Asphalt Binder Specifications and Round Robin Report

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Presentation Outline

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1. Summary of Specification Changes
2. Reasons for Round Robin
3. Round Robin Testing Plan (Rounds 1 and 2)
4. Summary of Results
5. Summary of Findings
6. Next Steps/Implementation Process
7. Forward Thinking – Where do we go from here?

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IDOT BDE Special Provision

January 1, 2023

Changes to Section 1032

Performance Graded (PG) Asphalt Binder Exclusions:

- Air Blown Asphalt
- Recycled Engine Oil Bottoms (ReOB)
- Polyphosphoric Acid (PPA)

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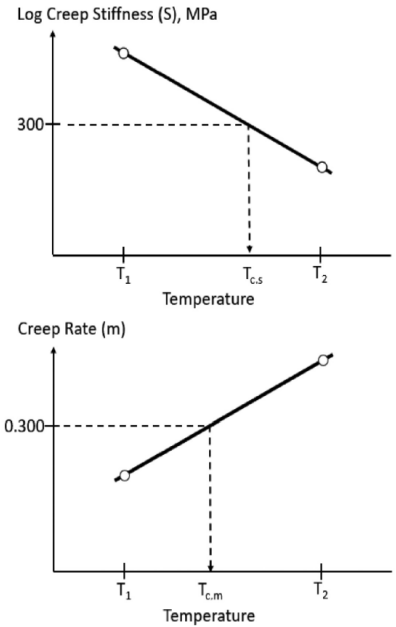
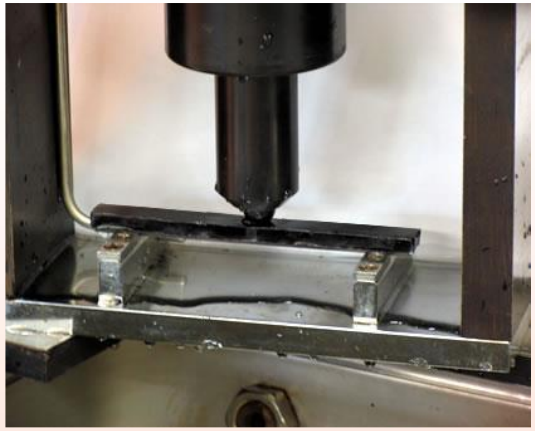
Binder Rheology and Fatigue Testing





BBR: ΔTc

Relaxation under creep loading

DSR LAS: Δ|G*|peak τ

Empirical relationship to ductility

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January 1, 2023

Changes to Section 1032

Performance Graded (PG) Binder

- Added a ΔTc parameter after 40 hr. PAV/2PAV -5°C min.

(a) Performance Graded (PG) Asphalt Binder. The asphalt binder shall meet the requirements of AASHTO M 320, Table 1 "Standard Specification for Performance Graded Asphalt Binder" for the grade shown on the plans and the following.

Test	Parameter
Small Strain Parameter (AASHTO PP 113) BBR, ΔTc, 40 hrs PAV (40 hrs continuous or 2 PAV at 20 hrs)	-5 °C min.

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Why add ΔTc to all PG Binders?

- IDOT's goal is to raise the bar and improve **all** the asphalt binders qualified for use in Illinois. Thus, gaining improved HMA pavement performance, sustainability, stewardship, and safety.
- ΔTc is a widely recognized small-strain, low-temperature parameter determined by BBR that is able to distinguish binder performance post 2PAV aging.

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January 1, 2023

Changes to Section 1032

Modified Performance Graded (PG) Binder. AASHTO M320 Table 1 and the following:

- No longer just polymer modification.
- Asphalt binder modification shall be done at the **SOURCE!**
- Modified binder shall be safe to handle under normal temperatures for construction, production, and storage.

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Why only at the SOURCE?

- IDOT has a robust PG Binder Qualification Policy. Allowance of modification at any point other than at the Source compromises the integrity of the policy and increases the risk to the Department beyond our tolerance.
- http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Materials/Aggregate/1-08%20asphaltbinder.pdf

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January 1, 2023

Changes to Section 1032

Softener Modification (SM) added:

- Specification and Protocol result of ICT R27-196 research.
- BDE allows the addition of organic compounds to the base binder to achieve the specified PG.

(3) Softener Modification (SM). Softener modification is the addition of organic compounds, such as engineered flux, bio-oil blends, modified vegetable oils, glycol amines, and fatty acid derivatives, to the base asphalt binder to achieve the specified performance grade. Softeners shall be dissolved, dispersed, or reacted in the asphalt binder to enhance its performance and shall remain compatible with the asphalt binder with no separation. Softeners shall not be added to modified PG asphalt binder as defined in Articles 1032.05(b)(1) or 1032.05(b)(2).

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Why allow new modifiers?

- IDOT recognizes the opportunity and needs for innovation and improvement and will continue to partner with the industry to advance our knowledge and understanding of asphalt binder modification.

- In addition, modifiers may allow more flexibility for HMA contractors in adding various types and amounts of recycled materials to HMA

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January 1, 2023

Changes to Section 1032

Softener modified asphalt binders shall meet the requirements in Table 4.

Table 4 - Requirements for Softener Modified Asphalt Binders	
Test	Asphalt Grade SM PG 46-28 SM PG 46-34 SM PG 52-28 SM PG 52-34 SM PG 58-22 SM PG 58-28 SM PG 64-22
Small Strain Parameter (AASHTO PP 113) BBR, ΔTc, 40 hrs PAV (40 hrs continuous or 2 PAV at 20 hrs)	-5°C min.
Large Strain Parameter (Illinois Modified AASHTO T 391) DSR/LAS Fatigue Property, Δ|G*|peak τ, 40 hrs PAV (40 hrs continuous or 2 PAV at 20 hrs)	≥ 54 %

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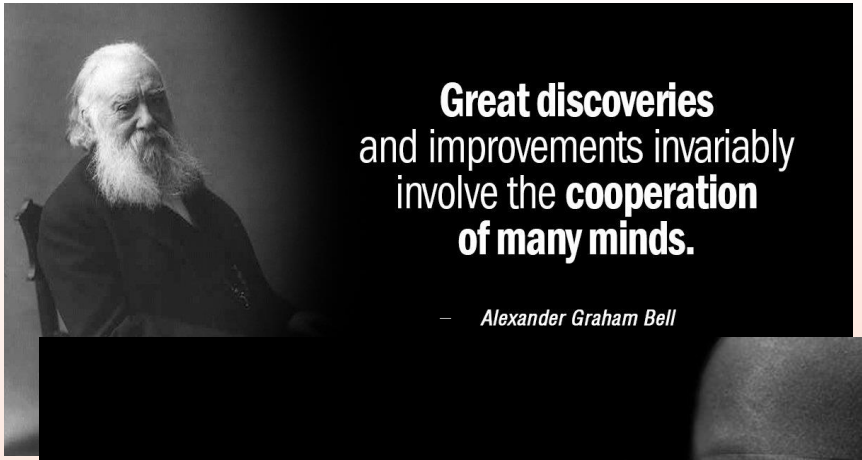
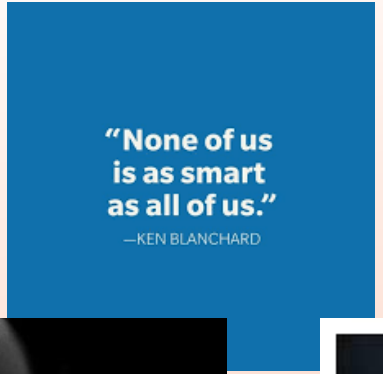
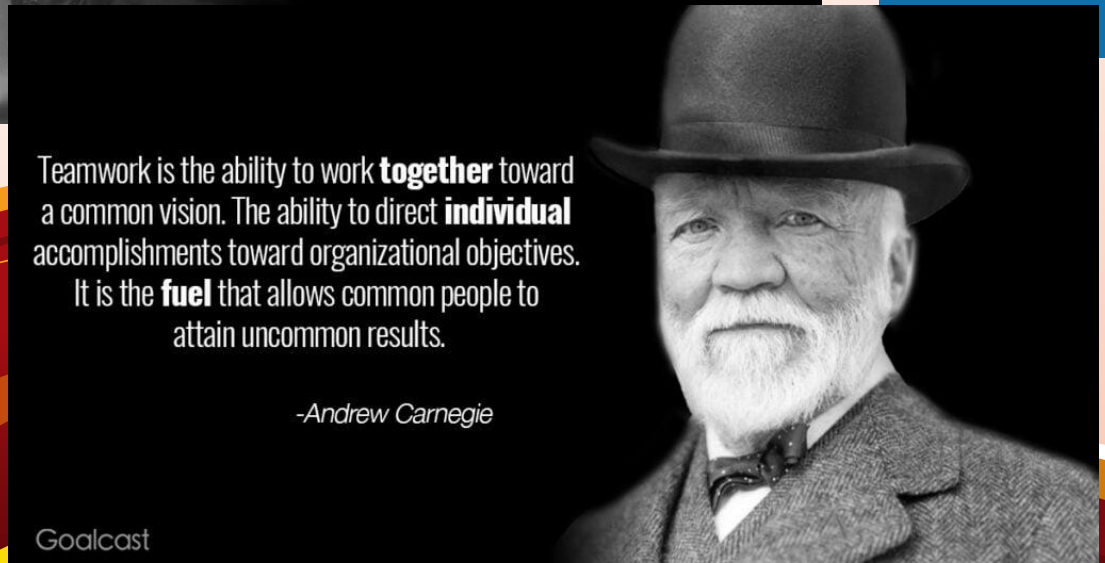
Why Δ|G*|peak τ or “Delta G”?

ICT Project R27-196HS developed a new, intermediate temperature, large-strain parameter collected by the DSR that modifies the AASHTO Linear Amplitude Sweep test to predict the performance of long-term aged, softener-modified binders. This new parameter differentiates binders based on fatigue performance and provides a unique look at binder performance in contrast to the small-strain, low-temperature parameter.

New Specifications=Need to Comprehend







How do we implement?

- New specifications and a new testing parameter = Questions and Concerns
- In order to understand the implementation steps forward, we need to know where we are starting.
- Asphalt Institute partnership with IAPA and IDOT to provide resources and guidance
  - Round Robin(s)
  - Reports, Findings, and Recommendations

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2021 Round Robin - ΔTc 40 Hour PAV

- Conducted by Asphalt Institute
- Participants
  - IDOT Central Materials Laboratory
  - 14 Supplier/ Consulting Laboratories
  - AI
- Materials
  - 3 – PG 58-28 and 3 – PG 64-22 collected from Illinois suppliers
- Scope
  - 1 of each grade type was randomly selected and delivered to participants
  - 2 Labs provided two sets of results (multiple operators)
  - 18 total data points for each type of binder

ΔTc 40 Hr PAV Round Robin 2021 Report

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Test Result	Sample	No. Labs	Average	Standard Deviation (1s)	Coefficient of Variation (1s%)	Acceptable Range of Two Results	
						d2s	d2s%
AASHTO PP113 ΔTc, °	ILS-PG58-28-1	18	-3.9	1.0	25.5%	2.8	72.2%
		18	-3.9	1.0	25.5%	2.8	72.2%
	ILS-PG64-22-1	18	-6.5	0.9	14.1%	2.6	39.8%
		18	-6.5	0.9	14.1%	2.6	39.8%

Note: Shaded cells show results after removing outlying data (3 or more standard deviations from the mean).

Lab ID	ILS-PG58-28-1		ILS-PG64-22-1	
	Result, °C	Rating	Result, °C	Rating
1	-1.6	2	-5.3	4
2	-2.6	4	-6.2	5
3	-3.9	5	-6.2	5
4	-3.8	5	-6.9	-5
5	-3.1	5	-5.6	5
6	-3.9	5	-5.9	5
7	-5.2	-4	-7.4	-5
8	-4.1	-5	-8.0	-3
9	-3.8	5	-5.5	4
10	-4.5	-5	-6.7	-5
11	-3.6	5	-5.9	5
12	-5.0	-4	-6.6	-5
13	-4.6	-5	-6.8	-5
14	-4.3	-5	-5.3	4
15	-3.5	5	-7.9	-3
16	-5.3	-4	-8.2	-3
17	-2.8	4	-5.9	5
18	-5.4	-4	-6.8	-5

Notes:

Ratings shown were calculated from computed standard deviations. A negative number is an indication that the lab result is lower than the average. A positive ranking means that the lab result is higher than the average. Ratings are as follows:

"5" data within 1.0 standard deviations of the mean.

"4" data within 1.5 standard deviations of the mean.

"3" data within 2.0 standard deviations of the mean

"2" data within 2.5 standard deviations of the mean.

"1" data within 3.0 standard deviations of the mean.

"0" data that is 3.0 or more standard deviations from the mean.

A blank result means that no data was supplied by the laboratory. Data resulting in a "0" rating is 3.0 or more standard deviations from the mean, and was therefore excluded from the statistical analysis.

Results and Findings from 2021 Round Robin

- PG 58-28 (1) and PG 64 -22 (1) Results
  - PG 58-28 Avg ΔTc = -3.9, Std Dev = 1.0 (Pass)
  - PG 64-22 Avg ΔTc = -6.5, Std Dev = 0.9; (Fail)
  - All labs would have failed PG 58-28
    - Rounding to -5 passes all labs (All results > 5.5° C)
  - All labs would have failed the PG 64-22
- Most labs received a “5” rating (within 1 stdev of mean)
  - 1 Lab had a “2” Rating on the PG 58-28; 3 Labs had a “3” Rating on the PG 64-22
- Comparable results between 40 hour continuous and 2 – 20 hour PAV
  - 6 of the 18 labs performed 2 – 20 hour PAV cycles
- Higher than expected variability
  - d2s% fell outside of allowable range per AASHTO T313 (> 5.8% for m-value, >15.7% for stiffness)
  - 5 of the 6 temperatures sets for m-value
  - 1 of the 6 temperature sets for Stiffness
    - Material analyzed in Round Robin does not reflect conditions specified in AASHTO T313 (20 hr PAV)
- Interpolation versus extrapolation
  - 7 of the 18 labs extrapolated data and did not bracket failure temperatures

Need for Deeper Understanding - 2022 Round Robin

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- 2022 Round Robin Objectives
  - Validation of the testing variability of PAV40 ΔT_c found in the first round of the study through the inclusion of other asphalt binders
  - Evaluation of the testing variability of PAV20 ΔT_c as a comparison to the testing variability of the same parameter on PAV40 material
  - Evaluation of PAV20 ΔT_c as a potential predictor of the same parameter on PAV40 material
  - Evaluation of the testing variability of Delta G on PAV-conditioned asphalt binder (20 and 40 hours)
  - Identification of potential sources of variability associated with the ΔT_c and Delta G parameters

2022 Round Robin - Materials

Performance Grade	ID
58-28	ILS-PG58-28-1
58-28	ILS-PG58-28-2
58-28	ILS-PG58-28-3
64-22	ILS-PG64-22-1
64-22	ILS-PG64-22-2
64-22	ILS-PG64-22-3

*Samples in gold were used in Round 1 only

2022 Round Robin Results

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- PAV40 ΔT_c – Round 1 (16 labs) vs Round 2 (15 labs)

Test Result	Sample	No. Labs	Average	Standard Deviation (1s)	Acceptable Range of Two Results (d2s)
AASHTO PP113 ΔTc, ° (PAV40)	ILS-PG58-28-1	18	-3.9	1.0	2.8
	ILS-PG58-28-2	15	-2.1	0.7	2.0
	ILS-PG58-28-3	15	-3.1	0.9	2.6
	ILS-PG58-28-2-AIPAV40	15	-1.9	0.6	1.7
	ILS-PG64-22-1	*18*	*-6.5*	*0.9*	*2.6*
	ILS-PG64-22-2	15	-2.1	0.7	2.0
	ILS-PG64-22-3	15	-1.2	0.7	1.9

2022 Round Robin Results

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- PAV20 versus PAV40 ΔT_c (15 labs)

Test Result	Sample	Conditioning	No. Labs	Average	Standard Deviation (1s)	Acceptable Range of Two Results (d2s)
AASHTO PP113 ΔTc, °	ILS-PG58-28-2	PAV20	15	0.3	0.5	1.5
		PAV40	15	-2.1	0.7	2.0
	ILS-PG58-28-3	PAV20	15	0.0	0.6	1.6
		PAV40	15	-3.1	0.9	2.6
	ILS-PG64-22-2	PAV20	15	0.3	0.6	1.6
		PAV40	15	-2.1	0.7	2.0
	ILS-PG64-22-3	PAV20	15	0.7	0.6	1.6
		PAV40	15	-1.2	0.7	1.9

2022 Round Robin Results

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- PAV20 & PAV 40 Delta G (12 labs)

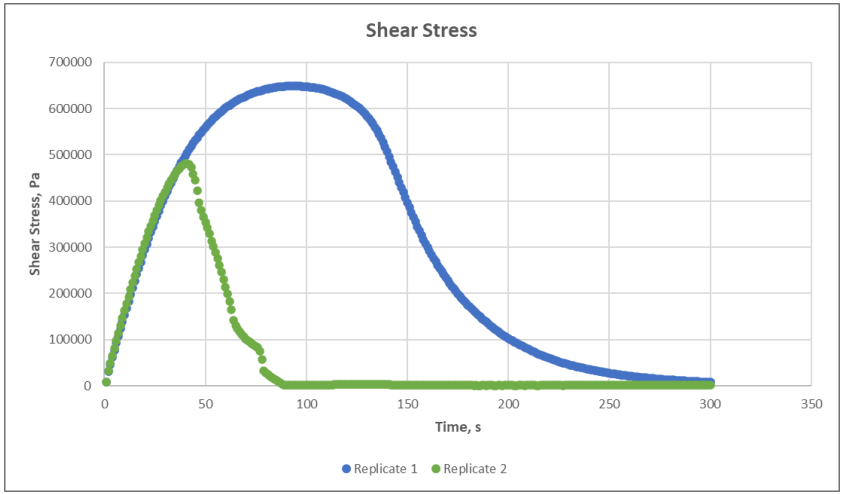
Test Result	Sample	Cond.	No. Labs	Average	Standard Deviation (1s)	Coefficient of Variation (1s%)	Acceptable Range of Two Results	
							d2s	d2s%
IL Modified AASHTO T 391-22 $\Delta\lvert G^*\rvert_{Peak\ \tau}$, %	ILS-PG58-28-2	PAV20	12	53.54	9.92	18.5%	28.1	52.5%
		PAV40	12	51.09	10.30	20.2%	29.2	57.1%
	ILS-PG58-28-3	PAV20	12	52.30	6.98	13.4%	19.8	37.8%
		PAV40	12	53.12	6.95	13.1%	19.7	37.0%
	ILS-PG64-22-2	PAV20	12	54.53	5.97	10.9%	16.9	31.0%
		PAV40	12	53.59	9.56	17.8%	27.0	50.5%
	ILS-PG64-22-3	PAV20	12	51.96	5.05	9.7%	14.3	27.5%
		PAV40	12	52.17	9.92	18.5%	28.1	52.5%

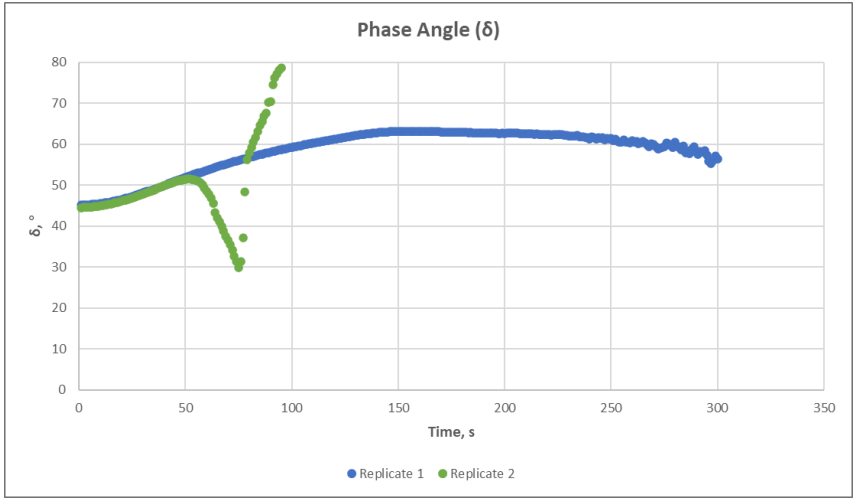
Conclusions

- Where is the testing error?
  - ΔT_c – Control sample for PAV40 seems to suggest that testing variability is in the BBR test
    - Raw data showed high variability in m-value
    - However, some data suggest that aging protocol may factor (i.e. 2x20 hour PAV vs continuous 40-hour PAV)
    - Calculations (i.e. “bracketing” critical values” correctly)
    - Lower variability in PAV20 binder
      - A function of less aging time and greater workability of material

Conclusions

- Where is the testing error?
  - Delta G – variability may lie in nature of the test
    - High strains
    - Sample loading temperature is important!





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Next Steps?

- Clarify test methodology to remove uncertainty
- Continue partnering with the industry to resolve outstanding DSR software needs
- Additional Round Robin work to monitor progress
- Additional Research to expand our knowledge and refine the work

Clarify Test Methodology

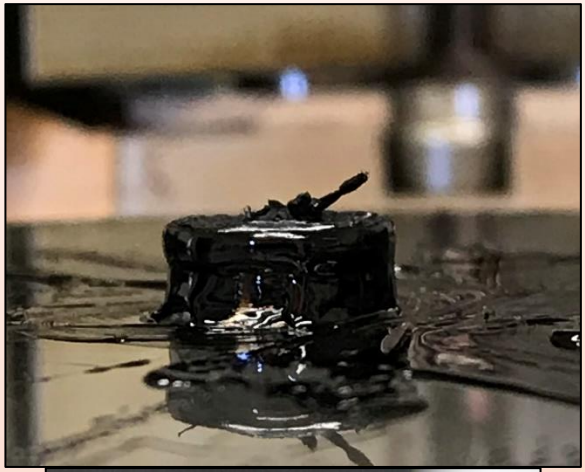
Illinois Modified T391 "Estimating Fatigue Resistance of Asphalt Binders Using the Linear Amplitude Sweep to Establish Delta G ($\Delta|G^*|_{peak\ T}$)"

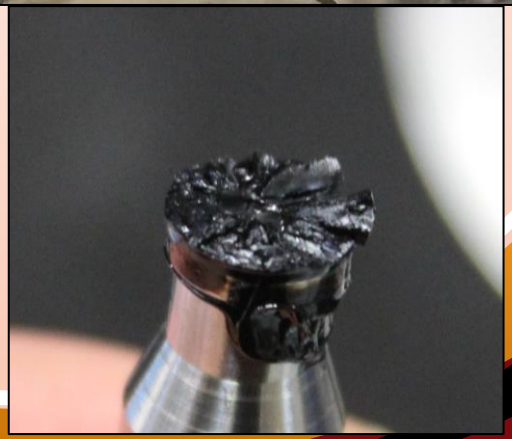
IL method adds the research-developed Delta G parameter to the standard Linear Amplitude Sweep test in AASHTO T391.

ITP T 391 Clarification

Revisions discussed as an outcome from Round Robin work:

- Sample preparation: loading temperature and sample mold vs. direct pour
- Amplitude Sweep: capture peak shear stress, but end test when reached
- Address repeatability (if results vary more than 10% run replicate to replace outlier)
- Include highlights to example tables to note important fields





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DSR Software and Templates

- Continue partnering with the industry to resolve any outstanding DSR software needs
- IDOT is currently evaluating a custom DSR test template that follows ICT LAS parameters and calculates the "Delta G" parameter without the need to extract and analyze data separately. It is expected to be refined to allow completion of the test once the peak shear stress is captured to reduce test time.

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Round Robin #3?

- Additional Round Robin work to monitor progress after a year of the specification experience and use.
- Work with AI to facilitate another round with new softener-modified binders and the best practices identified from the year to quantify the improvement in test data from rounds 1 and 2.

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Ongoing Research

ICT Project R27-250 (Completion Spring 2025)

“Using Advanced Binder Rheological Parameters to Predict Cracking Potential of Hot-Mix Asphalt Mixtures with Modified Binders.”

- Considering polymer-softener modification combination
- Mixture performance correlated with new binder protocol

Forward Thinking

- Continue to cooperate, learn, adapt, and improve
- Keep an eye on National research projects
- Be open to new ideas and continued progress toward binder performance improvement

Questions?

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