductility (AASHTO T51)

ARC Testing

- MSCR Study
  - Multiple Stress Creep and Recovery Test (MSCR)
  - Asphalt Mixture Performance test (AMPT)
- Further Testing
  - Elastic Recovery (T301)
  - Elastic Recovery (DSR)- New test procedure
- Collaboration Agreement with WCTG to validate PG+ with field performance.

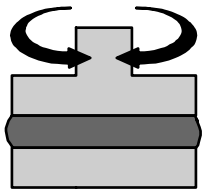
Research Methodology

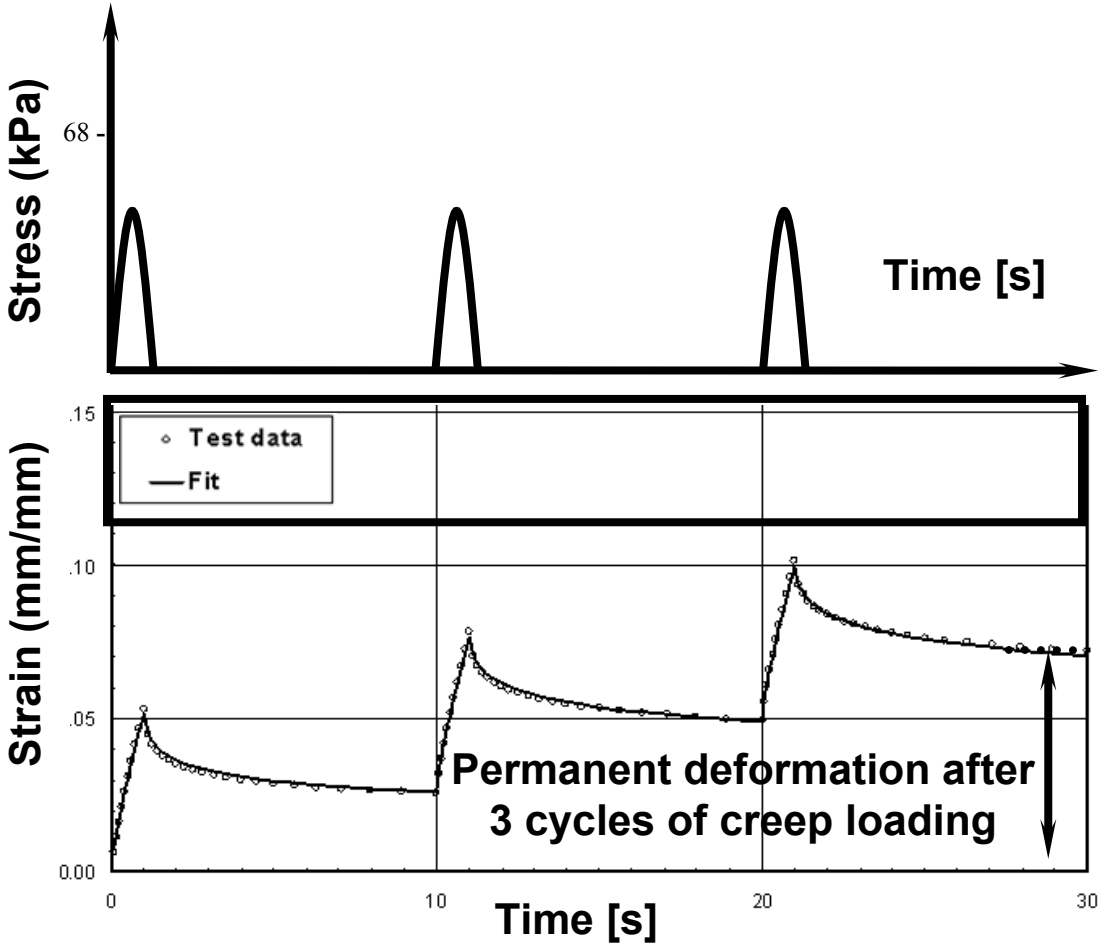
- Binder → Mastic → Mixture → Field Performance
  (with WCTG's help)
- Tests:
  - MSCR: Binder, Mastic.
  - Elastic Recovery: Binder
  - AMPT: Mixture

MSCR Test Evaluation

The Basis for the MSCR Test:
Creep and Recovery – *NCHRP 9-10 (2000)*

- **Repeated Creep Loading**





Is MSCR the Right Test ?

- Yes
- However, we need to answer these questions:
  - What should be reported ?
    - Jnr, % Recovery
  - What stress should be used ?
    - 0.1, 3.2 , 10 KP, ... ?
  - What is the relation to other PG+?

MSCR Study: Effect of Elasticity and Fillers

- Binder:
  - Elastomeric Modified (SBS) = Binder A
  - Plastomeric Modified (CBE) = Binder B
- Fillers
  - Granite
  - Hydrated Lime
- Mixtures
  - Aggregate: Granite (Washed)
  - Gradation: Coarse
  - Mixtures generated with varying the filler and binder types

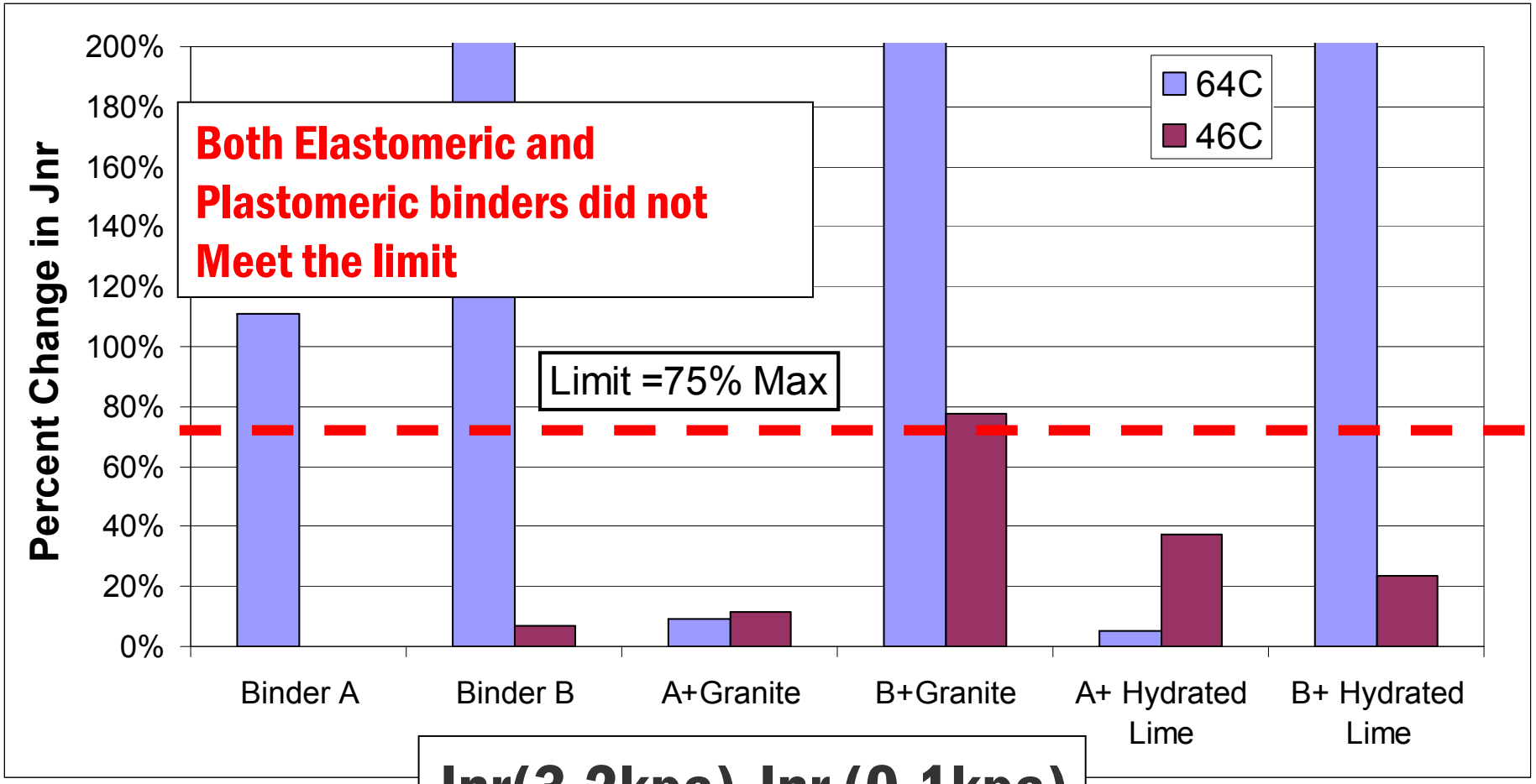
MSCR Testing

- The MSCR testing was performed at
  - Two temperatures,
    - 64˚C (high PG grade) and
    - 46˚C (mixture testing temperature)
  - Three Stresses: 0.1, 3.2, and 10kPa.
- 25mm parallel plate geometry.

Mixture Testing

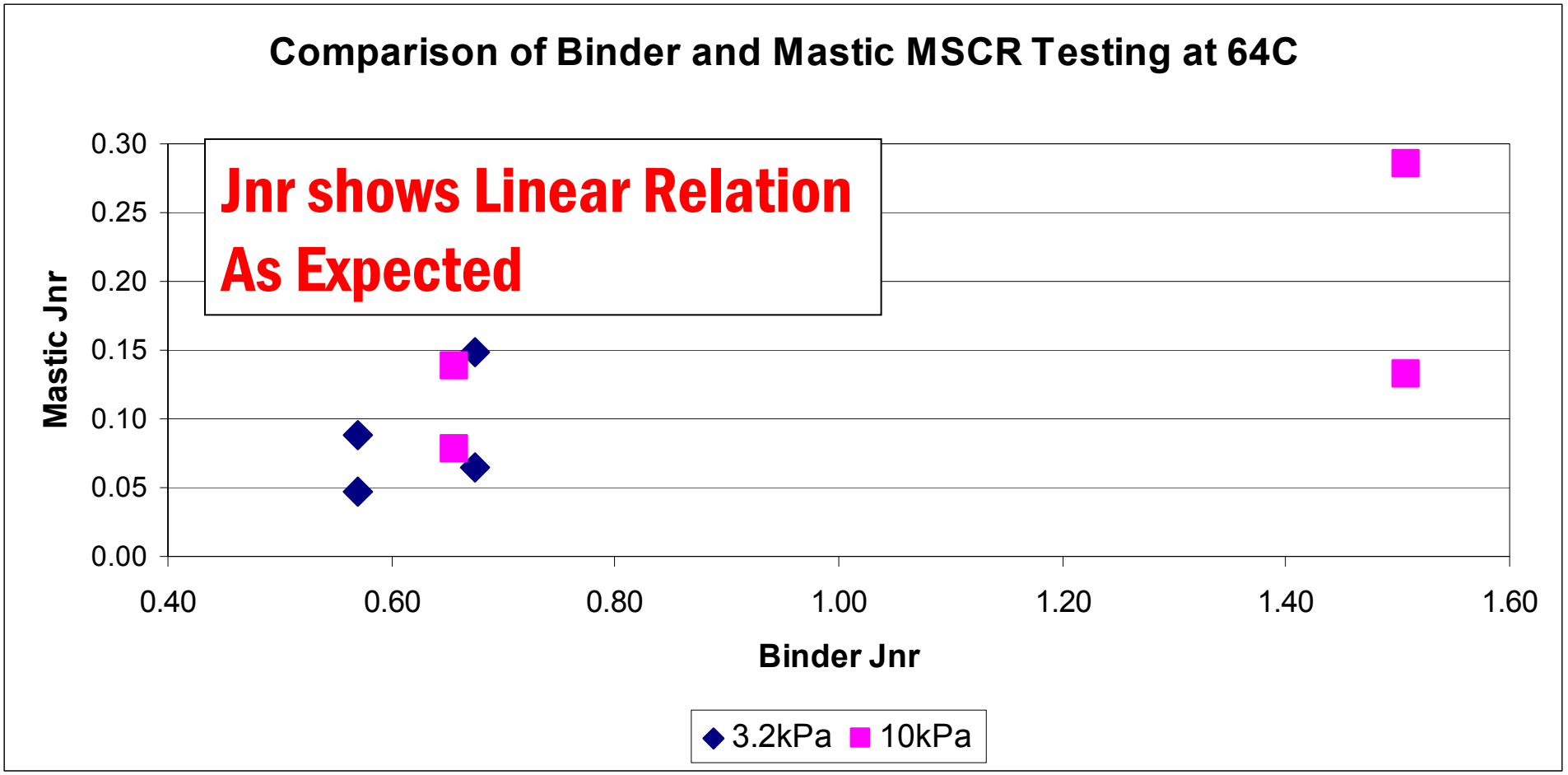
- Cylindrical specimens of 4” in diameter and 6” in height.
- Repeated Creep test with load period=1 sec and the rest period=9 seconds.
- Stress levels:
  - 50psi (0.435MPa), 100psi (0.689MPa), and 150psi (1.03MPa).
- All mixture testing was run at 46˚C

Stress Sensitivity of Binders and Mastics

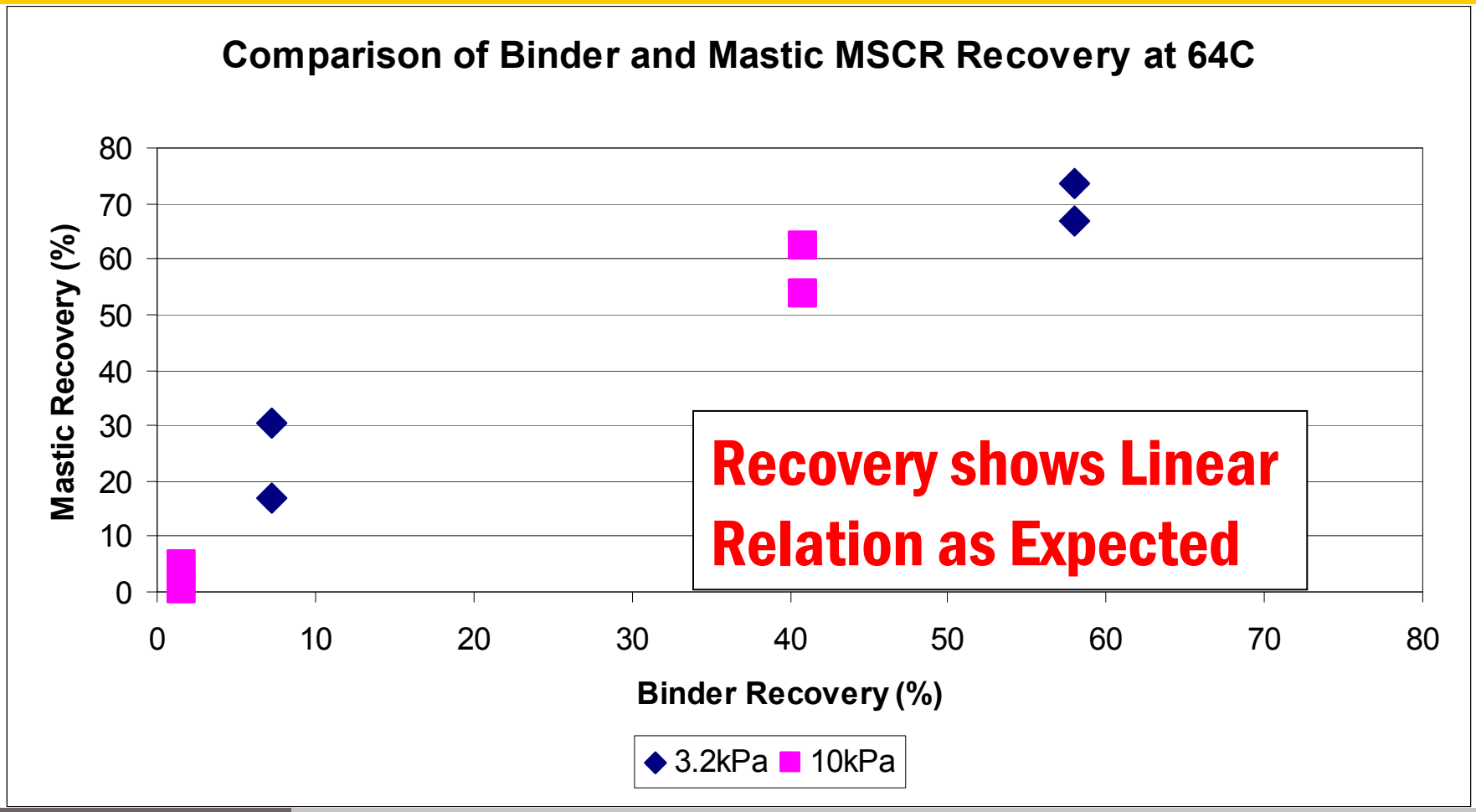


$$\frac{Jnr(3.2kpa)-Jnr(0.1kpa)}{Jnr(0.1kpa)}$$

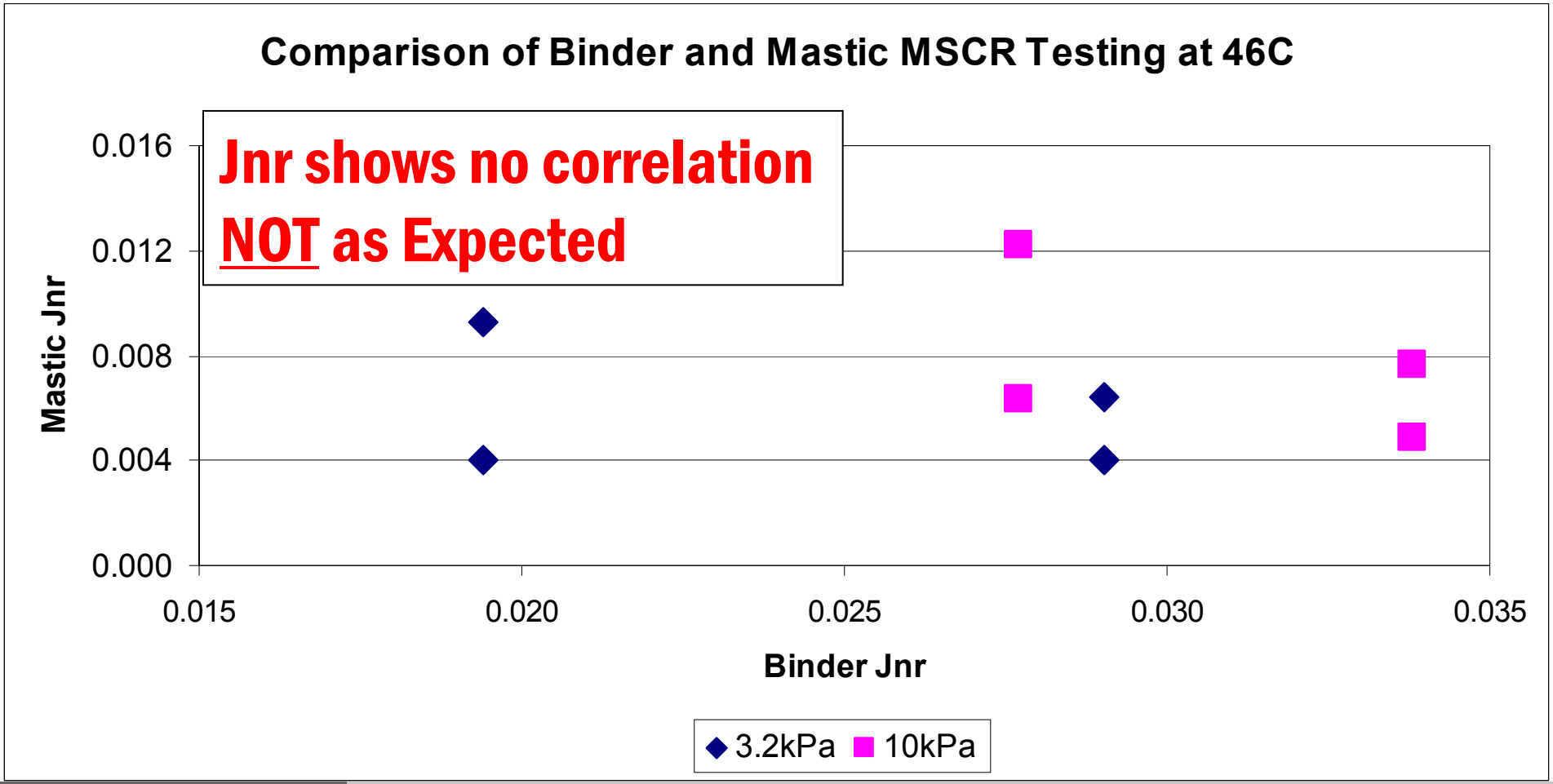
Binder → Mastic (Jnr At 64 C)



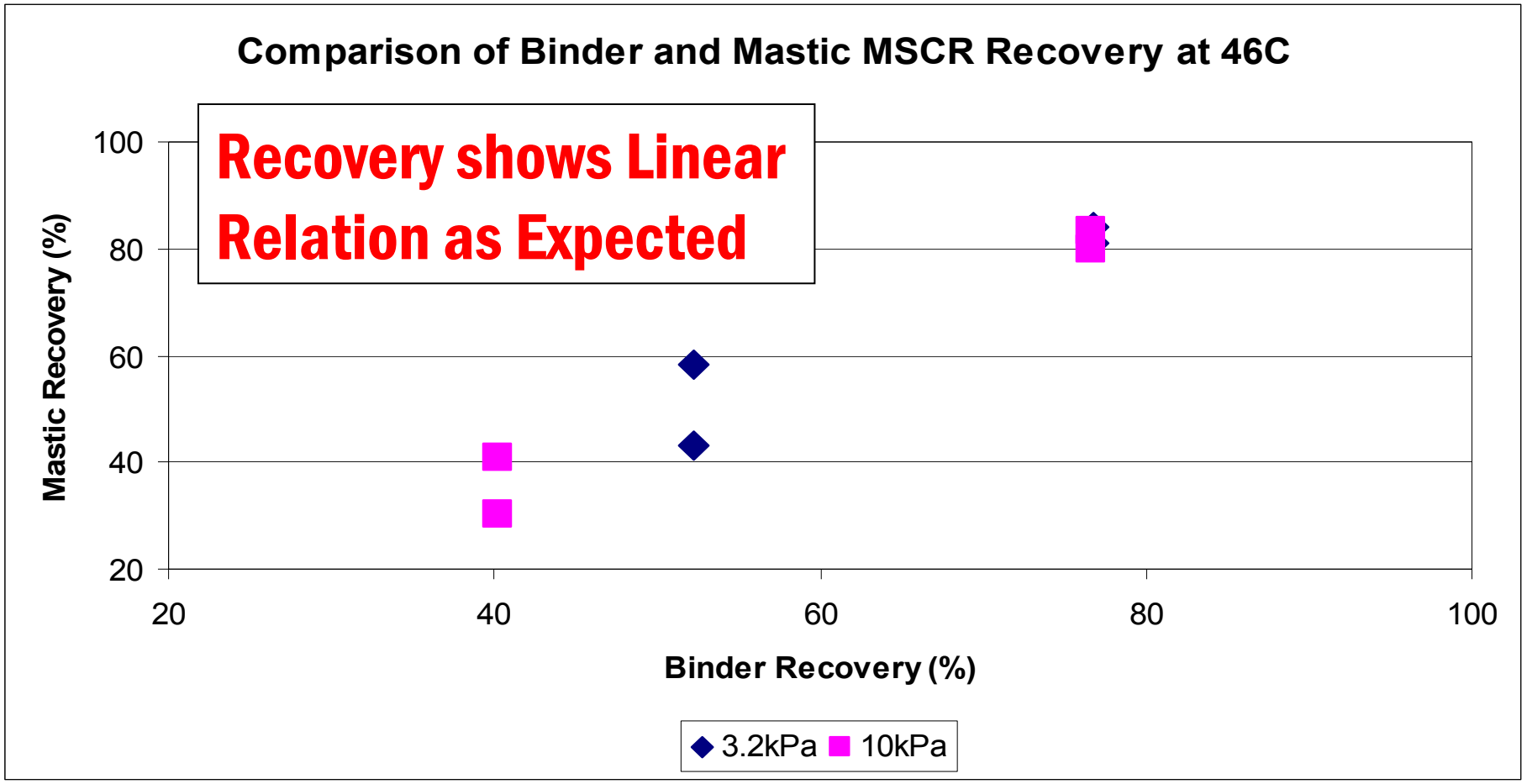
Binder ➔ Mastic Cont'd (% Recovery @ 64C)



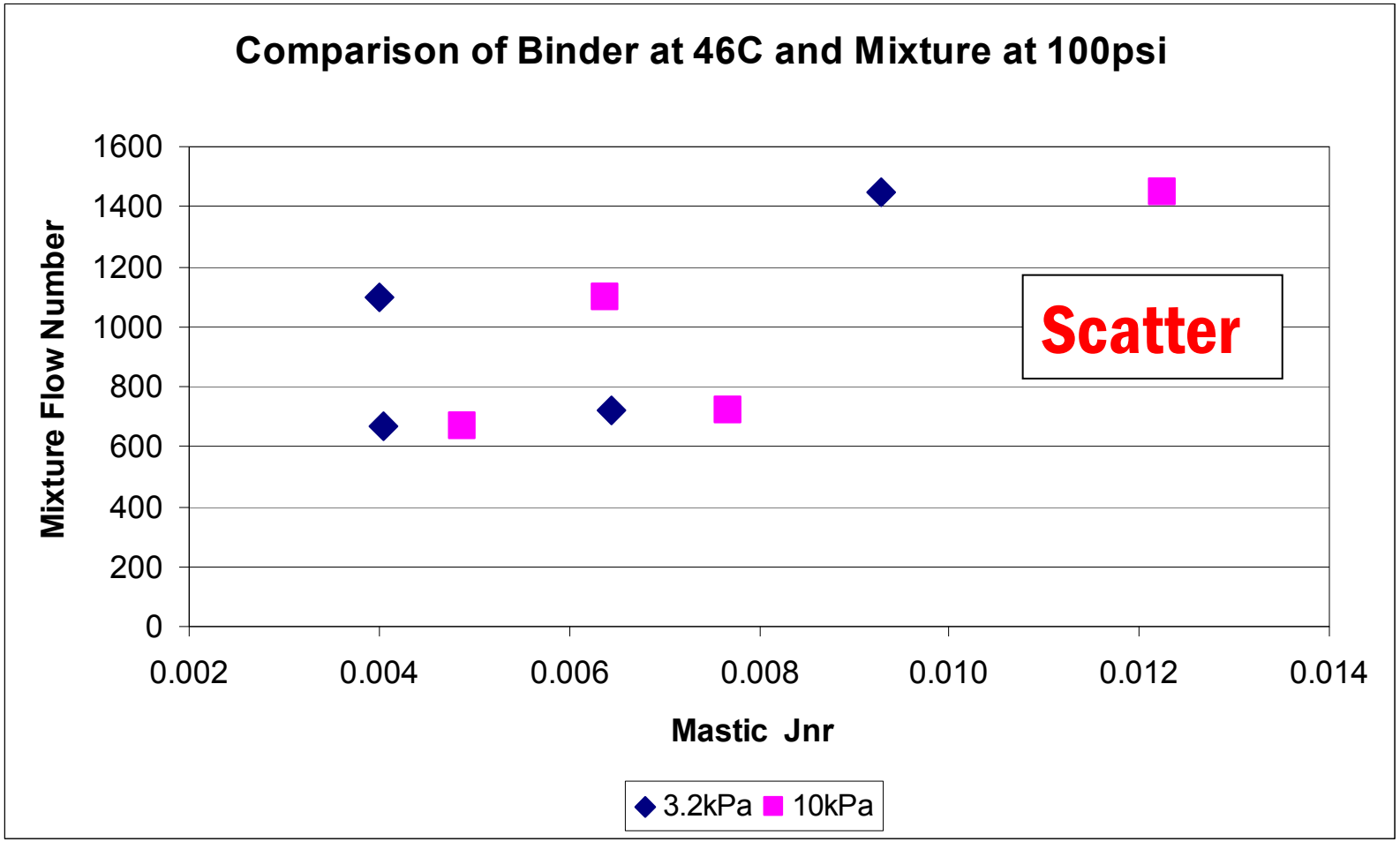
Binder → Mastic Cont'd (@ 46C)



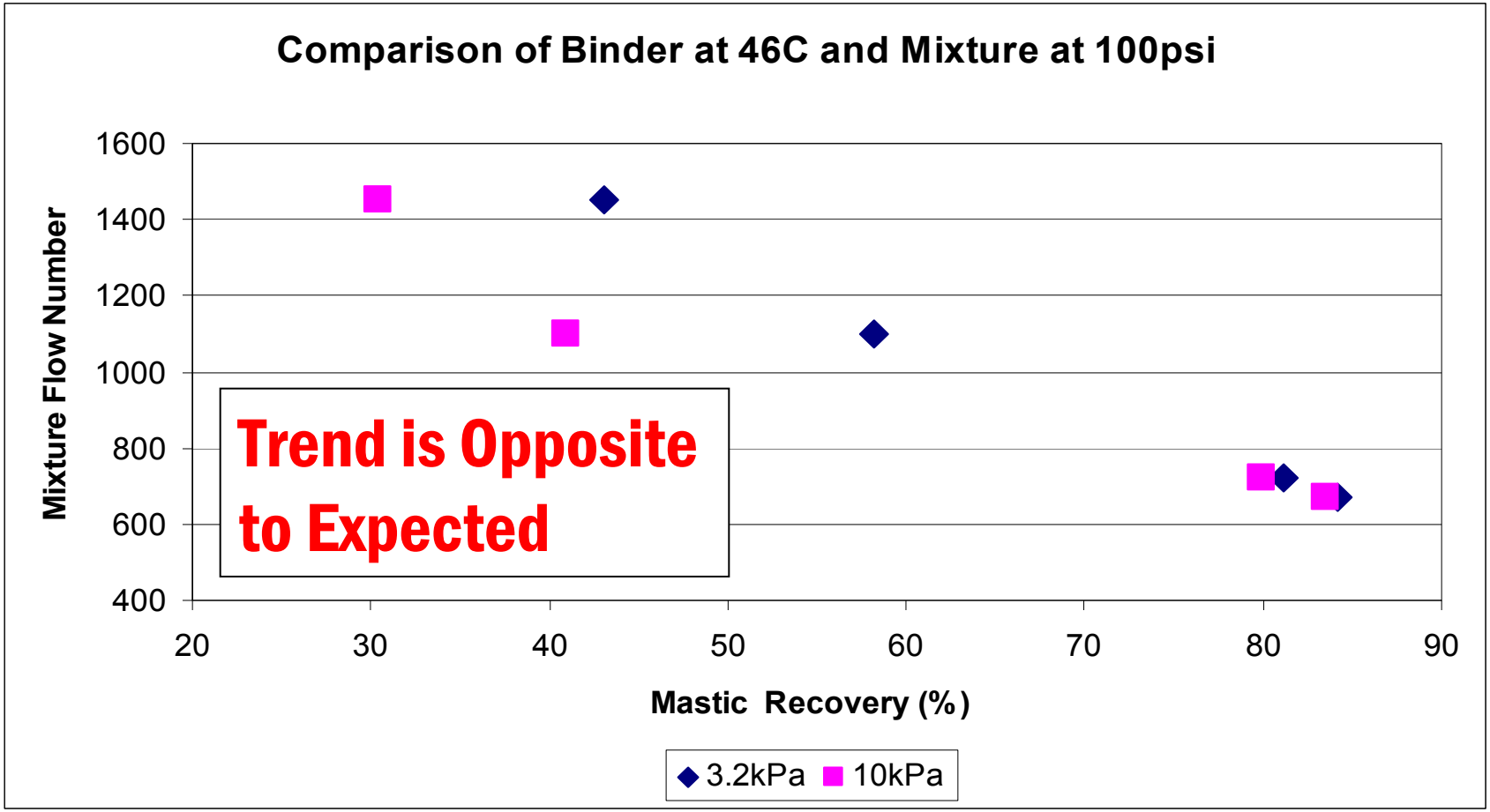
Binder → Mastic Cont'd (@ 46C)



Binder → Mixture (@ 46C)



Binder ➔ Mixture (@ 46C)



Findings

- The results show no stress sensitivity for the Jnr and Recovery
- Correlation of MSCR results and Mixture performance is Undetermined at this stage of testing.
- Binder type and Mineral fillers clearly influence Mastic and Mixture performance
- More testing is underway to better establish correlation between binder, mastic, mixture and field Performance.

Collaboration with WCTG

Database of Binder PG+ Performance

- Binders: **Provided by suppliers**
  - Different Modifications, and Grades
- PG+ results and Field Projects: **Provided by DOTs**
  - Identify paving project of future evaluation
- Goal: **Provided by UW-Madison**
  - Build database containing binder **PG+** results and **Field Performance** indicators.
  - Evaluation of PG+ tests in light of Field Performance

Collaboration with WCTG (Binder Testing)

- G* and δ (AASHTO M320)
- Toughness and Tenacity (ASTM D 5801-95)
- Elastic Recovery (AASHTO T301)
- MSCR (ASTM D7405)
  - Test at 2 temperatures
  - Test at 0.1, 3.2, and 10kPa
- Ductility (AASHTO T51)
- Direct Tension (AASHTO M320)

Replacing T301 (ER) with the DSR

Daranga et al, "Replacing the Elastic Recovery Test of Asphalt Binders with a DSR Test:
Development of Protocol and Relationship to Binder Fatigue"
Submitted to TRB 2010

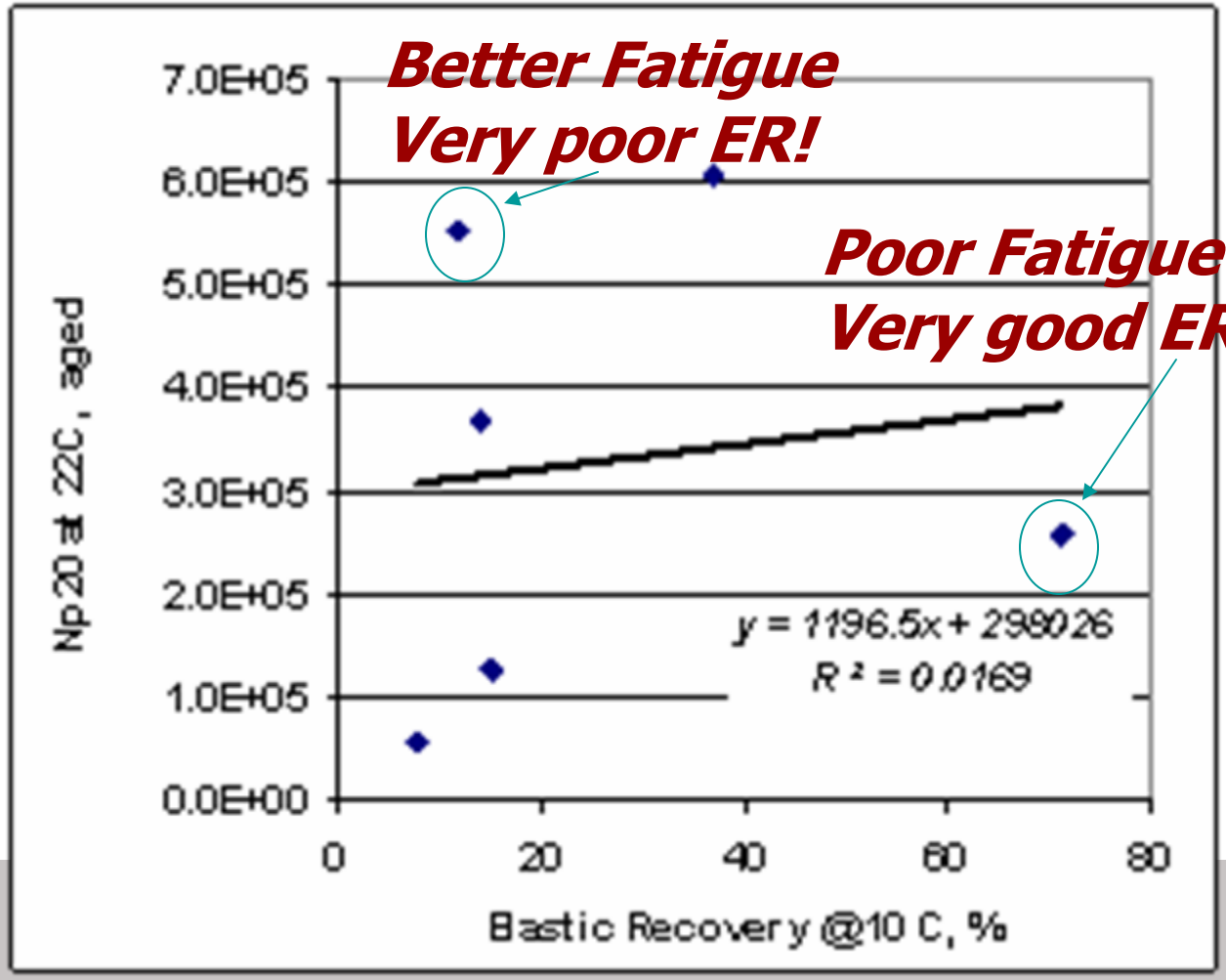
Motivation

- T301:
  - Inconsistent sample geometry
  - It is not clear what mixture property is targeted:
    - Fatigue? → Intermediate Temperature (25C)
    - Rutting? → Elongation recovery

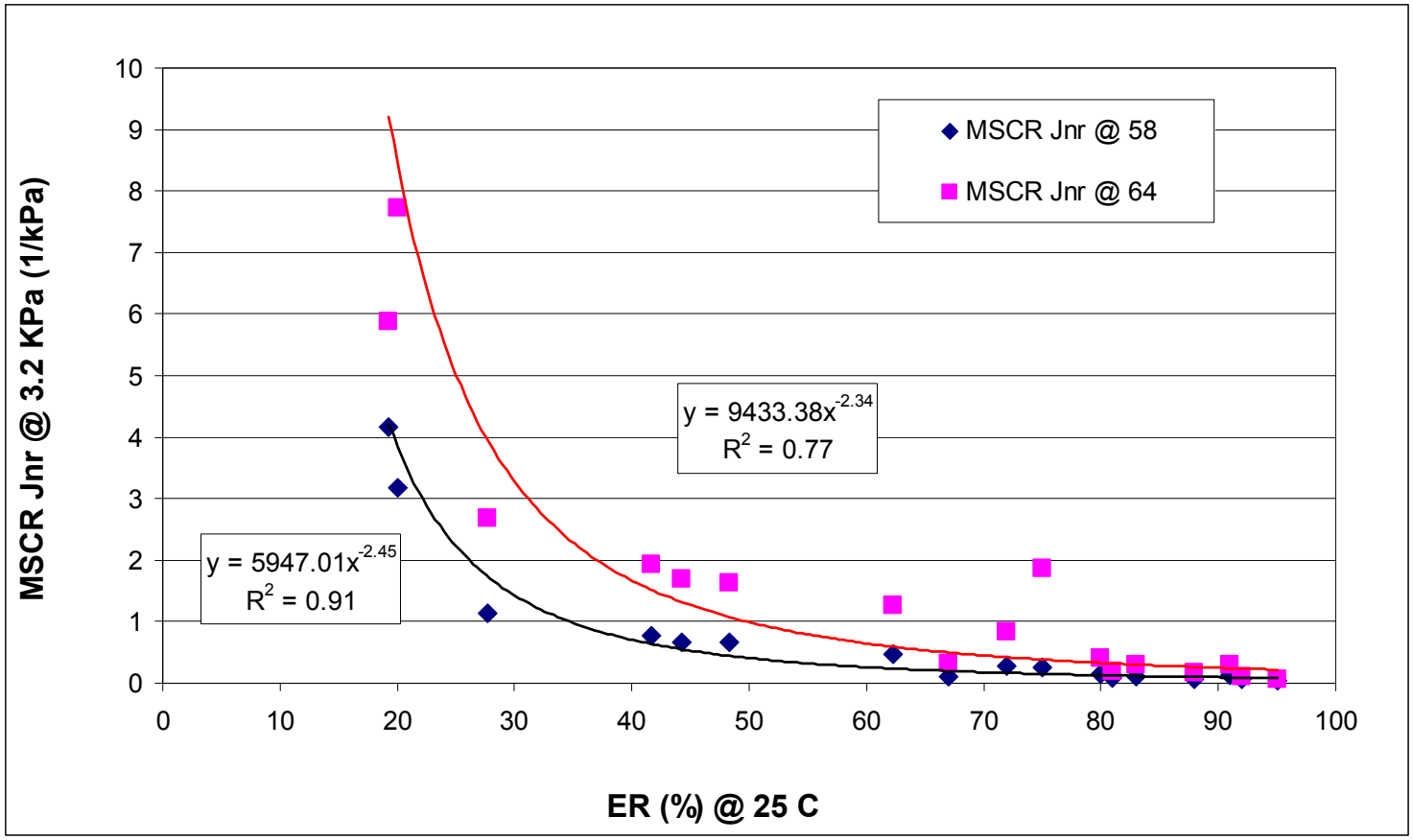
Is Elastic Recovery Important ? Binder Fatigue

do not Correlate with Elastic Recovery

Why Use Elastic Recovery?

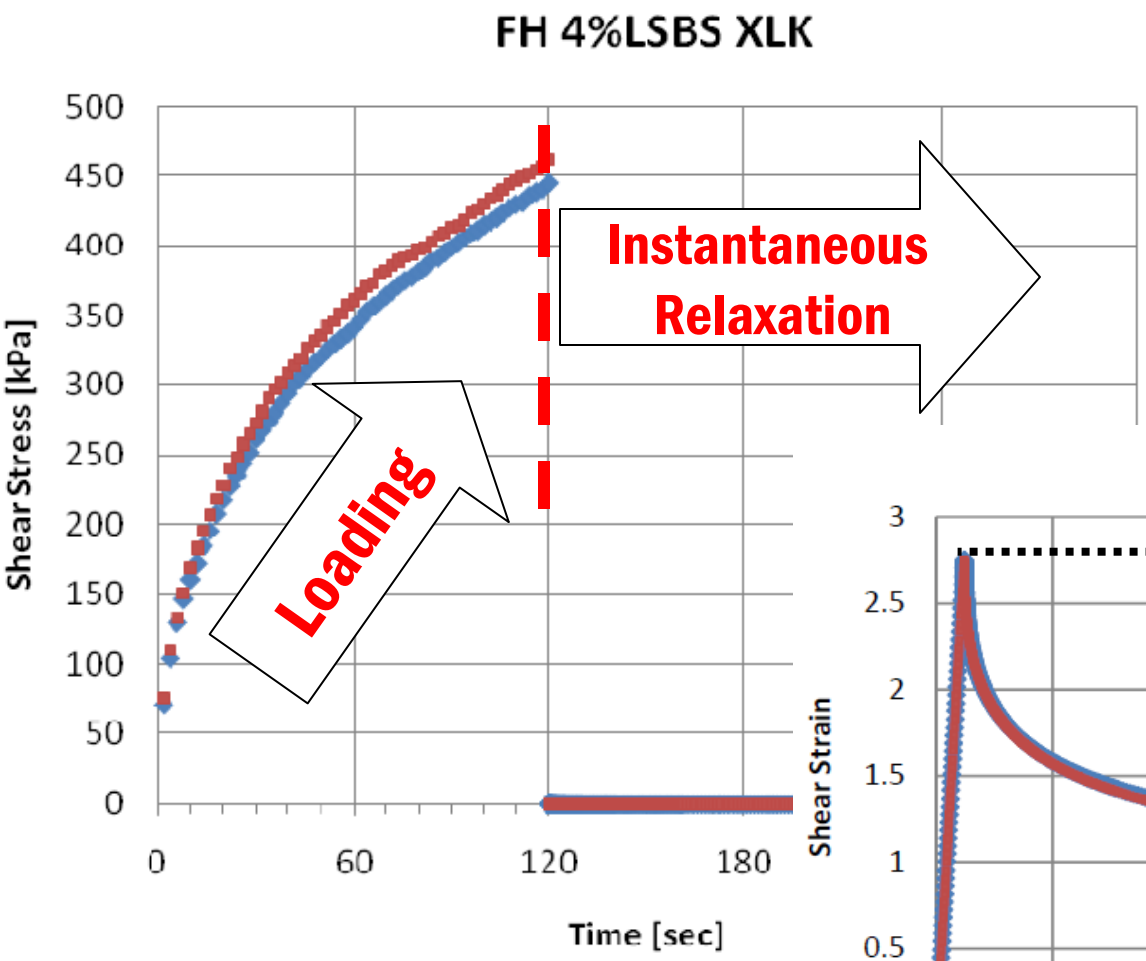


Is Elastic Recovery Important ? Binder Rutting Correlates with Elastic Recovery

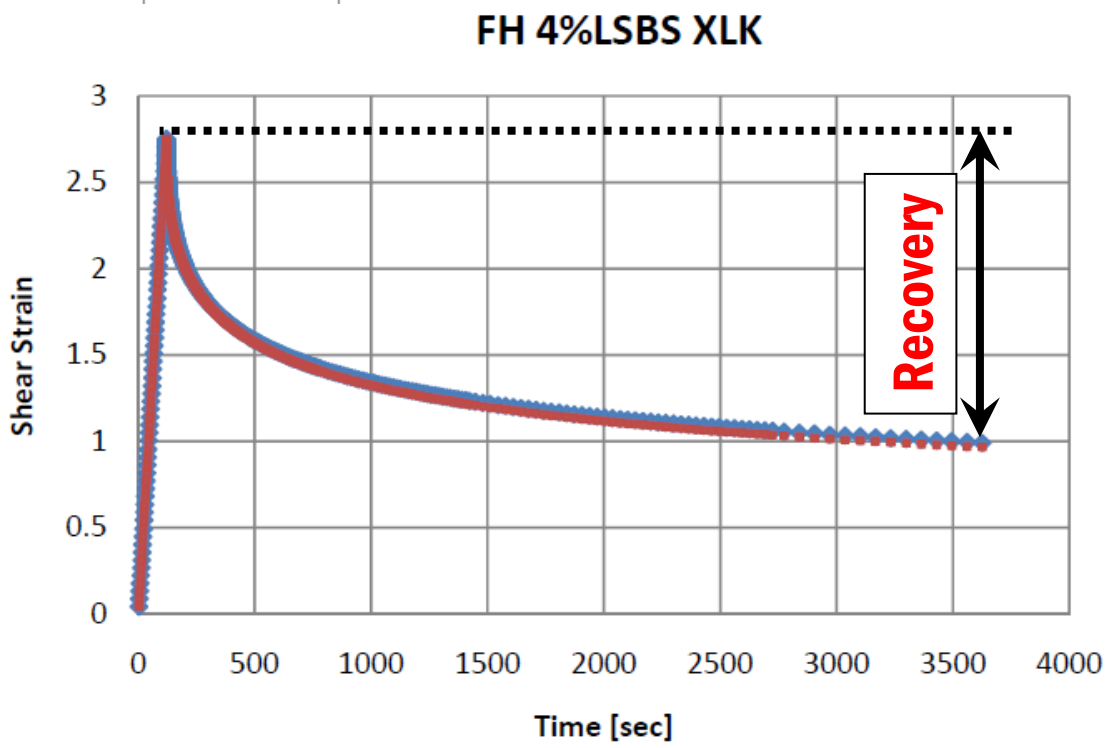


DSR Testing

- Measure elastic recovery using the DSR
- Strain Rate = 2.32%/Sec. Similar to AASHTO T301.
- Maximum strain = 278% based on 10cm elongation.
- All binders are PAV aged
- Tests at equal stiffness temperatures, G* = 18MPa
- The main difference between the two tests
  - DSR-run elastic recovery is performed in SHEAR,
  - AASHTO T301 procedure is run in Uniaxial Tension



Unlike T301, no pause before relaxation



Materials and Temperatures

All binders are tested at equal stiffness temperatures,

G* = 18MPa

Material	Grade	Temperature
Neat	PG64	21.3 °C
2%LSBS	PG70	24.6 °C
2%LSBS XLK	PG70	21.7 °C
4%LSBS	PG76	24.5 °C
4%LSBS XLK	PG82	21.9 °C
0.7%Elvaloy	PG70	22.9 °C
1.5%Elvaloy	PG76	21.7 °C
1%PPA	PG70	22.3 °C

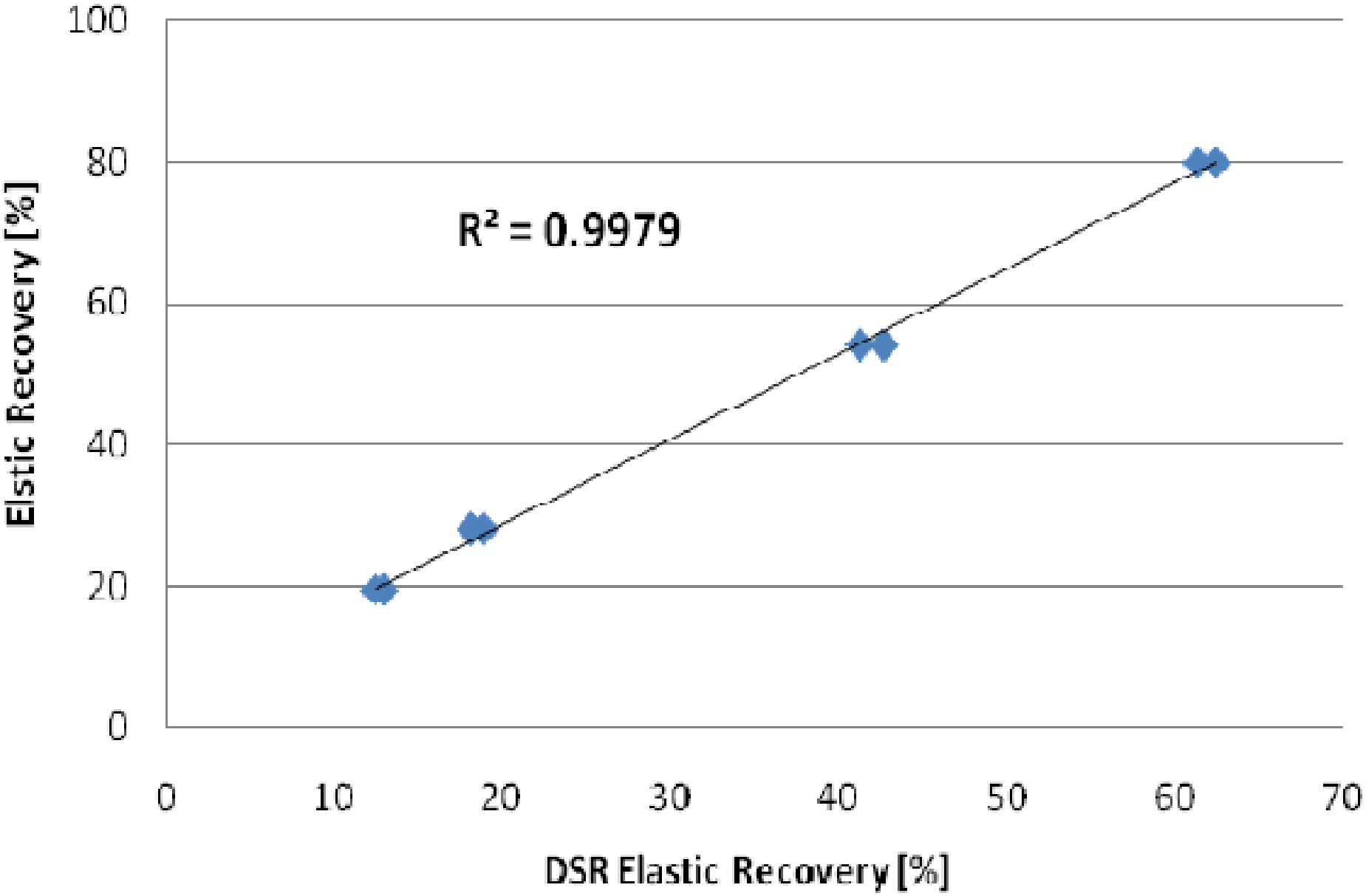
Results

Material	% recovery
Neat	24.77
2%LSBS	42.56
2%LSBS XLK	41.14
4%LSBS	53.47
4%LSBS XLK	63.93
0.7%Elvaloy	39.41
1.5%Elvaloy	48.18
1%PPA	29.61

The test seems to distinguish between different modifications

Validation

- A set of 4 binders modified with plastomers and elastomers.
- Tested using Standard T301 and new DSR elastic recovery
- Results compared to validate the concept


100
80
60
40
20
0
Elstic Recovery [%]
R² = 0.9979
0
10
20
30
40
50
60
70
DSR Elastic Recovery [%]

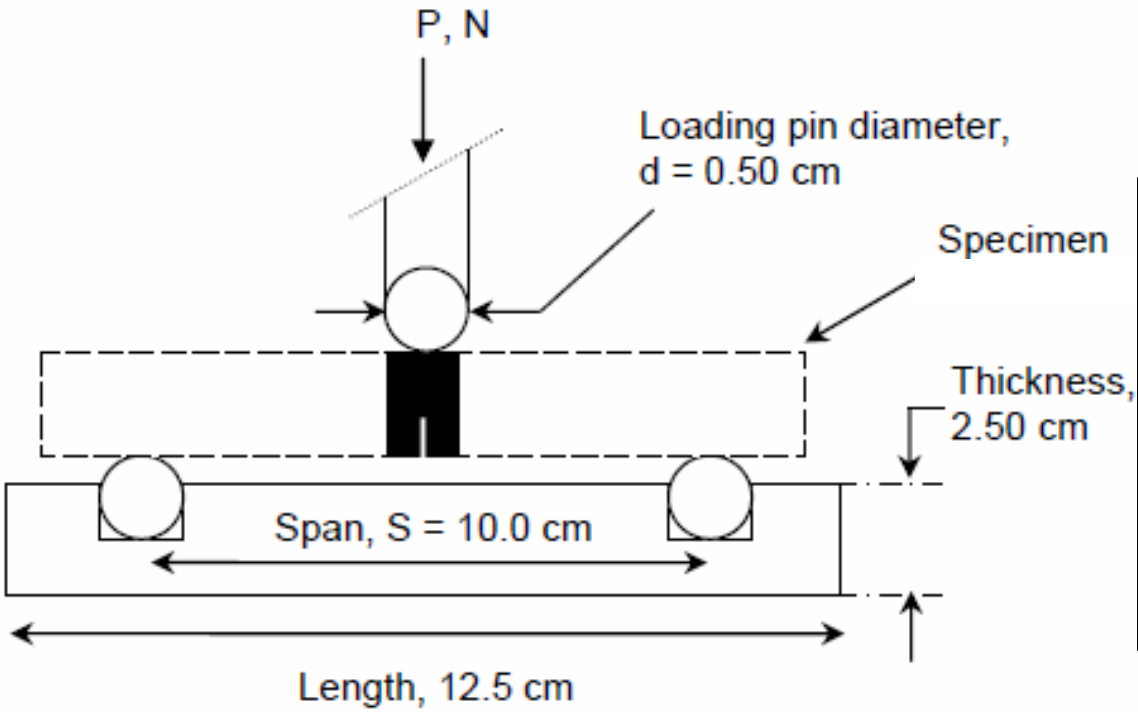
Advantages

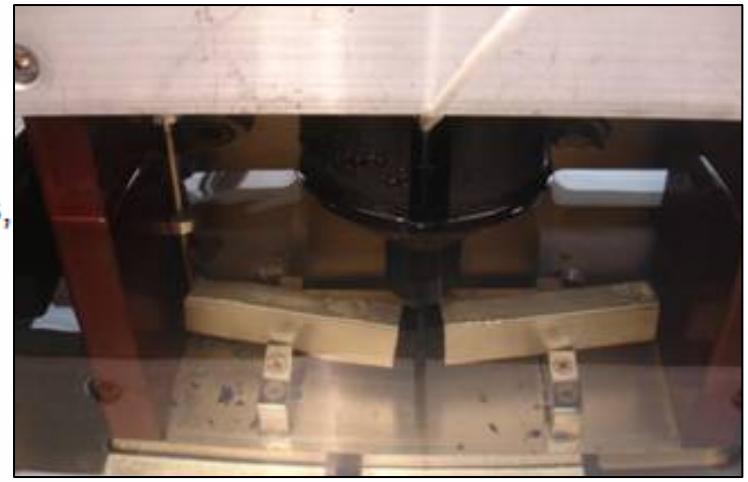
- Automated procedure
- Smaller sample size
- Quick and easy sample preparation
- Testing geometry stays constant throughout the test
- Temperature control is fast and accurate
- Strong correlation with T301

Low Temperature Testing

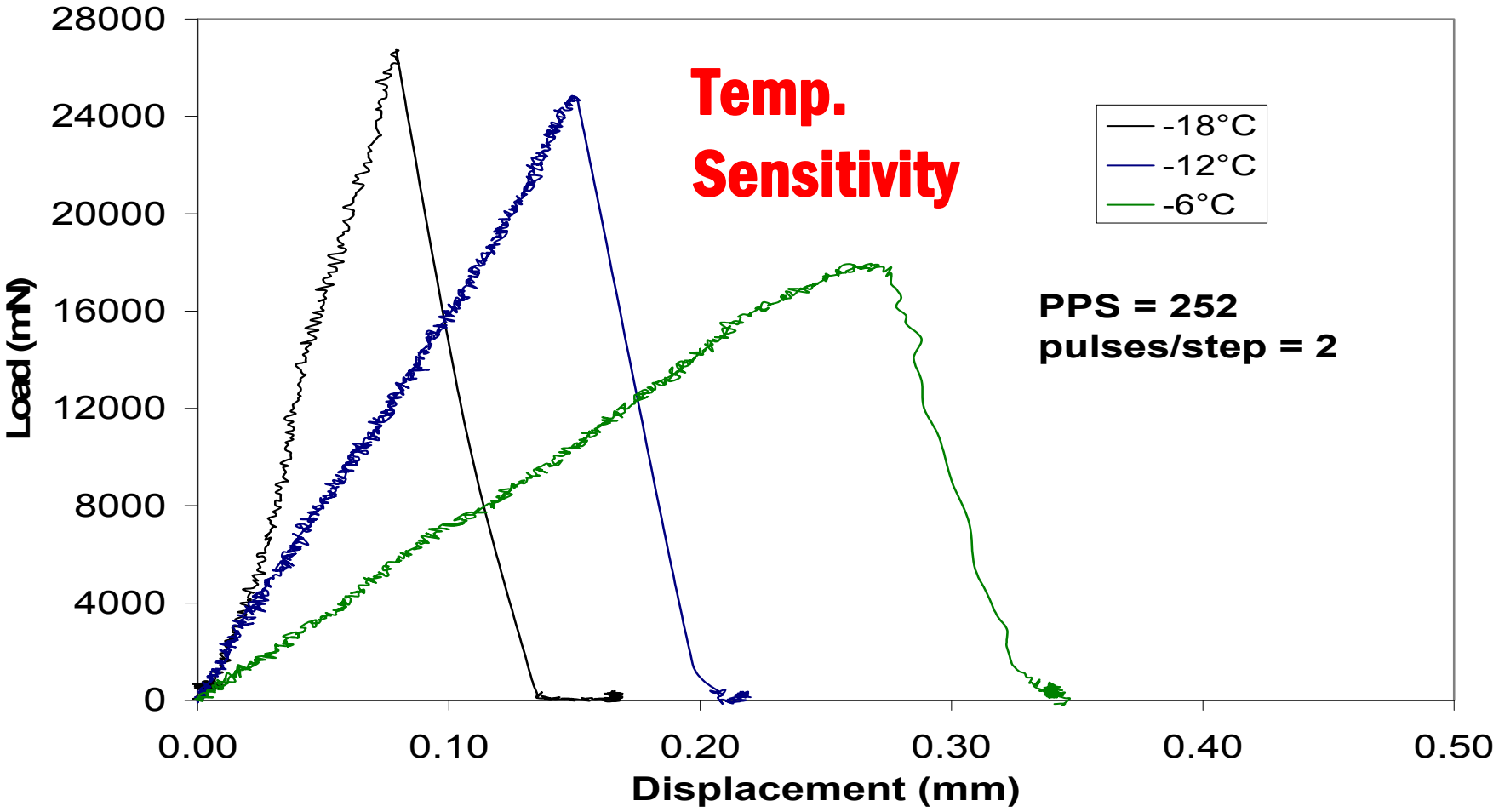
Fracture Tests

Single Edge Notched Bending Test (SENB)

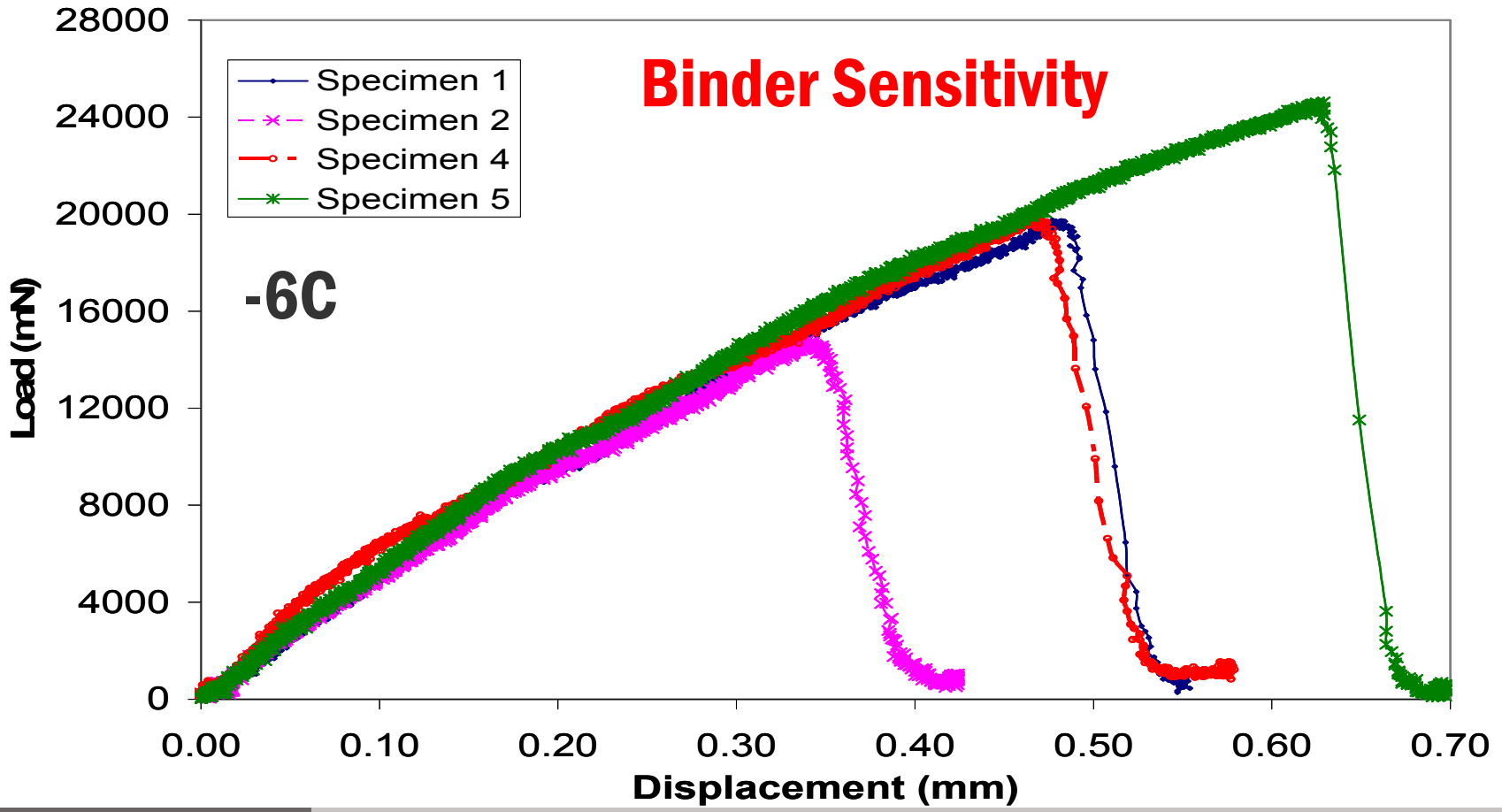




Test Development

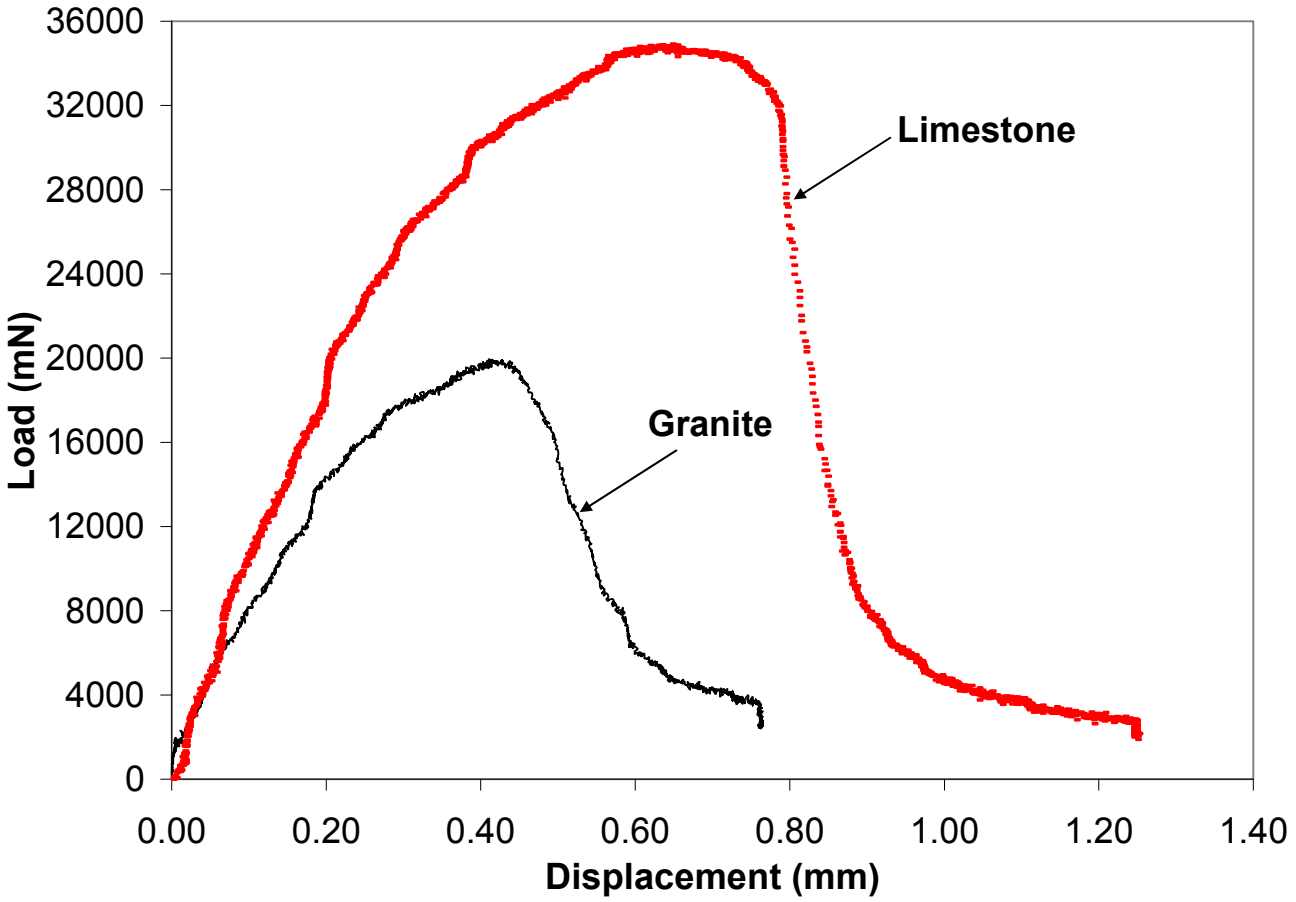


Test Development Cont'd



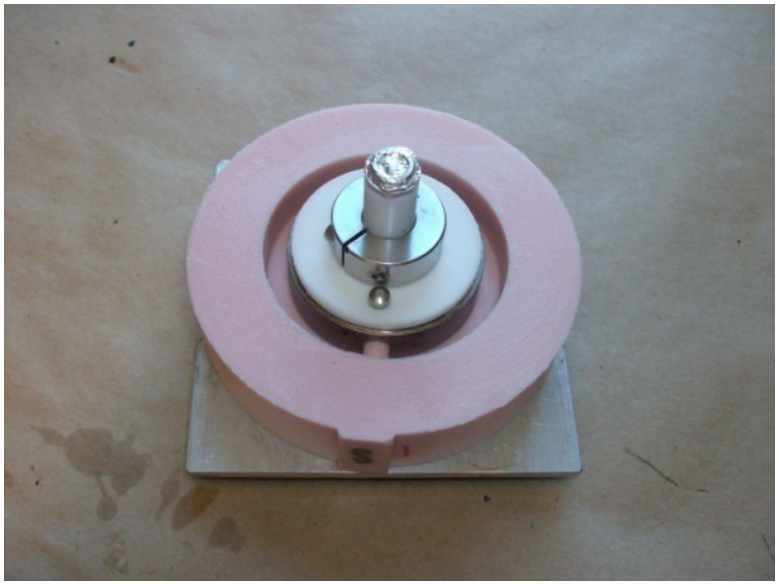
Test Development Cont'd

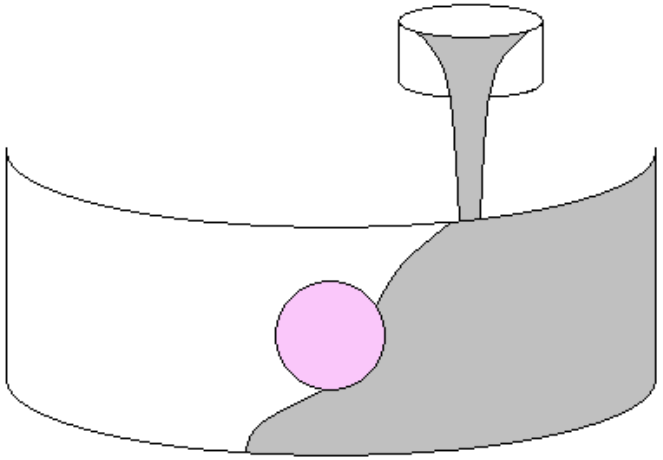
Material Sensitivity (Mastics)



Asphalt Binder Cracking Device (ABCD)

- A ring shaped asphalt specimen
- Exposed to a decreasing temperature profile





ABCD 1.1

Asphalt Binder Cracking Device, EZ Asphalt Technology LLC.

Project Name: ABCD Ruggedness | Sample ID: | Cooling Rate (deg C/HR): 20 | Operator: | 8/11/2008 | 2:11:14 PM

DAQ Configuration | Temperature Profile | ABCD Data Strip Chart

Temperature Profile

Modify Profile

Manual Operations

Get Temperature

25 Deg C

Set Temperature Set Point

25 Deg C

Amb Temp	Set Point 1	Set Point 2	Set Point 3	Set Point 4	Set Point 5
22.5	0	-60	25	25	25

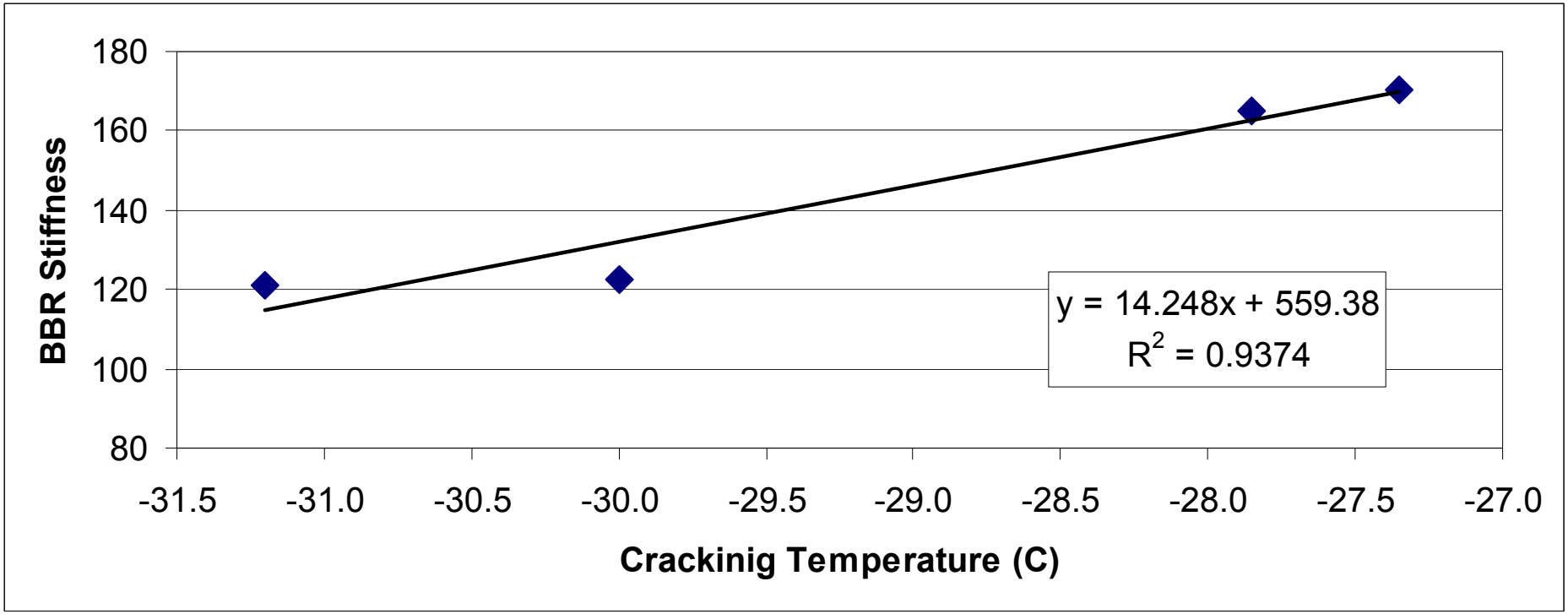
Time Start	Time Span 1	Time Span 2	Time Span 3	Time Span 4	Time Span 5
0	0.5	3	0	1	0

Message

Comment: Comment Here | File Path:

Start Data Collection Only | Begin Temperature Profile and Data Collection | Quit Program

Correlation with BBR



Findings

- SENB and ABCD show good potential.
- Further development in the SENB is required.
- Both tests will be correlated with Mixture Performance as part of the ARC

Summary and Future Plan

- MSCR is a good test
- Details to be worked on:
  - What is the stress level needed
    - 0.1 KPa is not needed
    - 3.2 KPa is a good start
    - 10.0 KPa could be needed
  - Is elasticity required?
    - Need validation
    - Need to justify limits

Summary and Future Plan Cont'd

- DSR Elastic Recovery shows Potential
- Details to be Worked on:
  - Correlation to Binder performance (Fatigue and/or Rutting)
  - Finalize testing protocol
  - Validate test with mixture performance

Summary and Future Plan Cont'd

- Low Temperature Fracture Tests are needed.
- Details to be worked on:
  - Finalize testing protocol for SENB
  - Correlation to Mixture performance

How can ARC work with RMAUPG?

- Provide information about where the binders will be used (location, traffic, mix design , etc.)
- Provide loose mixtures to test at UW
- Identify good and bad performing sections
- Provide binders for WCTG with various grades and modifications

Thank You

Acknowledgments

- Work is part of ARC, FHWA and WRI support is greatly appreciated
- The research team deeply appreciates the support from WCTG and RMAUPG
- Bloom Companies is not a part of ARC, but a subcontract is under consideration with UW.

Questions?

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