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Warm-Mix Asphalt Study: Field Test Performance Evaluation

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Partnered Pavement Research Center (PPRC) Contract Strategic Plan Element 4.18:
Warm Mix Asphalt

PREPARED FOR:

California Department of Transportation
Division of Research, Innovation, and System Information
Office of Materials and Infrastructure Roadway Research

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Abstract:

A number of warm-mix asphalt test sections were constructed in California between 2007 and 2010 to assess long-term performance under selected traffic and climate conditions. A range of pavement designs were assessed, but the six projects evaluated in this report focused on open-graded friction courses with polymer-modified (PG 58-34) and rubber-modified (PG 64-16) binders (three projects each). The main purpose of these experiments was to monitor performance under actual conditions and to quantify any benefits associated with using warm-mix asphalt under specific situations, such as with long hauls, in cool and/or damp conditions, under trafficking by large agricultural equipment, etc. Four of the test sections, which were located near Morro Bay, Point Arena, Orland, and Mendocino, had hot-mix controls. Two additional warm-mix asphalt projects, located near Marysville and Auburn, did not include control sections. The warm-mix technologies assessed in these projects included Advera WMA, Evotherm, Gencor Ultrafoam GX, Rediset, and Sasobit. Monitoring included a visual assessment from the shoulder and a photographic record.

The six open-graded friction course warm-mix asphalt projects in northern and central California were evaluated for periods of between two and five years. All of the sections performed well. On the projects that included hot-mix control sections, the warm-mix asphalt sections showed equal performance to the controls. On one project (Interstate-5), the warm-mix section showed some early minor rutting in the first six months, which was not observed on the control. However, after 12 months of trafficking rut depths on both sections were the same. This early rutting on the warm-mix section was attributed to less oxidation of the binder due to the lower production and placement temperatures. Once the rate of oxidation had stabilized (after ± 12 months), rutting performance appeared to be the same, and to progress at the same rate, on both sections. This observation was consistent with observations on earlier accelerated loading experiments and is not considered to be a concern given that rut depths were the same on the control and warm mix sections at the end of the testing/evaluation periods.

Based on the observations in this study, the use of warm-mix technologies in open-graded friction course mixes with polymer- and rubber-modified binders appears to be beneficial, especially on projects that require long hauls and/or placement in cold temperatures. The use of warm-mix technologies resulted in improved workability of the mix and better compaction, which should improve durability and prevent early raveling.

Keywords:
Warm-mix asphalt, field performance, open-graded friction course, rubberized open-graded friction course

Proposals for implementation:
Continue with statewide implementation.

Related documents:
UCPRC Research Reports: RR-2008-11, RR-2009-02, RR-2011-02, RR-2011-03, RR-2013-02, RR-2013-03

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PROJECT OBJECTIVES

The objective of this warm-mix asphalt study is to determine whether the use of additives that reduce the production and construction temperatures of hot-mix asphalt will influence the performance of the mix. This will be achieved through the following tasks:

1. Preparation of a workplan to guide the research;
2. Monitoring the construction of Heavy Vehicle Simulator (HVS) and in-service test sections;
3. Sampling of mix and mix components during asphalt concrete production and construction;
4. Trafficking of demarcated sections with the HVS in a series of tests to assess performance;
5. Conducting laboratory tests to identify comparable laboratory performance measures;
6. Monitoring the performance of in-service pilot test sections; and
7. Preparation of first- and second-level analysis reports and a summary report detailing the experiment and the findings.

This report covers Task 6.

EXECUTIVE SUMMARY

A number of warm-mix asphalt test sections were constructed in California between 2007 and 2010 to assess long-term performance under selected traffic and climate conditions. A range of pavement designs were assessed, but the six projects evaluated in this report focused on open-graded friction courses with polymer-modified (PG 58-34) and rubber-modified (PG 64-16) binders (three projects each). The main purpose of these experiments was to monitor performance under actual traffic and environmental conditions and to quantify any benefits associated with using warm-mix asphalt under specific situations, such as with long hauls, in cool and/or damp conditions, under trafficking by large agricultural equipment, etc. Four of the test sections, which were located near Morro Bay, Point Arena, Orland, and Mendocino, had hot-mix controls. Two additional warm-mix asphalt projects, located near Marysville and Auburn, did not include control sections. The warm-mix technologies assessed in these projects included Advera WMA, Evotherm, Gencor Ultrafoam GX, Rediset, and Sasobit. Monitoring included a visual assessment from the shoulder and a photographic record.

The six warm-mix asphalt projects in northern and central California were evaluated for periods of between two and five years. All of the sections performed well. On the projects that included hot-mix control sections, the warm-mix asphalt sections showed equal performance to the controls. On one project (Interstate-5), the warm-mix section showed some early minor rutting in the first six months, but no rutting was observed on the Control. After 12 months of trafficking, however, rut depths on both sections were the same. This early rutting on the warm-mix section was attributed to less oxidation of the binder due to the lower production and placement temperatures. Once the rate of oxidation stabilized (after ± 12 months), rutting performance appeared to be the same and to progress at the same rate on both sections. This observation was consistent with observations on earlier accelerated loading experiments and this rutting is not considered to be a concern given that rut depths were the same on the control and warm-mix sections at the end of the testing/evaluation period.

Based on the observations made in this study, the use of warm-mix technologies in open-graded friction course mixes with polymer- and rubber-modified binders appears to be beneficial, especially on projects that require long hauls and/or placement in cold temperatures. The use of warm-mix technologies resulted in improved workability of the mix and better compaction, which should improve durability and prevent early raveling.

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CONVERSION FACTORS

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	Millimeters	mm
ft	feet	0.305	Meters	m
yd	yards	0.914	Meters	m
mi	miles	1.61	Kilometers	Km
		AREA		
in^2	square inches	645.2	Square millimeters	mm^2
ft^2	square feet	0.093	Square meters	m^2
yd^2	square yard	0.836	Square meters	m^2
ac	acres	0.405	Hectares	ha
mi^2	square miles	2.59	Square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	Milliliters	mL
gal	gallons	3.785	Liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	Grams	g
lb	pounds	0.454	Kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	Lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	Newtons	N
lbf/in^2	poundforce per square inch	6.89	Kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	Inches	in
m	meters	3.28	Feet	ft
m	meters	1.09	Yards	yd
km	kilometers	0.621	Miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	Hectares	2.47	Acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	Milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	Gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	Ounces	oz
kg	kilograms	2.202	Pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	Poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380 (Revised March 2003)

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1. INTRODUCTION

1.1 Background

Warm-mix asphalt (WMA) is a relatively new technology. It was developed in response to the needs for reduced energy consumption and stack emissions during the production of asphalt concrete, and to allow longer haul distances, lower placement temperatures, improved workability, and better working conditions for plant and paving crews. Studies in the United States and Europe indicate that significant reductions in production and placement temperatures, and potentially related emissions, are possible.

The California Department of Transportation (Caltrans) has expressed interest in using warm-mix asphalt with a view to reducing stack emissions at asphalt plants, to allowing longer haul distances between asphalt plants and construction projects, to improving construction quality (especially during nighttime closures), to improving working conditions during construction, and to extending the annual period for paving. However, use of warm-mix asphalt technologies requires incorporating an additive into the mix, and/or changes in production and construction procedures specifically related to temperature, and these could influence the short- and long-term performance of the pavement as well as the emissions generated during production and placement. Consequently, Caltrans identified the need for research to address a range of concerns related to these changes before it would approve statewide implementation of the technology.

1.2 Project Objectives

The research presented in this report is part of Partnered Pavement Research Center Strategic Plan Elements 4.18 and 4.41.2 (PPRC SPE 4.18 and 4.41.2), titled "Warm-Mix Asphalt Study" *(1-6)* and "Environmental Impacts and Energy Efficiency of Warm Mix Asphalt" *(7,8)*, respectively. The 4.18 study was undertaken for Caltrans, while the 4.41.2 study was undertaken on behalf of both Caltrans and the California Department of Resources, Recycling, and Recovery (CalRecycle). The 4.18 study assessed the performance of warm-mix asphalt in laboratory, accelerated loading, and full-scale field trials on California highways. The 4.41.2 study investigated the effects of warm-mix asphalt technologies on binder aging and emissions, with special emphasis on rubberized asphalt mixes.

The objective of the warm-mix asphalt studies is to determine whether the use of additives to reduce the production and construction temperatures of hot-mix asphalt will influence the performance of the mix. This has been achieved through the following tasks:

1. Preparation of a workplan to guide the research;

2. Monitoring the construction of Heavy Vehicle Simulator (HVS) and in-service test sections;
3. Sampling of mix and mix components during asphalt concrete production and construction;
4. Trafficking of demarcated sections with the HVS in a series of tests to assess performance;
5. Conducting laboratory tests to identify comparable laboratory performance measures;
6. Monitoring the performance of in-service pilot test sections; and
7. Preparation of first-level analysis reports and a summary report detailing the experiment and the findings.

This report covers Task 6.

1.3 Structure and Content of this Technical Memorandum

This technical memorandum presents an overview of the work carried out to meet the objectives of the study, and is organized as follows:

- Chapter 2 summarizes the test plan, with details on the test sections and the assessment methodology.
- Chapters 3 through 8 summarize observations on each of the six test projects.
- Chapter 9 provides a project summary and conclusions.
- Appendix A contains an example of the visual assessment form used.
- Appendix B contains summary assessment sheets for each evaluation visit.

1.4 Measurement Units

Although Caltrans recently returned to the use of U.S. standard measurement units, metric units have always been used by the UCPRC in the design and layout of experiments, for laboratory and field measurements, and for data storage. In this report, both U.S. Customary and metric units (provided in parentheses after the U.S. Customary units) are provided in the general discussion. A conversion table is provided on page vii.

1.5 Terminology

The term “asphalt concrete” is used in this report as a general descriptor for asphalt concrete surfacings. The terms “hot-mix asphalt (HMA)” and “warm-mix asphalt (WMA)” are used respectively as descriptors to differentiate between the control and the warm-mixes discussed in this study.

2. TEST PLAN

2.1 Test Section Details

Details of the test sections monitored in this study are summarized in Table 2.1 and Table 2.2. All the sections monitored were open-graded friction courses. Three of the test section mixes used a polymer-modified (PM) binder; the remaining three test section mixes used a rubber-modified binder (wet process, produced at the asphalt plant).

Table 2.1: Test Section Location and Construction Details

Test Section	Location	EA Number	Paving Date	WMA Technology	Paving Contractor	Haul Time (Hrs.)
Morro Bay	05-SLO-01 PM 25.7 – 27.7	05-0P9904	05/05/2008	Control Advera Evotherm Sasobit	Burke	1.0
Point Arena	01-MEN-01 PM 15.3 – 20.8	01-484803	09/08/2008	Control Evotherm	North Bay	2.5
Orland	03-GLE-5 PM 20.0 – 28.8	03-3C8704	05/11/2009	Control Evotherm	Knife River	0.5
Marysville	03-YUB-70 PM 16.4 – 18.9	03-0A7104	06/23/2009	Evotherm	Teichert	0.5
Mendocino	01-MEN-1 PM 43.9 – 50.6	01-490103	07/01/2010	Control Advera Gencor Rediset	Granite	3.0
Auburn	03-PLA-49 PM 7.5 – 11.0	03-4M1401	08/07/2010	Evotherm	Granite	1.0

Table 2.2: Test Section Mix Details

Test Section	Asphalt Plant	Mix Type[1]	Binder Type	AC Thickness (ft. [mm])	Production Temperature (°F [°C])	Placement Temperature[1] (°F [°C])
Morro Bay	Union Asphalt Paso Robles	1/2 in. (13 mm) OGFC	58-34 PM[2]	0.10 (30).	C[4] – 325 (163) WA[5] – 270 (132) WE[6] – 275 (135) WS[7] – 266 (130)	C – 300 (150) WA – 260 (127) WE – 260 (127) WS – 260 (127)
Point Arena	Syar Santa Rosa	1/2 in. (13 mm) OGFC	58-34 PM[2]	0.08 (25)	C[4] – 325 (163) WE[6] – 300 (150)	C – 260 (127) WE – 240 (115)
Orland	Knife River Orland	1/2 in. (13 mm) R-OGFC[3]	64-16	0.10 (30)	C[4] – 320 (160) WE[6] – 290 (143)	C – 265 (130) WE – 250 (120)
Marysville	Teichert Marysville	1/2 in. (13 mm) R-OGFC[3]	64-16	0.10 (30)	WE[6] – 300 (150)	WE – 265 (130)
Mendocino	Granite Ukiah	1/2 in. (13 mm) OGFC	58-34 PM[2]	0.08 (25)	C[4] – 325 (163) WA[5] – 290 (143) WG[8] – 310 (155) WR[9] – 290 (143)	C – 260 (127) WA – 240 (115) WG – 260 (127) WR – 240 (115)
Auburn	Granite Bradshaw	1/2 in. (13 mm) R-OGFC[3]	64-16	0.10 (30)	WE[6] – 300 (150)	WE – 275 (135)

[1] Behind screed
[2] PM = Polymer-modified
[3] R-OGFC used in place of RHMA-O for consistency
[4] C = Control
[5] WA = Warm-mix (Advera)
[6] WE = Warm-mix (Evotherm)
[7] WS = Warm-mix (Sasobit)
[8] WG = Warm-mix (Gencor)
[9] WR = Warm-mix (Rediset)

2.2 Assessment Methodology

Monitoring of all sections consisted of a visual assessment from the road shoulder, with a photographic record. Observations were captured on a visual assessment form (Appendix A). No physical measurements were taken.

3. MORRO BAY

3.1 Introduction

This experiment was the first long-term warm-mix asphalt field project constructed in California. The experiment, located on the two northbound lanes of Highway 1 between San Luis Obispo and Morro Bay, consisted of a half-inch (13 mm) open-graded friction course with a PG 58-34 PM binder placed 0.1 ft. (30 mm) thick. Three different warm-mix technologies (Advera, Evotherm, and Sasobit) were compared against a hot-mix control. Located near the ocean and crossing rolling topography, each test section included a slope. The mixes were produced at the Union Asphalt plant in Paso Robles, about a one hour haul from the experiment. The Morro Bay area normally experiences cool temperatures and the purpose of this experiment was to investigate whether the use of warm-mix technologies would improve placement and compaction of the mix after relatively long hauls under these cool conditions. This road carries approximately 24,000 vehicles per day, about 5 percent of which is trucks.

3.2 Mix Design and Mix Production

The mix was designed by Caltrans and produced at Union Asphalt's hot-mix plant located in Paso Robles. The Advera and Sasobit technologies were blown into the port next to the RAP collar with calibrated and customized dosing equipment at rates of 2.0 percent and 1.5 percent by mass of the binder, respectively. Evotherm was blended with the asphalt binder through the liquid anti-strip system at a rate of 0.5 percent by mass of the binder.

3.3 Construction

The test sections were constructed by Burke Construction. The weather was foggy and cool, with temperatures ranging between 50°F and 62°F (10°C and 17°C). Tack coat was applied at a rate of approximately 0.08 gal./yd^2 (0.36 L/m^2). Haul distance from the plant to the site was approximately 35 miles (56 km) with a haul time of about one hour. Construction details are summarized in Table 3.1.

Table 3.1: Construction Details for Morro Bay Project

Parameter	Control	Advera	Evotherm	Sasobit
Production temperature (°F/°C)	325 (163)	270 (132)	275 (135)	266 (130)
Average temperature at load out (°F/°C)	316 (158)	265 (129)	269 (132)	262 (128)
Temperature behind paver at start (°F/°C)	300 (150)	260 (127)	260 (127)	260 (127)
Temperature after rolling at end (°F/°C)	220 (105)	215 (102)	166 (75)	237 (114)

3.4 Performance

The first assessment was undertaken two weeks after construction to obtain baseline measurements, and thereafter at approximate six-month intervals until June 2013. A summary of the observations from each visit is provided in Table B.1 in Appendix B. Photographs taken during the May 2007, May 2012, and June 2013 visits are shown in Figure 3.1 through Figure 3.16.

May 2007

All sections resembled a typical open-graded friction course and were given an overall rating of "good." However, evidence of trucks tracking tack coat onto the adjacent newly placed surfacing was observed in certain areas on each test section. No other problems were observed. No early stone loss was noted.

November 2007

No deterioration compared to the May 2007 baseline measurements was noted on the sections after six months of traffic. No raveling was observed on the track marks.

May 2008

No deterioration compared to the May 2007 baseline measurements was noted on the sections after 12 months of traffic. No raveling was observed on the track marks.

November 2008

No deterioration compared to the May 2007 baseline measurements was noted on the sections after 18 months of traffic. No raveling was observed on the track marks.

May 2009

No deterioration compared to the May 2007 baseline measurements was noted on the sections after 24 months of traffic. No raveling was observed on the track marks.

November 2009

No deterioration compared to the May 2007 baseline measurements was noted on the sections after 30 months of traffic. No raveling was observed on the track marks.

May 2010

No deterioration compared to the May 2007 baseline measurements was noted on the sections after 36 months of traffic. No raveling was observed on the track marks, which were less distinct than previous visits due to fading of the surface color.

November 2010

No deterioration compared to the May 2007 baseline measurements was noted on the sections after 42 months of traffic. No raveling was observed on the track marks, which continued to be less distinct.

May 2011

No deterioration compared to the May 2007 baseline measurements was noted on the sections after 48 months of traffic. The surface color had faded considerably and the track marks were difficult to locate.

November 2011

No deterioration compared to the May 2007 baseline measurements was noted on the sections after 54 months of traffic. The surface color had continued to fade and the track marks were difficult to locate.

May 2012

No deterioration compared to the May 2007 baseline measurements was noted on the sections after 60 months of traffic. The track marks were no longer visible on any of the sections.

November 2011

No deterioration compared to the May 2007 baseline measurements was noted on the sections after 66 months of traffic.

June 2013

No deterioration compared to the May 2007 baseline measurements was noted on the sections after 73 months of traffic. Although the surface color of all sections was considerably lighter compared to new asphalt, the surface was still in very good condition and only minor stone loss, consistent with the age of the surface, was observed. Permeability through the open-graded friction course also remained effective on all sections (Figure 3.16).

Figure 3.1: Morro Bay Control, May 2007 (0 months).

Figure 3.2: Morro Bay Control, May 2007 (0 months), track marks.

Figure 3.3: Morro Bay Control, May 2012 (60 months), track marks no longer visible.

Figure 3.4: Morro Bay Control, June 2013 (73 months).

Figure 3.5: Morro Bay Advera, May 2007 (0 months).

Figure 3.6: Morro Bay Advera, May 2012 (60 months), track marks no longer visible.

Figure 3.7: Morro Bay Advera, June 2013 (73 months).

Figure 3.8: Morro Bay Evotherm, May 2007 (0 months).

Figure 3.9: Morro Bay Evotherm, May 2007 (0 months), track marks.

Figure 3.10: Morro Bay Evotherm, May 2012 (60 months), track marks no longer visible.

Figure 3.11: Morro Bay Evotherm, June 2013 (73 months).

Figure 3.12: Morro Bay Sasobit, May 2007 (0 months).

Figure 3.13: Morro Bay Sasobit, May 2007 (0 months), track marks.

Figure 3.14: Morro Bay Sasobit, May 2012 (60 months), track marks no longer visible.

Figure 3.15: Morro Bay Sasobit, June 2013 (73 months).

Figure 3.16: Morro Bay Sasobit, June 2013 (73 months), showing effective drainage.

4. POINT ARENA

4.1 Introduction

This experiment was located on Highway 1 north of Point Arena and consisted of a half-inch (13 mm) open-graded friction course with a PG 58-34PM binder placed 0.08 ft. (25 mm) thick. The road has two lanes with shoulders, with prevalent sharp bends and steep grades. Located near the ocean, the experiment is, about a 2.5 hour haul from the Syar hot-mix plant in Santa Rosa. This location normally experiences cool temperatures and the purpose of this experiment was to investigate if the use of a warm-mix technology (Evotherm) would improve placement and compaction of the mix after a long haul. A hot-mix, dense-graded section was included though a flood plain section of the route. This was not considered to be a representative control section and no performance comparisons between the two sections were made. The road carries approximately 1,000 vehicles per day, about 5 percent of which is trucks.

4.2 Mix Design and Mix Production

The mix was designed by Syar Industries and produced at their Todd Road hot-mix asphalt plant, which is located in Santa Rosa . The Evotherm was fed into the binder stream through the liquid anti-strip system on the plant at a rate of 0.5 percent by mass of the binder.

4.3 Construction

The surfacing was placed by North Bay Construction. The weather was overcast and cool with temperatures averaging 55°F (13°C). Tack coat was applied at a rate of approximately 0.08 gal./yd^2 (0.36 L/m^2). The haul distance from the plant to the site was approximately 100 miles (160 km) with a haul time of between three and four hours. A material transfer vehicle was used during placement to minimize chunks in the mix. Some draindown was observed. Construction details are summarized in Table 4.1.

Table 4.1: Construction Details for Point Arena Project

Parameter	Control	Evotherm
Production temperature (°F/°C)	325 (163)	300 (149)
Average temperature at load out (°F/°C)	315 (157)	295 (146)
Temperature behind paver at start (°F/°C)	260 (127)	240 (115)
Temperature after rolling at end (°F/°C)	215 (102)	215 (102)

4.4 Performance

The first assessment was undertaken 10 days after construction to obtain baseline measurements, and thereafter at approximate six-month intervals through to December 2013. A summary of the observations from each visit is provided in Table B.2 in Appendix B. Photographs taken during the December 2008, November 2010, and December 2013 visits are shown in Figure 4.1 through Figure 4.4.

December 2008

The Evotherm section resembled a typical open-graded friction course and was given an overall rating of "good." No early stone loss was noted. Water was effectively draining through the friction course and out through the sides of the road. No other problems were observed.

June 2009

No deterioration compared to the December 2008 baseline measurements was noted on the section after six months of traffic.

December 2009

No deterioration compared to the December 2008 baseline measurements was noted on the section after 12 months of traffic.

June 2010

No deterioration compared to the December 2008 baseline measurements was noted on the section after 18 months of traffic. However, some longitudinal cracks were noted on the hill section around postmile 17. This was attributed to slope movement and not to performance of the warm-mix asphalt.

November 2010

No deterioration compared to the December 2008 baseline measurements was noted on the sections after 23 months of traffic. The number and severity of the longitudinal cracks had not increased. Drainage through the OGFC was still effective.

June 2011

No deterioration compared to the December 2008 baseline measurements was noted on the sections after 30 months of traffic. The number and severity of the longitudinal cracks had not increased.

December 2011

No deterioration compared to the December 2008 baseline measurements was noted on the sections after 30 months of traffic. The number and severity of the longitudinal cracks had not increased. Drainage through the OGFC was still effective.

June 2012

No deterioration compared to the December 2008 baseline measurements was noted on the sections after 36 months of traffic. Some additional longitudinal cracks were observed in the vicinity of the sharp curve around postmile 16.5.

November 2012

No deterioration compared to the December 2008 baseline measurements was noted on the sections after 41 months of traffic. The number and severity of the longitudinal cracks did not appear to have increased since the June 2012 visit. Drainage through the OGFC was still effective.

June 2013

No deterioration compared to the December 2008 baseline measurements was noted on the sections after 48 months of traffic. The number and severity of the longitudinal cracks did not appear to have increased since the June 2012 visit.

December 2013

No deterioration compared to the December 2008 baseline measurements was noted on the sections after 54 months of traffic. The number and severity of the longitudinal cracks did not appear to have increased since the June 2012 visit. Drainage through the OGFC was still effective.

Figure 4.1: Point Arena Evotherm, December 2008 (3 months).

Figure 4.2: Point Arena Evotherm, November 2010 (23 months).

Figure 4.3: Point Arena Evotherm, November 2010, showing longitudinal cracks.

Figure 4.4: Point Arena Evotherm, December 2013 (54 months).

5. ORLAND

5.1 Introduction

This project was located on Interstate-5 near Orland and consisted of a half-inch (13 mm) open-graded friction course with a PG 64-16 rubberized binder placed 0.1 ft. (30 mm) thick. The area experiences a typical California Central Valley climate with hot summers. The road, a divided highway with shoulders, is relatively straight and level. The experiment was evaluated for 24 months to monitor the effects of relatively heavy truck and car traffic on the thin warm-mix asphalt (Evotherm) surfacing. The highway carries approximately 26,500 vehicles per day, about 28 percent of which is trucks.

5.2 Mix Design and Mix Production

The mix was designed by Knife River Construction and produced at their Orland hot-mix asphalt plant. The Evotherm was fed into the binder stream through the liquid anti-strip system on the plant at a rate of 0.5 percent by mass of the binder.

5.3 Construction

The open-graded friction course was placed by Knife River Construction in May 2009 in a daytime paving operation. The weather was relatively cool with temperatures averaging between 60°F and 70°F (16°C and 21°C). Tack coat was applied at a rate of approximately 0.08 gal./yd^2 (0.36 L/m^2). The haul distance from the plant to the site was less than 10 miles (15 km) with a haul time of about 15 minutes. Construction details are summarized in Table 5.1.

Table 5.1: Construction Details for Orland Project

Parameter	Control	Evotherm
Production temperature (°F/°C)	320 (160)	290 (143)
Average temperature at load out (°F/°C)	315 (157)	285 (140)
Temperature behind paver at start (°F/°C)	265 (130)	250 (120)
Temperature after rolling at end (°F/°C)	230 (110)	230 (110)

5.4 Performance

The first assessment was undertaken 10 days after construction to obtain baseline measurements, and thereafter at approximate six-month intervals through to June 2011. A summary of the observations from each visit is provided in Table B.3 in Appendix B. Photographs taken during the June 2009 and June 2011 visits are shown in Figure 5.1 through Figure 5.4.

June 2009

The road surface resembled a typical open-graded friction course and was given an overall rating of "good." No early stone loss was noted. Water was effectively draining through the friction course and out through the sides of the road. No other problems were observed.

December 2009

Minor rutting (average between 0.08 in. and 0.1 in. [2.0 mm and 3.0 mm]) was measured in the wheelpaths of the truck lane on the warm-mix section. No rutting was measured on the control section. The difference in rutting performance was attributed to lower oxidation of the binder in the warm-mix and consequent lower stiffness. Similar early rutting on warm-mix test sections was observed during accelerated loading tests conducted earlier in the warm-mix asphalt study *(1)*. No other deterioration compared to the June 2009 baseline measurements was noted.

June 2010

Rut depths of approximately 0.16 in. (4.0 mm) were measured on both the control and Evotherm sections. This indicated that rut performance on the hot- and warm-mix sections was similar after 12 months of trafficking and that binder oxidation rates had probably stabilized. No other deterioration compared to the June 2009 baseline measurements was noted on the sections after 12 months of traffic.

December 2010

No additional rutting was measured on the sections after a further six months of traffic and no other deterioration compared to the June 2009 baseline measurements was noted on the sections.

June 2011

No additional rutting was measured on the sections after a further six months of traffic and no other deterioration compared to the June 2009 baseline measurements was noted on the sections.

Figure 5.1: Orland Control, June 2009 (1 month).

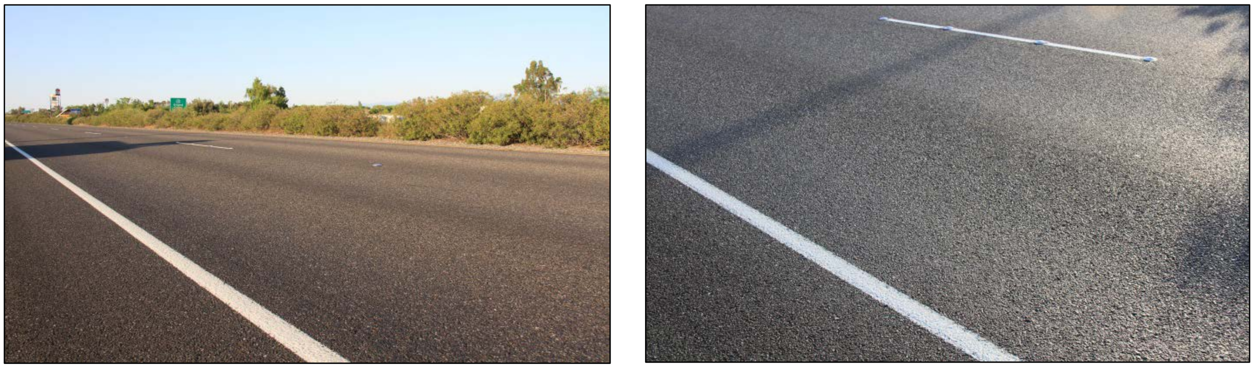

Figure 5.2: Orland Control, June 2011 (24 months). Note ruts in wheelpath.

Figure 5.3: Orland Evotherm, June 2009 (1 month).

Figure 5.4: Orland Evotherm, June 2011 (24 months). Note ruts in wheelpath.

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6. MARYSVILLE

6.1 Introduction

This project was located on Highway 70 north of Marysville, California, and consisted of a half-inch (13 mm) open-graded friction course with a PG 64-16 rubberized binder placed 0.1 ft. (30 mm) thick. The area experiences a typical California Central Valley climate with hot summers. The road has two lanes with shoulders and is relatively straight and level. It serves an agricultural area and heavy agricultural equipment uses the road with frequent entrances and exits. The experiment was evaluated for 24 months to monitor any damage to the warm-mix (Evotherm) asphalt surface caused by the turning movements of this equipment. This project did not include a hot-mix control section. The road carries approximately 14,600 vehicles per day, about 15 percent of which is trucks.

6.2 Mix Design and Mix Production

The mix was designed by Teichert Construction and produced at their Marysville hot-mix asphalt plant. The Evotherm was fed into the binder stream through the liquid anti-strip system on the plant at a rate of 0.5 percent by mass of the binder.

6.3 Construction

The open-graded friction course was placed by Teichert Construction in June 2009 in a nighttime paving operation. The weather was relatively cool with temperatures averaging 58°F (14°C). Tack coat was applied at a rate of approximately 0.08 gal./yd^2 (0.36 L/m^2). The haul distance from the plant to the site was approximately 25 miles (40 km) with a haul time of about 30 minutes. Construction details are summarized in Table 6.1.

Table 6.1: Construction Details for Marysville Project

Parameter	Evotherm
Production temperature (°F/°C)	300 (150)
Average temperature at load out (°F/°C)	295 (146)
Temperature behind paver at start (°F/°C)	265 (130)
Temperature after rolling at end (°F/°C)	220 (105)

6.4 Performance

The first assessment was undertaken 10 days after construction to obtain baseline measurements, and thereafter at approximate six-month intervals through to June 2011. A summary of the observations from each visit is provided in Table B.4 in Appendix B. Photographs taken during the June 2009 and June 2011 visits are shown in Figure 6.1 and Figure 6.2.

June 2009

The road surface resembled a typical open-graded friction course and was given an overall rating of "good." No early stone loss was noted. Water was effectively draining through the friction course and out through the sides of the road. Agricultural equipment movements on the road did not appear to have caused any damage. No other problems were observed.

December 2009

No deterioration compared to the June 2009 baseline measurements was noted on the section after six months of traffic.

June 2010

No deterioration compared to the June 2009 baseline measurements was noted on the section after 12 months of traffic.

December 2010

No deterioration compared to the June 2009 baseline measurements was noted on the section after 18 months of traffic.

June 2011

No deterioration compared to the June 2009 baseline measurements was noted on the section after 24 months of traffic, indicating that frequent and aggressive turning movements by large agricultural equipment is unlikely to negatively influence warm-mix asphalt surfacings.

Figure 6.1: Marysville Evotherm, June 2009 (0 months).

Figure 6.2: Marysville Evotherm, June 2011 (24 months).

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7. MENDOCINO

7.1 Introduction

This experiment was located on California Highway 1 between Albion and Mendocino and consisted of a half-inch (13 mm) open-graded friction course with a PG 58-34 polymer-modified binder placed 0.08 ft. (25 mm) thick. The road has two lanes with shoulders, and sharp bends and steep grades are prevalent. The experiment's location, which was near the ocean, required a roughly three-hour haul from Granite Construction Company's hot-mix plant in Ukiah. This location normally experiences cool temperatures, and the purpose of this experiment was to investigate if the use of warm-mix technologies (Advera, Gencor, and Rediset) would improve placement and compaction of the mix after the long haul. A short hot-mix control section was included although there were concerns of anticipated problems with temperature loss during the haul, which is known to lead to early raveling of open-graded friction courses. The road carries approximately 6,600 vehicles per day, about 5 percent of which is trucks.

7.2 Mix Design and Mix Production

The mix was designed by Granite Construction and produced at the company's hot-mix asphalt plant in Ukiah. The Advera and Rediset technologies were blown into the port next to the RAP (recycled asphalt pavement) collar with calibrated and customized dosing equipment at rates of 2.0 percent and 4.5 percent by mass of the binder, respectively. For the Gencor mix, water was added at a rate of 1.5 percent by mass of the binder through the foaming attachment.

7.3 Construction

The test sections were constructed by Granite Construction in sunny, clear weather with temperatures ranging between 52°F and 67°F (11°C and 19°C). Tack coat was applied at a rate of approximately 0.08 gal./yd^2 (0.36°L/m^2). The haul distance from the plant to the site was approximately 60 miles (100 km) with a haul time of between 2.5 and 3.0 hours. A material transfer vehicle was used during placement of the mix to minimize chunks. Construction details are summarized in Table 7.1.

Table 7.1: Construction Details for Mendocino Project

Parameter	Control	Advera	Gencor	Rediset
Production temperature (°F/°C)	325 (163)	290 (143)	310 (155)	290 (143)
Average temperature at load out (°F/°C)	315 (157)	285 (141)	295 (146)	285 (141)
Temperature behind paver at start (°F/°C)	260 (127)	240 (115)	260 (127)	240 (115)
Temperature after rolling at end (°F/°C)	215 (102)	215 (102)	215 (102)	215 (102)

7.4 Performance

The first assessment was undertaken two weeks after construction to obtain baseline measurements, and thereafter at approximate six-month intervals through to December 2013. A summary of the observations from each visit is provided in Table B.5 in Appendix B. Photographs taken during the July 2010 and December 2013 visits are shown in Figure 7.1 through Figure 7.8.

July 2010

All sections resembled a typical open-graded friction course and were given an overall rating of "good." Some evidence of compacted binder strings was noted on the Advera sections, but not on the other sections. No early stone loss was noted. No other problems were observed.

November 2010

No deterioration compared to the July 2010 baseline measurements was noted on the sections after five months of traffic.

June 2011

No deterioration compared to the July 2010 baseline measurements was noted on the sections after 12 months of traffic.

December 2011

No deterioration compared to the July 2010 baseline measurements was noted on the sections after 18 months of traffic.

June 2012

No deterioration compared to the July 2010 baseline measurements was noted on the sections after 24 months of traffic.

December 2012

No deterioration compared to the July 2010 baseline measurements was noted on the sections after 30 months of traffic. However, minor raveling was noted on a short section of the outside wheelpath on a sharp bend on the Advera section.

June 2013

No deterioration compared to the July 2010 baseline measurements was noted on the sections after 36 months of traffic. The raveling observed on the Advera section during the December 2012 visit had not deteriorated.

December 2013

No deterioration compared to the July 2010 baseline measurements was noted on the sections after 42 months of traffic. The raveling observed on the Advera section during the December 2012 visit had not deteriorated.

Figure 7.1: Mendocino Control, July 2010 (0 months).

Figure 7.2: Mendocino Control, December 2013 (42 months).

Figure 7.3: Mendocino Advera, July 2010 (0 months).

Figure 7.4: Mendocino Advera, December 2013 (42 months). Note raveling in outside wheelpath.

Figure 7.5: Mendocino Gencor, July 2010 (0 months).

Figure 7.6: Mendocino Gencor, December 2013 (42 months).

Figure 7.7: Mendocino Rediset, July 2010 (0 months).

Figure 7.8: Mendocino Rediset, December 2013 (42 months).

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8. AUBURN

8.1 Introduction

This project was located on Highway 49 north of Auburn and consisted of a half-inch (13 mm) open-graded friction course with a PG 64-16 rubberized binder placed 0.1 ft. (30 mm) thick. The project did not include a hot-mix control section. The area experiences typical Sierra foothills climate with hot summers. The road has four lanes with shoulders, and has gentle curves and a rolling vertical alignment. The road carries mostly commuter traffic totaling about 15,000 vehicles per day, about 8 percent of which is trucks. The surface was badly cracked prior to being overlaid. The experiment was evaluated for 24 months to monitor any early reflective cracking in the warm-mix (Evotherm) asphalt.

8.2 Mix Design and Mix Production

The mix was designed by Granite Construction and produced at their Bradshaw hot-mix asphalt plant. The Evotherm was fed into the binder stream through the liquid anti-strip system on the plant at a rate of 0.5 percent by mass of the binder.

8.3 Construction

The open-graded friction course was placed by Granite Construction in August 2010 in a nighttime paving operation. The weather was cool with temperatures averaging 60°F (15°C). Tack coat was applied at a rate of approximately 0.08 gal./yd^2 (0.36 L/m^2). The haul distance from the plant to the site was approximately 40 miles (65 km) with a haul time of about 60 minutes. Construction details are summarized in Table 8.1.

Table 8.1: Construction Details for Auburn Project

Parameter	Evotherm
Production temperature (°F/°C)	300 (150)
Average temperature at load out (°F/°C)	295 (146)
Temperature behind paver at start (°F/°C)	275 (135)
Temperature after rolling at end (°F/°C)	220 (105)

8.4 Performance

The first assessment was undertaken 10 days after construction to obtain baseline measurements, and thereafter at approximate six-month intervals through to July 2012. A summary of the observations from each visit is provided in Table B.6 in Appendix B. Photographs taken just prior to construction and then during the August 2010 and July 2012 visits are shown in Figure 8.1 through Figure 8.3.

August 2010

The road surface resembled a typical open-graded friction course and was given an overall rating of "good." Some localized areas of what appeared to be segregation in the mix were noted. Some open longitudinal joints were also noted. No early stone loss was noted, and no other problems were observed. Water was effectively draining through the friction course and out through the sides of the road.

December 2010

No deterioration compared to the August 2010 baseline measurements was noted on the section after five months of traffic.

July 2011

No deterioration compared to the August 2010 baseline measurements was noted on the section after 12 months of traffic.

December 2011

No deterioration compared to the August 2010 baseline measurements was noted on the section after 18 months of traffic.

July 2012

Reflected transverse cracking and some minor raveling in the outside wheelpath of the outside lanes was noted in some areas of the project. Given that no hot-mix control was available for comparison purposes, it was not clear whether these distresses were related to the warm-mix technology, to construction issues, or to other factors. No further deterioration compared to the August 2010 baseline measurements was noted.

Figure 8.1: Auburn Evotherm, July 2010, one month prior to paving.

Figure 8.2: Auburn Evotherm, August 2010 (0 months). Note segregation and open joint.

Figure 8.3: Auburn Evotherm, July 2012 (24 months). Note deterioration and reflected crack.

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9. CONCLUSIONS

Six open-graded friction course warm-mix asphalt projects in northern and central California were evaluated for periods of between two and five years. Three of the projects used rubberized binders (PG 64-16) and the other three used polymer-modified binders (PG 58-34). All of the sections performed well. On the four projects that included hot-mix control sections, the warm-mix asphalt sections showed equal performance to the controls. On one project (Interstate-5), the warm-mix section showed some early minor rutting in the first six months, which was not observed on the control. However, after 12 months of trafficking, rut depths on both sections were the same. This early rutting on the warm-mix section was attributed to less oxidation of the binder due to the lower temperatures. Once the rate of oxidation stabilized (after ± 12 months), rutting performance appeared to be the same, and to progress at the same rate, on both sections. This observation was consistent with observations on earlier accelerated loading experiments and is not considered to be a concern given that rut depths were the same on the control and warm-mix sections at the end of the testing/evaluation periods.

Based on the observations made in this study, the use of warm-mix technologies in open-graded friction course mixes with polymer- and rubber-modified binders appears to be beneficial, especially on projects that require long hauls and/or placement in cold temperatures. The use of warm-mix technologies resulted in improved workability of the mix and better compaction, which should improve durability and prevent early raveling.

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REFERENCES

1. JONES, D., Wu, R., Tsai, B., Lu, Q. and Harvey, J. 2008. **Warm-Mix Asphalt Study: Test Track Construction and First-Level Analysis of Phase 1 HVS and Laboratory Testing.** Davis and Berkeley, CA: University of California Pavement Research Center. (UCPRC-RR-2008-11).
2. JONES, D., Wu, R., Tsai, B., Lu, Q. and Harvey, J. 2008. **Warm-Mix Asphalt Study: First-Level Analysis of Phase 2 HVS and Laboratory Testing, and Phase 1 and Phase 2 Forensic Assessments.** Davis and Berkeley, CA: University of California Pavement Research Center. (UCPRC-RR-2009-02).
3. JONES, D. and Tsai, B. 2012. **Warm-Mix Asphalt Study: First-Level Analysis of Phase 2b Laboratory Testing on Laboratory Prepared Specimens.** Davis and Berkeley, CA: University of California Pavement Research Center. (UCPRC-RR-2012-07).
4. JONES, D., Wu, R., Tsai, B. and Harvey, J. 2011. **Warm-Mix Asphalt Study: Test Track Construction and First-Level Analysis of Phase 3a HVS and Laboratory Testing (Rubberized Asphalt, Mix Design #1).** Davis and Berkeley, CA: University of California Pavement Research Center. (UCPRC-RR-2011-02).
5. JONES, D., Wu, R., Tsai, B. and Harvey, J. 2011. **Warm-Mix Asphalt Study: Test Track Construction and First-Level Analysis of Phase 3b HVS and Laboratory Testing (Rubberized Asphalt, Mix Design #2).** Davis and Berkeley, CA: University of California Pavement Research Center. (UCPRC-RR-2011-03).
6. JONES, D. 2012. **Warm-Mix Asphalt Study: Field Test Performance Evaluation.** Davis and Berkeley, CA: University of California Pavement Research Center. (UCPRC-TM-2013-08).
7. FARSHIDI, F., Jones, D. and Harvey, J.T. 2013. **Warm-Mix Asphalt Study: Evaluation of Rubberized Hot- and Warm-Mix Asphalt with Respect to Binder Aging.** Davis and Berkeley, CA: University of California Pavement Research Center. (UCPRC-RR-2013-02).
8. FARSHIDI, F., Jones, D. and Harvey, J.T. 2013. **Warm-Mix Asphalt Study: Evaluation of Rubberized Hot- and Warm-Mix Asphalt with Respect to Emissions.** Davis and Berkeley, CA: University of California Pavement Research Center. (UCPRC-RR-2013-03).

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APPENDIX A: VISUAL ASSESSMENT FORM

The following forms and tables are included in this Appendix:

Form A.1: Visual Assessment Form

Form A.1: Visual Assessment Form

CALTRANS WMA STUDY VISUAL ASSESSMENT FORM						**Date**	
Evaluator			**Project #**			**District**	
Road No		**Begin PM**		**End PM**		**Section**	

			Surfacing assessment				**Sketch**
Surfacing type							
Texture	Varying	Fine	F - M	Medium	M - C	Course	
Voids	Varying	None	N - F	Few	F - M	Many	
Permeability	Good	Fair	Poor	None			

	Degree						Extent					Length	Width	Number	Location
	Slight					Severe	<5				>80				
Mechanical distress	0	1	2	3	4	5	1	2	3	4	5				
Other distress	0	1	2	3	4	5	1	2	3	4	5				
Bleeding/flushing	0	1	2	3	4	5	1	2	3	4	5				
Asphalt stringers	0	1	2	3	4	5	1	2	3	4	5	Narrow	Wide	Position	
Surface cracks	0	1	2	3	4	5	1	2	3	4	5				
Binder condition	0	1	2	3	4	5	1	2	3	4	5	Active	Stable	Position	
Aggregate loss	0	1	2	3	4	5	1	2	3	4	5				

Structural assessment

	Degree						Extent					Narrow (% area)	Wide (% area)	Position	Location
	Slight					Severe	<5				>80				
Cracks - block	0	1	2	3	4	5	1	2	3	4	5				
Cracks - longitudinal	0	1	2	3	4	5	1	2	3	4	5				
Cracks - transverse	0	1	2	3	4	5	1	2	3	4	5				
Cracks - alligator	0	1	2	3	4	5	1	2	3	4	5				
Pumping	0	1	2	3	4	5	1	2	3	4	5				
Rutting	0	1	2	3	4	5	1	2	3	4	5				
Undulation/settlement	0	1	2	3	4	5	1	2	3	4	5				
Edgebreak	0	1	2	3	4	5	1	2	3	4	5	Number	Diameter		
Potholes	0	1	2	3	4	5	1	2	3	4	5				
Delamination	0	1	2	3	4	5	1	2	3	4	5				
												Small	Medium	Large	Location
Patching/digouts	0	1	2	3	4	5	1	2	3	4	5				

Functional assessment

	Degree					Influencing factors									
	Good				Poor										
Riding quality	1	2	3	4	5	Potholes		Patching		Undulation		Corrugation		Fatigue	
Skid resistance	1	2	3	4	5	Bleeding		Polishing							
Surface drainage	1	2	3	4	5										
Side drainage	✓	×													

Notes	**Photos**	

APPENDIX B: SUMMARY OF MONITORING EVALUATIONS

The following tables are included in this Appendix:

Table B.1: Summaries of Monitoring Observations for Morro Bay Project
Table B.2: Summary of Monitoring Observations for Point Arena Project
Table B.3: Summaries of Monitoring Observations for Orland Project
Table B.4: Summary of Monitoring Observations for Marysville Project
Table B.5: Summaries of Monitoring Observations for Mendocino Project
Table B.6: Summary of Monitoring Observations for Auburn Project

Table B.1: Summary of Monitoring Observations for Morro Bay Project: Control

Parameter	Control										
	May 08	**Nov 08**	**May 09**	**Nov 09**	**May 10**	**Nov 10**	**May 11**	**Nov 11**	**May 12**	**Nov 12**	**Jun 13**
Overall performance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Texture	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No	No	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No	No	No	No	No	No	No
Other damage	Yes[1]	Yes[1]	Yes[1]	Yes[1]	No	No	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No	No	No	No	No	No	No
Asphalt stringers	No	No	No	No	No	No	No	No	No	No	No
Surface cracks	No	No	No	No	No	No	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No	No	No	No	No	No	No
Cracks - block	No	No	No	No	No	No	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No	No	No	No	No	No	No
Cracks - transverse	No	No	No	No	No	No	No	No	No	No	No
Cracks - alligator	No	No	No	No	No	No	No	No	No	No	No
Pumping	No	No	No	No	No	No	No	No	No	No	No
Rutting	No	No	No	No	No	No	No	No	No	No	No
Raveling/stone loss	No	No	No	No	No	No	No	No	No	No	No
Undulation/settlement	No	No	No	No	No	No	No	No	No	No	No
Edgebreak	No	No	No	No	No	No	No	No	No	No	No
Potholes	No	No	No	No	No	No	No	No	No	No	No
Delamination	No	No	No	No	No	No	No	No	No	No	No
Patching	No	No	No	No	No	No	No	No	No	No	No
Other repairs	No	No	No	No	No	No	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good

Notes

[1] Track marks from trucks driving on tack coat in adjacent lane. No longer visible after 54 months of monitoring.

Table B.1: Summary of Monitoring Observations for Morro Bay Project: Advera

Parameter	Advera										
	May 08	**Nov 08**	**May 09**	**Nov 09**	**May 10**	**Nov 10**	**May 11**	**Nov 11**	**May 12**	**Nov 12**	**Jun 13**
Overall performance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Texture	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No	No	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No	No	No	No	No	No	No
Other damage	Yes[1]	Yes[1]	Yes[1]	Yes[1]	No	No	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No	No	No	No	No	No	No
Asphalt stringers	No	No	No	No	No	No	No	No	No	No	No
Surface cracks	No	No	No	No	No	No	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No	No	No	No	No	No	No
Cracks - block	No	No	No	No	No	No	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No	No	No	No	No	No	No
Cracks - transverse	No	No	No	No	No	No	No	No	No	No	No
Cracks - alligator	No	No	No	No	No	No	No	No	No	No	No
Pumping	No	No	No	No	No	No	No	No	No	No	No
Rutting	No	No	No	No	No	No	No	No	No	No	No
Raveling/stone loss	No	No	No	No	No	No	No	No	No	No	No
Undulation/settlement	No	No	No	No	No	No	No	No	No	No	No
Edgebreak	No	No	No	No	No	No	No	No	No	No	No
Potholes	No	No	No	No	No	No	No	No	No	No	No
Delamination	No	No	No	No	No	No	No	No	No	No	No
Patching	No	No	No	No	No	No	No	No	No	No	No
Other repairs	No	No	No	No	No	No	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good

Notes

[1] Track marks from trucks driving on tack coat in adjacent lane. No longer visible after 54 months of monitoring.

Table B.1: Summary of Monitoring Observations for Morro Bay Project: Evotherm

Parameter	Evotherm										
	May 08	Nov 08	May 09	Nov 09	May 10	Nov 10	May 11	Nov 11	May 12	Nov 12	Jun 13
Overall performance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Texture	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No	No	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No	No	No	No	No	No	No
Other damage	Yes[1]	Yes[1]	Yes[1]	Yes[1]	No	No	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No	No	No	No	No	No	No
Asphalt stringers	No	No	No	No	No	No	No	No	No	No	No
Surface cracks	No	No	No	No	No	No	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No	No	No	No	No	No	No
Cracks - block	No	No	No	No	No	No	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No	No	No	No	No	No	No
Cracks - transverse	No	No	No	No	No	No	No	No	No	No	No
Cracks - alligator	No	No	No	No	No	No	No	No	No	No	No
Pumping	No	No	No	No	No	No	No	No	No	No	No
Rutting	No	No	No	No	No	No	No	No	No	No	No
Raveling/stone loss	No	No	No	No	No	No	No	No	No	No	No
Undulation/settlement	No	No	No	No	No	No	No	No	No	No	No
Edgebreak	No	No	No	No	No	No	No	No	No	No	No
Potholes	No	No	No	No	No	No	No	No	No	No	No
Delamination	No	No	No	No	No	No	No	No	No	No	No
Patching	No	No	No	No	No	No	No	No	No	No	No
Other repairs	No	No	No	No	No	No	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good

Notes

[1] Track marks from trucks driving on tack coat in adjacent lane. No longer visible after 54 months of monitoring.

Table B.1: Summary of Monitoring Observations for Morro Bay Project: Sasobit

Parameter	Sasobit										
	May 08	Nov 08	May 09	Nov 09	May 10	Nov 10	May 11	Nov 11	May 12	Nov 12	Jun 13
Overall performance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Texture	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No	No	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No	No	No	No	No	No	No
Other damage	Yes[1]	Yes[1]	Yes[1]	Yes[1]	No	No	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No	No	No	No	No	No	No
Asphalt stringers	No	No	No	No	No	No	No	No	No	No	No
Surface cracks	No	No	No	No	No	No	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No	No	No	No	No	No	No
Cracks - block	No	No	No	No	No	No	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No	No	No	No	No	No	No
Cracks - transverse	No	No	No	No	No	No	No	No	No	No	No
Cracks - alligator	No	No	No	No	No	No	No	No	No	No	No
Pumping	No	No	No	No	No	No	No	No	No	No	No
Rutting	No	No	No	No	No	No	No	No	No	No	No
Raveling/stone loss	No	No	No	No	No	No	No	No	No	No	No
Undulation/settlement	No	No	No	No	No	No	No	No	No	No	No
Edgebreak	No	No	No	No	No	No	No	No	No	No	No
Potholes	No	No	No	No	No	No	No	No	No	No	No
Delamination	No	No	No	No	No	No	No	No	No	No	No
Patching	No	No	No	No	No	No	No	No	No	No	No
Other repairs	No	No	No	No	No	No	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good

Notes

[1] Track marks from trucks driving on tack coat in adjacent lane. No longer visible after 54 months of monitoring.

Table B.2: Summary of Monitoring Observations for Point Arena Project: Evotherm

Parameter	Evotherm										
	Dec 08	Jun 09	Dec 09	Jun 10	Nov 10	Jun 11	Dec 11	Jun 12	Dec 12	Jun 13	Dec 13
Overall performance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Texture	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No	No	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No	No	No	No	No	No	No
Other damage	No	No	No	No	No	No	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No	No	No	No	No	No	No
Asphalt stringers	No	No	No	No	No	No	No	No	No	No	No
Surface cracks	No	No	No	No	No	No	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No	No	No	No	No	No	No
Cracks - block	No	No	No	No	No	No	No	No	No	No	No
Cracks - longitudinal	No	No	No	Yes[1]	Yes[1]	Yes[1]	Yes[1]	Yes[1]	Yes[1]	Yes[1]	Yes[1]
Cracks - transverse	No	No	No	No	No	No	No	No	No	No	No
Cracks - alligator	No	No	No	No	No	No	No	No	No	No	No
Pumping	No	No	No	No	No	No	No	No	No	No	No
Rutting	No	No	No	No	No	No	No	No	No	No	No
Raveling/stone loss	No	No	No	No	No	No	No	No	No	No	No
Undulation/settlement	No	No	No	No	No	No	No	No	No	No	No
Edgebreak	No	No	No	No	No	No	No	No	No	No	No
Potholes	No	No	No	No	No	No	No	No	No	No	No
Delamination	No	No	No	No	No	No	No	No	No	No	No
Patching	No	No	No	No	No	No	No	No	No	No	No
Other repairs	No	No	No	No	No	No	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good

Notes

[1] Some longitudinal cracks only on hill/sharp curve between PM15.4 and PM17.0. Cracks were attributed to slope movement, not asphalt performance.

Table B.3: Summary of Monitoring Observations for Orland Project: Control

Parameter	**Control**				
	Jun 09	**Dec 09**	**Jun 10**	**Dec 10**	**Jun 11**
Overall performance	Good	Good	Good	Good	Good
Texture	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No
Other damage	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No
Asphalt stringers	No	No	No	No	No
Surface cracks	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No
Cracks - block	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No
Cracks - transverse	No	No	No	No	No
Cracks - alligator	No	No	No	No	No
Pumping	No	No	No	No	No
Rutting	No	No	Yes	Yes	Yes
Raveling/stone loss	No	No	No	No	No
Undulation/settlement	No	No	No	No	No
Edgebreak	No	No	No	No	No
Potholes	No	No	No	No	No
Delamination	No	No	No	No	No
Patching	No	No	No	No	No
Other repairs	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good
Notes					

Table B.3: Summary of Monitoring Observations for Orland Project: Evotherm

Parameter	Evotherm				
	Jun 09	Dec 09	Jun 10	Dec 10	Jun 11
Overall performance	Good	Good	Good	Good	Good
Texture	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No
Other damage	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No
Asphalt stringers	No	No	No	No	No
Surface cracks	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No
Cracks - block	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No
Cracks - transverse	No	No	No	No	No
Cracks - alligator	No	No	No	No	No
Pumping	No	No	No	No	No
Rutting	No	Yes	Yes	Yes	Yes
Raveling/stone loss	No	No	No	No	No
Undulation/settlement	No	No	No	No	No
Edgebreak	No	No	No	No	No
Potholes	No	No	No	No	No
Delamination	No	No	No	No	No
Patching	No	No	No	No	No
Other repairs	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good
Notes					

Table B.4: Summary of Monitoring Observations for Marysville Project: Evotherm

Parameter	Evotherm				
	Jun 09	Dec 09	Jun 10	Dec 10	Jun 11
Overall performance	Good	Good	Good	Good	Good
Texture	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No
Other damage	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No
Asphalt stringers	No	No	No	No	No
Surface cracks	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No
Cracks - block	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No
Cracks - transverse	No	No	No	No	No
Cracks - alligator	No	No	No	No	No
Pumping	No	No	No	No	No
Rutting	No	No	No	No	No
Raveling/stone loss	No	No	No	No	No
Undulation/settlement	No	No	No	No	No
Edgebreak	No	No	No	No	No
Potholes	No	No	No	No	No
Delamination	No	No	No	No	No
Patching	No	No	No	No	No
Other repairs	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good
Notes					

Table B.5: Summary of Monitoring Observations for Mendocino Project: Control

Parameter	**Control**							
	Jun 10	**Nov 10**	**Jun 11**	**Dec 11**	**Jun 12**	**Dec 12**	**Jun 13**	**Dec 13**
Overall performance	Good	Good						
Texture	Good	Good	Good	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No	No	No	No
Other damage	No	No	No	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No	No	No	No
Asphalt stringers	No	No	No	No	No	No	No	No
Surface cracks	No	No	No	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No	No	No	No
Cracks - block	No	No	No	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No	No	No	No
Cracks - transverse	No	No	No	No	No	No	No	No
Cracks - alligator	No	No	No	No	No	No	No	No
Pumping	No	No	No	No	No	No	No	No
Rutting	No	No	No	No	No	No	No	No
Raveling/stone loss	No	No	No	No	No	No	No	No
Undulation/settlement	No	No	No	No	No	No	No	No
Edgebreak	No	No	No	No	No	No	No	No
Potholes	No	No	No	No	No	No	No	No
Delamination	No	No	No	No	No	No	No	No
Patching	No	No	No	No	No	No	No	No
Other repairs	No	No	No	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good	Good	Good	Good
Notes								

Table B.5: Summary of Monitoring Observations for Mendocino Project: Advera

Parameter	Advera							
	Jun 10	Nov 10	Jun 11	Dec 11	Jun 12	Dec 12	Jun 13	Dec 13
Overall performance	Good	Good						
Texture	Good	Good	Good	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No	No	No	No
Other damage	No	No	No	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No	No	No	No
Asphalt stringers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Surface cracks	No	No	No	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No	No	No	No
Cracks - block	No	No	No	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No	No	No	No
Cracks - transverse	No	No	No	No	No	No	No	No
Cracks - alligator	No	No	No	No	No	No	No	No
Pumping	No	No	No	No	No	No	No	No
Rutting	No	No	No	No	No	No	No	No
Ravelling/stone loss	No	No	No	No	No	Yes[1]	Yes[1]	Yes[1]
Undulation/settlement	No	No	No	No	No	No	No	No
Edgebreak	No	No	No	No	No	No	No	No
Potholes	No	No	No	No	No	No	No	No
Delamination	No	No	No	No	No	No	No	No
Patching	No	No	No	No	No	No	No	No
Other repairs	No	No	No	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good	Good	Good	Good

Notes

[1] Minor stone loss in short section on sharp bend. Did not deteriorate overtime.

Table B.5: Summary of Monitoring Observations for Mendocino Project: Gencor

Parameter	**Gencor**							
	Jun 10	**Nov 10**	**Jun 11**	**Dec 11**	**Jun 12**	**Dec 12**	**Jun 13**	**Dec 13**
Overall performance	Good	Good	Good	Good	Good	Good	Good	Good
Texture	Good	Good	Good	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No	No	No	No
Other damage	No	No	No	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No	No	No	No
Asphalt stringers	No	No	No	No	No	No	No	No
Surface cracks	No	No	No	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No	No	No	No
Cracks - block	No	No	No	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No	No	No	No
Cracks - transverse	No	No	No	No	No	No	No	No
Cracks - alligator	No	No	No	No	No	No	No	No
Pumping	No	No	No	No	No	No	No	No
Rutting	No	No	No	No	No	No	No	No
Ravelling/stone loss	No	No	No	No	No	No	No	No
Undulation/settlement	No	No	No	No	No	No	No	No
Edgebreak	No	No	No	No	No	No	No	No
Potholes	No	No	No	No	No	No	No	No
Delamination	No	No	No	No	No	No	No	No
Patching	No	No	No	No	No	No	No	No
Other repairs	No	No	No	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good	Good	Good	Good
Notes								

Table B.5: Summary of Monitoring Observations for Mendocino Project: Rediset

Parameter	Rediset							
	Jun 10	**Nov 10**	**Jun 11**	**Dec 11**	**Jun 12**	**Dec 12**	**Jun 13**	**Dec 13**
Overall performance	Good	Good	Good	Good	Good	Good	Good	Good
Texture	Good	Good	Good	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No	No	No	No
Other damage	No	No	No	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No	No	No	No
Asphalt stringers	No	No	No	No	No	No	No	No
Surface cracks	No	No	No	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No	No	No	No
Cracks - block	No	No	No	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No	No	No	No
Cracks - transverse	No	No	No	No	No	No	No	No
Cracks - alligator	No	No	No	No	No	No	No	No
Pumping	No	No	No	No	No	No	No	No
Rutting	No	No	No	No	No	No	No	No
Ravelling/stone loss	No	No	No	No	No	No	No	No
Undulation/settlement	No	No	No	No	No	No	No	No
Edgebreak	No	No	No	No	No	No	No	No
Potholes	No	No	No	No	No	No	No	No
Delamination	No	No	No	No	No	No	No	No
Patching	No	No	No	No	No	No	No	No
Other repairs	No	No	No	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good	Good	Good	Good
Notes								

Table B.6: Summary of Monitoring Observations for Auburn Project: Evotherm

Parameter	Evotherm				
	Aug 10	**Dec 09**	**Jul 11**	**Dec 11**	**Jul 12**
Overall performance	Good	Good	Good	Good	Good
Texture	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No
Permeability	Good	Good	Good	Good	Good
Mechanical damage	No	No	No	No	No
Other damage	Yes[1]	Yes[1]	Yes[1]	Yes[1]	Yes[1]
Bleeding/flushing	No	No	No	No	No
Asphalt stringers	No	No	No	No	No
Surface cracks	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No
Cracks - block	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No
Cracks - transverse	No	No	No	No	Yes[2]
Cracks - alligator	No	No	No	No	No
Pumping	No	No	No	No	No
Rutting	No	No	No	No	No
Ravelling/stone loss	No	No	No	No	Yes[3]
Undulation/settlement	No	No	No	No	No
Edgebreak	No	No	No	No	No
Potholes	No	No	No	No	No
Delamination	No	No	No	No	No
Patching	No	No	No	No	No
Other repairs	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good

Notes

[1] Some segregation of aggregate and some open longitudinal joints

[2] Reflected transverse cracks visible in some areas

[3] Some stone loss in outer wheel path of outside lane in areas that showed earlier signs of segregation