Evotherm Warm Mix Asphalt in Crow Wing County, Minnesota: Eliminating Thermal Cracking at Reduced Cost

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INTRODUCTION

Evotherm Warm Mix Asphalt (WMA) is produced at temperatures ranging from 30 to 50ºC (80 to 100ºF) below comparably formulated hot mix asphalt (HMA). It is widely known that with lower the mix production temperatures comes less binder oxidation. Less oxidation leads to improvements in crack resistance. Numerous studies have demonstrated that the use of Evotherm WMA pavement specimens exhibit improved thermal, fatigue, and reflective cracking compared to HMA. Of particular interest to transportation departments in northern climates are the benefits in thermal cracking or cold fracture resistance.

Disk-shaped compact tension tests (also called DC(T) tests) are commonly used in the asphalt engineering community to study the cold fracture properties of compacted asphalt pavement specimens. DC(T) studies at the University of Illinois Champagne have demonstrated that the use of Evotherm WMA significantly reduced the cold fracture temperature of pavement compared to conventional hot mix asphalt (1). In that study, Evotherm WMA compacted specimens were produced at 120ºC (248ºF) using a mix consisting of 12.5 mm NMAS dense-graded aggregate and PG 64-22 binder. At critical temperatures of -10, -20, and -30ºC (14, -4, and -22ºF), the compacted Evotherm cores exhibited 18-39% higher resistance to thermal cracking (cold fracture) than the comparably formulated hot mix asphalt (HMA) produced at 150ºC (300ºF).

Findings such as these and others have led Departments of Transportation to employ Evotherm technology for the purpose of reducing or eliminating thermal cracking in asphalt pavements.

BACKGROUND

In 2008, the Department of Transportation engineers in Crow Wing County, Minnesota, envisioned the use of Evotherm warm mix asphalt as a means to reduce the occurrence of thermal cracks in their dense-graded surface mixes. Moreover, the Department of Transportation sought to replace the commonly-used polymer-modified PG 58-34 with a less expensive unmodified PG 58-28 bitumen. PG 58-28 costs about three dollars per ton less than the PG 58-34 binder. Minnesota binder grades for varying ESAL counts and traffic speeds are detailed thoroughly in website in Reference 4.

It was reasoned (and subsequently demonstrated in 2009 via visual crack counting) that the reduced production temperatures for Evotherm WMA mixes would result in the PG 58-28 maintaining its low-temperature grading of . Producing Evotherm WMA mixes at 30-50ºC below the typical temperature of the HMA control mix results in substantially less binder oxidation and less loss of low-temperature resilience.

EVOTHERM 3G TECHNOLOGY – TYPICAL PROCESSING

The heart of Evotherm 3G technology is a package of high-flash point (>200ºC) surface active chemicals which may be added directly to molten bitumen. Evotherm 3G chemicals are

designed to be used with both polymer-modified or unmodified bitumens. Evotherm 3G is compatible with all common polymer modifications (SBS, SBR, Evaloy, EVA, etc.). Additionally, the technology is suitable for use with bitumens modified with polyphosphoric acid.

Bitumen treated with Evotherm 3G chemistry has been used to produce a wide variety of mix types in both continuous and batch mix plants. Mixes produced with Evotherm 3G technology include

- Dense-graded Superpave mixes with up to 30% Reclaimed Asphalt Pavement (RAP)
- SMA mixes based on polymer-modified bitumen
- Open-graded mixes containing RAP and crumb rubber-modified binder
- Base, binder, and surface mixes for asphalt pavements supporting wide-ranging loads, volumes, and traffic speeds

Evotherm 3G technology has been used to construct a wide variety of asphalt pavement structures ranging from mill and fill overlays on low-ADT rural roads to full depth lifts for taxiways at the largest commercial cargo airport in the U.S.A. (2).

Processing Evotherm 3G is convenient for all end users, including contractors, asphalt terminals, and asphalt refineries. Typically the chemical package is added at a dosage ranging from 0.4 to 0.8% by weight of the total bitumen (virgin plus RAP binder). The chemical package may be added to the tanker truck, to day tanks, or metered directly into the asphalt line at the mix plant. In the projects in Crow Wing County, MN, Evotherm 3G was added to the asphalt tankers prior to shipment from the Flint Hills Resources Refinery in St. Paul, MN.

FIGURE 1. Night Photograph of Flint Hills Resources Refinery

MOISTURE RESISTANCE OF EVOTHERM SURFACE MIX FORMULATION

Studies have demonstrated that Evotherm 3G chemical packages are stable during storage in a wide range of bitumens for up to 20 days at elevated temperatures (3). The Evotherm WMA used in Crow Wing County projects showed improved TSR over the HMA control mix. Table I shows these results.

TABLE I. TSR of Evotherm WMA and HMA Control Mixes

Mix Type	Dry Indirect Tensile Strength (psi)	Conditioned Indirect Tensile Strength (psi)	TSR (%)
HMA Control Mix	69.5	55.0	79
Evotherm WMA	69.4	65.2	94

CONSTRUCTION SITE

Crow Wing County is located roughly 120 miles (200 km) northwest of Minneapolis, MN, and about 140 miles (224 km) from the US border with Canada.

Two projects were constructed in Crow Wing County using Evotherm WMA. In 2008, roughly 2000 tons of PG 58-28 surface mix was placed on CR 108. After the first winter (2008-2009), the average number of cracks in the Evotherm PG 58-28 pavement was comparable to the average number exhibited by the HMA control pavement, which used a PG 58-34 binder.

In 2009, over 20,000 tons of PG 58-28 of 12.5 mm NMAS Superpave Evotherm WMA was placed in two lifts for a total of roughly 5-6 inches (125 – 150 mm). Total binder content was 5.2%, including the binder contributed from the 30% RAP used in the Evotherm mix formulation. It is important to add that not only were lower production temperatures achieved

using the Evotherm technology, but the use of 30% RAP provided another cost-savings benefit. The HMA control mix contained only 20% RAP. Had higher RAP contents been used in the HMA, experience shows that the resulting binder modulus becomes too high, leading to early low temperature thermal cracking. Since the Evotherm mixes were produced at roughly 40ºC lower mix temperature, less binder oxidation occurred allowing for the use of the higher RAP content.

CONCLUSIONS

The Crow Wing County Department of Transportation estimates that it could realize roughly $1,000,000 annually in savings by using Evotherm WMA technology over its 613 mile (980 km) road network (4). Savings are realized by 1) lowering fuel consumption by producing mix at an average of 40ºC lower temperature than the HMA control mix, 2) using 30% RAP rather than 20% in the HMA control mix, and 3) substituting a PG 58-28 binder for the polymer-modified PG 58-34 binder typically used in the HMA mixes.

In their final report, the Crow Wing County Department of Transportation engineers arrived at the following key conclusion. "Assuming [Evotherm] WMA is suitable for all new construction, and all roads were reconstructed, the cost savings over the life of the roadways using WMA would be approximately $1,000,000 per year." That equates to savings of over $1000 per center-line kilometer.

REFERENCES

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