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Ruggedness Evaluation of AASHTO TP7 and TP9: Phase 1
Simple Shear Test at Constant Height (TP7)

Executive Summary
Federal Highway Administration
National Asphalt Training Center II
Task J

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Purpose of Ruggedness Testing

Engineers believe that results from a test method should not be subject to extreme variability caused by very minor differences in equipment or operator technique. When a test method is still early in its development, ruggedness testing evaluates whether minor variations in test parameters cause major variations in test results. A ruggedness experiment is aimed at evaluating a proposed test procedure so that potential sources of variability can be identified. According to ASTM C1067, "...ruggedness testing has as its purpose the detection and control of sources of testing variation prior to programming an interlaboratory study. One of the most productive uses of a ruggedness or screening evaluation is the elimination of those test methods shown to have poor precision even after making vigorous efforts to reduce the variation." Thus the goal of the experiment is to identify sources of variation in the AASHTO TP7 (Simple Shear at Constant Height) test procedure and to propose necessary changes such that variability is reduced to tolerable levels.

Participating Laboratories

Labs involved in the ruggedness experiment evaluating the Simple Shear Test at Constant Height (SSCH) include those shown in Table 1 below:

Table 1: Participating Labs in AASHTO TP7 (SSCH) Ruggedness Evaluation

Test Method	Laboratory	Equipment
	University of California at Berkeley[1]	Cox and Sons SST (Prototype)
	Auburn University (Southeast Superpave Center)	Interlaken SST
AASHTO TP7	University of Texas at Austin (South Central Superpave Center)	Interlaken SST
	University of Nevada at Reno (Western Regional Superpave Center)	Interlaken SST
	Asphalt Institute (National Asphalt Training Center)	Cox and Sons SST

1 - Originating laboratory.

Experimental Conditions

A 12.5-mm nominal Superpave coarse mixture (using a PG 64-22 asphalt binder) was selected as the experimental asphalt mixture. ASTM C1067 recommends that seven main experimental factors be evaluated for each procedure. Table 2 provides a description of the seven main factors and their associated levels for the Simple Shear Constant Height test (SSCH).

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Table 2: Main Factors and Levels for SSCH Test

	Level	
Main Factor	Low	High
Air Void Content	6.5%	7.5%
Temperature Stabilization Time[1]	30 minutes	60 minutes
Test Temperature	38.0° C	42.0° C
Stress Loading Rate	65 kPa/s	75 kPa/s
Glue Type	5-minute epoxy	2-hour epoxy
Specimen Orientation	bottom of specimen	top of specimen
Order of Test	before FSCH	after FSCH
[1] Temperature preconditioning time is constant at 2 hours		

The tests in the experimental matrix were conducted in accordance with AASHTO TP7 except as noted in Table 2.

Results

Table 3 presents F-values calculated following the ASTM C1067 analysis procedure. The critical F-value was determined to be 5.59 for this set of experimental data. Table 4 is a summary of the statistical significance of the main factors for the SSCH ruggedness experiment.

Table 3: F-Values for SSCH Ruggedness (ASTM C1067 Analysis)

	Main Factor						
Lab	Air Voids	Temp. Stab.	Test Temp	Load Rate	Glue Type	Spec. Orient.	Test Order
SCSC	0.15	16.09	1.81	0.53	5.71	1.75	4.20
AI	0.00	0.90	0.75	0.09	0.02	0.18	0.54
UCB	0.14	8.78	0.63	0.78	0.03	2.99	0.19
SESC	0.48	0.05	8.39	0.05	1.00	0.37	0.78
WRSC	0.47	59.02	0.01	2.41	1.64	0.70	1.39
$F_{critical}$ = 5.59							

Table 4: Summary of Statistical Significance for SSCH Ruggedness (ASTM C1067 Analysis)

	Main Factor						
Lab	Air Voids	Temp. Stab.	Test Temp	Load Rate	Glue Type	Spec. Orient.	Test Order
SCSC	NS	**16.09**	NS	NS	**5.71**	NS	NS
AI	NS	NS	NS	NS	NS	NS	NS
UCB	NS	**8.78**	NS	NS	NS	NS	NS
SESC	NS	NS	**8.39**	NS	NS	NS	NS
WRSC	NS	**59.02**	NS	NS	NS	NS	NS

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Of the seven main factors in the SSCH Ruggedness experiment, only temperature stabilization time appears to be important. Three of the five labs (SCSC, UCB, and WRSC) indicated this factor as significant. Of the two labs that did not indicate temperature stabilization time as significant, it is worth noting that AI indicated it as the most significant factor within lab. The poor repeatability between replicate samples may have resulted in AI not indicating the factor as significant. To determine the effects of temperature stabilization time on peak shear strain results, test results from determinations having a low level of this main factor (3,4,7, and 8) were compared to test results from determinations having a high level of this main factor (1,2,5, and 6). Results are indicated in Table 5 and Figure 2.

Table 5: Effect of Temperature Stabilization Time on Peak Shear Strain (mstrain)

	Temperature Stabilization Time	
Lab	30 minutes	60 minutes
SCSC	4,839	8,463
AI	4,358	6,170
UCB	15,772	22,477
SESC	4,469	4,359
WRSC	3,914	6,957

Table 5 and Figure 1 indicate that peak shear strain from the SSCH test increases significantly from 30 to 60 minutes for four of the five labs. This is an indication that 30 minutes stabilization time may be insufficient to allow the specimen to reacquire temperature after having been subjected to preconditioning and instrumentation.

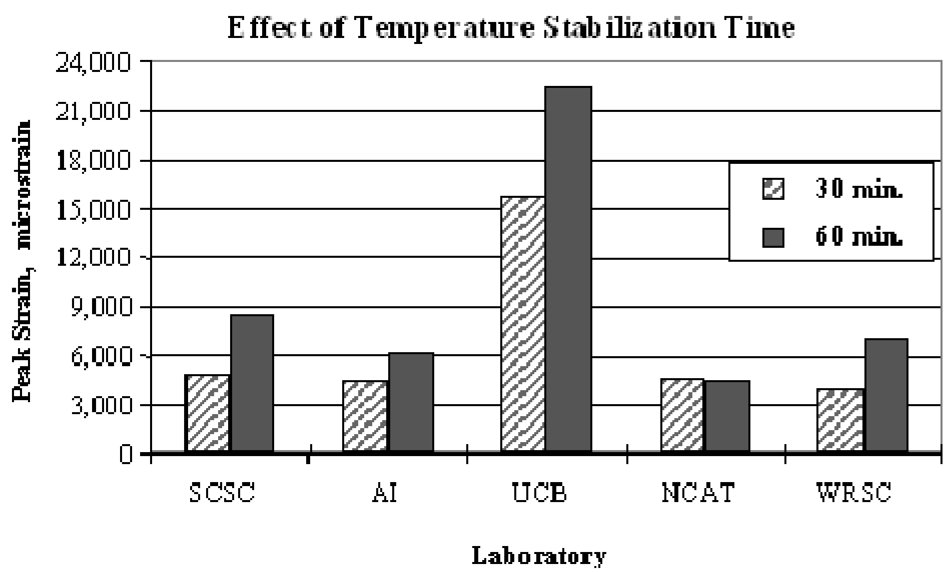

Figure 1: Effect of Temperature Stabilization Time on Peak Shear Strain

Conclusions and Recommendations

A change is recommended to the requirement that the system be allowed to stabilize for 25 ± 5 minutes after instrumentation of the specimen, but before initiating the test. It is recommended that Section 13.5 of AASHTO TP7 be changed to:

"13.5 Confirm that the environmental chamber temperature control is activated and on the setting required to maintain the specified test temperature ± 0.5° C. Allow the system to stabilize for 60 ± 5 minutes (*Note 14*), after locking the environmental chamber in place, prior to initiating the test."

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Note 14: A temperature stabilization time of 60 minutes allows sufficient time for the test specimen to reacquire the appropriate test temperature. The actual time for stabilization may vary depending on the test temperature (higher temperatures require more stabilization time) and proficiency of the operator in instrumenting the specimen quickly to minimize temperature loss. It is recommended that a dummy test specimen is instrumented and placed in the test *chamber at the same time as the actual test specimen to measure specimen temperature. Laboratories may use less than 60 minutes for stabilization provided sufficient documentation is available indicating that the temperature of the specimen can recover sooner than 60 minutes. In no case should the temperature stabilization time be less than 20 minutes.*

Recommended tolerances on test temperature (± 0.5° C) and loading rate (± 5 kPa/s) appear reasonable based on the analysis of the test data. Glue type (specified in Section 5.1 and Note 2) did not indicate any significant effect on peak shear strain results.

Specimen preparation variables also were generally insignificant. The specimen orientation, whether the test specimen was cut from the top or bottom half of the larger (140 mm height) performance specimen, did not have an effect on the test results. Also, the percentage of air voids within the specimen did not have a significant effect on the test results for the tolerance selected. As such, it appears acceptable to require performance test specimens to have 7.0 ± 0.5 percent air voids. Additional experimentation may indicate that this tolerance should be increased further.

Finally the order in which the tests were conducted did not have an effect on the peak shear strain at 40° C. This was considered a potential problem since most labs conduct the simple shear test and the frequency sweep test on the same test specimen. The analysis indicated that simple shear test results were unaffected by performing the frequency sweep test first. This result was not unexpected since the frequency sweep test is (theoretically) conducted in the linear viscoelastic region (no permanent shear damage).

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