Standard Practice for

Evaluating the Elastic Behavior of Asphalt Binders Using the Multiple Stress Creep Recovery (MSCR) Test

AASHTO Designation: PP xx-14

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1. SCOPE

1.1. This practice provides a means of evaluating the elastic behavior of an asphalt binder by using the results (percent recovery and non-recoverable creep compliance) from the Multiple Stress Creep Recovery (MSCR) test. The MSCR test is conducted using the Dynamic Shear Rheometer (DSR) at a specified temperature. It is primarily intended for use with residue from T 240 (Rolling Thin-Film Oven Test (RTFOT)), but may also be run on residue from R 28 (Pressurized Aging Vessel (PAV)).

1.2. The elastic behavior of an asphalt binder can provide insight to the technologist indicating to what extent, if any, the binder could be modified with an elastomeric polymer.

1.3. This practice may be used in conjunction with M 320, *Specification for Performance-Graded Asphalt Binder*, or M 332, *Performance-Graded Asphalt Binder Using the Multiple Stress Creep Recovery (MSCR) Test.*

1.4. The values stated in SI units are to be regarded as the standard.

1.5. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use*.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- T 350, Multiple Stress Creep Recovery (MSCR) Test of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)
- T 315, Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)
- R 28, Accelerated Aging of Asphalt Binder Using Pressurized Aging Vessel (PAV)
- T 240, Effect of Heat and Air on Moving Film of Asphalt (Rolling Thin-Film Oven Test)
- M 320, Performance-Graded Asphalt Binder
- M 332, Performance-Graded Asphalt Binder Using the Multiple Stress Creep Recovery (MSCR) Test

2.2. *ASTM Standard*:

- D 8, Standard Terminology Relating to Materials for Roads and Pavements

3. TERMINOLOGY

3.1. *Definitions*:

3.1.1. Definitions of terms used in this practice may be found in ASTM D 8, determined from common English usage, or combinations of both.

3.2. *Definitions of Terms Specific to This Standard*:

3.2.1. *creep and recovery*—a standard rheological test protocol whereby a specimen is subjected to a constant load for a fixed time period and then allowed to recover at a constant zero load for a fixed time period.

3.2.2. *non-recoverable creep compliance* (J_{nr})—the residual strain in a specimen after a creep and recovery cycle divided by the stress applied.

3.2.3. *percent recovery (Rec)*—the ratio of the difference between the peak strain and the residual strain to the peak strain, expressed as a percentage. This is a measure of the elastic response of an asphalt binder at a given temperature and applied stress level.

4. SUMMARY OF PRACTICE

4.1. This practice is used to evaluate the elastic response of an asphalt binder under shear creep and recovery at a specified temperature. For most asphalt binders, this temperature will be the high temperature grade as determined only by environmental conditions (not as adjusted for traffic speed or loading).

4.2. Asphalt binder is first aged using T 240 (RTFOT). A sample of the RTFO-aged asphalt is tested using T 350 (MSCR). Unless otherwise specified, the 25-mm parallel plate geometry is used with a 1-mm gap setting. The sample is tested in creep and recovery at two stress levels. The stress levels used are 0.1 kPa and 3.2 kPa. The creep portion of the test lasts for one second which is followed by a nine-second recovery. Ten creep and recovery cycles are tested at each stress level. Two parameters are derived from the MSCR test – the non-recoverable creep compliance (J_{nr}) and percent recovery (Rec).

4.3. Using the J_{nr} and Rec values from testing conducted at 3.2 kPa shear stress (identified as Jnr-3.2 and Rec-3.2, respectively) data is compared to a curve of Rec as a function of J_{nr}. Values that plot on or above the curve are considered to represent an asphalt binder with a significant elastic response indicative of modification using elastomeric polymers.

4.3.1. As an alternative, the equation of the curve may be used and the Rec-3.2 value compared to the calculated minimum Rec-3.2 value determined using the measured Jnr-3.2 value.

5. SIGNIFICANCE AND USE

5.1. This practice is used to evaluate the elastic response of an asphalt binder under shear creep and recovery at a specified temperature. Like existing parameters which also attempt to evaluate elastic behavior in an asphalt binder – such as Elastic Recovery – the MSCR percent recovery, Rec-3.2, has no quantified relationship to performance. Nevertheless, some users may still want to ensure that an asphalt binder is modified using an elastomeric polymer due to a belief that polymers will increase cracking resistance and durability. In any case the exact nature of the effect of polymer modification of an asphalt binder should more appropriately be determined through asphalt mixture testing.

6. APPARATUS

6.1. Use apparatus as specified in T 315 and T 350.

7. PROCEDURE

7.1. *Conditioning* – Unless otherwise specified, condition the asphalt binder to be tested in accordance with T 240 (RTFOT).

7.2. *Sample preparation* – The sample for the MSCR test is prepared the same as samples for T 315 using 25-mm plates. The temperature control will also follow the T 315 requirements.

7.3. *Testing* – Conduct testing on the asphalt binder sample at the desired temperature following the test procedure described in T 350. For most asphalt binders, the test temperature will be the high temperature grade as determined only by environmental conditions (not as adjusted for traffic speed or loading) using the LTPPBind 3.1 software or the principles behind the temperature determination in LTPPBind. In the absence of this information, use the temperature that corresponds to the high temperature grade of the standard unmodified grade of asphalt binder that would be used for the project location.

7.4. *Analysis* – After determining the Jnr-3.2 and Rec-3.2 values for the asphalt binder at the specified temperature, plot the data on either Figure 1a or 1b. Data that is plotted on or above the curve in Figure 1a or 1b is considered to have a significant elastic response for the associated value of non-recoverable creep compliance (indicating that the asphalt binder has been modified).

7.4.1. Alternatively, if the Jnr-3.2 value is between 0.10 and 2.00 kPa^{-1}, inclusive, substitute the Jnr-3.2 value determined from testing the asphalt binder into the equation as shown below and solve for the minimum required Rec-3.2 value.

$$\text{Rec-3.2}_{min} = 29.371*(\text{Jnr-3.2})^{-0.2633}$$

where:

Rec-3.2_{min} = minimum required value of Rec-3.2 to indicate significant elastic behavior, %

Jnr-3.2 = measured value of Jnr-3.2 from T 350 testing, kPa^{-1}

7.4.2. If the Jnr-3.2 value is less than 0.10 kPa^{-1} then the Rec-3.2_{min} value is 55.0%.

7.4.3. If the Jnr-3.2 value is greater than 2.00 kPa^{-1} then the Rec-3.2_{min} value is 0.0%.

7.4.4. Compare the measured value of Rec-3.2 from TP 70 testing to the Rec-3.2_{min} value as determined in 7.4.1 to 7.4.3 or the curve shown in Figures 1a and 1b. If the measured Rec-3.2 value equals or exceeds the Rec-3.2_{min} value (represented by the curve in Figures 1a and 1b), then the asphalt binder sample is considered to have shown a significant elastic response for the associated value of non-recoverable creep compliance – indicating that the asphalt binder has been modified.

Note 1 – the Rec-J_{nr} curve shown in Figures 1a and 1b, and Rec-3.2_{min} values described in Sections 7.4.1 – 7.4.3, are intended to be used to evaluate the elastic response of modified asphalt binders when tested at the appropriate climatic temperature. It should not be used with asphalt binders that have Jnr-3.2 values greater than 2.00 kPa^{-1}.

8. REPORT

8.1. *Report the following information*:

8.1.1. Sample identification;

8.1.2. PG grade and test temperature, nearest 0.1°C;

8.1.3. Average percent recovery at 3.2 kPa, *Rec-3.2*, to nearest 0.1%;

8.1.4. Non-recoverable creep compliance at 3.2 kPa, *Jnr-3.2*, to nearest 0.01 kPa^{-1}; and

8.1.5. Figure 1a or 1b with data point plotted representing the measured Jnr-3.2 and Rec-3.2 values or calculation showing the minimum required value of Rec-3.2 ($Rec\text{-}3.2_{min}$) compared to the measured Rec-3.2 value to indicate significant elastic behavior.

9. PRECISION AND BIAS

9.1. *Precision* – The research required to develop precision estimates has not been conducted.

9.2. *Bias* – The research required to establish the bias has not been conducted.

10. KEYWORDS

10.1. Asphalt binders; creep and recovery; creep compliance; Dynamic Sheer Rheometer (DSR); elastomer identification; Multiple Stress Creep and Recovery (MSCR) Test; percent recovery; polymer modification; elastic behavior.

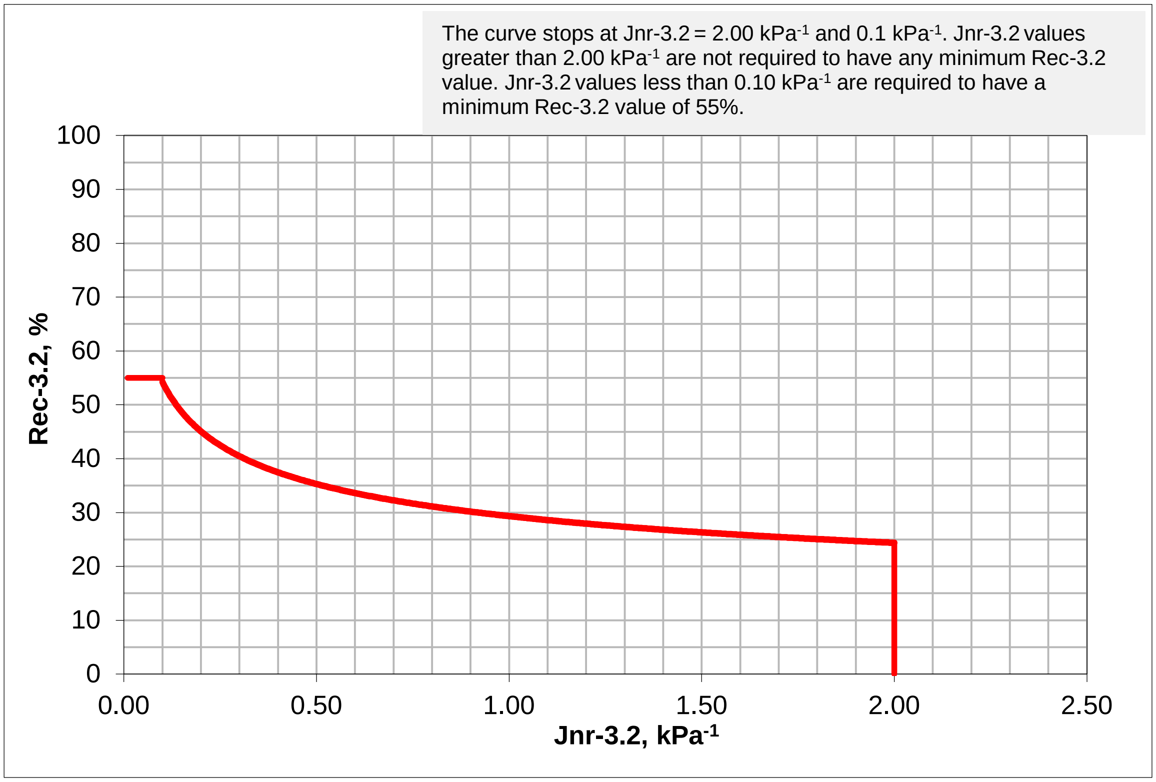

FIGURE 1a: Comparison of MSCR Jnr-3.2 and Rec-3.2 to Assess Elastic Response

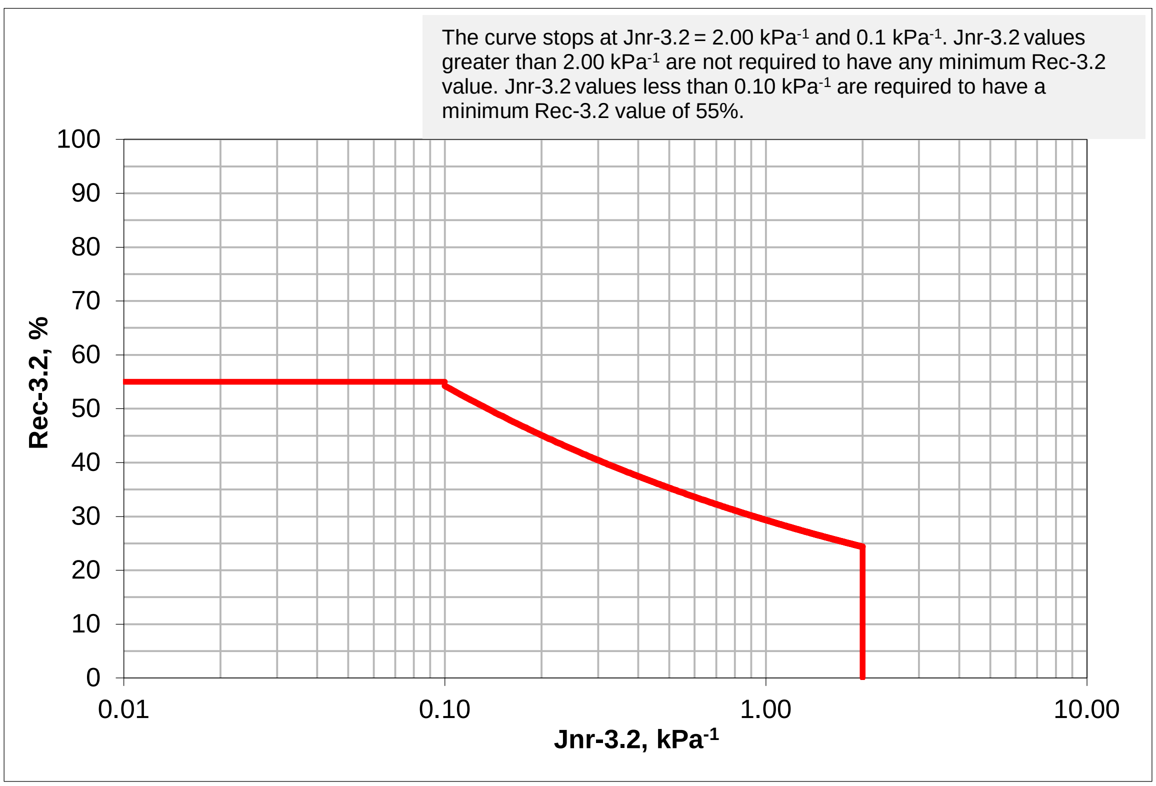

FIGURE 1b: Comparison of MSCR Jnr-3.2 and Rec-3.2 to Assess Elastic Response (Semi-Log)