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EVALUATION OF STRATA® REFLECTIVE CRACK RELIEF SYSTEM

FINAL REPORT

WISCONSIN TECHNICAL SERVICES DEPARTMENT OF TRANSPORTATION

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16. Abstract

In 2001, the Wisconsin Department of Transportation (WisDOT) initiated this Federal Experimental Project to evaluate the effectiveness of Strata® Reflective Crack Relief System, an interlayer designed to delay cracks from reflecting through hot mix asphalt (HMA) overlays placed on concrete pavements. Test sections were constructed in Racine County in 2001 and in St. Croix County in 2002. After the existing HMA pavements were milled off, the existing underlying concrete pavement was repaired. A tack coat was applied prior to paving a one-inch thick Strata® interlayer. The interlayer was then overlaid with HMA.

Crack surveys were conducted annually for several years. The results from the Racine County project showed that the Strata® interlayer delayed reflective cracking in an HMA overlay, over a concrete pavement with doweled full-depth patches, for two years. However, there was no conclusive evidence that Strata® would reduce reflective cracking longer than two years. The results from the St. Croix project showed that the lanes/sections with Strata® performed very well and typically better than the lanes/sections without Strata® for the first two years. Test sections that had Strata® in only one lane consistently performed well in the lane with the Strata®, but very poorly in the adjacent lane without Strata®. Although the test section that had Strata® in both lanes performed fairly well after three years and had an average percentage of reflective cracking in both lanes of 47.5 percent, Control Section 1, which didn't have an interlayer, performed the best with an average percentage of reflective cracking in both lanes of 40 percent.

The Strata® Reflective Crack Relief System was able to delay reflective cracking for two years. By the third year, the test sections with a Strata® interlayer performed comparably to those without an interlayer. Since WisDOT typically performs crack maintenance beginning in year three, the ability of Strata® to reduce reflective cracking for only two years does not result in any cost savings to WisDOT. Thus, the Strata® Reflective Crack Relief System is not a cost effective solution to reduce reflective cracking of an HMA overlay placed over a concrete pavement.

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Wisconsin Federal Experimental Project # FEP-01-06

Final Report # FEP-01-07

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INTRODUCTION

Many deteriorated pavements are overlaid with hot mix asphalt (HMA) to provide a smoother riding surface and prolong the pavement life. Reflective cracking is a problem that can develop in HMA overlays when they are placed over existing concrete or HMA pavements. A reflective crack is formed when a joint or crack in the existing pavement propagates up into the HMA overlay. Reflective cracks are primarily caused by horizontal or vertical movement of the underlying pavement at the transverse joints or cracks. An old rule of thumb is that reflective cracks propagate up through the HMA overlay at a rate of one inch per year. However, experience has shown that reflective cracks have appeared within one year of construction of overlays of varying thicknesses. Eventually the entire crack pattern of the underlying pavement can reflect into the HMA overlay. The reflective cracking results in a poor ride, increased maintenance costs, and a shorter pavement life. To prevent further deterioration of the pavement, Wisconsin Department of Transportation's (WisDOT's) standard practice is to seal or rout and seal cracks beginning three years after construction of the overlay.

Many products designed to reduce or eliminate reflective cracking have been introduced in the market over the years. In 2001, WisDOT initiated this Federal Experimental Project to evaluate the effectiveness of Strata® Reflective Crack Relief System, an interlayer designed to delay cracks from reflecting through HMA overlays placed on concrete pavements.

PRODUCT DESCRIPTION

The Strata® Reflective Crack Relief System, currently designed and marketed by SemMaterials, L.P., consists of a highly elastic, impermeable hot mix interlayer to be overlaid with HMA. The interlayer is comprised of a high percentage of polymer modified asphalt binder in a dense fine aggregate mixture. The HMA overlay, which is to be paved over the Strata® interlayer, is designed to complement the Strata® interlayer, while meeting the local traffic demands. The Strata® system consists of site selection recommendations, the interlayer mix design, HMA overlay mix design recommendations, and SemMaterials' technical support. It should be noted that at the origin of this research study, the Strata® Reflective Crack Relief System was designed and marketed by Koch Pavement Solutions. However, since SemMaterials is the current owner of Strata® technology, all references in this report will be to them.

Literature from SemMaterials suggests that the Strata® Reflective Crack Relief System can provide several advantages. Firstly, the Strata® system can delay the initial appearance of reflective cracks for approximately two years. Also, complete reflective cracking will be delayed three to five years longer than with a fabric and HMA overlay. The service life of the pavement structure is also estimated to increase by five years. In addition, the impermeable interlayer protects the underlying pavement from moisture damage. The Strata® interlayer is manufactured and applied using standard HMA procedures and equipment. Finally, the Strata® material can be recycled.

The Strata® system is designed for use on concrete pavements that are structurally sound, with doweled joints in good condition. Any severely distressed areas should be repaired prior to placing the Strata® interlayer.

HISTORY

In 2001, at the start of this research project, several states, including New Jersey, Illinois, Kansas, Texas, Missouri, Oklahoma and Iowa, had used Strata® or a sand anti-fracture layer (SAF) on one or more projects. The SAF layer, very similar to Strata®, is a fine aggregate graded asphalt mixture using highly polymerized asphalt cement, and is placed between a concrete pavement and an HMA overlay. In 2001, performance results reported by the other states varied from good to bad to indifferent. Recently, SemMaterials reported that through 2006, approximately 585 lane-miles (4.0 million yd^2) of Strata® Reflective Crack Relief System have been placed in twenty states throughout the U.S.

In 2006, the Center for Advanced Infrastructure & Transportation at Rutgers University initiated a study for the New Jersey DOT to develop guidelines for the selection of flexible pavement “systems” on rigid pavements. As part of that study, states were surveyed on their use of flexible pavement overlays on rigid pavements. Twenty-eight state responses were received and of those 28, 16 responded they had tried “Strata”-type interlayer mixes, and of those 16, 7 reported that the use of “Strata”-type interlayer mixes was successful.

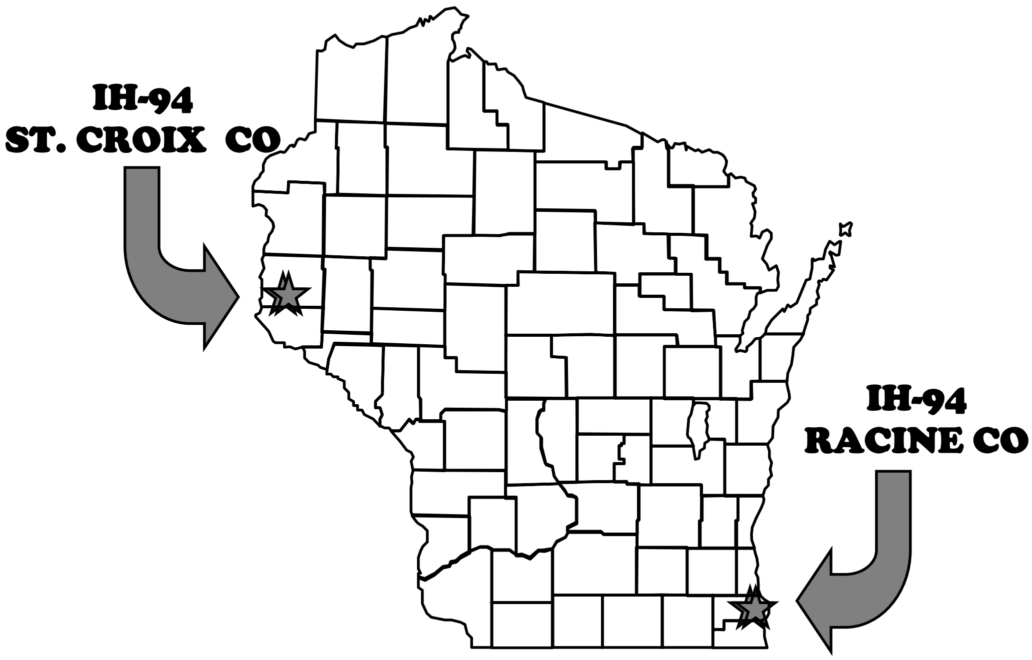
RESEARCH DESCRIPTION

The primary objective of this study was to determine if the Strata® Reflective Crack Relief System is a suitable and cost-effective system for delaying or eliminating reflective cracking in HMA overlays. Another objective was to determine the effectiveness of Strata® at protecting the underlying concrete pavement from surface water seeping through any cracks that did develop in the overlay. Two separate concrete pavement rehabilitation projects were selected for this research to perform in-situ evaluations of Strata®’s reflective crack mitigation and sealing characteristics. Test sections and control sections were constructed at each project site; these sections were monitored and the performance characteristics of the different sections were documented.

TEST SITES

As illustrated in Figure 1, the test sites were located on IH-94 in Racine and St. Croix counties.

Figure 1. Strata® Test Sites



Racine County

The first project location (Project ID 1032-01-72) was on I-94 in Racine County, a six-lane divided highway—three lanes in both directions. Technically this interstate is referred to as an east-west corridor, but in this specific segment the interstate runs north and south. The existing pavement structure consisted of a variable thickness (4-inch average) HMA overlay over a concrete pavement. The concrete pavement was originally constructed in 1960 as a 10-inch jointed reinforced concrete pavement (JRCP), over 8 inches of crushed aggregate, over 9 inches of granular subbase. The reinforcement of the 10-inch concrete pavement consisted of wire mesh within the slabs and dowel bars at the joints that were spaced 40 feet apart. This roadway is a principal arterial with a 20-year design equivalent single axle load (ESAL) of 19.5 million, and an average daily traffic (ADT) projection of 128,000 for the year 2020, with 15 percent trucks.

In the summer of 2001 this highway section was resurfaced. The project limits included all six lanes and extended for ten miles, from the Kenosha/Racine County Line to the

Racine/Milwaukee County Line. Four research sections were constructed within the project limits for performance evaluations (one control and one test section in each direction). Each section spanned the width of the driving lane and one half of the center lane. The eastbound (EB) research sections began just east (south) of Golf Road and extended for 1.6 miles. Strata® was applied to 0.8 miles of this stretch; the remaining 0.8 miles of this segment was constructed without Strata®, the same as the remainder of the project, and was considered the control section. A Rosphalt HMA overlaid bridge deck existed within the control section limits and was disregarded in this research effort. The westbound (WB) research sections extended for 1.6 miles as well, and were located between State Trunk Highway (STH) 20 and 58th Rd. Strata® was applied to a 0.8-mile segment of the WB driving lane and half of the center lane, with the remaining 0.8 miles serving as an additional control section. See Figure 2 on page 7 for a layout of the test and control sections.

The test sections consisted of a 1-inch Strata® interlayer, followed by two 2-inch layers of Superpave E-30. The control sections, as well as the remainder of the project, consisted of a 1-inch layer of Superpave E-30, followed by two 2-inch layers of Superpave E-30. The pavement structure details of all four sections are as follows:

<u>Test Section 1: Station 1000+00 to 958+00, EB</u>

2-inch Superpave E-30, 12.5 mm HMA surface (PG 70-28p)
2-inch Superpave E-30, 12.5 mm HMA lower layer (PG 64-22)
1-inch Strata® interlayer
10-inch existing jointed reinforced concrete pavement
8 inches existing crushed aggregate base
9 inches existing granular subbase

<u>Test Section 2: Station 770+00 to 813+00, WB</u>

2-inch Superpave E-30, 12.5 mm HMA surface (PG 70-28p)
2-inch Superpave E-30, 12.5 mm HMA lower layer (PG 64-22)
1-inch Strata® interlayer
10-inch existing jointed reinforced concrete pavement

8 inches existing crushed aggregate base

9 inches existing granular subbase

Control Section 1: 958+00 to Station 914+91, EB

2-inch Superpave E-30, 12.5 mm HMA surface (PG 70-28p)

2-inch Superpave E-30, 12.5 mm HMA lower layer (PG 64-22)

1-inch Superpave E-30, 12.5 mm HMA lower layer (PG 64-22)

10-inch existing jointed reinforced concrete pavement

8 inches existing crushed aggregate base

9 inches existing granular subbase

Control Section 2: Station 813+00 to 856+00, WB

2-inch Superpave E-30, 12.5 mm HMA surface (PG 70-28p)

2-inch Superpave E-30, 12.5 mm HMA lower layer (PG 64-22)

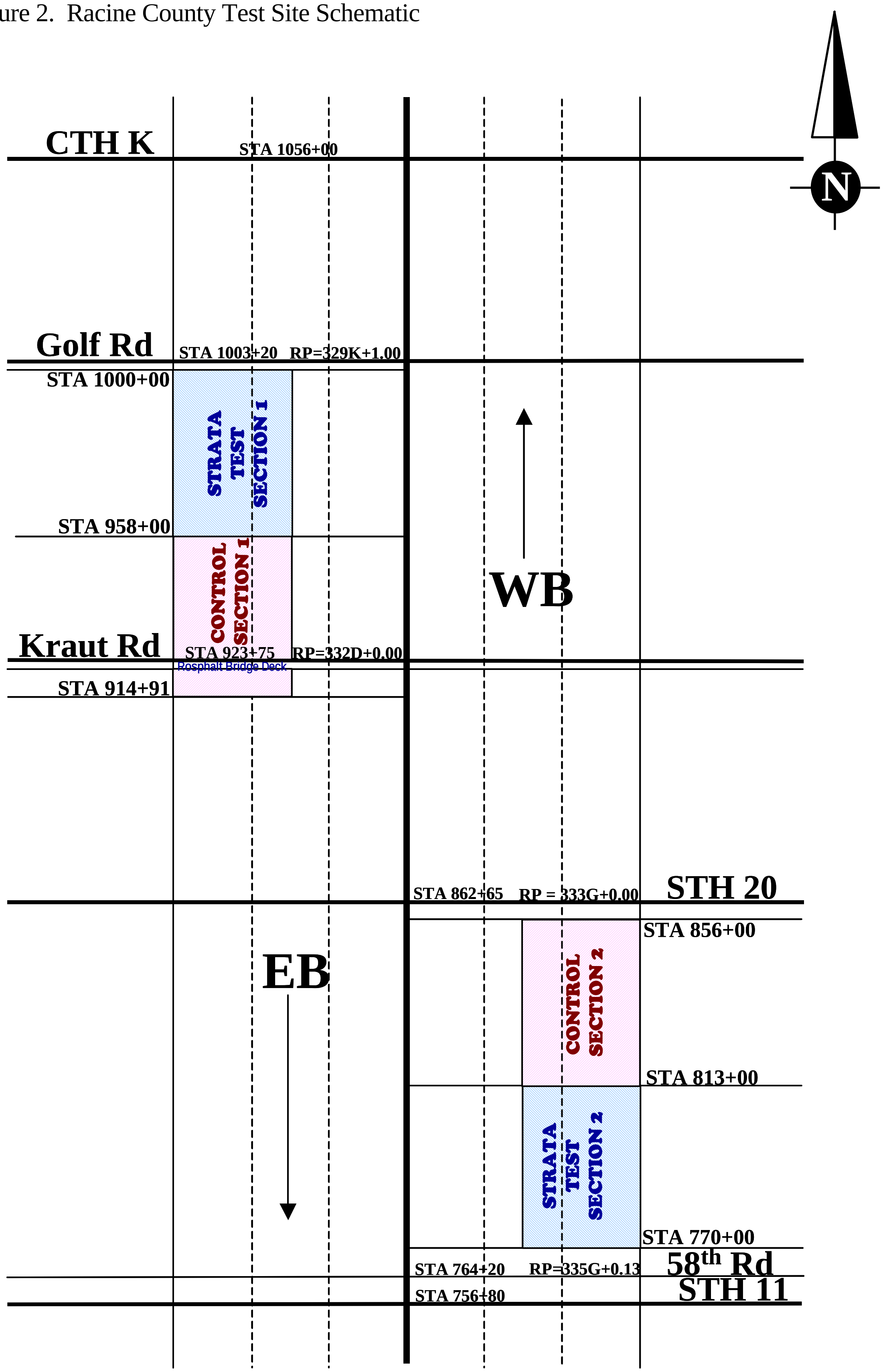
1-inch Superpave E-30, 12.5 mm HMA lower layer (PG 64-22)

10-inch existing jointed reinforced concrete pavement

8 inches existing crushed aggregate base

9 inches existing granular subbase

Figure 2. Racine County Test Site Schematic



St. Croix County

The second project (ID 1020-06-70) location was in St. Croix County on I-94 near the town of Woodville. This part of I-94 is a four-lane divided highway with two lanes in both eastbound (EB) and westbound (WB) directions. The existing pavement structure consisted of a variable thickness HMA overlay (2 inches on the east half of the project and 3.5-4 inches on the west half) over a cracked and seated concrete pavement. The concrete pavement was originally constructed in 1959 as a 9-inch JRCP over 6 inches of crushed aggregate, over 9 inches of granular subbase. The reinforcement consisted of wire mesh within the slabs and dowel bars at the joints that were spaced 80 feet apart. The pavement was cracked and seated and overlaid with HMA in 1988. This roadway is a principal arterial with 20-year design ESALs of 42 million and an ADT projection of 39,300 for the year 2020, with 24 percent trucks.

In the summer of 2002, one year after the Racine County Strata® test sections were constructed, this section of I-94 in St. Croix County was resurfaced. The project limits included both EB and WB lanes and extended for 6.3 miles, roughly from County Trunk Highway (CTH) BB to STH 128. A total of five sections were constructed within the project limits in the EB lanes for research purposes (three test sections and two control sections). Test Section 1 consisted of the Strata® interlayer applied to the passing lane only. Test Section 2 was split into two segments (2A and 2B) because of a bridge structure and involved a Strata® interlayer in both the passing and driving lanes. Test Section 3 consisted of the Strata® interlayer applied to the driving lane only. Test Sections 1 and 3 were constructed to determine if applying a Strata® interlayer to just one lane, which was less costly than applying it to both lanes, was effective at delaying or eliminating reflective cracking in either one or both lanes. The two control sections, which were constructed without Strata®, were placed directly before and directly after the test sections. In total, the test and control sections spanned a 1.9-mile segment of the project. See Figure 3 on page 11 for a schematic of the test sections.

The test sections consisted of a 1-inch Strata® interlayer, a 1.5-inch layer of Superpave E-10, followed by a 2-inch layer of stone matrix asphalt (SMA). The control sections, as well as the rest of the project, consisted of a 2.5-inch lower layer of Superpave E-10, followed by a 2-inch surface layer of SMA. The pavement structure details of all the sections are as follows:

<u>Control Section 1: Station 130+70 to 136+00, EB</u>

2-inch SMA, 12.5 mm, surface (PG 70-28p)
2.5-inch Superpave E-10, 12.5 mm, lower layer (PG 64-22)
9-inch existing cracked and seated jointed reinforced concrete pavement
6 inches existing crushed aggregate base
9 inches existing granular subbase

<u>Test Section 1: Station 136+00 to 149+00, EB</u>

2-inch SMA, 12.5 mm, surface (PG 70-28p)
1.5-inch Superpave E-10, 12.5 mm, lower layer (PG 64-22)
1-inch Strata® interlayer in passing lane
9-inch existing cracked and seated jointed reinforced concrete pavement
6 inches existing crushed aggregate base
9 inches existing granular subbase

<u>Test Sections 2A & 2B: Stations 149+00 to 155+00 and 161+00 to 206+00, EB</u>

2-inch SMA, 12.5 mm, surface (PG 70-28p)
1.5-inch Superpave E-10, 12.5 mm, lower layer (PG 64-22)
1-inch Strata® interlayer in driving lane and passing lane
9-inch existing cracked and seated jointed reinforced concrete pavement
6 inches existing crushed aggregate base
9 inches existing granular subbase

<u>Test Section 3: Station 206+00 to 219+00, EB</u>

2-inch SMA, 12.5 mm, surface (PG 70-28p)
1.5-inch Superpave E-10, 12.5 mm, lower layer (PG 64-22)
1-inch Strata® interlayer in driving lane

9-inch existing cracked and seated jointed reinforced concrete pavement

6 inches existing crushed aggregate base

9 inches existing granular subbase

Control Section 2: Station 219+00 to 232+00, EB

2-inch SMA, 12.5 mm, surface (PG 70-28p)

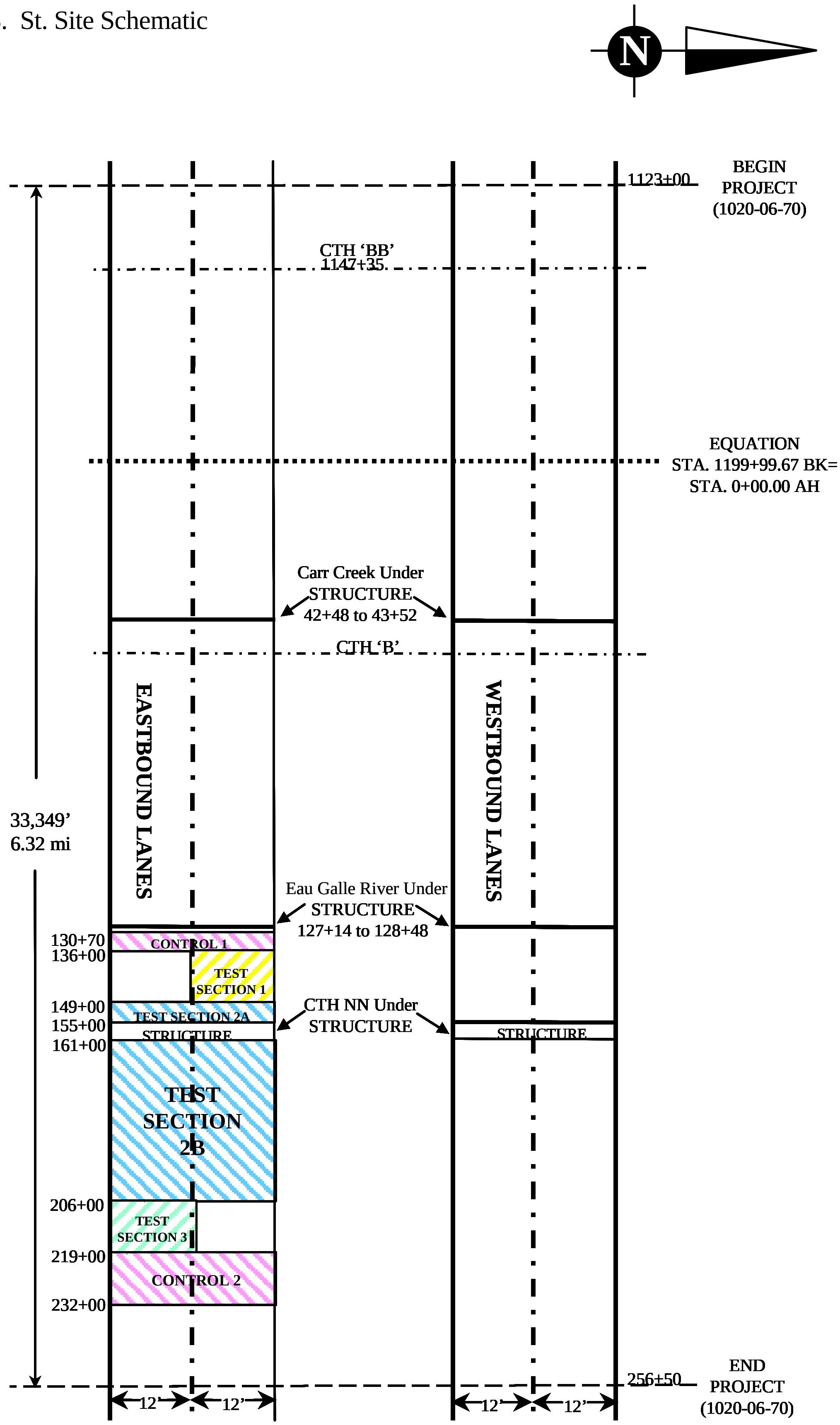
2.5-inch Superpave E-10, 12.5 mm, lower layer (PG 64-22)

9-inch existing cracked and seated jointed reinforced concrete pavement

6 inches existing crushed aggregate base

9 inches existing granular subbase

Figure 3. St. Site Schematic



MIX DESIGN

The Strata® interlayer mixtures for both projects were designed by SemMaterials. These mix designs were based on performance-related specifications and verified using the flexural bending fatigue test (AASHTO T 321). SemMaterials also provided recommendations for the HMA overlay mix designs. Project contractors designed, produced, and placed the HMA overlay mixtures according to standard WisDOT specification requirements and common construction practices.

Designed as a highly elastic product and intended to provide maximum stress relief, Strata® mixtures typically include 8-10 percent of polymer modified asphalt binder. The percentage of asphalt binder used in the Strata® mixes of the two projects fell within that typical range, with 8.0 percent on the Racine County project and 9.3 percent on the St.Croix County project. The asphalt binder on both projects was polymer modified to provide maximum flexibility to withstand cold Wisconsin winter temperatures and to help recover from repeated strains imposed on the pavement. Local materials were used to compose the dense-graded fine aggregate structure associated with Strata®.

The overlay mixtures were designed meeting standard WisDOT Superpave parameters for projected traffic levels between 10 and 30 million ESALs (based on a 20-year service life). The overlay mixture used in Racine County had a 5.4 percent optimum asphalt binder content, while the SMA mixture placed on the St. Croix County project contained 5.3 percent asphalt binder. The upper layers of the overlay mixtures for both projects also contained polymer modified asphalts (as recommended for these Strata® project applications). Table 1 indicates a portion of the JMFs (Job Mix Formulas) developed for the standard overlays. Full mix design details can be found in Appendix A.

Table 1. Project HMA Overlay Job Mix Formulas (JMFs)

	JMF Property	E-30 Overlay	SMA Overlay
	NMAS	12.5 mm	12.5 mm
	N des gyrations	100	100
	Optimum % Asphalt	5.4	5.3
	Asphalt Binder PG	64 - 22	70 - 28
	% VMA	14.0	15.7
	% VFB	71.0	74.6
3/4"	19.0 mm	100.0	100.0
1/2"	12.5 mm	97.8	89.5
3/8"	9.5 mm	87.5	70.3
# 4	4.75 mm	58.3	27.4
# 8	2.36 mm	38.1	17.5
# 16	1.18 mm	25.3	14.3
# 30	0.600 mm	16.4	12.3
# 50	0.300 mm	9.2	10.9
# 100	0.150 mm	5.8	9.3
# 200	0.075 mm	4.5	8.1
	FAA	46.3	47.8

Additional reference tables describing current WisDOT standard specifications for HMA mixtures are located in Appendix B.

CONSTRUCTION

The Racine County project was paved by Payne and Dolan, Inc. in August and September of 2001, while the St. Croix County project was paved by Mathy Construction Company in September 2002. Both projects began by milling the existing HMA pavement. The full depth of the HMA pavement was milled on the Racine County project. The St. Croix County HMA pavement was milled two inches. Since the existing HMA pavement varied in thickness from two inches on the east half of the project to about four inches on the west half, the east half (where the Strata® test sections were to be located) was milled down to the existing concrete pavement while approximately two inches of HMA remained on the west half. After milling was completed, the existing concrete pavement was repaired. The Racine County project's badly deteriorated joints, slabs, and existing base patches were repaired using full-depth doweled concrete patches. The moderately deteriorated transverse joints and cracks were filled with asphalt joint repair material and the longitudinal joints were V-milled and backfilled with HMA. The St. Croix County project's badly deteriorated joints were repaired using full-depth undoweled concrete patches.

Although product literature suggests that a tack coat is not needed, a tack coat was applied on the existing concrete pavement on both projects prior to the Strata® application as a precautionary measure to minimize or prevent blistering of the interlayer, which had occurred in other states. A one-inch thick Strata® interlayer was placed over the tack coat in the Strata® test sections. The Racine County project Strata® interlayer was paved 18 feet wide, covering the driving lane and half of the center lane in both test sections. Figures 4 and 5 are photos that were taken from the Racine County project. During construction, a small section of the Strata® interlayer was removed from the underlying concrete pavement (Figure 4) and the flexibility of the interlayer was demonstrated (Figure 5). The St. Croix County project Strata® interlayer placement varied between the three test sections. The interlayer either extended across just the passing lane, just the driving

Figure 4. Applied Strata® Interlayer

Figure 5. Flexibility Demonstration of Strata®

lane, or across both lanes. Traffic was not allowed to travel on the Strata® interlayer on either project until the remaining HMA layers were placed.

No construction problems were encountered during paving operations. The Strata® mix was produced at about half the rate of a standard mix, but was placed at a similar rate. The Strata® interlayer had a slightly higher shine on the surface than a standard HMA mix due to the high asphalt content. Release agents were applied to the hauling and paving equipment during the construction process, resulting in minimal sticking of the polymer modified mix. No blistering was observed on the interlayer. According to a SemMaterials representative, the blistering that had occurred in other states was caused by entrapped moisture in the concrete pavement, in conjunction with hot weather (90 ºF and higher) and no tack coat. The maximum ambient temperatures during construction of the Wisconsin projects were 77 ºF on the Racine project and 79 ºF on the St Croix project, but the mean temperatures were only 72 ºF and 63 ºF respectively. Since these temperatures were relatively mild, a tack coat was probably unnecessary, but was used nonetheless as a precautionary measure.

PAVEMENT PERFORMANCE RESULTS

Crack Surveys

Pavement crack surveys of the existing concrete pavement were conducted after the existing HMA pavements were milled off. All joints and cracks of the existing concrete pavement within each test and control section were documented to establish baseline data. Crack surveys were then conducted annually for several years. The total linear feet of cracking that developed was compared to the original linear feet of cracking to determine the percentage of reflective cracking. Since the pavements were monitored for overall performance, no attempt was made to distinguish between reflective cracking and fatigue cracking, with all cracks being reported as reflective cracks.

Racine County

The crack survey results for Racine County are summarized in Table 2. Since Strata® was only paved in the driving lane and half of the center lane, only the driving lane results are displayed. Table C-1 in Appendix C contains the total amounts (in linear feet) of cracking.

Table 2. Percentage of Reflective Cracking in Driving Lane, Racine County Project

	2002 (1-YR)	2003 (2-YR)	2004 (3-YR)	2005 (4-YR)
Test Section 1	0%	5%	16%	21%
Control 1	0%	11%	15%	19%
Test Section 2	0%	1%	6%	6%
Control 2	0%	13%	19%	20%

After one year, none of the sections showed any reflective cracking. After the second year, the two Strata® test sections had only 5 percent and 1 percent reflective cracking, less than the two control sections which had 11 and 13 percent. By the third year, Test Section 1, Control Section 1 and Control Section 2 had comparable amounts of reflective cracking (16, 15 and 19 percent, respectively). Test Section 2 performed the best, with only 6 percent reflective cracking. Fourth-year results were similar to the previous year with Test Section 1 and Control Sections 1 and 2 performing comparably—21, 19 and 20 percent reflective cracking, respectively. Test Section 2 still showed only 6 percent reflective cracking in the fourth year, the same as the previous year.

Evident from saw cuts that extended into the adjacent shoulder and from cores taken from the project in 2004, most of the reflective cracks were over the joints of the full-depth concrete patches. Thus, the reflective cracking was likely due to movement of the underlying patches. Although the full-depth concrete patches of the underlying concrete pavement were doweled, they were still “working” joints experiencing differential vertical and horizontal movements. The movement was apparently more than the interlayer could endure, particularly in Test Section 1.

A review of some soil borings taken throughout the project length indicated that the subsurface soils were generally uniform in the test and control sections, consisting mainly of silty clay. The two worst sections were Control Section 1, which had a layer of clayey organics at a depth of six feet, and Strata® Test Section 2, which had a wet layer at a depth of six to seven feet. Hence, the subgrade didn't appear to be a factor in the differing performances between Strata® Test Sections 1 and 2. A summary of the soil boring information from the Racine County project is located in Appendix D.

In summary, Strata® was able to delay reflective cracking for two years; however, because of the inconsistent results between the two Strata® test sections, the Racine County project showed no conclusive evidence that Strata® would reduce reflective cracking longer than two years.

St. Croix County

The placement of the Strata® interlayer at the St. Croix County project varied among the three test sections. The Strata® interlayer either extended across just the passing lane (Test Section 1), across both lanes (Test Section 2), or across just the driving lane (Test Section 3). This layout was designed to identify potential differences in the Strata® interlayer performance and determine which is most cost-effective. Accordingly, crack survey results for the St. Croix County site are broken down by lane and are summarized in Table 3. Tables C-2 and C-3 in Appendix C show the total amounts (in linear feet) of cracking.

Table 3. Percentage of Reflective Cracking, St. Croix County Project*

	2003 (1-YR)		2004 (2-YR)		2005 (3-YR)	
	DL	PL	DL	PL	DL	PL
Control 1 (No Strata)	20%	30%	37%	40%	47%	40%
Test Section 1 (Strata in PL)	29%	23%	47%	39%	56%	48%
Test Section 2 (Strata in both lanes)	23%	26%	34%	36%	44%	51%
Test Section 3 (Strata in DL)	23%	47%	31%	53%	43%	91%
Control 2 (No Strata)	21%	33%	38%	54%	48%	73%

DL = Driving Lane
PL = Passing Lane

* It should be reiterated that, unlike the repairs of the Racine County project, the full-depth concrete repairs on this project were not doweled; consequently, the concrete patches and the old existing concrete pavement could move independently while subjected to temperature variations and dynamic loading. Hence, the horizontal and vertical movements at the joints of the patches were likely much greater than those on the Racine project, resulting in much greater amounts of reflective cracking.

After one year, Control Sections 1 and 2, which didn't have a Strata® interlayer, showed the lowest percentage of reflective cracking in the driving lanes (20 and 21 percent respectively). Test Section 1, which had Strata® in the passing lane only, had the lowest percentage of reflective cracking in the passing lane (23 percent), but the highest percentage of reflective cracking in the driving lane (29 percent) after one year. Test Section 2, which had Strata® in both lanes, performed second best in the passing lane after one year. Test Section 3, which had Strata® in the driving lane only, had, by far, the highest percentage of reflective cracking in the adjacent passing lane, 47 percent, after one year.

Second-year results showed that Test Sections 2 and 3, which both contained Strata® in the driving lane, had the least amount of reflective cracking in the driving lane (34 and 31 percent respectively). Similarly, Test Sections 1 and 2, which both contained Strata® in the passing lane, had the least amount of reflective cracking in the passing lane (39 and 36 percent respectively). Test Section 1, which had Strata® in the passing lane only, had the highest percentage of reflective cracking in the adjacent driving lane (47 percent). Test Section 3, which had Strata® in the driving lane only, had the second highest percentage of reflective cracking in the adjacent passing lane after two years (53 percent). Overall, after two years, Test Section 2, which had Strata® in both lanes, performed the best.

By the end of the third year, Test Sections 2 and 3, which both had Strata® in the driving lane, still had the least amount of reflective cracking in the driving lane (44 and 43 percent respectively); but Control Section 1, which didn't have a Strata® interlayer, had the least amount of reflective cracking in the passing lane. Following the same trend of the previous two years, Test Section 1 (Strata® in passing lane only) continued to have the highest percentage of reflective cracking in the adjacent driving lane (56 percent), and Test Section 3 (Strata® in driving lane only) had the highest percentage of reflective cracking in the adjacent passing lane (91 percent). Although Test Section 2, which had Strata® in both lanes, performed fairly well after three years and had an average percentage of reflective cracking in both lanes of 47.5 percent, Control Section 1 (without Strata®) performed the best with an average percentage of reflective cracking of 40 percent.

Soil Conservation Service maps from the soil survey of St. Croix County indicated that the soil was relatively uniform in the area of the test and control sections, consisting primarily of silt loam.

In summary, the results of the first two years showed that the lanes/sections with Strata® performed better than the lanes/sections without Strata®. Test Sections 1 and 3, which only had Strata® applied to one lane, consistently showed the highest percentage of reflective cracking in the adjacent lanes without Strata® after all three years. Thus, applying Strata® to only one lane of a multi-lane facility was ineffective. By the third year, Control Section 1, which didn't have a Strata® interlayer, performed the best overall.

Ride Measurements

Ride was measured with a South Dakota-type profiler and recorded in International Roughness Index (IRI) values. The IRI is a ride quality measurement of the longitudinal profile of the pavement and the values were recorded in the standard units of meters/kilometer. In general, IRI values below 1.5 represent a smooth ride, while values in excess of 2.5 indicate a relatively rough riding pavement. Initial measurements were taken shortly after construction of the Racine County project and one year after construction of the St. Croix County project to establish baseline data. Subsequent surveys were conducted annually through 2007 for the Racine County project and 2006 for the St. Croix County project. The IRI readings for both projects are shown in Tables 4 and 5.

Ride values were collected in the driving lane and center lane of the Racine County project; however, since Strata® was only applied in the driving lane and half of the center lane, only the driving lane results are shown. After six years, the Racine County project results showed Strata® Test Sections 1 and 2 and Control Section 2 performing uniformly well with IRI values of 0.74, 0.73, and 0.74, respectively. Control Section 1 had a slightly higher IRI than the other sections after six years (1.06), but that was also true in 2001 shortly after construction. So, that appears to be a construction issue rather than performance related. The final IRI values for the St. Croix County project showed all sections performing relatively equal with IRI values ranging from 0.90 to 1.10 in both the driving lane and the passing lane. Overall, the results from both projects show all sections performing relatively equal, with IRI values indicative of a smooth ride.

Table 4. Racine County Driving Lane IRI (units in m/km)

	2001	2002	2003	2004	2005	2006	2007
Strata Test Section 1	0.66	0.85	1.04	0.69	1.14	0.68	0.74
Control 1	0.95	1.06	1.07	0.95	1.33	0.95	1.06
Strata Test Section 2	0.36	0.66	1.18	1.01	0.82	0.76	0.73
Control 2	0.33	0.57	1.39	0.80	0.90	0.80	0.74

Table 5. St. Croix County IRI (units in m/km)

	2003		2004		2005		2006	
	DL	PL	DL	PL	DL	PL	DL	PL
Control 1	1.29	-	1.25	1.28	0.90	1.15	0.98	0.95
Strata Test Section 1	1.14	1.31	1.26	1.14	0.93	1.01	0.93	1.10
Strata Test Section 2	1.39	1.07	1.22	1.15	0.86	0.99	0.90	0.92
Strata Test Section 3	0.99	1.28	1.26	1.06	0.95	0.93	0.95	0.96
Control 2	1.17	1.26	1.23	1.06	0.96	0.88	0.99	1.03

Rut Depth Surveys

Rut depths were also measured with the road profiler and recorded in units of inches. The rut measurements are shown in Tables 6 and 7. All sections on both projects showed minimal rutting with only negligible differences among the sections.

Table 6. Racine County Rutting (units in inches)

	2001	2002	2003	2004	2005	2006	2007
	DL	DL	DL	DL	DL	DL	DL
Strata Test Section 1	0.01	0.03	0.10	0.09	0.09	0.11	0.11
Control 1	0.01	0.03	0.08	0.09	0.06	0.11	0.12
Strata Test Section 2	0.01	0.06	0.11	0.12	0.12	0.13	0.16
Control 2	0.02	0.07	0.08	0.05	0.06	0.09	0.09

Table 7. St. Croix County Rutting (units in inches)

	2003		2004		2005		2006	
	DL	PL	DL	PL	DL	PL	DL	PL
Control 1	0.03	0.02	0.03	0.04	0.06	0.06	0.06	0.04
Strata Test Section 1	0.05	0.01	0.02	0.05	0.04	0.08	0.03	0.09
Strata Test Section 2	0.03	0.02	0.04	0.05	0.08	0.09	0.07	0.07
Strata Test Section 3	0.02	0.05	0.05	0.04	0.06	0.06	0.08	0.04
Control 2	0.03	0.06	0.03	0.05	0.04	0.08	0.04	0.07

Coring

Nine cores were taken on cracks from the St. Croix County project in 2003, less than one year after construction. The cracks were all over joints or full-depth undoweled concrete patches. Of the nine cores, seven were from the Strata® test sections and only four of those cores were intact. Of the four intact cores, two of them showed that the Strata® had also cracked, allowing moisture access to the underlying concrete pavement and subgrade. The Strata® was not cracked in the other two cores. Both of the control section cores were cracked through the depth of the HMA.

Six cores were taken over cracks from the Racine County project in 2004, four of which were from Strata® Test Section 1. The cracks were all over joints or full-depth doweled concrete patches. Of the four cores taken from the Strata® test section, the Strata® interlayer was cracked in three of them, again allowing moisture infiltration to the underlying concrete pavement and subgrade. Figure 8 shows a core taken over a banded crack with the Strata® interlayer also cracked. Figure 9 shows the one core with the Strata® intact. The remaining two cores taken from the St. Croix project were from Control Section 1 and both were completely cracked through the HMA.

Figure 8. Core Revealing Cracked Strata® Interlayer

Figure 9. Core of Strata® Interlayer Intact

In summary, the majority of the cores (5 out of 8) showed that the Strata® interlayer was also cracked. Thus, any water that seeped through the cracks in the overlay could infiltrate to the underlying concrete pavement and subgrade.

COSTS

The difference in cost for premium, production, and paving of the Strata® interlayer versus a standard Type E-30 mix for the Racine County project was an additional $2.83 per square yard. Thus, the total cost of the Strata® interlayer was approximately $4.88 per square yard. The total cost of the Strata® interlayer for the St. Croix County project was $5.49 per square yard.

WisDOT began routing and sealing the cracks on the projects after three years. Since Strata® did not reduce reflective cracking longer than two years on either of the projects, the amount of necessary crack routing and sealing was not reduced. Thus, WisDOT did not experience cost savings. Therefore, a life cycle cost analysis was not performed and the costs are shown here for informational purposes only.

SUMMARY AND CONCLUSIONS

Construction of the Strata® interlayer went smoothly and no problems were encountered during paving operations. The Strata® interlayer was placed at about the same rate as a standard mix.

Results from the Racine County project showed that the Strata® Crack Relief System was able to delay reflective cracking for two years on an HMA pavement over a concrete pavement with doweled full-depth concrete patches. After three and four years, the results were inconsistent—while one of the Strata® test sections performed the best and had the least amount of reflective cracking, the other Strata® test section performed similarly to the two control sections. Most of the reflective cracks present were over the joints of full-depth doweled concrete patches. Since the joints of full-depth doweled patches, similar to contraction joints, were "working" joints, some movement at the joints was expected. It is unclear, however, why one Strata® test section showed less reflective cracking than the other sections. A review of soil borings indicated that the subgrade was relatively uniform and didn't appear to be a factor in the differing performances between the Strata® test sections. If the superior performance was due to the Strata® interlayer, it is assumed the results would be similar in both Strata® test sections. Since the results between the two test sections were inconsistent, there was no conclusive evidence that Strata® would reduce reflective cracking longer than two years on an HMA pavement over a concrete pavement with doweled full-depth concrete patches.

Results from the St. Croix County project showed that the Strata® interlayer slightly delayed reflective cracking for only two years in an HMA overlay over a concrete pavement with undoweled full-depth concrete patches. After three years, one of the control sections (without Strata®) performed the best overall.

Ride and rut measurements were taken through 2007 on the Racine County project and through 2006 on the St. Croix County project. Overall, the final IRI measurements on both projects showed all sections performing comparably well, and were representative of a smooth riding pavement. Final rut measurements were minimal in all sections on both projects, with only negligible differences among the sections.

As determined from core samples extracted from both projects, the Strata® interlayer was cracked in 5 out of 8 cores. Thus, the Strata® interlayer did not protect the underlying concrete pavement and subgrade from moisture infiltration.

In summary, the Strata® interlayer delayed reflective cracking on both projects for two years. Third-year results from both projects showed the Strata® test sections performing similarly to the control sections. Since WisDOT typically performs crack maintenance (sealing or routing and sealing) beginning in year three, the ability of Strata® to reduce reflective cracking for only two years does not result in any cost savings to WisDOT. In addition, the service lives of these pavement structures are not expected to be increased because of the Strata® interlayer. With no foreseeable benefits to justify the increased initial construction costs, a life cycle cost analysis was not necessary. Hence, the Strata® interlayer is not cost-effective in reducing reflective cracking of an HMA overlay placed over a concrete pavement.

RECOMMENDATION

Based on the results of this study, it is recommended that WisDOT not use Strata® Reflective Crack Relief System to reduce reflective cracking or to extend the service life of an HMA overlay placed on a concrete pavement.

APPENDIX A: MIX DESIGNS

Figure A-1. Racine County Project E-30 Mix Design

Test Number: 0 - 250 - 0172 - 2001

Labsite:

Page 1 of 1

Materials Laboratory Testing System Tests On:
Asphalt mix design
Type: DR - DESIGN REVIEW

Wisconsin Department of Transportation
Bureau of Highway Construction Lab
Truax Center, 3502 Kinsman Blvd.
Madison, WI 53704

Main Project ID: 0617-32-10
CENTRAL LABORATORY GENERAL TESTING

Quantity:

Date Sampled:	**Date Received:**	**Date Tested:**
06/22/01	06/25/01	
By: JACK WEIGEL		By: K. HORNBECK

Source: *SOURCE NOT AVAILABLE **Legal Description:** , , Section: , T: N, R:, **County:**

Design Lab: PAYNE & DOLAN (WAUKESHA) Mix Type: E30-12.5
Design ID: 504101 Last Field Change Test Number:
Date:

	Material Description	Aggregate Source	Pit/Quarry	Location	Test Number
1	5/8" CHIP	FRANKLIN	QRY	NE, Section: 10, T: 5 N, R: 21, E	
2	3/8" CHIP	FRANKLIN	QRY	NE, Section: 10, T: 5 N, R: 21, E	
3	MFG'D SAND				
4	NATURAL SAND				

Sieve Sizes	1	2	3	4	JMF Blend
25.0 (1")	100.0	100.0	100.0	100.0	100.0
19.0 (3/4")	100.0	100.0	100.0	100.0	100.0
12.5 (1/2")	89.0	100.0	100.0	100.0	97.8
9.5 (3/8")	39.5	98.4	100.0	100.0	87.5
4.75 (#4)	6.0	19.0	96.5	89.4	58.3
2.36 (#8)	4.6	5.9	63.3	72.2	38.1
1.18 (#16)	4.3	5.1	38.9	56.3	25.3
0.600 (#30)	4.1	4.8	23.8	36.2	16.4
0.300 (#50)	3.9	4.6	13.4	11.9	9.2
0.150 (#100)	3.7	4.3	7.7	5.2	5.8
75 µm (#200)	3.2	3.7	5.6	4.0	4.5
Agg Blend %:	20.0	25.0	45.0	10.0	100.0
Gsb:	2.599	2.600	2.722	2.671	2.662

% AC (Total): 5.4 Added	**% Air Voids:** 4.04%	**Agg. Angularity (Fines):** 46.3
Grade: PG 64-22	**Gmm:** 2.523	**Gmm Dryback Correction:**
Source: AMOCO	**Gmb:** 2.421	**Unit Wt (PCF):** 150.68
AC Sp. Gr: 1.033 @ 25/25°C	**Gse:** 2.749	**Fracture:** 98.6 1F 98.4 2F
RAP % AC:	**%VMA** 14.0	**Thin/Elong:** 1.2
Mixing Temp (°C): 163-168	**% VFB:** 71.0	**TSR:** 87.4
Compaction Temp (°C): 152	**Sand Equiv. (%)** 86.4	**TSR Comp. Effort:** 48.0 N
Design Comp. Effort: 100 Ndes	**Stability (N):**	**Anitstrip:** NONE

Remarks: Satisfactory
Nini = 8, %Gmm = 86.2
Nmax = 160, %Gmm = 97.5
DP = 1.2
MOISTURE ABSORPTION = 1.7
Matr'l 1,2 agg test = 217-146-98
Matr'l 3,4 = HONEY CREEK PIT S6, T3N, R19E RACINE CO.
This design and review have been updated to reflect the additional satisfactory use of B.P. Amoco PG 64-22 (having a

Verified Date: 06/25/2001 **Verified By:** JUDIE RYAN

Figure A-2. St. Croix County Project SMA Mix Design

Test Number: 0 - 250 - 0064 - 2002

Labsite:

Materials Laboratory Testing System Tests On:
Asphalt mix design
Type: DR - DESIGN REVIEW

Wisconsin Department of Transportation
Bureau of Highway Construction Lab
Truax Center, 3502 Kinsman Blvd.
Madison, WI 53704

Main Project ID: 1020-06-70
HUDSON - MENOMONIE RD,
CTH BB - STH 128
I 94

Quantity:

Date Sampled: 05/09/02

Date Received: 05/10/02

Date Tested:

By: JOHN JORGENSON

By: JAMES BONGARD

Source: LAWIN **Legal Description:** , NE, Section: 18, T: 30 N, R: 8, W **County:** CHIPPEWA

Design Lab: MATHY CONSTRUCTION CO. Mix Type: E30-12.5 SMA

Design ID: 26-2-1-SMA-12.5 Last Field Change Test Number:

Date:

	Material Description	Aggregate Source	Pit/Quarry	Location	Test Number
1	5/8" COARSE ROCK	LAWIN	Pit	NE, Section: 18, T: 30 N, R: 8, W	
2	3/8" COARSE	LAWIN	Pit	NE, Section: 18, T: 30 N, R: 8, W	
3	MAN SAND	LAWIN	Pit	NE, Section: 18, T: 30 N, R: 8, W	
4	5/8" X 3/8" ROCK	LAWIN	Pit	NE, Section: 18, T: 30 N, R: 8, W	
5	FLY ASH				

Sieve Sizes	1	2	3	4	5	JMF Blend
25.0 (1")	100.0	100.0	100.0	100.0	100.0	100.0
19.0 (3/4")	100.0	100.0	100.0	100.0	100.0	100.0
12.5 (1/2")	62.0	100.0	100.0	91.0	100.0	89.5
9.5 (3/8")	11.0	95.0	100.0	65.0	100.0	70.3
4.75 (#4)	1.5	10.0	96.0	21.0	100.0	27.4
2.36 (#8)	1.3	3.2	61.0	7.5	100.0	17.5
1.18 (#16)	1.1	2.8	41.0	4.8	100.0	14.3
0.600 (#30)	1.1	2.5	28.0	3.9	99.0	12.3
0.300 (#50)	0.9	2.2	20.0	3.2	97.0	10.9
0.150 (#100)	0.8	1.8	12.0	2.5	92.0	9.3
75 µm (#200)	0.6	1.3	8.3	1.9	87.0	8.1
Agg Blend %:	22.0	35.0	12.0	24.0	7.0	100.0
Gsb:	2.748	2.726	2.689	2.765	2.400	2.713

% AC (Total): 5.3 Added	**% Air Voids:**	4.02%	**Agg. Angularity (Fines):** 47.8
Grade: 70-28	**Gmm:**	2.513	**Gmm Dryback Correction:**
Source: MIF	**Gmb:**	2.412	**Unit Wt (PCF):** 150.12
AC Sp. Gr: 1.031 @ 25/25°C	**Gse:**	2.733	**Fracture:** 100.0 1F 98.6 2F
RAP % AC:	**%VMA**	15.8	**Thin/Elong:** 18.3
Mixing Temp (°C): 135-149	**% VFB:**	74.6	**TSR:** 96.5
Compaction Temp (°C):	**Sand Equiv. (%)**	74.0	**TSR Comp. Effort:** 30.0 N
Design Comp. Effort: 100 Ndes	**Stability (N):**		**Anitstrip:** NONE

Remarks: Satisfactory

Nini = 8 %Gmm = 85.7
Nmax = 160 %Gmm = 97.9
DP = 1.6
MA = 0.9
DRAINDOWN = 0.02%

Verified Date: 05/10/2002 **Verified By:** JUDIE RYAN

APPENDIX B: 2008 WISDOT STANDARD SPECIFICATIONS FOR HMA MIXTURES

Table B-1. Aggregate Gradation Master Range and VMA Requirements

SIEVE SIZE	PERCENTS PASSING DESIGNATED SIEVES						
	NOMINAL SIZE						
	37.5 mm	25.0 mm	19.0 mm	12.5 mm	9.5 mm	SMA 12.5 mm	SMA 9.5 mm
50.0 mm	100						
37.5 mm	90 –100	100					
25.0 mm	90 max	90 -100	100				
19.0 mm	____	90 max	90 -100	100		100	
12.5 mm	____	____	90 max	90 -100	100	90 - 97	100
9.5 mm	____	____	____	90 max	90 -100	58 - 72	90 - 100
4.75 mm	____	____	____	____	90 max	25 - 35	35 - 45
2.36 mm	15 – 41	19 - 45	23 - 49	28 - 58	20 - 65	15 - 25	18 - 28
75 µm	0 – 6.0	1.0 - 7.0	2.0 - 8.0	2.0 - 10.0	2.0 - 10.0	8.0 - 12.0	10.0 - 14.0
PERCENT MINIMUM VMA	11.0	12.0	13.0	14.0	15.0	16.0	17.0

Table B-2. Mixture Requirements

Mixture type	E - 0.3	E - 1	E - 3	E - 10	E - 30	E - 30x	SMA
ESALs x 10^6 (20 yr design life)	< 0.3	0.3 - < 1	1 - < 3	3 - < 10	10 - < 30	≥ 30	——
LA Wear (AASHTO T 96)							
100 revolutions(max % loss)	13	13	13	13	13	13	13
500 revolutions(max % loss)	50	50	45	45	45	45	45
Soundness (AASHTO T 104) (sodium sulfate, max % loss)	12	12	12	12	12	12	12
Freeze/Thaw (AASHTO T 103) (specified counties, max % loss)	18	18	18	18	18	18	18
Fractured Faces (ASTM 5821) (one face/2 face, % by count)	60 / __	65 / __	75 / 60	85 / 80	98 / 90	100/100	100/90
Flat and Elongated (ASTM D4791) (max %, by weight)	5 (5:1 ratio)	5 (5:1 ratio)	5 (5:1 ratio)	5 (5:1 ratio)	5 (5:1 ratio)	5 (5:1 ratio)	20 (3:1 ratio)
Fine Aggregate Angularity (AASHTO T304, method A, min)	40	40	43	45	45	45	45
Sand Equivalency (AASHTO T 176, min)	40	40	40	45	45	50	50
Gyratory Compaction							
Gyrations for N_{ini}	6	7	7	8	8	9	8
Gyrations for N_{des}	40	60	75	100	100	125	65
Gyrations for N_{max}	60	75	115	160	160	205	160
Air Voids, %V_a (%G_{mm} @ N_{des})	4.0 (96.0)	4.0 (96.0)	4.0 (96.0)	4.0 (96.0)	4.0 (96.0)	4.0 (96.0)	4.0 (96.0)
% G_{mm} @ N_{ini}	≤ 91.5[1]	≤ 90.5[1]	≤ 89.0[1]	≤ 89.0	≤ 89.0	≤ 89.0	——
% G_{mm} @ N_{max}	≤ 98.0	≤ 98.0	≤ 98.0	≤ 98.0	≤ 98.0	≤ 98.0	——
Dust to Binder Ratio[2] (% passing 0.075/P_{be})	0.6 - 1.2	0.6 - 1.2	0.6 - 1.2	0.6 - 1.2	0.6 - 1.2	0.6 - 1.2	1.2 - 2.0
Voids filled with Binder (VFB or VFA, %)	70 - 80 [4] [5]	65 - 78 [4]	65 – 75 [4]	65 - 75 [3] [4]	65 - 75 [3] [4]	65 - 75 [3] [4]	70 - 80
Tensile Strength Ratio (TSR) (ASTM 4867)							
no antistripping additive	0.70	0.70	0.70	0.70	0.70	0.70	0.70
with antistripping additive	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Draindown at Production Temperature (%)	——	——	——	——	——	——	0.30

[1] The percent maximum density at initial compaction is only a guideline.

[2] For a gradation that passes below the boundaries of the caution zone(ref. AASHTO MP3), the dust to binder ratio limits are 0.6 - 1.6.

[3] For 9.5mm nominal maximum size mixtures, the specified VFB range is 73 - 76%.

[4] For 37.5mm nominal maximum size mixes, the specified VFB lower limit is 67%.

[5] For 25.0mm nominal maximum size mixes, the specified VFB lower limit is 67%.

APPENDIX C: TOTAL CRACK COUNTS

Table C-1. Racine County Linear Feet of Reflective Cracking in Driving Lane

	Linear Feet Cracking in Driving Lane				
	Pre-Con 2001	2002	2003	2004	2005
Test Section 1	3007	0	154	468	622
Control 1	2997	6	316	441	571
Test Section 2	2748	0	24	166	173
Control 2	2076	0	262	398	406

Table C-2. St. Croix County Linear Feet of Reflective Cracking in Driving Lane

	Linear Feet Cracking in Driving Lane			
	Pre-Con 2002	2003	2004	2005
Control 1 (No Strata)	180	36	66	84
Test Section 1 (Strata in PL)	396	115	188	220
Test Section 2 (Strata in both lanes)	1140	261	389	499
Test Section 3 (Strata in DL)	264	62	83	114
Control 2 (No Strata)	288	60	108	139

Table C-3. St. Croix County Linear Feet of Reflective Cracking in Passing Lane

	Linear Feet Cracking in Passing Lane			
	Pre-Con 2002	2003	2004	2005
Control 1 (No Strata)	120	36	48	48
Test Section 1 (Strata in PL)	372	84	145	177
Test Section 2 (Strata in both lanes)	996	254	354	509
Test Section 3 (Strata in DL)	180	84	96	164
Control 2 (No Strata)	216	72	116	157

APPENDIX D: RACINE COUNTY SOIL BORING INFORMATION

Table D-1. Summary of Soil Boring Information from the Racine County Project

Test Section 1 (Strata® 1)				Control 1				Test Section 2 (Strata® 2)			Control 2			
# 157	# 159	# 161	# 163	# 149	# 151	# 153	# 155	# 126	# 128	# 130	# 132	# 134	# 136	# 138
5” HMA	5” HMA	5” HMA	5” HMA	7” HMA	5” HMA	6” HMA	5” HMA	5” HMA	4.5” HMA	4” HMA	5” HMA	5” HMA	5” HMA	5” HMA
11” concrete	11” concrete	11” concrete	11” concrete	10” concrete	11” concrete	10” concrete	11” concrete	10” concrete	9” concrete	10” concrete	10” concrete	10” concrete	10” concrete	10” concrete
14” base co.	18” base co.	12” base co.	12” base co.	12” base co.	14” base co.	14” base co.	14” base co.	13” base co.	12” base co.	12” base co.	13” base co.	13” base co.	13” base co.	12” base co.
CL 2.7’-10’	CL 2.8’-10’	CL 2.4’-10’	CL 2.5’-10’	CL 2.7’-10’	CL 2.6’-10’	CL 2.7’-6’	ML 2.7’-5.5’	ML 2.3’-3.5’	CL 2.1’-10’	CL 2.2’-10’	CL 2.3’-10’	CL 2.3’-10’	CL 2.3-3’	SC 2.2’-10’
						OL 6’-9’	**OL** 5.5’-8’	CL 3.5’-10’					ML 3’-8’	
						CL 9’-10’	CL 8’-10’						CL 8’-10’	
AE – 1.5’-4.0’	AE – 1.5’-7.0’	AE – 1.5’-10.0’	AE – 1.5’-5.0’	AE – 1.5’-7.0’	AE – 1.5’-10.0’	AE – 1.5’-9.0’	AE – 1.5’-8.0’	AE – 1.5’-5.5’	AE – 1.5’-5.0’	AE – 1.5’-5.0’	AE – 1.5’-6.0’	AE – 1.5’-6.0’	AE – 1.5’-10’	AE – 1.5’-10.0’
moist	moist	moist	moist	moist	moist	moist	moist	moist	moist wet at 6.0’	moist wet at 7.5’	moist	moist	moist	moist

base co. – Base Course
CL – Silty Clay
ML – Clayey Silt, Slightly Organic
OL – Clayey Topsoil or Clayey Peat
SC – Clayey Sand
AE – Auger Easy