# Advancements in Characterization of Polymer Modified Asphalts

Hussain Bahia and Codrin Daranga
***The University of Wisconsin-Madison, USA***

Kitae Nam
***The University of Washington, Pullman, USA***

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# Outline

- Need for Modified Asphalts
- Are modified asphalts better than conventional asphalts
- Limitations of ASTM and Superpave technologies
- New procedures for evaluating polymer modified asphalts
  - Rutting Resistance – MSCR test
  - Fatigue Resistance
- Final Remarks

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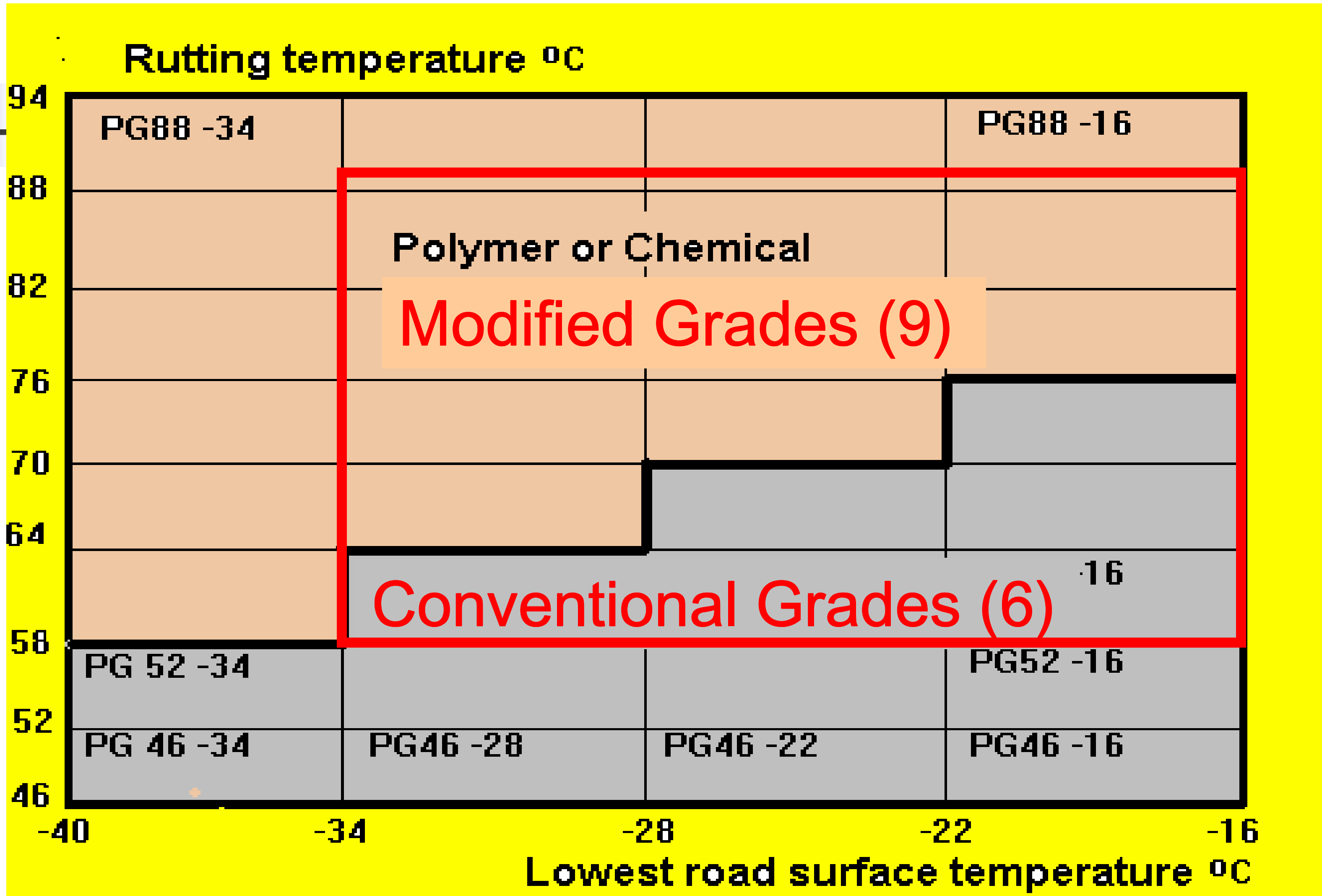
# The Need for Asphalt Modification

- Limitations of Oil Refining Practice
  - Asphalt is only one of many products
  - Little incentive to improve quality
- Physical Nature of Asphalt
  - Very sensitive to temperature
  - Soft at high temperature /Brittle at low temperatures
- Increased heavy traffic (trucks) volumes
- Some Premature Pavement Failures

# The Need for Modified Asphalts



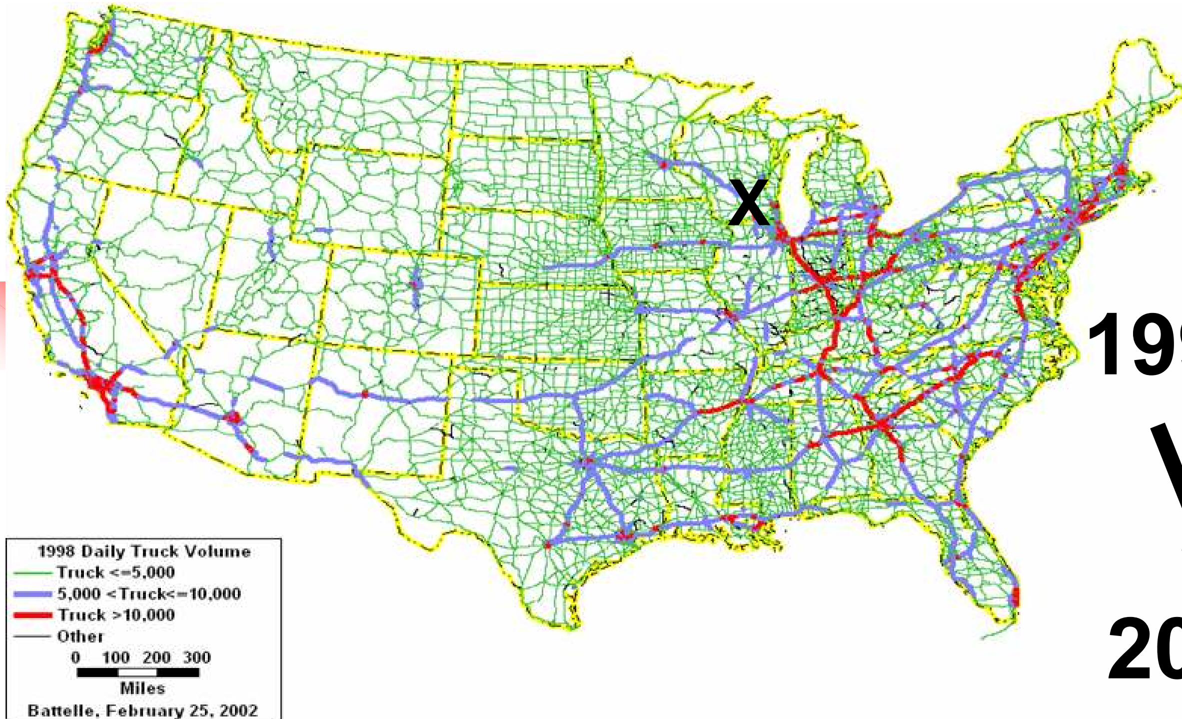

**32 PG grades, 15 Widely used, 9 Modified**

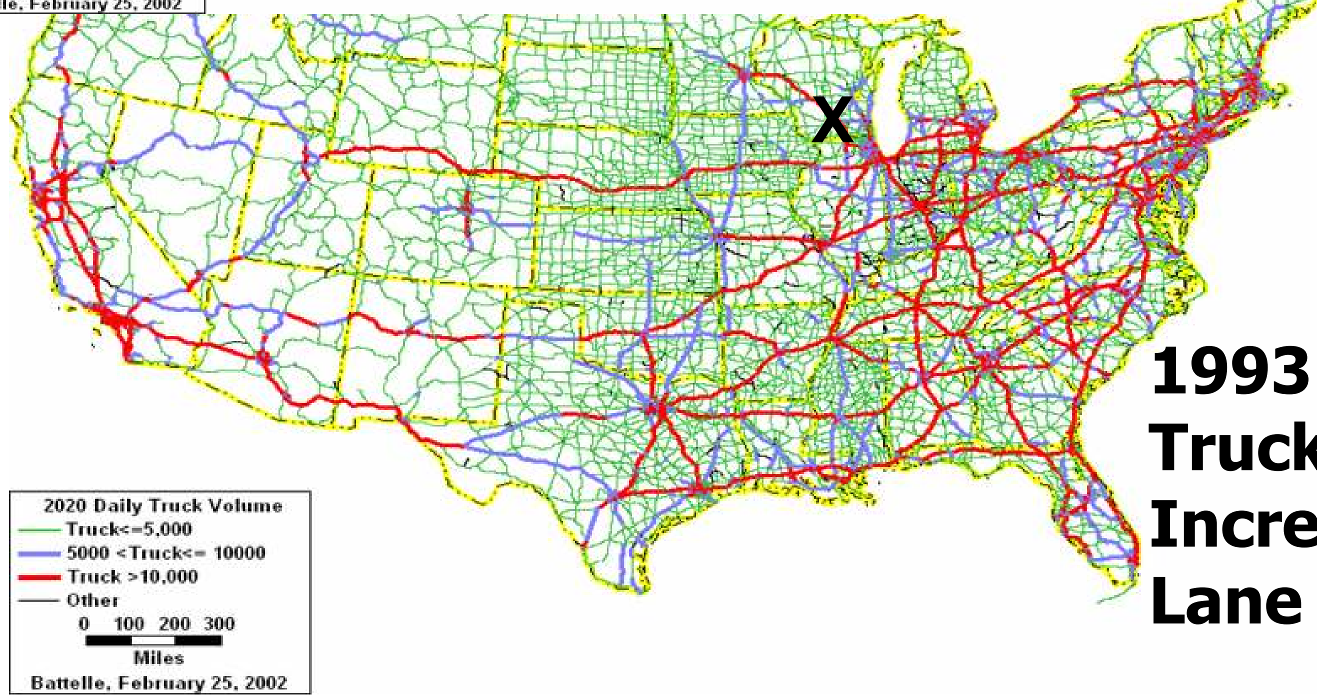
# *Expected growth of truck traffic on the National Highway System.*

*Source: FHWA office of asset management.*

1998

2020




**1993 -2002 Truck Traffic Increased by 33%, Lane miles by 2%**

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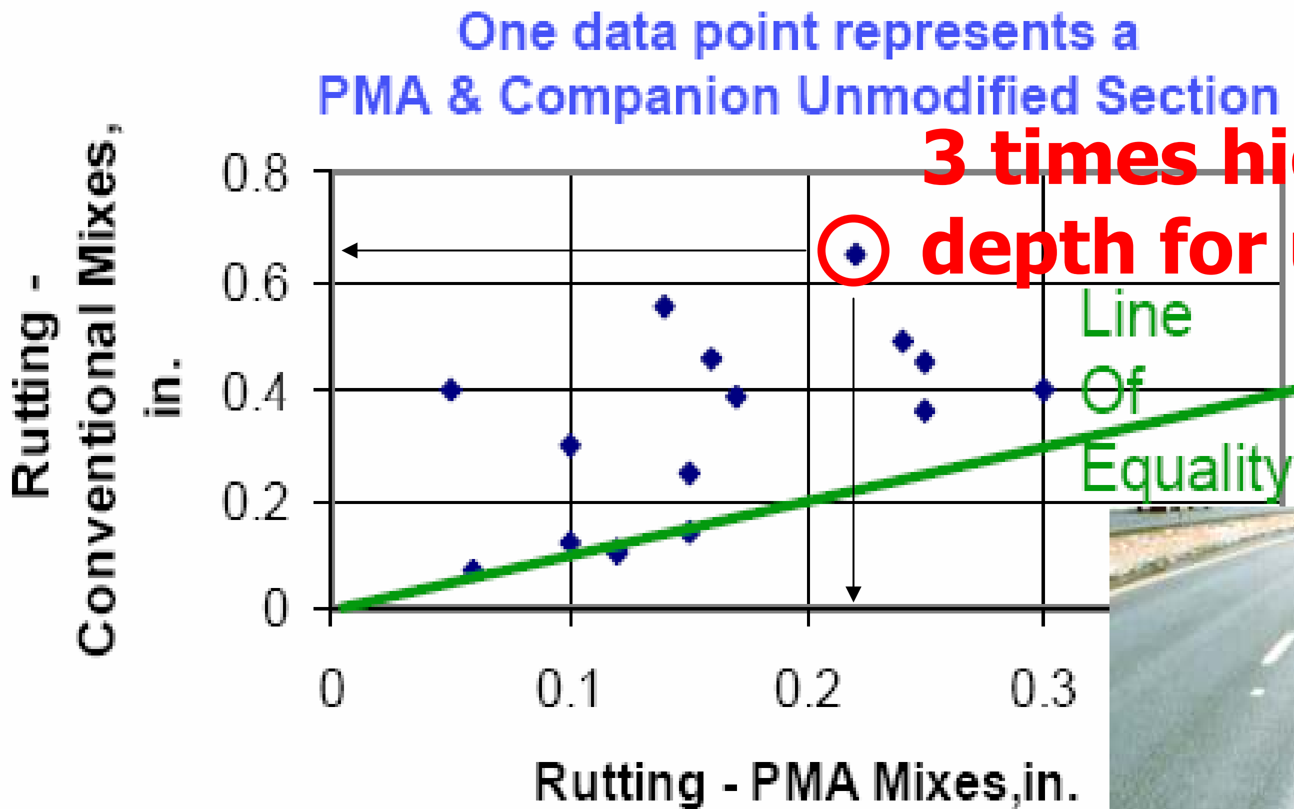
# Enhanced Performance of HMA by Use of Polymer Modification

***(H. Von Quintus – AMAP Meeting 2/2004***

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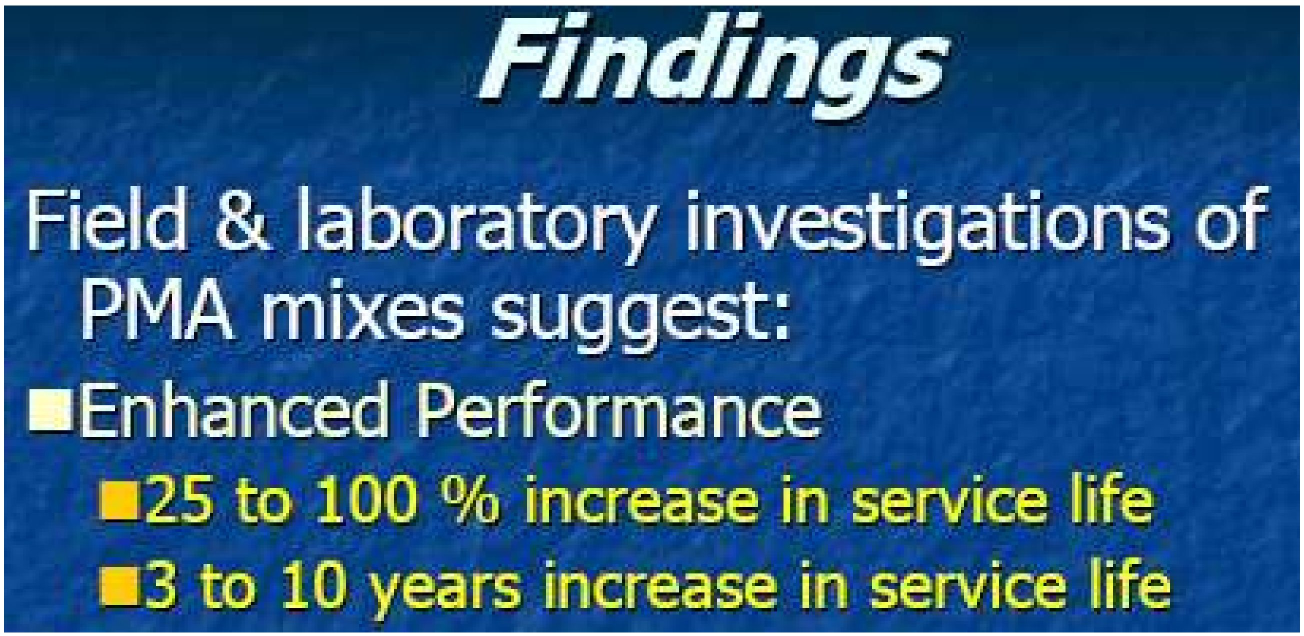

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# Specifications & Tests of Modified Bitumen / First Generation

- AASHTO-AGC-ARTBA-~ 1990- Task Force 31 - Polymer Modified Asphalts
  - ASTM Standards:
    - Table 1 - Styrene Block Copolymers
    - Table 2 - Styrene Butadiene Rubber Latexes or Neoprene Latex
    - Table 3 - Ethylene Vinyl Acetate or Polyethylene

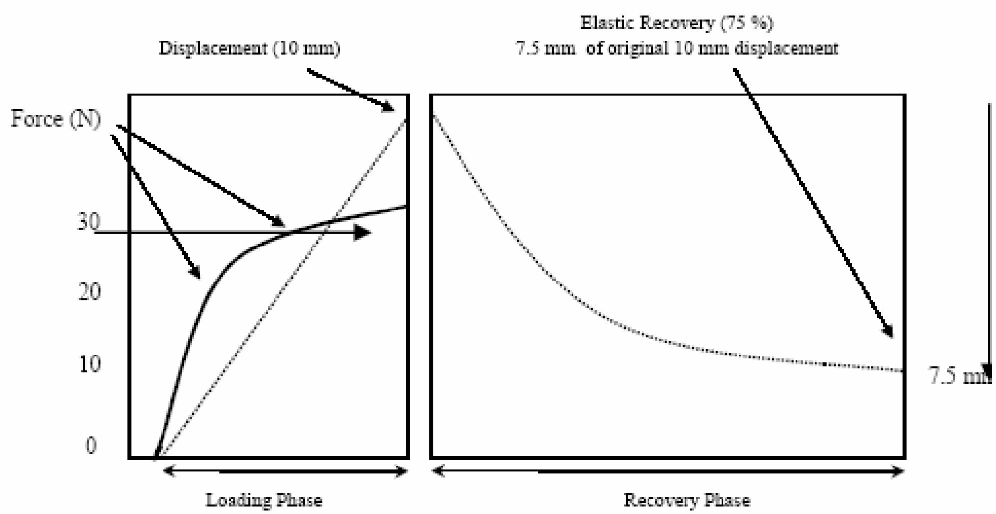
# First Generation Specifications Pre- PG grading

- Task Force 31: Polymer Modified Asphalts- Table 2
- ***Styrene Butadiene Rubber Latexes or Neoprene Latex***

| | | 2-A | 2-B | 2-C |
|---|---|---|---|---|
| **Penetration, 77 F, 100 g, 5 sec** | **min** | **100** | **70** | **80** |
| **Viscosity, 140 F, Poises** | **min** | **800** | **1600** | **1600** |
| **Viscosity, 275 F, cSt** | **max** | **2000** | **2000** | **2000** |
| **Ductility, 39.2, 5 cpm, cm** | **min** | **50** | **50** | **25** |
| **Flash Point, F** | **min** | **450** | **450** | **450** |
| **Solubility, %** | **min** | **99.0** | **99.0** | **99.0** |
| **Toughness, 77 F, 20 ipm, in-lbs** | **min** | **75** | **110** | **110** |
| **Tenacity, 77 F, 20 ipm, in-lbs** | **min** | **50** | **75** | **75** |
| ***RTFOT or TFOT Residue*:** | | | | |
| **Viscosity, 140 F, Poises** | **max** | **4000** | **8000** | **8000** |
| **Ductility Retention, 39.2 F, 5cpm, cm** | **min** | **25** | **25** | **8** |
| **Toughness, 77 F, 20 ipm, in-lbs** | **min** | **-** | **-** | **110** |
| **Tenacity, 77 F, 20 ipm, in-lbs** | **min** | **-** | **-** | **75** |

# Elastic Recovery- Questionable Value

## *USA Ductility & Australian Elastometer*



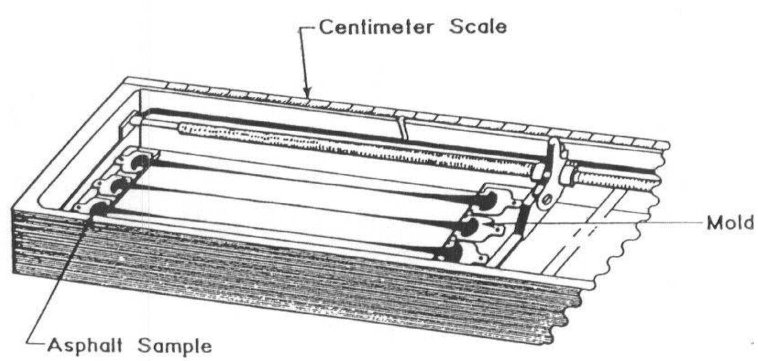




Figure 2–19. Ductility Test

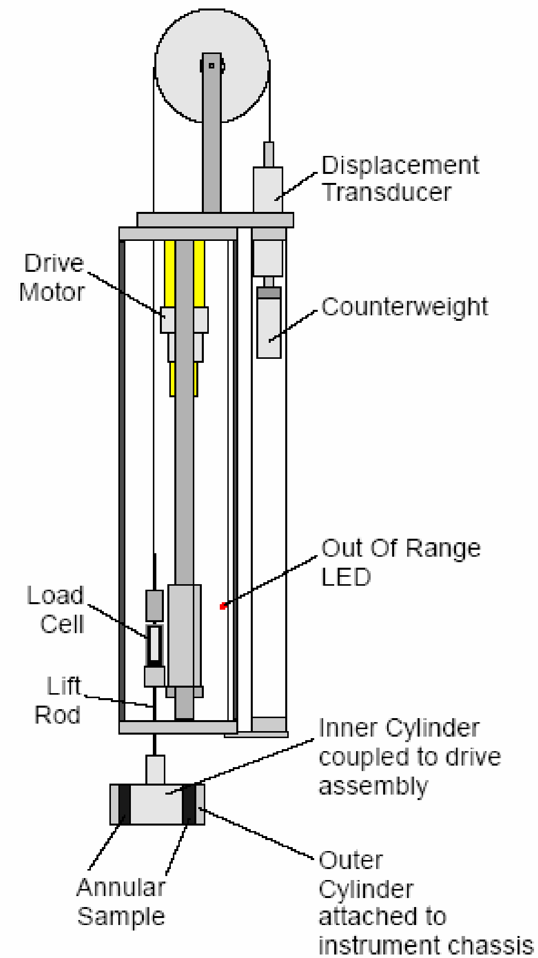
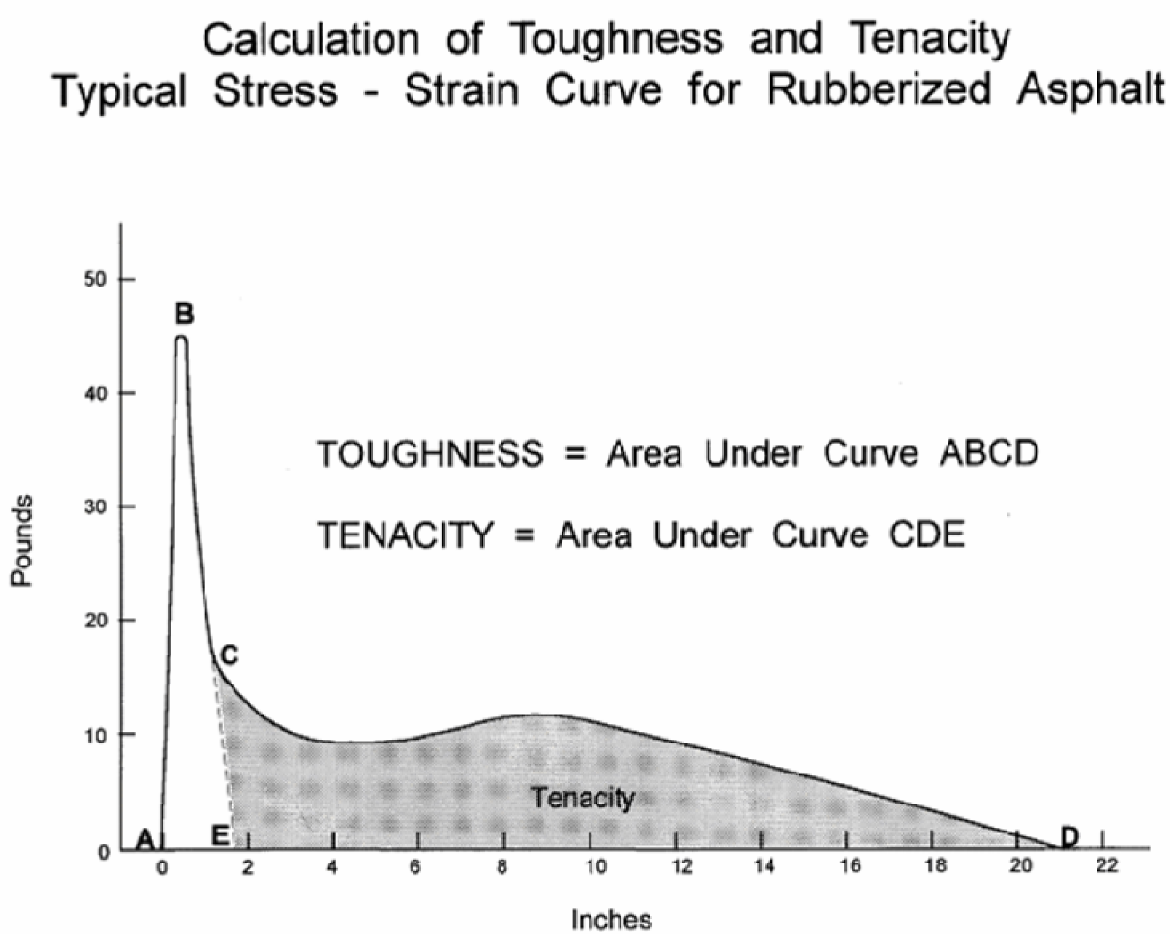
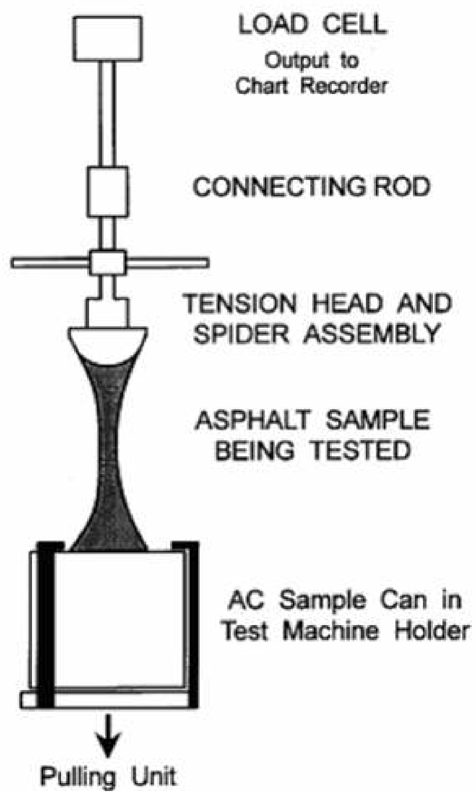



Fig. 1 Schematic of Elastometer.

# Toughness and Tenacity
# Not very scientific!



# Elastic Recovery – Many Different Methods
## (MD, NJ, NY, RI, PA & Port Authority)

| Specs | AASHTO T301 | ASTM D6084 | LC25-005 Quebec | ASTM D6084 PennDOT | ASTM D6084 NJDOT | ASTM D6084 Mod.AASHTO T301 - NY |
|---|---|---|---|---|---|---|
| Sample Elongation | 200 mm | 100 mm +/- 25mm | 200 mm | 100 mm +/- 25mm | 2 in/min | 100 mm |
| Sample Hold Time | 5 min | Immediately Cut | 5 min | Immediately Cut | 90 min | None |
| Relaxation Time | 1 hour | 1 hour | 1 hour | 1 hour | 1 hour | 1 hour |
| Min. ER | | | 40% & 60% | 60% | 50% | 60% |
| Test Temp. | 25 °C Standard | 25 °C Standard | 10 °C | 25 °C Standard | 25 °C | 25 °C |
| Clips | Straight | Straight | Straight | Straight | As per ASTM | T301-95 or 99 (as noted) |

*Mooney – NEAUPG Meeting 2005*

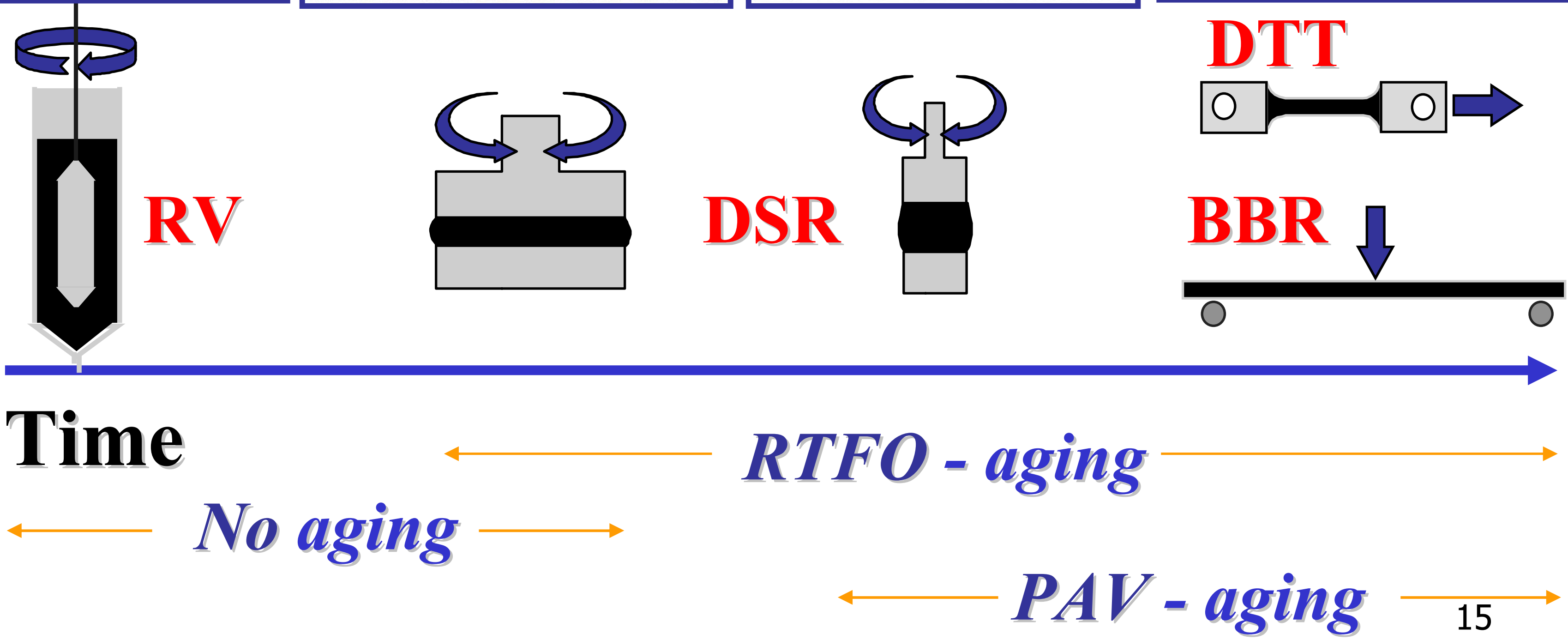
# *Second Generation –*
# *SHRP - Superpave Technology*

***Production***

***Rutting***

***Fatigue Cracking***

***Thermal Cracking***



# Is Superpave Applicable to Modified Asphalts ?

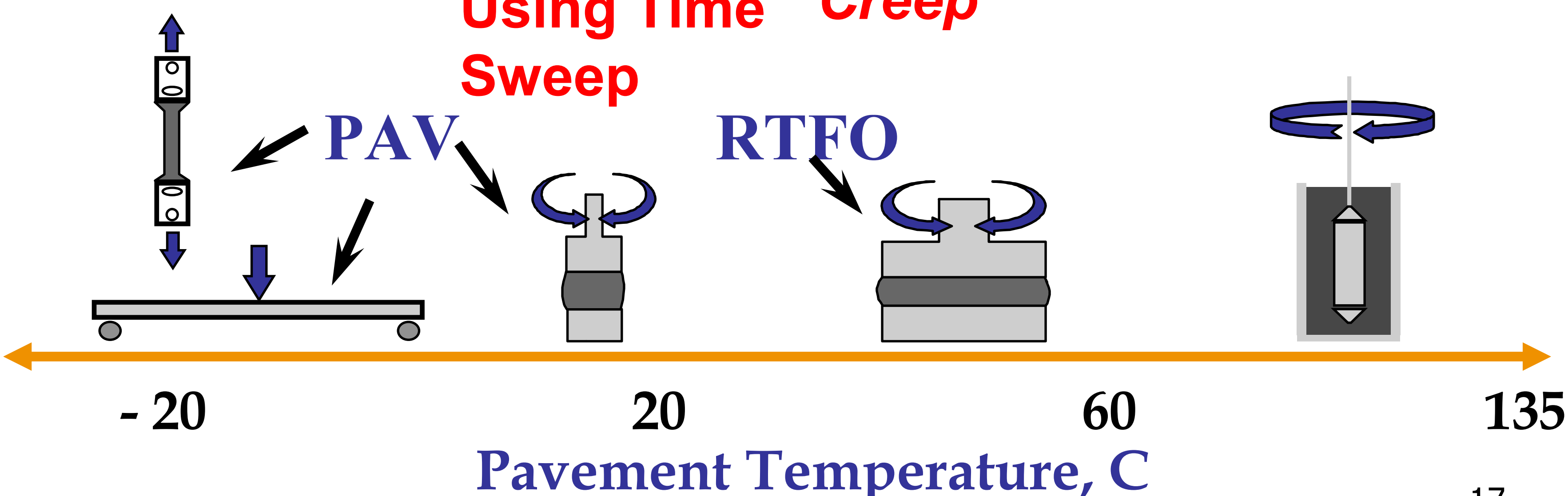
- Superpave Plus specifications
- NCHRP 9-10 – 1996- 2000
  - $G^*$ & $\sin\delta$ do not accurately characterize the rutting and fatigue performance of modified binders
  - Creep and Recovery , binder fatigue were proposed for testing modified binders

# Third Generation
# Measuring Damage Resistance

| Thermal Cracking | Fatigue Cracking | Permanent Deformation | (mixing & compaction) |
|---|---|---|---|

**2. Binder Fatigue Resistance Using Time Sweep**

***1. Binder Rutting Resistance Using Repeated Creep***



| Binder ID | PG Grade | Modification |
|---|---|---|
| C5 | PG 58-28 | - |
| B9 | PG 58-34 | Elvaloy |
| D4 | PG 58-34 | SBS |
| B7 | PG 58-40 | Elvaloy |
| C4 | PG 64-22 | SBS |
| A3 | PG 64-28 | SBS |
| B2 | PG 64-28 | Elvaloy |
| D1 | PG 64-28 | SB |
| B5 | PG 64-34 | Elvaloy |
| D2 | PG 64-34 | SB |
| D5 | PG 64-40 | SB |
| A1 | PG 70-28 | SBS |
| B4 | PG 70-28 | Elvaloy |
| C2 | PG 70-28 | SBS |
| B8 | PG 70-28 | Elvaloy |
| D6 | PG 70-34 | SB |
| B3 | PG 76-28 | Elvaloy |
| C6 | PG 76-28 | SBS |
| B6 | PG 76-34 | Elvaloy |

Study for WI-DOT included 19 Binders

1 no additive

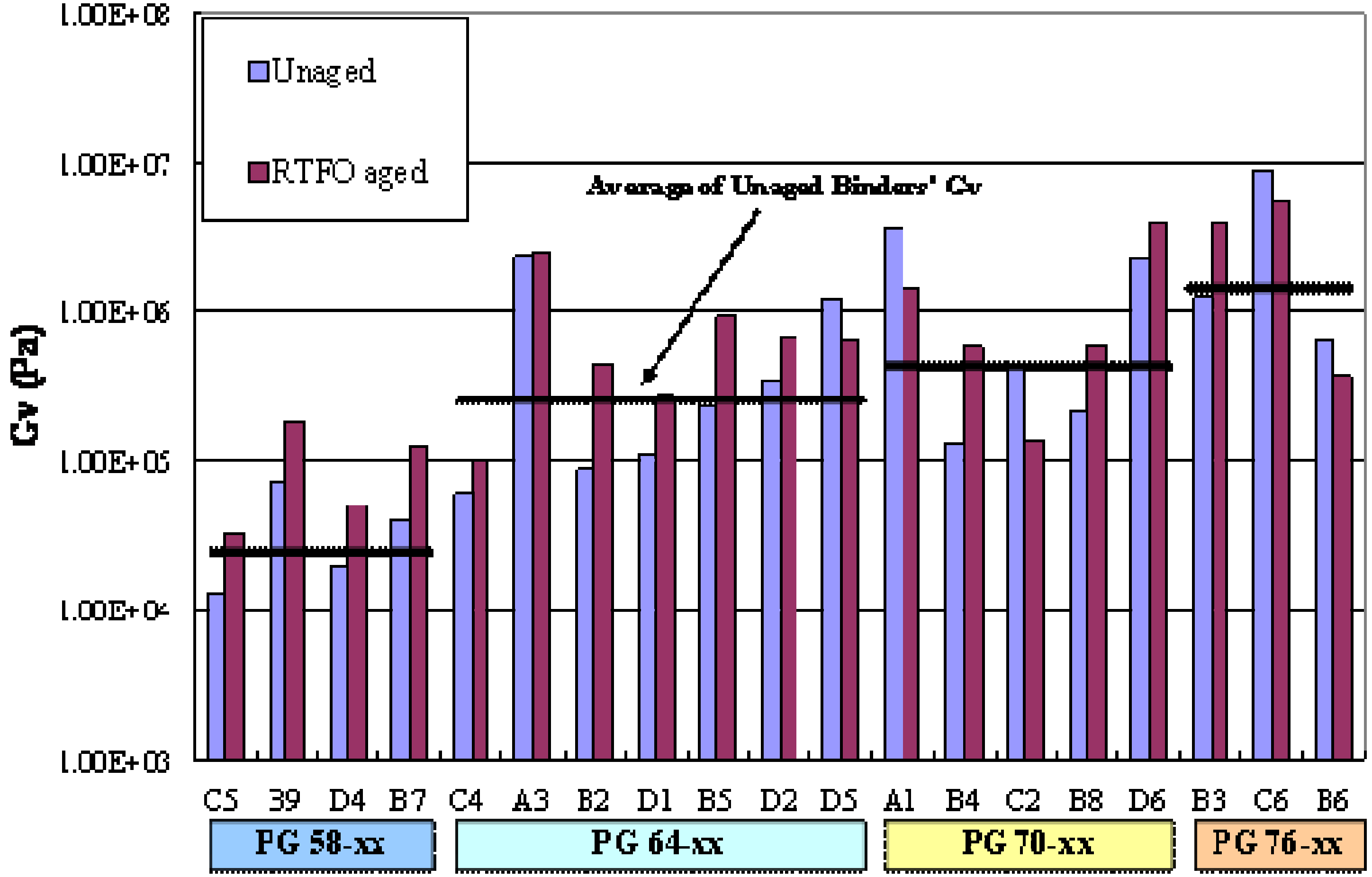
***4 With SB***

***6 With SBS***

***8 with Elvaloy***

# Effect of Additives
# A,C= SBS, B=Elvaloy, D= SB

*Higher Gv= Better resistance to rutting*



# Binder Fatigue

## *Third Generation Tests*

***Modified***
***And***
***Conventional***
***Binders***

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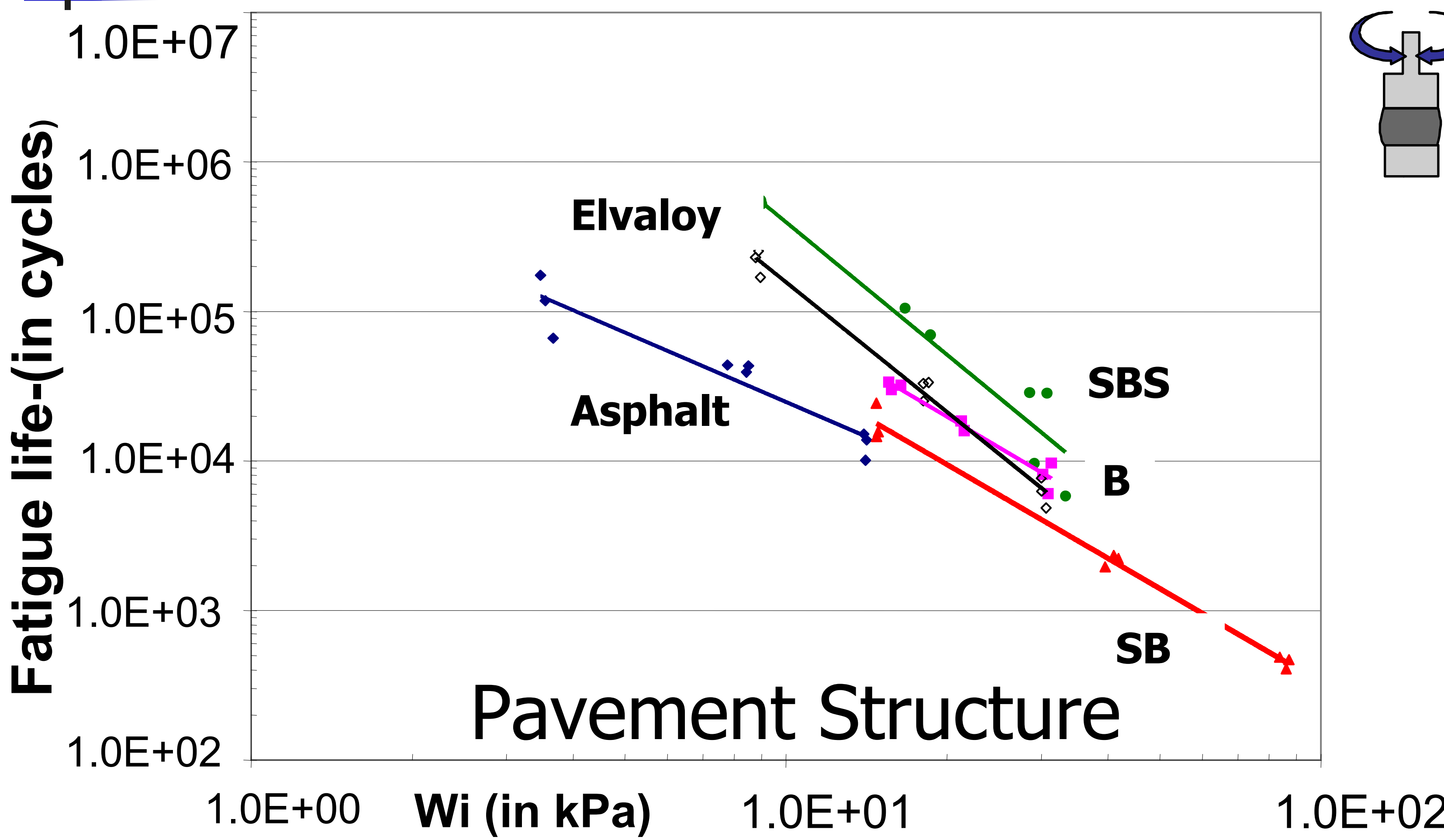
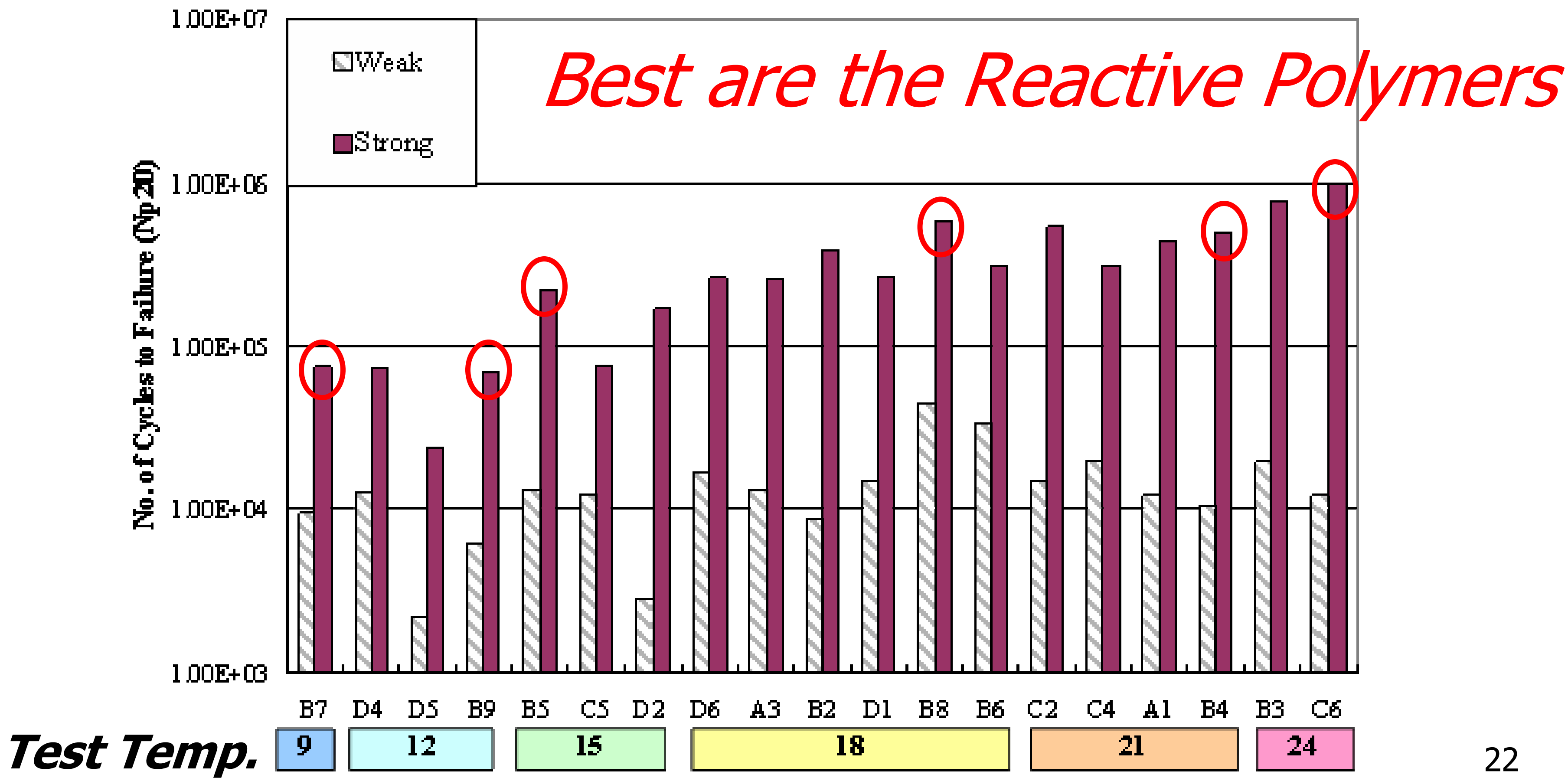
# Effect of Polymers on Fatigue Life – Different Pavement Layers Results @ 25 C



# Effect of Additives
# A,C= SBS, B=Elvaloy, D= SB

*Higher Np20= Better resistance to Fatigue*



# Concluding Remarks

- The results show that modification with SBS and Elvaloy additives can significantly improve resistance of binders to rutting and fatigue damage.
- The effects are not being accurately captured by simply measuring G* and sinδ.
- There is critical need to use damage resistance testing to accurately predict performance and select modifiers.

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- Opinions and Conclusions are those of the researchers. They are not necessarily those of sponsors.