



Low Temperature and Moisture Susceptibility of RAP Mixtures with Warm Mix Technology

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REPORT #10-3

ABSTRACT

A major concern with the use of Warm Mix Asphalt (WMA) technologies has been their impact on the moisture susceptibility of asphalt paving mixtures. This is due to the lower production temperatures associated with mixtures incorporating these technologies which could lead to inadequate drying of aggregates. The moisture susceptibility concern may be compounded if high amounts of Reclaimed Asphalt Pavement (RAP) are added to the mixture. RAP is mixed with the heated aggregates in an attempt to avoid further stiffening of the binder present in the RAP. Therefore, if the aggregates in a mixture are heated at lower temperatures than the conventional temperatures due to WMA, the RAP will be exposed to less heat which might lead to residual moisture in the RAP being present in the mixture. Residual moisture may lead to adhesive and/or cohesive failures. The purpose of this study was to better understand the influence of moisture on the performance of plant produced high RAP content mixtures incorporating WMA technologies fabricated at reduced mixing temperatures.

Nine 12.5-mm Superpave mixtures were produced in two drum plants using three WMA technologies and three RAP contents. The three WMA technologies were wax-based SonneWarmix™, chemical-based Evotherm®, and the Stansteel ACCU-SHEAR™ foaming process.

Post production moisture in each mixture was negligible which means that moisture had no effect on mixture performance. The quality of blending analyses showed that the majority of the mixtures had poor blending, which would indicate that there should be performance issues with many of these mixtures. However, the quality of blending had no apparent effect on mixture performance. It did not explain any poor performance or any difference in performance.

Overall, some WMA with RAP contents up to approximately 50% RAP provided acceptable performance. Field trials or full-scale pavement accelerated tests with rigorous pavement monitoring are needed to confirm the findings of this study.

ACKNOWLEDGMENTS

The research data and results presented in this paper were part of a New England Transportation Consortium (NETC) project study entitled "Low temperature and Moisture Susceptibility of RAP Mixtures with Warm Mix Technology." NETC is a funded research cooperative between the state DOTs of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont.

Moisture Susceptibility Data

The three moisture susceptibility tests generally indicated acceptable performance regardless of the WMA technology or RAP content. The only significant failure was provided by the low RAP content of 15% RAP in combination with one WMA technology when tested by the HWTD. However, the mixture easily passed the other two tests. The three tests for moisture susceptibility did not always agree with one another. All rut depths in the HWTD were low except for the mixture which failed from moisture damage.

| Plant | Mixture | Warm Mix Asphalt Technology | AASHTO T283 Tensile Strength Ratio (TSR), % | HWTD Stripping Inflection Point | ESR @10Hz |
|---------------|-----------|-----------------------------|---|---------------------------------|-----------|
| Drum Plant #1 | 15% RAP | 0.5% SonneWarmix™ | 92.0 | 11,766 F | 101.4 |
| Drum Plant #1 | 27.8% RAP | 0.5% SonneWarmix™ | 88.7 | NONE | 99.8 |
| Drum Plant #1 | 46.3% RAP | 0.5% SonneWarmix™ | 93.9 | NONE | 96.5 |
| Drum Plant #2 | 29% RAP | 0.5% Evotherm® | 82.2 | NONE | 90.4 |
| Drum Plant #2 | 39% RAP | 0.5% Evotherm® | 77.5 F | NONE | 89.2 |
| Drum Plant #2 | 48% RAP | 0.5% Evotherm® | 85.9 | NONE | 81.7 |
| Drum Plant #2 | 29% RAP | Foaming | 94.8 | NONE | 94.6 |
| Drum Plant #2 | 39% RAP | Foaming | 90.1 | NONE | 94.7 |
| Drum Plant #2 | 48% RAP | Foaming | 86.8 | NONE | 98.0 |

F = Failed the specification

Low Temperature Cracking Data

Results from the TSRST and DC(T) did not indicate any influence of moisture on mixture performance in terms of low temperature cracking for all mixtures. The TSRST provided acceptable thermal cracking performances. The DC(T) showed that all mixtures would have acceptable thermal cracking performances for pavements with low or medium traffic levels.

| Plant | Mixture | Warm Mix Asphalt Technology | TSRST Average Failure Temperature (°C) | Average Fracture Energy (J/m ²) |
|---------------|-----------|-----------------------------|--|---|
| Drum Plant #1 | 15% RAP | 0.5% SonneWarmix™ | -27.0 | 499 |
| Drum Plant #1 | 27.8% RAP | 0.5% SonneWarmix™ | -27.3 | 518 |
| Drum Plant #1 | 46.3% RAP | 0.5% SonneWarmix™ | -26.6 | 474 |
| Drum Plant #2 | 29% RAP | 0.5% Evotherm® | -25.5 | 504 |
| Drum Plant #2 | 39% RAP | 0.5% Evotherm® | -26.2 | 562 |
| Drum Plant #2 | 48% RAP | 0.5% Evotherm® | -26.8 | 562 |
| Drum Plant #2 | 29% RAP | Foaming | -26.9 | 548 |
| Drum Plant #2 | 39% RAP | Foaming | -25.8 | 517 |
| Drum Plant #2 | 48% RAP | Foaming | -23.0 | 582 |

CONCLUSIONS

A major concern with using a WMA technology and RAP is the potential for residual moisture from the RAP to be present in the mixture after production due to the reduced production temperatures associated with WMA and also any residual moisture if a WMA foaming process is used. The residual moisture contents of the mixtures in this study after plant production were negligible, which means that moisture had no effect on mixture performance. The results indicate that moisture can be dried out of these types of mixtures by a drum plant. The moisture contents of the RAP stockpiles ranged from 1.6 to 4.1%. However, field trials or full-scale pavement accelerated tests with rigorous pavement monitoring are needed to confirm the findings of this study.