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Rapid assessment of the tracking resistance of bituminous crack sealants

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Abstract

The bituminous sealants used in the preventive maintenance of pavements sometimes deform (track) under the action of passing vehicles. In summer, this is the prevalent mode of sealant failure. To assess the propensity of a sealant to deform in summer a standard flow test is used, but the imprecision in the results have prevented any correlation with field performance. In an attempt to find an alternative means of assessing deformation, two methods were evaluated. The first method relied on the use of the French rut tester, whereas the second method relied on the use of a Taber abraser. The first method was found to be inappropriate to test sealants because of its severity, but the second method proved promising. The Taber abraser allowed for the measurement of sealant displacement at various temperatures, and for distinguishing the deformation propensity of sealants.

Keywords: pavements, roadways, maintenance, sealants, sealing, specification, testing, performance.

Introduction

Bituminous hot-poured sealants are used extensively in the preventive maintenance of roadways (Masson et al. 2003). To be effective, sealants must bond to the crack walls and remain in place. In summer, however, soft sealants may be displaced as they can track under the repeated action of tires as shown in Figure 1 (Masson 1992a; Marino 1995).

The propensity of sealants to deform in summer temperatures is currently assessed by means of the flow test in ASTM D 5329: test methods for sealants and fillers, hot-applied for joints and cracks in asphaltic and Portland cement concrete pavements. In the flow test, a sealant resting at an angle of 75° while at 60°C must flow less than 3 mm for acceptance. This is an easy test to perform, but the fixed temperature is not representative of the maxima across North America, best represented by the upper limit of the performance grades (PG) for asphalt binder (46°C to 82°C, in steps of 6°C) as expressed in ASTM D6373: standard specification for performance graded asphalt binder. Possibly because the flow test is empirical, the relationship between the standard test results and the field performance of sealants, or their tracking propensity, has never been established.

To assess the propensity of fresh sealants to deform in the summer temperatures encountered throughout North America, the preferred course of action would be to perform field tests. Ideally, the experimental conditions in at least seven locations (one location for each of the positive PG temperature) would be the same. This would allow for an easy comparison of the results from different sealants at each location. In addition, the pavement type, the sealant lots, the installation method and the contractor would need to be identical for each location. The only difference would be the maximum temperature at each site. In practice, this approach would be

time consuming and costly, and it would be difficult to control the type of hot-mix asphalt (HMA), the sealant lot and the workmanship.

Because of the difficulty in conducting field tests, it was deemed appropriate to estimate the tracking propensity of sealants in the laboratory. In an investigation of a limited scope, the suitability of the French Rut Tester and the Taber-Abraser for inducing sealant deformation and tracking between 46°C and 82°C was investigated. The results of this evaluation are presented in this short communication.

French Rut Tester (FRT)

The FRT is normally used to test the resistance of a HMA to permanent deformation (rutting) at 60°C, according to the French specification NF P 98-253-1. In this test, a HMA is subjected to repeated passes of a wheel fitted with a tire inflated to 0.6 MPa, mounted on a carriage that moves back and forth at 1 Hz. The standard wheel load is 5 kN, and the angle of motion of the wheel with respect to the HMA long axis is normally 0°, but it can be increased up to 10°.

To allow for the testing of the crack sealant on a solid non-deforming base, Portland cement concrete (PCC) slabs were used (Figure 2). Prior to testing, the sealants were given different geometries by sawing one to three troughs across the concrete slabs: 3 mm wide by 20 mm deep with a 10 mm overband on either side of the cut; 20 mm x 20 mm reservoir with an overband; and a 30 mm wide by 10 mm deep reservoir flush-filled with sealant. The first geometry was meant to simulate crack filling, whereas the other two were meant to simulate crack treatments where cracks are routed and overbanded (Masson et al. 2003). The concrete slabs were about 180 mm wide by 625 mm long and 75mm thick.

Because of the lack of a rotational driving force, the back and forth movement of the wheel in the FRT does not reproduce the shear of a passing vehicle; it simply applies a load on the slab.

In an attempt to apply some shear to the surface of the sealants, the wheel of the FRT was first set to travel at a 10° angle to the long axis of the PCC slab. The wheel load was reduced from the standard 5 kN to 500 N because of the interest in sealant deformation rather than the load bearing capacity of the PCC.

The sealant was tested at 50°C, a temperature readily achieved with the FRT. To achieve this temperature as quickly as possible and to maintain this temperature in the FRT, the PCC slabs were preheated and the air within the FRT was maintained at $50 \pm 3^\circ\text{C}$ by means of the internal heater. The temperature at the surface of the sealant was monitored with a thermocouple imbedded at the sealant surface. Tests were conducted at different temperatures, but temperatures beyond 70°C were inaccessible, even with secondary heating as provided by hot-air blowers.

The result of the test on a sealant, after 100 cycles across the concrete slab at 50°C, is shown in Figure 3. The sealant overbands were completely removed from the surface, whereas the sealant was pushed sideways in the flush-filled 30 x 10 mm² reservoir. The observed failures were unlike those shown in Figure 1, where the sealant is simply pushed in the traffic direction. The use of cement powder on the tire and sealant led to the same catastrophic failure.

In an attempt to prevent the pulling-out of sealants during the test, the shear stress was lowered. To this effect, the angle of the wheel with respect to the direction of travel was reduced from 10° to 0°, and the wheel load was reduced further to 125 N, the lowest possible load in the FRT. Under these conditions, sealants were unaffected; they did not deform or adhere to the tire.

The goal of the preliminary tests was to achieve a sealant deformation between those obtained at 0° and 10°. Consequently, the angle of wheel travel was increased to 2°. The effect of this slight change was to push the sealant sideways along the sealant bead, an unusual deformation for a

sealant. In addition, small cracks appeared on the surface of the sealant (Figure 4). Such cracks might appear at the surface of stiff weathered sealants (Masson et al. 1992b), but they were atypical of the sealants that deform in summer.

In summary, the use of the FRT to assess tracking propensity did not yield the anticipated results. Temperatures up to 82°C were not readily accessible, and the sealant distresses differed significantly from those in the field. Consequently, the tests with the FRT were deemed inappropriate for the evaluation of sealant deformation and tracking.

Small scale deformation test

In an effort to induce the deformation of sealants in a manner, and at temperatures, typical of those observed in the field, a method that applied a unidirectional stress was sought. One such method is based on an abrasion test described in ASTM D4060: standard test method for abrasion resistance of organic coatings by the Taber abraser. In this test, an abrasive wheel rolls on a coated aluminium panel and creates a circular wear path in the coating.

The standard abrasion test was adapted for the testing of bituminous sealants. A non-abrasive rotating wheel covered with a band of natural rubber was used, and the aluminium panel was replaced with a circular PCC disk with a trough flush filled with sealant (Figure 5). To evaluate the method, the deformation of two sealants was measured at 52°C, 60°C and 70°C after 10 to 50 rotations of the concrete disk. To control the temperature, the samples and the abraser were placed in an oven at a set temperature. Figure 6 shows how the displacement of a sealant was measured. For each test condition and sealant, the maximum displacement length of the sealant from the initial border of the trough was measured, along with the size of the area newly covered with sealant.

The displacement of sealants A and D at the various temperatures is shown in Figure 7 (the surface area newly covered with sealant was proportional to the maximum displacement length, so it is not shown).^[ILA1] It shows that temperature had only a slight effect on the displacement of sealant D, which increased slightly with increments in temperature. In contrast, the displacement of sealant A was much more affected by temperature. After only 10 cycles at 70°C, the displacement of this sealant was quite large (and the test discontinued at this temperature). At 52°C and 60°C, the sealant displacement increased with temperature and the number of cycles.

At all test temperatures, the displacement of sealant A was greater than that of sealant D. Figure 8 shows the data at 60°C, which suggest that sealant A may be more susceptible to deformation than sealant D. Interestingly, the 60°C flow of both sealants in the standard test was 0.5 mm (Masson et al. 1999).

Conclusion

Two laboratory tests were evaluated, the purpose being to find an improved method to rapidly assess the tracking resistance of bituminous crack sealants. The French Rut Tester was not useful in this regard. It caused failures unlike those in the field. In contrast, a small-scale deformation test allowed for the measurement of sealant displacement between 50 and 70°C and for differentiating between two sealants, which could not be achieved with the standard method. The results of a study with this small scale test on twenty-one sealants tested at 46°C to 82°C, at intervals of 6°C will be provided in a forthcoming full paper.

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Fig. 1. Tracking of sealants within hours of installation (top, from Masson 1992a), and later in the service life (bottom, from Marino 1995).

Fig. 2. French Rut Tester with its door open to show the PCC slab with sealant.

Fig. 3. Deformation of a sealant at 50°C after 100 cycles in the French rut tester. Configurations, from left to right: overbanded 20 x 20 mm², overbanded 3 x 20 mm², and flush-filled 30 x 10 mm² reservoir.

Fig. 4. Sealant deformation and cracking after the testing at a 2° angle. The flow is indicated by the arrows and an example of cracking is indicated by the circle.

Fig. 5. The small scale deformation test for bituminous sealants.

Fig. 6. Sealant A before (left) and after 10 cycles at 70°C. PCC disk rotation was counter-clockwise.

Fig. 7. Displacements of sealants A and D at 60 °C during the small scale deformation test.

Fig. 8. Displacement of sealants A and D during the small scale deformation test.