MSCR AND GTR

WHAT IS MSCR?

As specified in AASHTO T350 and AASHTO M332, The Multiple Stress Creep Recovery (MSCR) test, provides the user with a high-temperature binder specification that more accurately indicates the rutting performance of the asphalt binder compared to the existing Dynamic Shear Rheometer (AASHTO T315) specification. It uses the same device and sample preparation method as the DSR test. The test applies 1 second creep load and allows 9 seconds of rest time for the binder at two different stress levels- 0.1 kPa and 3.2 kPa (hence the name 'multiple stress creep and recovery'). The application of load at higher stress levels (3.2 kPa) allows the test to measure the delayed elastic effects of polymer modification as opposed to measurements in the DSR testing at low stress levels. The test measures two parameters:

a. Rutting parameter: Jnr, or the non-recoverable compliance. It is measured at the two different stress levels, and annotated as Jnr,3.2 and Jnr,0.1
b. Stress Sensitivity parameter: Jnr,diff is the difference between Jnr,3.2 and Jnr,0.1 divided by Jnr,0.1

The test temperature is based on the PG high temperature grade of the binder. Based on the Jnr,3.2 value, a letter grade is assigned to the binder to denote the appropriate traffic level, as follows:

Letter Grade	Traffic Level	Jnr,3.2 (kPa^{-1})
E	Extremely Heavy	<0.5
V	Very Heavy	<1.0
H	Heavy	<2.0
S	Standard	<4.5

In all cases,a passing Jnr,diff value should be less than 0.75. The original reason behind this parameter's existence was to identify the additives which cause yielding in binders. In binders which are prone to yielding and are close to specification limits (for instance, say a binder's Jnr3.2, is 0.520 kPa^{-1}, it is V grade binder but very close to being an E grade binder), there is a possibility that slightly higher-than-expected stress levels could result in a sudden loss of strength of binder. Thus, the sensitivity parameter has a maximum limit of 0.75 (or 75%).

ASPHALT BINDER MSCR TESTING AND GTR MIX MODIFICATION

When the Georgia DOT began working with dry process rubber modification of asphalt mixes in high-traffic areas in the early 2000's, initial specification of dry process rubber included a requirement that combined samples of the GTR product and the binder used in the planned mix design produced a stress sensitivity parameter of less than 0.75 (or 75%) in the MSCR test. As the state began testing GTR streams with local binders, they found that a number of binder/GTR blends did not consistently pass proposed state MSCR testing standards. At the same time, the Georgia DOT (GDOT) noted that field pavements built with dry process GTR performed exceptionally well when compared to polymer-modified asphalt mix designs. After careful study, GDOT also noted that as mix rubber content increased, pavement performance improved as well, regardless of MSCR results.

Based on good to excellent pavement performance with dry process rubber, GDOT dropped the MSCR requirement for dry process rubber-modified mix designs. In order to ensure enhanced pavement performance with dry process rubber, GDOT mandated a minimum of 10.45% GTR (as a fraction of neat binder content) in state asphalt mix designs when replacing two-grade-bump polymer mix designs. GDOT has more than 2 million tons of dry process rubber-modified asphalt mixes in service at this time, and almost two decades of experience with dry process rubber.

Given that dry process rubber-modified asphalt mixes perform well in the field, the field performance raises an obvious question: if the dry process rubber pavements perform well in the field, shouldn't one see passing MSCR scores with a GTR-modified asphalt binder? Surprisingly, the answer to that question is no. Understanding the reasoning requires a closer look at MSCR testing and the impact of dry process rubber additions.

MSCR ISSUES WITH GTR AND OTHER POLYMER-MODIFIED BINDERS

As noted above, the stress sensitivity parameter Jnr,diff is often an issue when a tested binder is close to any particular specification limit. When a tested binder is below 0.5 kPa^{-1} - which is the upper end of the specification limit (lower Jnr,3.2 is better) - the stress sensitivity parameter serves no purpose. ***This is the case in many binders modified with rubber or polymers where the Jnr,3.2 value is low. In those situations, Jnr,diff measurements do not provide useful data on the performance characteristics of those binders.*** In addition, the low Jnr numbers often artificially balloon the Jnr,diff parameter as well (see Figure 1 for low Jnr values reported for rubber modified binders). This issue was discussed in detail by John D'Angelo, one of the developers of elements of the FHWA SuperPave system (1). His detailed description of this issue with the MSCR stress sensitivity parameter along with other examples of various wax-based binder modifications can be found here.
https://asphalt.mydigitalpublication.com/articles/what-is-jnr-diff-

MSCR TESTING WITH GTR MIX MODIFICATION

When the Georgia DOT began early work with Dry Process ECR, they included a requirement that if GTR was planned for a mix design, the designer would have to demonstrate that the addition of ECR to the binder passed MSCR. After multiple tests, GDOT found that when ECR was used in binders, MSCR testing often demonstrated that the binder/GTR blend would not pass due to the issues enumerated above. At the same time, GTR/binder mixes failing MSCR were performing very well in the field. GDOT removed the MSCR requirement for Dry Process pavements and instead required approximately 10% (as a fraction of neat binder weight) instead.

If MSCR testing is desired with dry process GTR products, testing requires direct addition of GTR to the binder selected for a specific application. This testing would be exposed to all of the issues outlined above and is not recommended as a process likely to generate useful information on the expected performance of that mix in the field. At the same time, it should be noted that both polymer-modified mix designs and terminal blend rubber-modified mix designs have been frequently replaced with dry process rubber mix designs in ten states and five countries. In both extensive lab testing and extensive field observation, there are no material differences in cracking and rutting resistance between the binder-modified (polymer, terminal blend rubber, PPA) mixes and dry process rubber (ECR) mix-modified pavements.

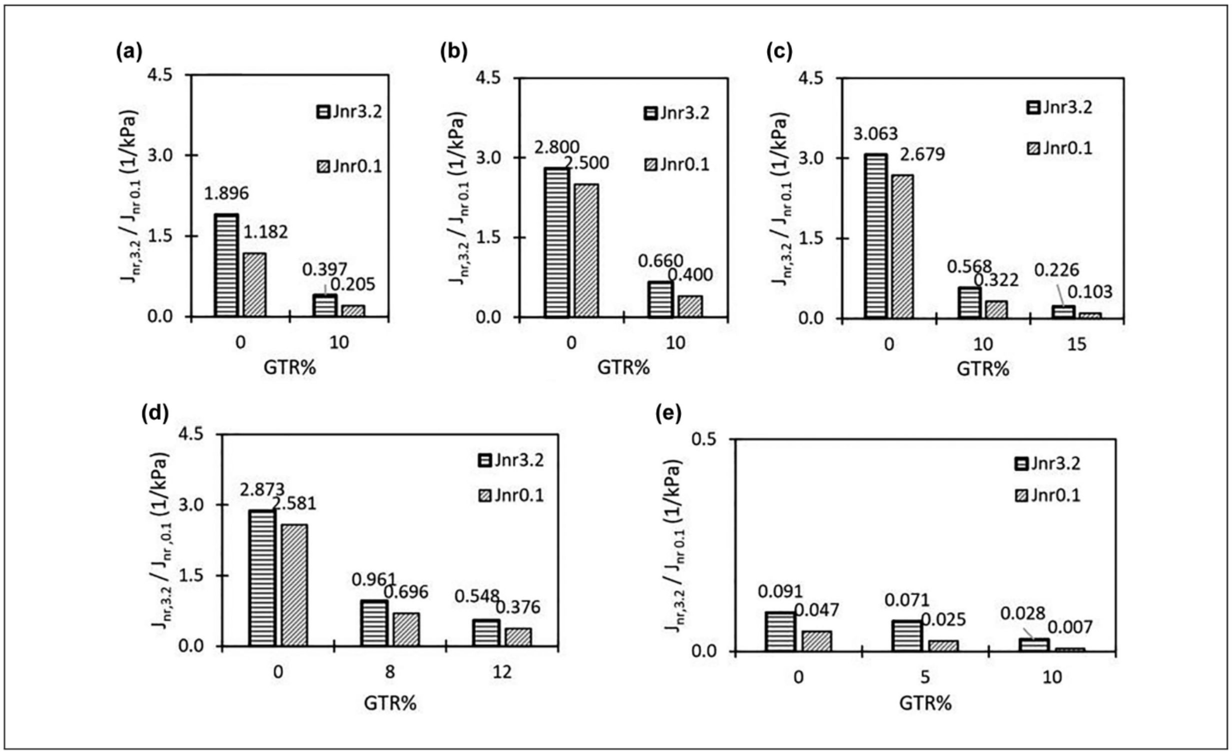

Figure 1. a,b,c,d,e – Non-recoverable compliance for various binders with GTR modification. Note the significant drop in Jnr values upon addition of rubber.

D'Angelo, John (2018) "What is Jnr diff?" Asphalt: Volume 33, No. 3, pp 36-39
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