

Asphalt Institute Guidance Document

Implementation of the Multiple Stress Creep Recovery Test and Specification

The purpose of this document is to provide guidance to the asphalt industry, users and producers, regarding the implementation of the new high temperature binder test and specification using the Multiple Stress Creep Recovery (MSCR) test. The MSCR test replaces the existing AASHTO M320 Dynamic Shear Rheometer (DSR) test used for characterizing the high temperature performance properties

of an asphalt binder after short-term aging. It is the Asphalt Institute's opinion that the MSCR test and specification represent a technical advancement over the current PG specification that will allow for better characterization of the high temperature performance-related properties of an asphalt binder.

Background

One of the objectives in the development of the Superpave Binder Specification was the use of performance-related criteria specific for a distress and related to climate and traffic loading. This objective implies that test measurements should be made at temperatures and loading rates consistent with conditions existing in the pavement. Based on this, the high temperature criteria stays the same for $G^*/\sin \delta$ (1.00 kPa for unaged and 2.20 kPa for RTFO-aged binder) regardless of the location of the pavement, but the test temperature where this criteria must be met is derived from the actual pavement temperature.

While this concept worked well for conventional speed, moderate traffic volume pavements, it needed some refinement for pavements that had slow speed loading and high traffic volumes. Rather than change criteria and/or test conditions to reflect a change in loading time and traffic volume, the architects of the PG system elected to simply adjust for traffic speed and volume by “grade-bumping” or testing at higher temperatures than indicated by the climate. So for a standard traffic asphalt pavement the designer might use a PG 58-28 asphalt binder, but a high volume highway pavement might require a PG 70-28 asphalt binder – even though the pavement temperature will likely never get above 58°C. This was a simple way to ensure that a stiffer asphalt binder would be used in high volume and/or slow loading conditions. One problem with grade-bumping in the PG system was that a PG 70-28 asphalt binder would have its performance-related properties determined at a temperature that would be at least 12°C hotter than the highest pavement temperature that would be experienced. Such high specified testing temperatures in some instances have caused asphalt suppliers to manufacture binders that are very highly modified and thus difficult to use at reasonable temperatures.

Another objective of the PG system was that the performance-related properties that defined the performance grade of an asphalt binder would be blind to modification. In other words, all asphalt binders of the same performance grade would be expected to perform the same in the same traffic/environmental conditions regardless of how they were produced. This would allow the asphalt industry to divest itself of the specification proliferation that had become increasingly more common as modification of asphalt binders became more common.

While the $G^*/\sin \delta$ parameter did capture viscous and elastic effects, it was unable to adequately capture the benefits of elastomeric modification because of the relatively small impact of phase angle (δ) on the overall value of $G^*/\sin \delta$. As a result, the additional empirical tests (sometimes referred to as “plus” tests) continued so that a user agency could have assurance that they were getting a polymer-modified asphalt binder as they had in the past.

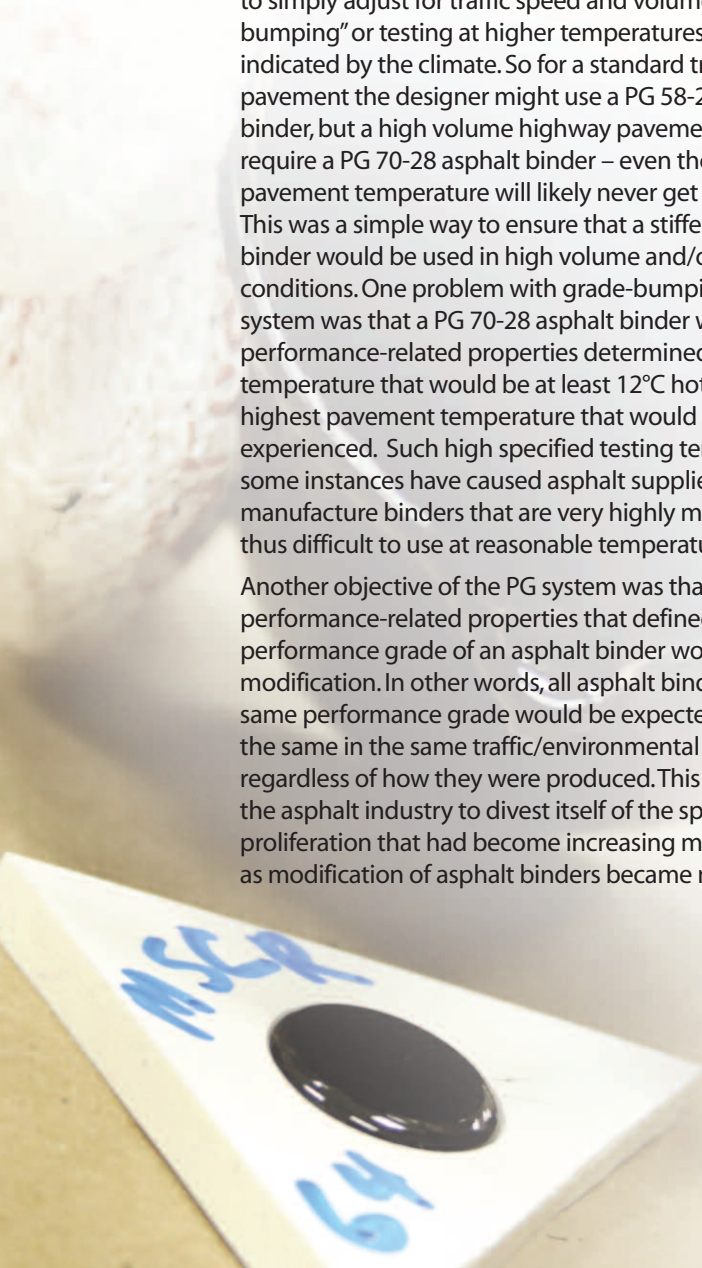
MSCR Test and Specification

The MSCR test was developed based on creep and recovery work conducted on asphalt binders and mixtures. During SHRP, researchers at the University of California at Berkeley developed the Repeated Simple Shear Test at Constant Height (RSST-CH) for asphalt mixtures. The RSST-CH was developed to characterize the rutting performance of asphalt mixtures and was conducted using repeated cycles of 0.1-second shear load followed by a 0.6-second rest period. Based on this mixture work, the NCHRP 9-10 research used a repeated creep-recovery test to characterize the expected rutting performance of modified asphalt binders.

The MSCR test procedure, published as AASHTO TP70, captures the non-recoverable creep compliance (J_{nr}) and percentage of recovery (MSCR Recovery) during each loading cycle. Values are reported as the average of 10 loading cycles at each shear stress level.

The MSCR test is an improvement in several ways:

1. J_{nr} is better correlated with rutting potential than $G^*/\sin \delta$.
2. The MSCR test results from just the one test can be used with modified and unmodified asphalt binders, thereby eliminating the need for additional tests to properly characterize the high temperature performance of modified asphalt binders.
3. There is now criteria to eliminate binders that are overly stress sensitive, which would previously have passed the PG criteria and potentially been susceptible to rutting in the field.
4. MSCR Recovery is faster/easier to determine than other “PG Plus” tests like the Elastic Recovery test and does a better job of characterizing polymer modified asphalt binders.
5. The MSCR test is conducted at the actual pavement temperature, regardless of traffic loading.



Implementation

As stated earlier, the Asphalt Institute believes that the MSCR test and specification are improvements to the current PG system that will allow for better characterization of the high temperature performance-related properties of asphalt binders. As such, AI encourages user agencies to make the transition to the test (AASHTO TP70) and specification (AASHTO MP19). To make an effective transition, several items need to be addressed, as shown in the following sections.

Become Familiar with the MSCR Test

The MSCR test is a DSR test that is performed using the same equipment and techniques as the standard DSR test procedure (AASHTO T315). The only thing that varies is the actual execution of the test. If AASHTO T315 identifies a practice that will affect test results, you can be assured that the same practice will affect the MSCR test results. Temperature control, calibration, and proper sample preparation are all critical to minimizing testing variability. Users should also check with their DSR manufacturer to ensure that they have the proper application script in the software to perform the MSCR test.

Once the test can be performed, it is recommended that regional round robin testing be conducted, specifically between users and producers, to ensure that the test is being *properly* performed and is within acceptable testing variability.

Become Familiar with the Specification

The biggest change in the specification is the naming of the binder performance grades. All binders will have numerical grades based on the environment in which they are intended to be used. Following the numerical grade will be a letter designation that identifies the traffic loading (volume and/or speed) where the asphalt binder is expected to perform. Designations include "S" (standard traffic loading), "H" (heavy traffic loading), "V" (very heavy traffic loading), and "E" (extreme traffic loading). The numerical grade tells the user the temperatures at which testing is conducted. The letter designation tells the user the criterion for judging if the asphalt binder meets the specification. An example of the new grades is PG 64-22S. Changes from AASHTO M320 Table 1 are as follows:

- Determination of the value of $G^*/\sin \delta$ after RTFO aging is replaced by the determination of J_{NR} at 3.2 kPa shear stress using the MSCR test.

- A stress sensitivity calculation which determines the percent increase in J_{NR} as the stress level increases from 0.1 to 3.2 kPa is also required. The percent increase in J_{NR} at 3.2 kPa must be less than or equal to 75% of the J_{NR} at 0.1 kPa. The requirement to keep the percent increase in J_{NR} below 75% is to insure that the binder will not be overly stress sensitive to unexpected heavy loads or unusually high temperatures.
- MSCR Recovery is usually determined, but is not required in the specification.
- Determination of the value of $G^*\sin \delta$ after Pressure Aging Vessel (PAV) aging remains the same, but the criterion changes to a maximum value of 6000 kPa for any letter grade designation other than "S".

Conduct Transitional Testing As Needed

Many users transition to a new system by conducting transitional testing. In this testing, an asphalt binder is tested according to the current specifications and its acceptability for use is judged based on that set of results. At the same time, testing is conducted using the new specification to evaluate how the new system relates with the current system. If this is to be done, users will find that they will need to conduct, at the most, three additional tests: (1) Original DSR to determine $G^*/\sin \delta$ at the selected environmental grade temperature; (2) RTFO MSCR at the selected environmental grade temperature to determine J_{NR} , J_{NR} Ratio, and MSCR Recovery; and (3) PAV DSR to determine $G^*\sin \delta$ at the intermediate temperature based on the environmental grade. What does this mean? To evaluate the new specification for a PG 76-22 asphalt binder, the technologist would, in addition to the normal AASHTO M320 Table 1 tests, perform:

- Original DSR to determine $G^*/\sin \delta$ at the selected environmental grade temperature. For Kentucky, the Department of Highways has selected 64°C as the standard high temperature grade based on the environment. For the Southeastern United States, the selected environmental grade temperature may be 67°C. For parts of the Southwestern and Western US, the selected environmental grade temperature may be 70°C.
- RTFO MSCR to determine J_{NR} (3.2 kPa shear stress) and the J_{NR} ratio at the selected environmental grade temperature. See Item #1.
- PAV DSR to determine $G^*\sin \delta$ at the environmental intermediate grade temperature. In AASHTO M320 Table 1 a PG 76-22 asphalt binder is tested at an intermediate temperature of 31°C. If the same binder were tested using the MSCR specification (AASHTO MP19) in Kentucky (PG 64-22 standard climatic grade), then it would be tested at an intermediate temperature of 25°C.

Before testing, users will need to choose an environmental grade temperature that matches the climate in which the binder will be used. One tool that can be employed for selecting environmental grade temperature is the latest version of LTPPBind. But the environmental grade temperature can also be selected on the basis of engineering judgment, which takes into account local experience, performance, and current design practice in the pavements and materials engineering community.

It is critical to note that in any transitional testing, results are only indicative of current products and formulations. Products are likely to change once the full specification is implemented. This is a perfectly normal market reaction that was observed as the industry transitioned from penetration and viscosity based specifications to the PG specification in AASHTO M320 Table 1.

Transition Regionally and Uniformly

Producers may market their asphalt products into more than one state. To avoid having an interruption in supply, producers would prefer that neighboring states or regions transition to a new specification in the same manner. AI encourages user agencies to work within their user producer group to make a uniform transition to the new MSCR specification (AASHTO MP19).

Use MSCR Recovery if there is a Need to Identify Elastomeric Modification in an Asphalt Binder...

In AASHTO MP19, there is no requirement for MSCR Recovery. This is done because J_{NR} is the parameter that relates to rutting potential. However, MSCR Recovery provides an indication of the delayed elastic response of the asphalt binder. A high delayed elastic response is an

indication that the asphalt binder has a significant elastic component at the test temperature. In AASHTO TP70, a chart and table are provided if a user agency wants to incorporate MSCR Recovery with J_{NR} in the specification. If a user agency does not use "PG Plus" tests (such as Elastic Recovery) with AASHTO M320 Table 1, then we would not expect the agency to necessarily require MSCR Recovery.

...And Eliminate the Use of Other "PG Plus" Tests

If a user agency does use "PG Plus" tests, then it is recommended that MSCR Recovery should replace other "PG Plus" tests that are intended to have a similar purpose. In other words, MSCR Recovery should replace Elastic Recovery, Force Ductility, and Toughness and Tenacity tests. Other tests that have a different purpose, like the Separation test, may still be required.

Although technologists will no doubt conduct comparative testing between MSCR Recovery and other "PG Plus" tests, they are cautioned not to expect strong correlations. Test conditions are sufficiently different between the MSCR and "PG Plus" tests that a strong relationship would be unlikely.

Closing

This document is only intended to provide suggestions to a user agency interested in implementing the MSCR test (AASHTO TP70) and specification (AASHTO MP19). Considerations in the implementation process are shown above, but may not represent an exhaustive list. The Asphalt Institute recommends that user agencies work within their user-producer groups to resolve implementation questions. The Asphalt Institute will be pleased to assist users in better understanding the MSCR test and specification.

Additional information may be obtained from the following references:

D'Angelo, J. and R. Dongre. "Development of a High Temperature Performance Based Binder Specification in the United States," 10th International Conference on Asphalt Pavements, Quebec City, Canada, International Society for Asphalt Pavements, 2006.

D'Angelo, J., R. Dongre, and G. Reinke. "Evaluation of Repeated Creep and Recovery Test Method as an Alternative to SHRP+ Requirements for Polymer Modified Asphalt Binders," *Proceedings*, Canadian Technical Asphalt Association, November 2006.

D'Angelo, J. et al. "Revision of the Superpave High Temperature Binder Specification: The Multiple Stress Creep Recovery Test." *Journal of the Association of Asphalt Paving Technologists*, Vol. 76, 2007.

D'Angelo, J. and R. Dongre. "Practical Use of the MSCR Test: Characterization of SBS Dispersion and Other Additives in PMA Binders," Transportation Research Board Annual Meeting, 2009.

Prepared by: Asphalt Institute Technical Advisory Committee in cooperation with Federal Highway Administration

April 2010