The Effect of High Stress on Asphalt Binders and Hot Mix Asphalt

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ABSTRACT

The rutting resistances of eleven modified polymers and one conventional asphalt binder were investigated in this study. All binders studied were modified to obtain a similar performance grade level of close to PG 64-xx. Multiple Stress Creep Recovery (MSCR) tests were conducted on these binders at three different temperatures (50, 60, and 70°C) and at five different shear stress loadings (0.1, 3.2, 6.4, 12.8, and 25.6 kPa).

To investigate which MSCR stress level correlates best with the asphalt binder's high temperature properties, MSCR test results were compared with the Hamburg wheel-track testing results obtained at 60°C.

RÉSUMÉ

Les résistances à l'orniérage de onze bitumes modifiés aux polymères et d'un liant bitumineux conventionnel ont été examinées dans cette étude. Tous les liants étudiés ont été modifiés pour obtenir un niveau de performance similaire proche d'un PG 64-XX. Des tests de recouvrement du fluage aux contraintes multiples (MSCR) ont été effectués sur ces liants à trois températures différentes (50, 60 et 70°C) et à cinq charges de cisaillement différentes (0.1, 3.2, 6.4, 12.8 et 25.6 kPa).

Pour étudier quel niveau de contrainte MSCR est le mieux corrélé avec les propriétés à haute température du liant bitumineux, les résultats du test MSCR ont été comparés avec les résultats des essais d'orniérage Hamburg obtenus à 60°C.

1.0 THE EFFECT OF RUTTING

Expected growth in the transportation sector requires an efficient system of high-performing infrastructure. The increase in traffic loads, combined with other factors like the impact of changing temperatures, results in faster development of deformations (i.e., rutting) in asphalt pavements, along with other pavement distress modes. Polymer modification helps to significantly improve both low- and high-temperature performance of straight-run asphalt binders, thus mitigating the creation of pavement distresses and extending the lifetime of asphalt roads. Polymer modification improves the rheological and engineering properties of asphalt binders such as elastic response, tensile strength, adhesion, etc. [1].

Empirical methods can distinguish between conventional asphalt binders with relative accuracy, but they cannot reflect the new capabilities of polymer modified binders such as the elastic reaction of asphalt pavement to traffic loads. In 1993, the Strategic Highway Research Program (SHRP) addressed this issue by publishing the first version of the American Association of State Highway and Transportation Officials (AASHTO) specification M320 for Performance Graded (PG) binder, also called the Superpave™ binder specification [2]. This new specification was questioned by many researchers [3–5], as it is based on the study of unmodified binders and seemed inappropriate for modified binders at higher temperatures. In response, the Federal Highway Administration (FHWA) has proposed a performance-based binder test.

The Multiple Stress Creep Recovery (MSCR) test supplements the determination of High Critical Temperature (HCT) via Dynamic Shear Rheometer (DSR) [6, 7]. The MSCR test shows better correlation between the rutting resistance of asphalt mixtures and the performance of modified binders [8–11]. AASHTO M350 describes this test and implements it in the Standard Specification for Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) test with a designation of M332, formerly MP19 [6]. The MSCR test has proven through numerous evaluations that it can, to some extent, distinguish between the differences in the rutting potential of various binders; both modified and unmodified.

Test results indicate that the non-recoverable compliance, J_{nr}, may be a good supplement or even a possible replacement for the current DSR high-temperature binder criteria of $|G^*|sin\delta$ [8, 9, 11–13]. Several studies [8, 13] suggest a good correlation between rutting of asphalt mixtures (rut depth) and the J_{nr} obtained at 3.2 kPa of shear stress. Others report that the evaluation of the J_{nr} at higher shear stress levels may be a more accurate determination of which binder is more rut resistant [11, 14], possibly because the 3.2 kPa stress level used in the current MSCR test may be lower than the stresses experienced in the pavement.

If the asphalt binder's production method (e.g., distillation, oxidation, polymer modification by different polymers) does impact MSCR test results, only two parameters would impact the J_{nr} value: temperature and shear stress level. These parameters should correlate with the rut resistance results of the Hamburg Wheel-Tracking Test (HWTT). This should hold true for each temperature and each level of shearing stress. If the asphalt binder's preparation method does have an impact on its behaviour in MSCR testing, then we must determine the best shear stress to use to show the differences between asphalt binders. This will determine whether 3.2 kPa is the optimal shear stress value to use in the MSCR test.

2.0 CURRENT INVESTIGATION

2.1 Materials

A total of 12 asphalt binders were used in this study. Of these, 11 binders were polymer modified and one was a straight-run asphalt binder. To achieve more generalized results, three different Penetration-graded