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DSR-PAV Test Improvement

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Sarnia Technology Applications & Research

Select Correct Glasses for Observation

“The observation is only as good as the measurement method”

Poor Test Resolution→ Increased Cost

- Representation (Pass or Fail?)
- Feedstock management
- Production/quality control
- Logistics

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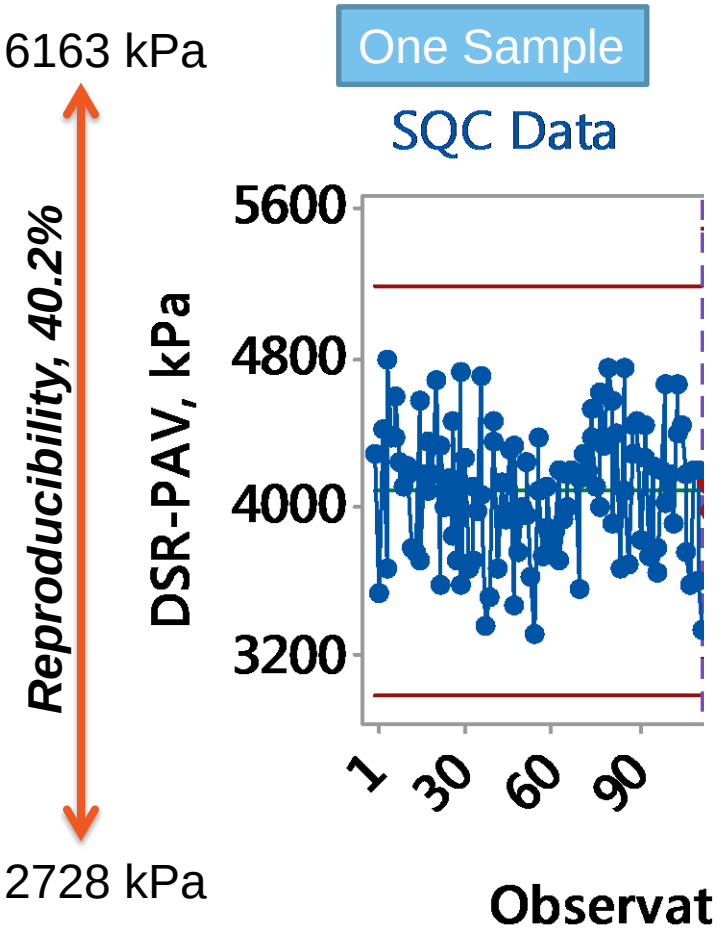
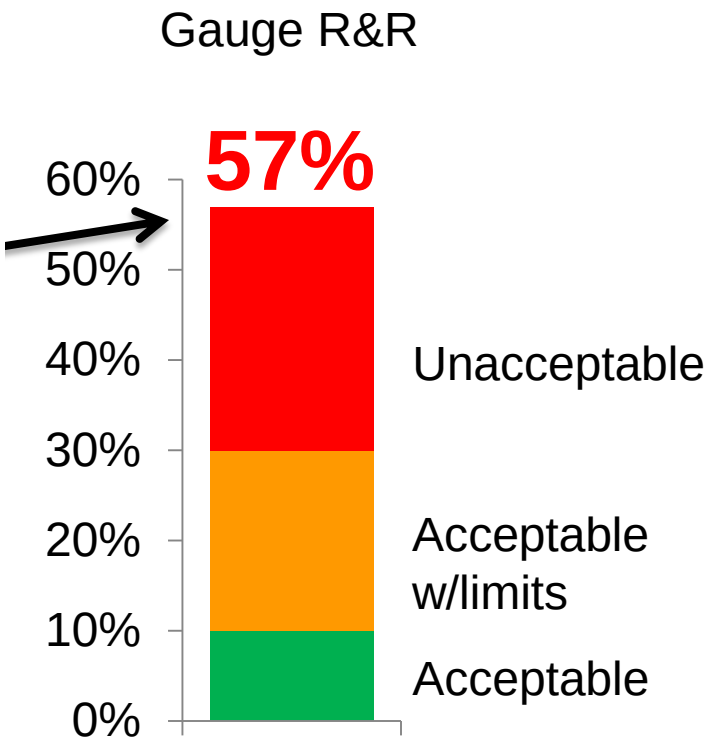
Case for Action: DSR-PAV Is Too Variable





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Approach to DSR-PAV Variability Improvement

- Sample RTFO & PAV aging shown insignificant to DSR-PAV variability
- Study focused on DSR test improvement

Focus of this presentation

1. Sample preparation
   - Direct pour
   - Plates at 46 °C
2. Trimming & gap setting
   - Plates at 46 °C
3. Conditioning
   - Fixed cooling rate
   - Fixed wait time

- Review setting in T315 for contributions to variability
- Test variables in Statistical Design of Experiment (DoE)

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Statistical Design of Experiment (DoE)

Table 1: Parameters Tested for Impact on Variability

Factor	+1	−1	Reason
Thermal	Direct Transfer	Mold	Use of molds, 46 °C loading T
Geometry	8 mm PP*	25 mm PP*	Simple shear, trimming
	2 mm gap	1 mm gap	
Strain (%)	0.1	1	Linear viscoelasticity
Sample	Naphthenic	Waxy	Hardening tendency
Operator	New	Experienced	Experience

- 5 factors at 2 levels total 2^5 or 32 individual test settings
- Test matrix was generated and randomized using Minitab® software
- Each setting was repeated four times to calculate standard deviation
- Half design (16 settings) found to be statistically significant in identifying contributors to test variability
- Total of 64 individual DSR measurements was performed

**Parallel plates*

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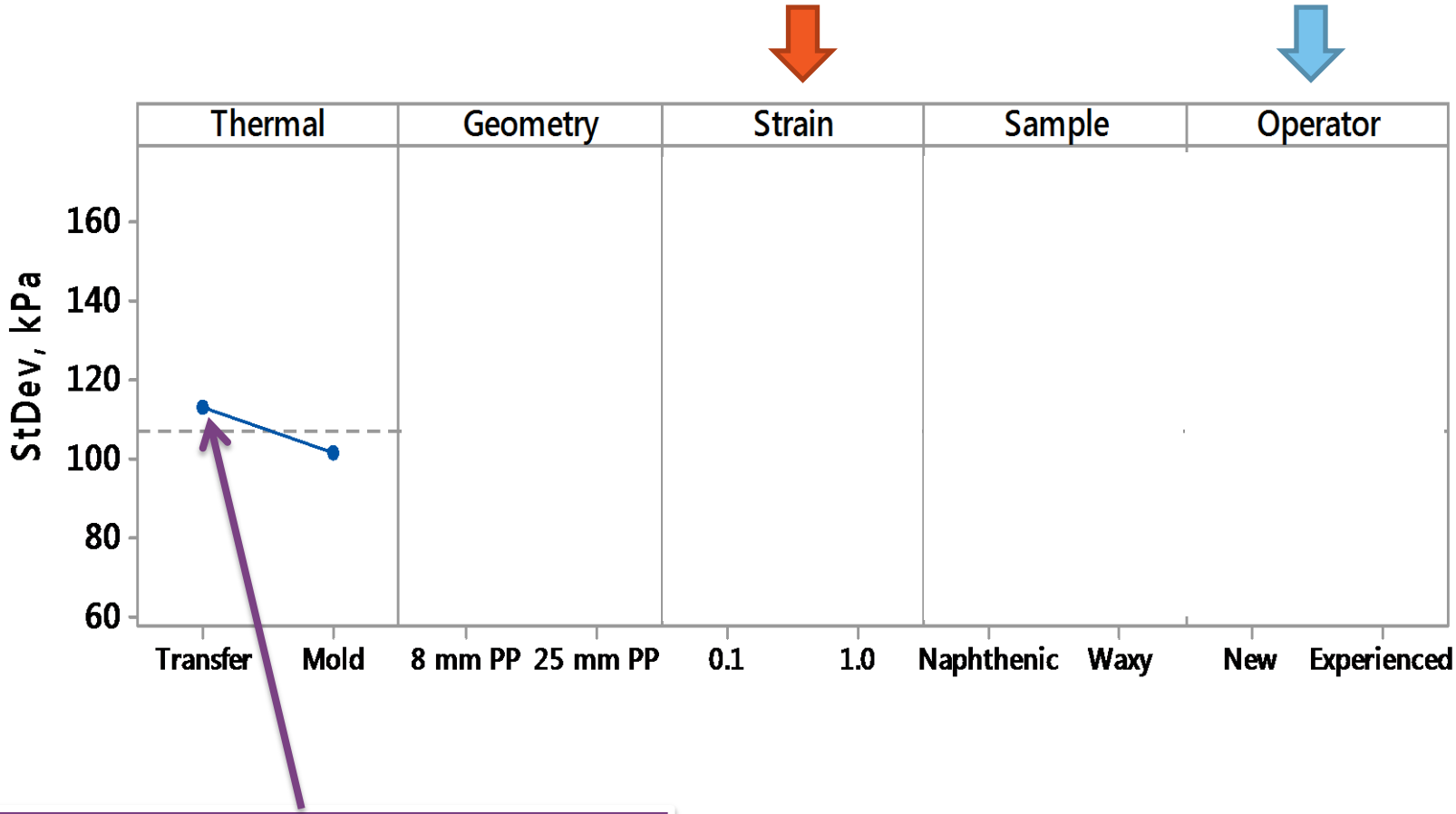
Strain = Major Factor Affecting **Variability**



Each point represents a mean of one half (32) of all experiments (64)

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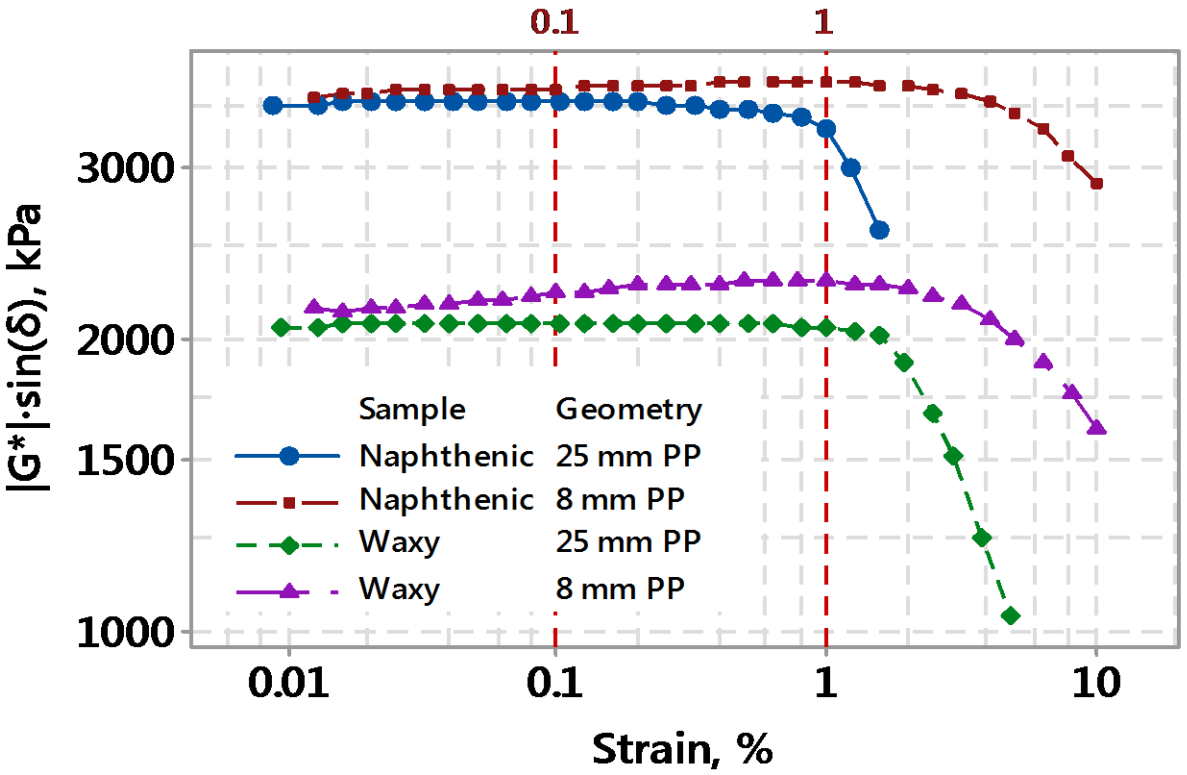
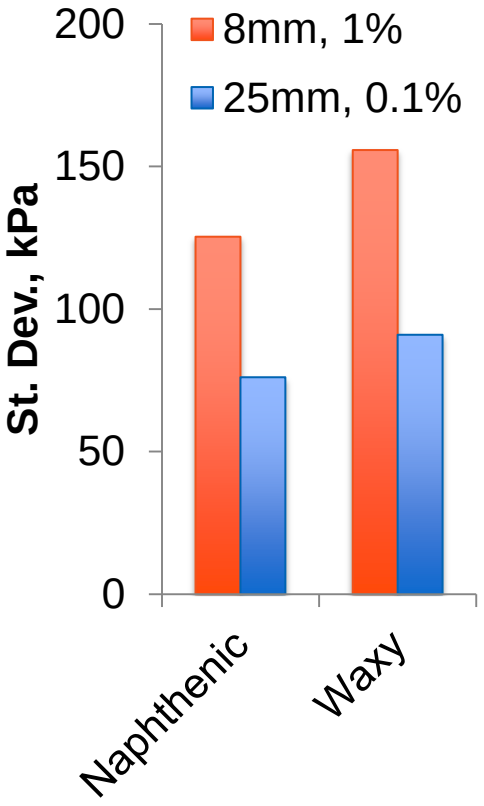
Linear Viscoelasticity Challenged at 1% Strain

- 8PP: modulus increases with strain likely due to edge effect
- Strain below 0.1 % desirable





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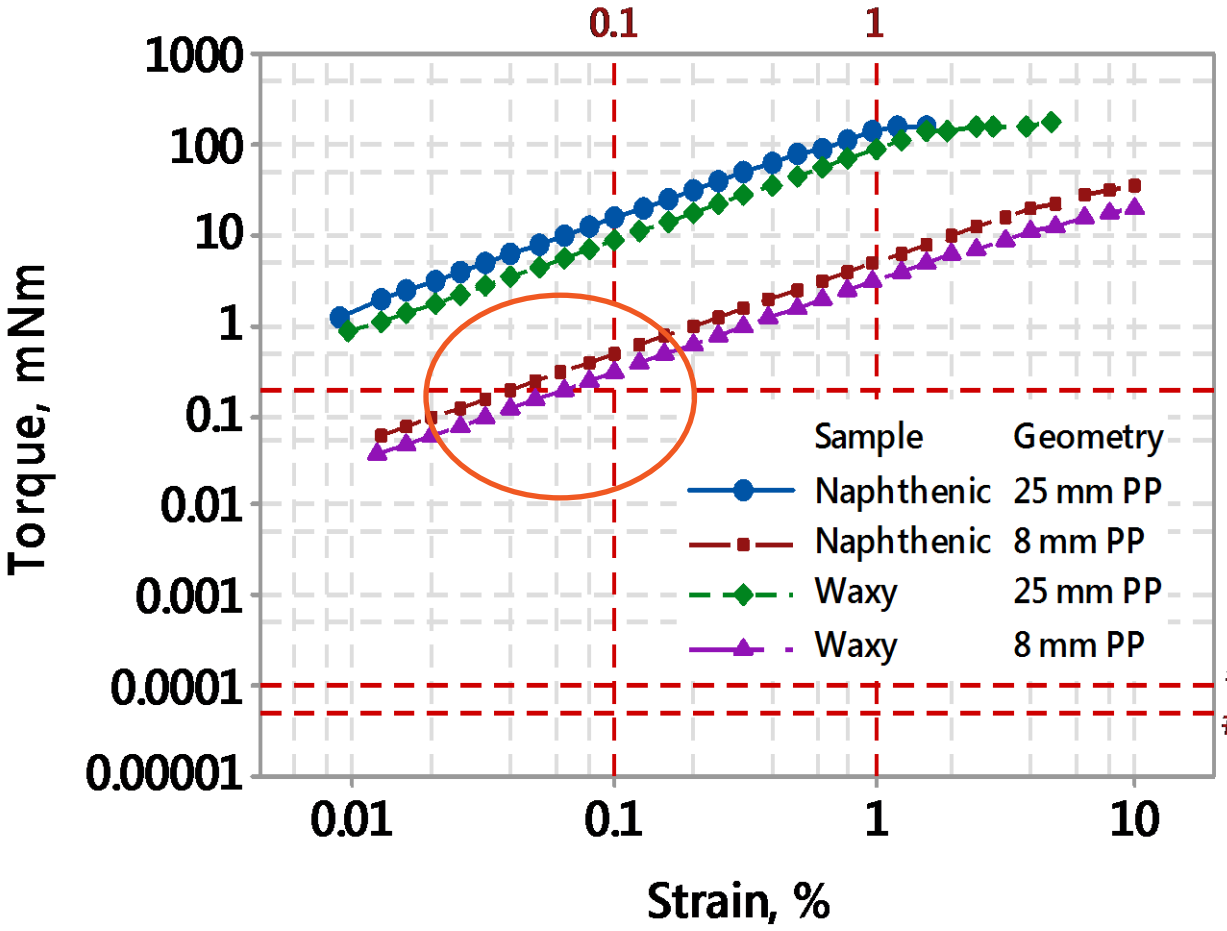
High Test Strain & 8 mm Plates = Artifact of 1990s DSR Capability



1993 instrument min. torque

2008, 2014 instruments min. torque

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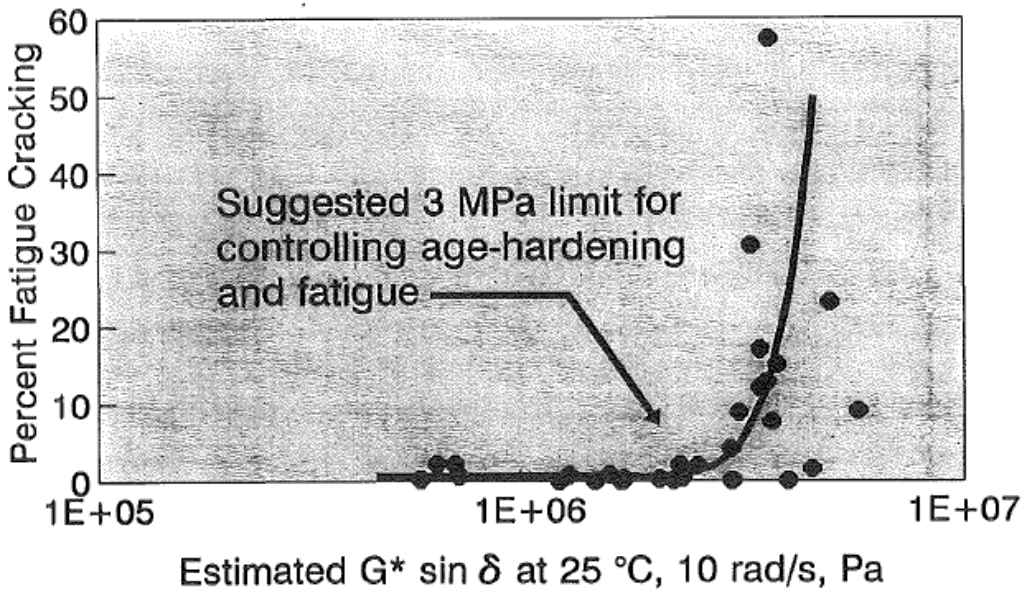
Consider Limit Increase

- 5000 kPa limit suggested on very limited data developed from tests on asphalts used in the Zaca-Wigmore Test Road[1]
- Deacon et al.[2] showed that a general trend between G" & fatigue can only be observed when material properties are vastly different (2 – 18 MPa)

Change to



ix data

Figure 10.1. Eff
cycles to failure f

Figure 13. Analysis of a Zaca-Wigmore Performance Results using G* sin δ

gate source on simulated
cm [6 in.] asphalt layer)

[1]Anderson, D.A. and T.W. Kennedy, "Development of SHRP Binder Specification", J AAPT, Vol. 62, 1993, pp. 481-507.
[2]A.A. Tayebali et al., "Fatigue Response of Asphalt-Aggregate Mixes", SHRP-A-404, National Research Council, Washington, DC, 1994.

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Conclusions

1. DSR-PAV test is not able to distinguish quality easily
2. High test variability is partly driven by the test method parameters
3. Lower strain & higher plate diameter-to-gap ratio is desirable

Recommendation:

1. Adopt 0.1% (or lower) strain and 25 mm PP for DSR-PAV test
2. Increase specification limit (e.g. to 6000 kPa) to ensure DSR (Original/RTFO) & BBR (m or S) are PG limiting specifications

Output:

- Improved asphalt production without impact to performance

Suggested Path Forward

Improve the Test Method

Objective: Improve the test method in AASHTO T315

Suggested Approach for RR to improve T315:

1. Sign up for RR
2. Select binder samples (e.g. Canada, California, …) – AI repository
3. Compare existing & suggested test setup (strain level, plate size, load T) → 8 DSR tests per sample (2 setups, 4 replicates)
4. Analyze data and develop updated T315 test method
5. Seek AASHTO adoption

Timeline:

Target data analysis presentation at April 2017 ETG

Increase Specification Limit

Objective: Increase DSR-PAV limit in AASHTO M320 to 6000 kPa

Next Steps: Need ETG Input

Question & Comments?

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Appendix

Lean Six Sigma

- Lean Six Sigma offers a powerful approach to continuous improvement
- DMAIC approach & numerous tools ranging from brainstorming & mind mapping to design of experiments & statistical analysis were utilized

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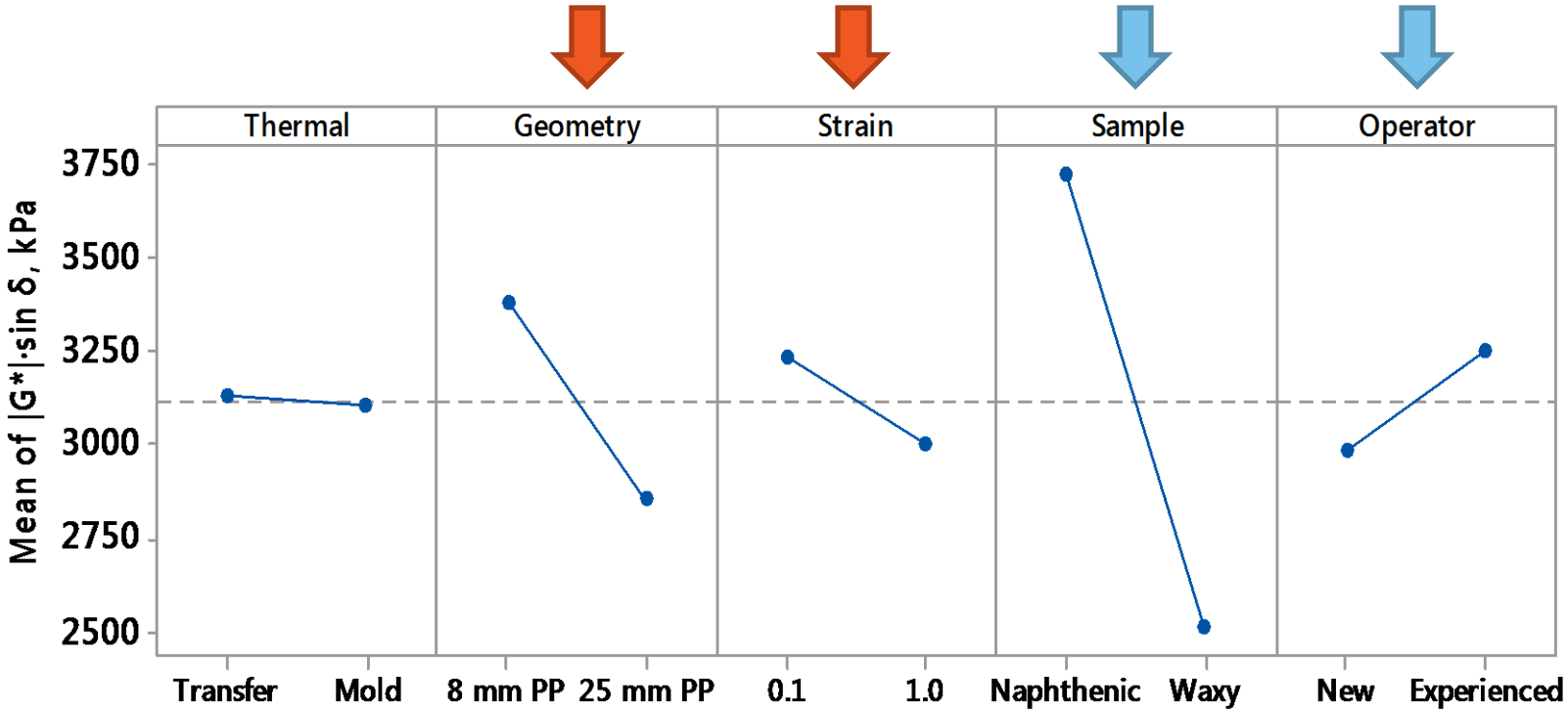
Strain & Geometry Impact Result **Magnitude**



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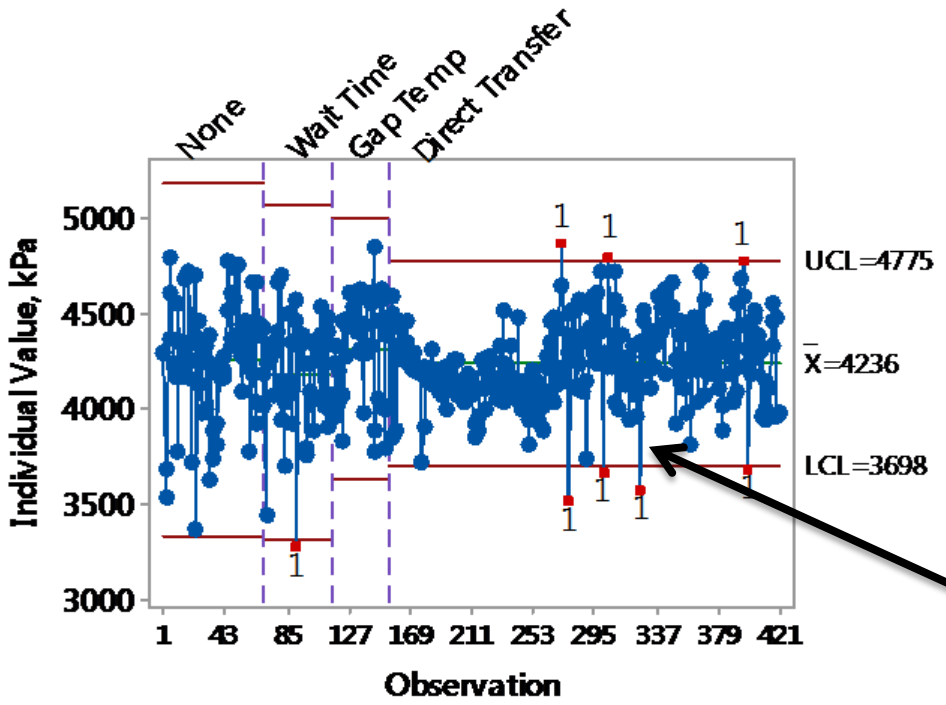
Standardizing Sample Management

1. Wait Time = silicon mold time standardized at 10 minutes
2. Gap Temperature = Sample load, gap setting, trimming done at 46 °C
3. Direct Transfer = molds discontinued, hot asphalt transferred to plates



Improvements Were Not Sustained

Gradual Improvement

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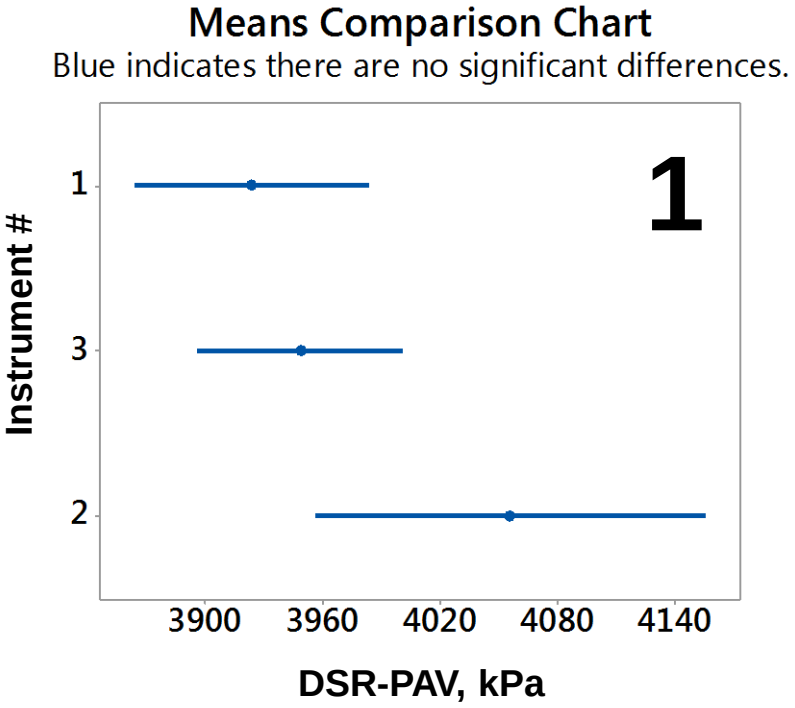
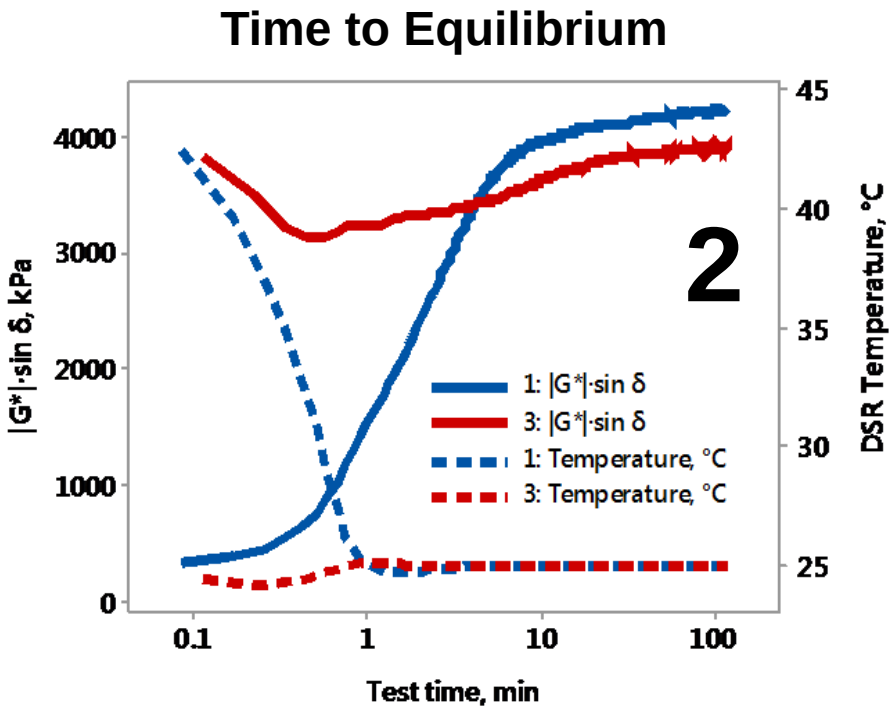
Time to Thermal Equilibrium in DSR

1. No significant difference among 3 instruments ($n > 30$ datapoints)
2. Minor increase (sample dependent) due to hardening
   - 10-25 min wait time increased modulus by ~5%





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