GEOSYNTHETIC MATERIALS IN REFLECTIVE CRACK PREVENTION

Final Report

SR 537

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16. Abstract

Reflective cracking due to shrinkage and brittleness in asphalt pavements can seriously degrade an asphalt overlay before it is near the end of its design life. Geosynthetics have been used to impede the reflection of existing transverse cracking to the new overlay. The geosynthetics are intended to minimize the tension transferred to the overlay from the existing pavement. The Oregon Department of Transportation (ODOT) installed a test section consisting of 98 transverse cracks treated with five different geosynthetic types, 22 transverse cracks treated with crack filling only and a control section of 20 untreated transverse cracks.

The test and control sections were monitored from 1999 to 2007. Each of the 140 test sites were revisited once each year to determine if the cracks had reflected, and if they had, measure their length and width. At the end of the study comparisons were made to determine if the geosynthetic materials were effective at controlling (by preventing or lessening the return of) reflective cracking.

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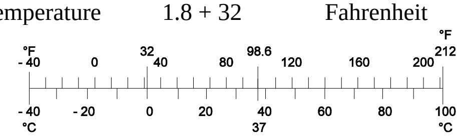
SI* (MODERN METRIC) CONVERSION FACTORS

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	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	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	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

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	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

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GEOSYNTHETICS MATERIALS IN REFLECTIVE CRACK PREVENTION
FINAL REPORT

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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

Several factors including daily, weekly, monthly and yearly fluctuations in temperature contribute to transverse cracking of asphalt pavements in roadways. Transverse cracking has been a major distress on the southern portion of US 97 in Oregon for decades. The large cracks form at almost regular intervals in the asphalt pavement due to shrinkage and brittleness during very cold temperatures. Factors such as traffic loads and moisture levels tend to worsen crack severity. The cracks create a bumpy ride and tend to spall which further deteriorates the highway surface. When the old surface is overlaid, the same transverse cracks reflect through the new overlay in a short time, allowing water to reach the base and subgrade, which ultimately shortens the pavement life.

The prevention of reflective cracks would help to extend the life of an overlay and generally reduce highway maintenance costs. The research study detailed in this report examined ways to prevent reflective cracks on a section of US 97. The study included the testing of five different geosynthetic product types. The use of geosynthetic material was intended to minimize the tension transferred to the overlay from the existing pavement.

1.2 RESEARCH OBJECTIVES

The objective of this study was to test, evaluate and identify the most effective geosynthetic reflective crack prevention treatment. Though the original scope of the project specified that the study would span three years, evaluations were conducted over a nine-year period, from 1998 to 2007. The Oregon Department of Transportation (ODOT) installed a test section consisting of 98 transverse cracks treated with five different geosynthetic types, 22 transverse cracks treated with crack filling only and a control section of 20 untreated transverse cracks, for a total of 140 cracks. Five geosynthetic materials were compared to one another and to a control sample and fill sample with no geosynthetic product applied.

The seven test sections were constructed as follows (*Sposito and Brooks 1999*):

1. Overlay only (control).
2. Clean crack, fill with D-mix (12.5 mm max. aggregate size), overlay.
3. Clean crack, fill with D-mix, place Glasgrid 8502® over crack, overlay.
4. Clean crack, fill with D-mix, place GeoTac® over crack, overlay.
5. Clean crack, fill with D-mix, place PavePrep SA® over crack, overlay.
6. Clean crack, fill with D-mix, place Polyguard Cold Flex 2000 SA™ over crack, overlay.
7. Clean crack, fill with D-mix, place Polyguard 665™ over crack, overlay.

1.3 PROJECT AREA LOCATION

The project area was generally located in the forested mountainous region of northern Klamath County, near Crater Lake. Specifically the test section was on Oregon State Highway No. 4 (US 97) between Milepoint 213.58 and 217.64 in Township 29 South, Range 7 East, Sections 12, 13, 24, 25 and 36, Willamette Meridian (Figures 1.1 and 1.2). The nearest elevation point was Diamond Lake Junction at 4,609 feet (ft) above mean sea level (amsl). To locate the project area from Salem, travel south on I-5 to US 58 (65.2 miles) then head southeast to the intersection with US 97 (86.7 miles). Go south to the town of Chemult (8.1 miles) and continue to Diamond Lake Junction (10.5 miles). The test area began 0.58 mile south of Diamond Junction and extended approximately four miles.

Figure 1.1: Overview photograph of the project area

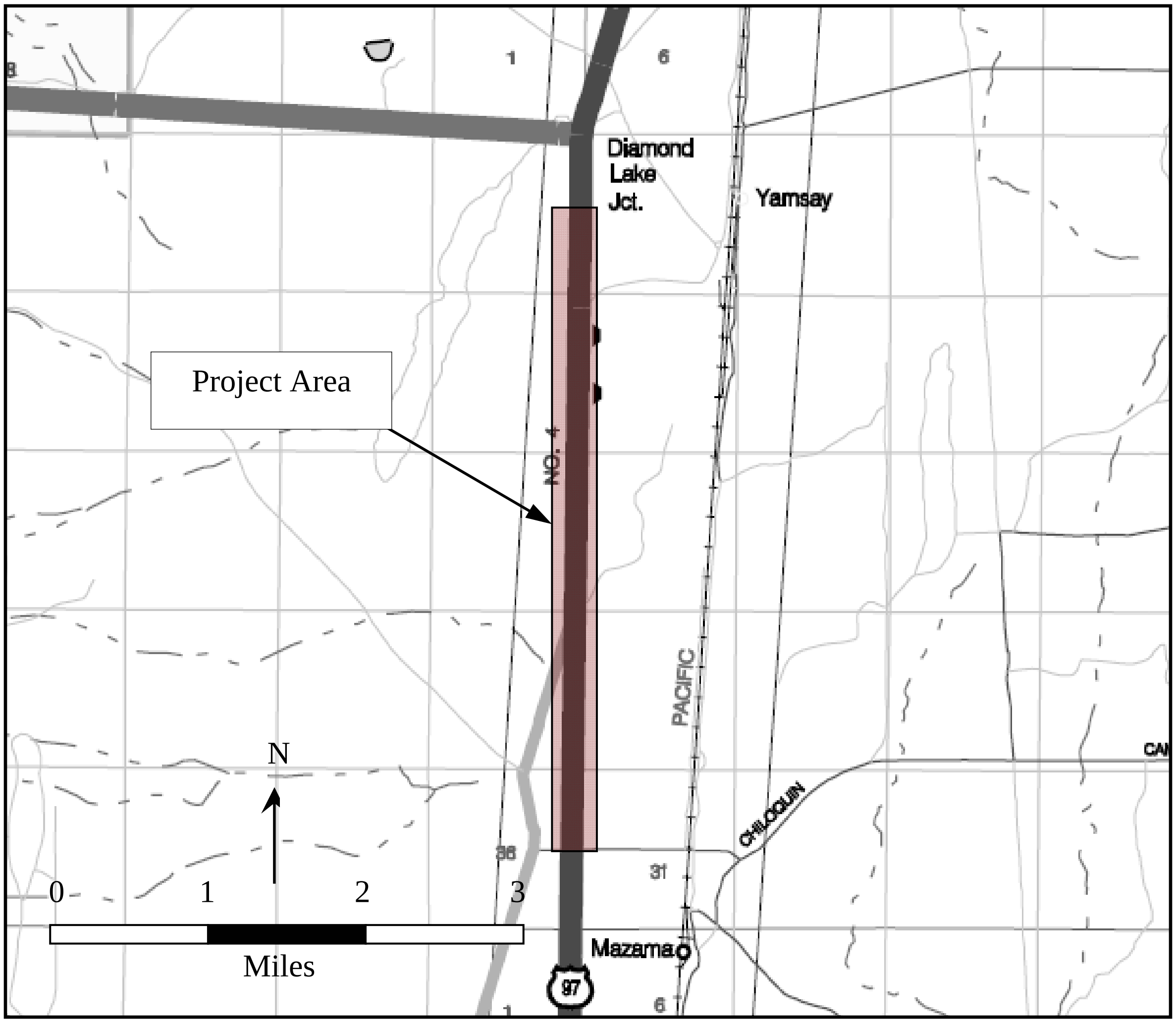

Figure 1.2: Project area location as depicted on the GIS ODOT 2006, Klamath County, Oregon Transportation Map

2.0 BACKGROUND RESEARCH

2.1 LITERATURE REVIEW

Several studies and evaluations of reflective crack prevention have been conducted across the United States (US). A map showing the location of selected favorable and unfavorable paving fabric installations in the US was used in a report published by Ahlrich in 1986 and cited by Cleveland, et al. in 2002. The map shows that the most favorable results were concentrated in the southern states. In general temperatures are more moderate and mild in southern sections of the US.

The Oregon Department of Transportation (ODOT) has conducted other studies of reflective crack prevention in the state. One study on Interstate 5 (I-5) continued for over 12 years and was considered successful. The project was a 150 mm dense-graded asphalt overlay of jointed concrete. A continuous roll of geotextile was placed before the asphalt concrete (AC) overlay. A special technique called bond breaker, which included fine gravel and tarpaper, was placed over the cracks, prior to overlaying (*Bish, et al. 1989*).

The City of Portland also conducted a study with ODOT's assistance. East Burnside Street, which was a jointed concrete section with a dense-graded AC overlay, had 50 mm of deteriorated AC removed and replaced. Selected transverse cracks had either Glasgrid 8502® or Polyguard® geosynthetics placed over them after a leveling course was placed. The sections were overlaid with 50 mm of AC (*Phipps and Nodes 1992*). After seven years only a few lineal meters of the cracks have reflected through the overlay. The success of this application was believed to be due to a well-designed and placed overlay rather than the geotextiles (*Armstrong 1994*).

In another study on I-84 near Ontario, Oregon, one 610 mm geotextile strip of AMOCO CEF style 4545 was placed on the existing asphalt concrete over the cracks before a polymer modified dense-graded Class "B" (25 mm max. aggregate size) asphalt concrete mix was laid. These cracks reflected through before the end of the first year (*Scholl and Rusnak 1990*).

2.2 ENVIRONMENTAL CONDITIONS

As stated above, the project area was located along US 97 between Milepoint 213.58 and 217.64 at approximately 4,609 ft amsl. The nearest town was Chemult, Oregon, to the north of the test evaluation area. Daily temperatures, including extreme low temperatures as well as monthly and yearly average temperatures were available for the town of Chemult for the years of the study (Table 2.1) (*Hale 2007*). In months such as June, July, August and September, daily temperatures sometimes ranged from a high of 80 degrees Fahrenheit (F) to a low below freezing. The coldest temperatures were recorded in 1998, which had a low of -26 degrees F. From 1999 to 2004 extreme lows did not exceed -10 degrees F.

Table 2.1: Average annual and extreme low temperatures for Chemult, Oregon from 1998-2006

	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total Average
Average High	57	58	50	59	59	56	57	50	56	56
Average Low	29	26	23	27	26	27	27	24	25	26
Extreme Low	-26	-8	0	-1	-5	-1	3	-13	-15	-7

Note: Temperatures are in Fahrenheit

Precipitation in the project area typically occurs as snow or rain (Figure 2.1). The average annual precipitation for Chemult between 1998 and 2006 was 24.7 inches (in) (Table 2.2) (*Hale 2007*). The largest amount of precipitation fell in 1998, totaling close to 40in, while in 2000 and 2001 only 13.8in and 15.9in, respectively, were recorded.

Figure 2.1: Photograph showing accumulation of snow on shoulder of road

Table 2.2: Annual precipitation for Chemult, Oregon from 1998-2006

	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total Average
Amount (in)	38.6	24.1	13.8	15.9	24	20.6	24.7	29.1	31.3	24.7

2.3 TRAFFIC

The section of US 97 that includes the project area receives traffic from vacation travelers, daily commuters, and commercial semi trucks. A permanent automatic traffic recorder (ATR) station near Chemult, recorded that between 1998 to 2005 the average daily traffic on US 97 was 4,899 vehicles (Transportation Systems Monitoring Unit 2006). There are 14 different vehicle classifications recorded at the ATR, the three most prevalent (comprising over 85% of the total) were: passenger cars, other 2 axle 4 tire vehicles, and Single Trailer Truck 5 axle (Figure 2.2).

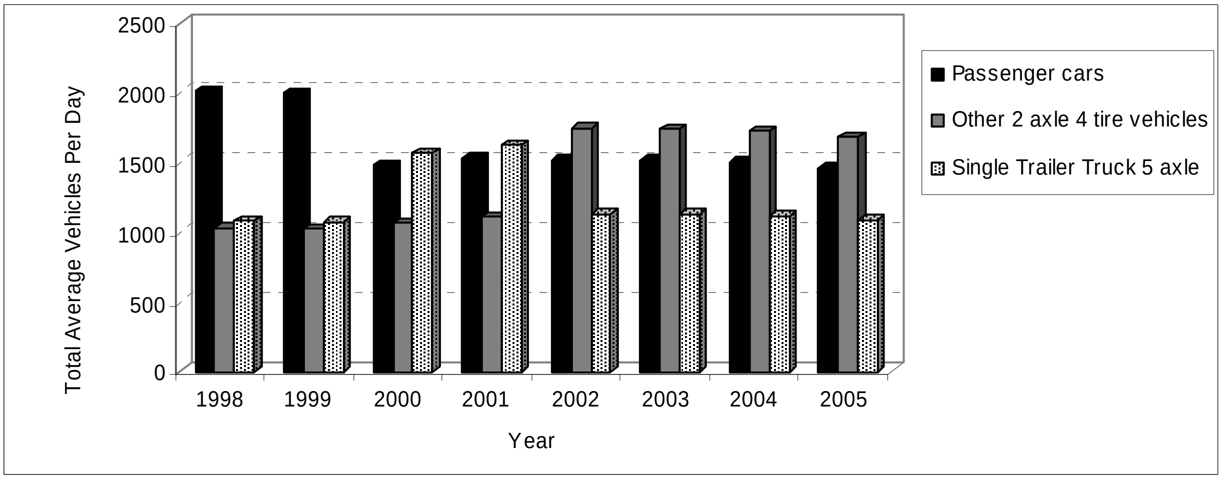

Figure 2.2: Total average daily traffic recorded for top 3 vehicle types that make up over 85% total vehicles

Passenger cars and other 2 axle 4 tire vehicles were the dominant vehicle type on the roadway. Single Trailer Trucks with 5 axles numbered on average 1,000 per day, except in 2000 and 2001 when the number increased by at least 500 vehicles.

2.4 PAVEMENT HISTORY

Core sampling of the project area was used to determine the history of existing pavement materials. The information was gathered and provided by the ODOT Pavement Services Unit. The average pavement depth prior to overlay was 278 mm. A total of six pavement lifts of varying material types and depths were present. The type and depth of materials are shown in the pavement lift depth and pavement lift type columns of Table 2.3. The last lift prior to 1998 was built in 1990 (*Sposito and Brooks, 1999*).

Table 2.3: Existing pavement materials

Lift Number	Lift Depth	Pavement Lift Type
1	40-50 mm	Open-Graded Asphalt Concrete
2	50 mm	Dense-Graded Asphalt Concrete (Heavy Oil)
3	40-100 mm	Dense-Graded Asphalt Concrete
4	0-70 mm	Open-Graded or Dense-Graded Asphalt Concrete
5	30-60 mm	Loose Red Rock Asphalt Concrete
6	30-60 mm	Red Rock Dense Asphalt Concrete

2.5 GEOSYNTHETIC SPECIFICATIONS

Five types of Geosynthetic materials were tested and evaluated. Table 2.4 shows the manufacturers' material parameters of interest. The table includes the product name, a brief description, the tensile strength and tensile test for the product, as well as its thickness and width.

Table 2.4: Specifications of geosynthetic materials used in the research study (*Sposito and Brooks 1999*)

Material	Tensile Strength	Tensile Strength Test	Thickness (mm)	Width (mm)
Glasgrid 8502®	200 x 100	G.R.I.	1.73	1.52
Pavement reinforcing mesh consisting of fiberglass reinforcement coated with an elastomeric polymer and a pressure sensitive adhesive backing (Bayex, 1997).	kN/m	GG 1-87		
GeoTac®	8.9	ASTM	2.03	0.61
Peel-and-stick, thick waterproofing membrane manufactured from a rubberized asphalt, with a top layer of durable, tightly bonded polyester geotextile (Contech, 1994).	kN/m	D882 (modified)		
PavePrep SA®	167	ASTM	3.43	0.61
Heavy-duty crack reduction/stress relief interlayer consisting of a flexible high density asphaltic membrane laminated between a nonwoven and woven polyester geotextile, with an adhesive backing (Contech, Guide, 1996).	kg/cm*cm	D412-87		
Polyguard Cold Flex 2000 SA™	53	ASTM	3.43	0.61
Peel-and-stick pavement repair membrane consisting of two layers of high strength polypropylene fabric with a layer of flexible mastic to provide stress relief (Polyguard, May-June 1998).	kN/m	D412		
Polyguard 665™	16	ASTM	1.65	0.61
Pavement waterproofing membrane consisting of a rubberized asphalt waterproofing adhesive, laminated to a strong woven polypropylene backing, with a silicone treated release sheet (Polyguard, January 1998).	kN/m	D882 (Method B)		

3.0 METHODS

3.1 CRACK IDENTIFICATION AND CLASSIFICATION

At the start of the project all major transverse cracks (cracks crossing both travel lanes) were marked. A total of 140 transverse cracks were first identified in the four miles of the project area. The cracks were numbered sequentially from north to south and were marked with the crack number on the adjacent road shoulder. Each crack was mapped, photographed and the crack length, width and severity (see crack severity descriptions below) were recorded.

The severity of each crack was determined as low, medium or high, based on guidelines from the *Distress Identification Manual for the Long-Term Pavement Performance Project* (*National Research Council 1993*). The ranking system was based on the mean width measurement of the crack, and is summarized in Table 3.1.

Table 3.1: Cracking severity level classifications. Adapted from (National Research Council 1993)

Severity	Mean Width
Low	An unsealed crack with a mean width <= 6 mm; or a sealed crack with sealant material in good condition, and with a width that cannot be determined.
Medium	Any crack with a mean width> 6 mm and <= 19 mm; or any crack with a mean width <=19 mm, and adjacent low severity random cracking.
High	Any crack with a mean width > 19 mm; or any crack with a mean width <=19 mm, and adjacent moderate to high severity random cracking.

The number and length of each transverse crack and its severity level was recorded. The entire transverse crack was rated at the highest severity level present for at least 10% of the total length of the crack.

3.2 DIVISION OF TEST SECTIONS

The project area was divided into seven sections from 800m to 1000m each; six test sections and one control section. Colored tags were placed on posts set on both sides of the roadway to mark the start of a new section. Of the 140 cracks, 98 were treated with five different geosynthetic materials, 22 were treated with crack fill only, and the remaining 20 were left untreated as a control sample (Table 3.2). Control and crack fill only sections were interspersed between the geosynthetic treatment areas. A total of 66 cracks were classified as medium severity, while 74 were identified as high severity.

Table 3.2: Summary of treatment types applied and summary of crack severity

Crack Number	Treatment Type	Total Medium Severity Cracks	Total High Severity Cracks
1 − 5	Control (none)	5	0
6 − 15	Crack Fill Only	4	6
16 − 35	Glasgrid 8502®	9	11
36 − 37	Crack Fill Only	0	2
38 − 55	GeoTac®	11	7
56 − 75	PavePrep SA®	10	10
76 − 85	Control (none)	2	8
86 − 105	Polyguard Cold Flex 2000 SA™	5	15
106 − 125	Polyguard 665™	14	6
126 − 135	Crack Fill Only	6	4
136 − 140	Control (none)	1	4

3.3 CRACK PREPARATION

Virtually all of the cracks were filled with “sanding” material from previous winter ice control operations. Accordingly, only the larger cracks needed a better means of being filled to achieve the various geosynthetic manufacturers’ stated requirements of filled cracks. As D-Mix is the preferred material to fill cleaned cracks and the maximum aggregate size of this mix is 12.5 mm, the following procedure was followed:

1. All cracks that were less than 19 mm overall nominal width were not cleaned.
2. All cracks 19 mm and greater were “blown-out” with compressed air to a depth of 50 mm. The blown-out material was removed from the pavement in the area where the geosynthetic was placed.
3. D-Mix asphalt concrete at a minimum temperature of 140° C was placed in the cleaned crack to achieve a “tightly” filled crack. The finished elevation of the D-Mix is the same as the abutting pavement as closely as could be achieved, never exceeding the abutting pavement surface.

3.4 GEOSYNTHETIC TESTING

Placement tests were performed on Glasgrid 8502® with and without a nonwoven geosynthetic backing, Polyguard Cold Flex 2000 SA™ and PavePrep SA®. The objective of the placement test was to evaluate the ease/difficulty of covering the crack and having the geosynthetic remain in place under traffic prior to the overlay. The Polyguard™ and PavePrep SA® geosynthetics were easy to place and the geosynthetics were still bonded to the pavement after one month of being exposed to 4000 vehicles per day. The Glasgrid 8502® with nonwoven geosynthetic backing did not bond well to a CSS-1 tack coat, which was not considered an acceptable way of holding the geosynthetic in place. Glasgrid 8502® was placed without backing, relying on the self-adhesive properties, prior to hot mix overlay and care was taken to not have vehicles "shove" it by stopping on it.

3.5 FOLLOW-UP INSPECTIONS AND EVALUATIONS

The test area was to be visited once a year, for three years from 1999 to 2001. The goal of the project, however, was to monitor the geosynthetic products until failure or until the road was re-paved or repaired. This allowed the project to continue into 2007 when many of the cracks were filled and before which point the road surface would be re-paved.

On-site inspections were conducted once every year (Table 3.3). One or two inspectors walked the entire test section, focusing on the 140 transverse cracks. Each crack was reinvestigated and recorded on an inventory form. The recorded information included the location of the crack, the treatment applied, an estimation of the crack length and severity. The severity and length of the reflected crack were then compared to the original data as well as to previous years. Because of the pavement type, cracks were often difficult to see. Factors such as precipitation and time of day influenced crack visibility.

Table 3.3: Inspection schedule

Date	Month	Activity
1998	September	Installation/Construction
1999	May	Inspection
2000	May	Inspection
2001	September	Inspection
2002	October	Inspection
2003	May	Inspection
2004	April	Inspection
2005	May	Inspection
2006	May	Inspection
2007	May	Final Inspection

4.0 CONSTRUCTION AND TEST IMPLEMENTATION

Geosynthetics were placed by the contractor from September 21st through the 24th, 1998 (Figure 4.1). The contractor swept both shoulders prior to placing the geosynthetics in order to have good adhesion with the pavement. The geosynthetics were not overlapped due to concern regarding the impacts on ride quality. Where the geosynthetic was placed in pieces, the edges were butted against each other, creating a seam. Geosynthetics were placed across both travels lanes in all cracks except 32 through 35 where Glasgrid 8502® was applied to the northbound lane only.

The placement of Glasgrid 8502® was very labor intensive as tack was applied by hand to secure the material to the pavement (*Sposito and Brooks 1999*). The labor cost to install this material was nearly $6 more per meter than any other material. An installation problem occurred at crack 30 when the paver hooked the geosynthetic material and pulled about 2 m of it from the southbound shoulder. The result was the exposure of Glasgrid 8502® geosynthetic material at an isolated area on the paved surface (Figure 4.2). In general, Glasgrid 8502® adhered well to the pavement.

Figure 4.1: Geosynthetic on roadway

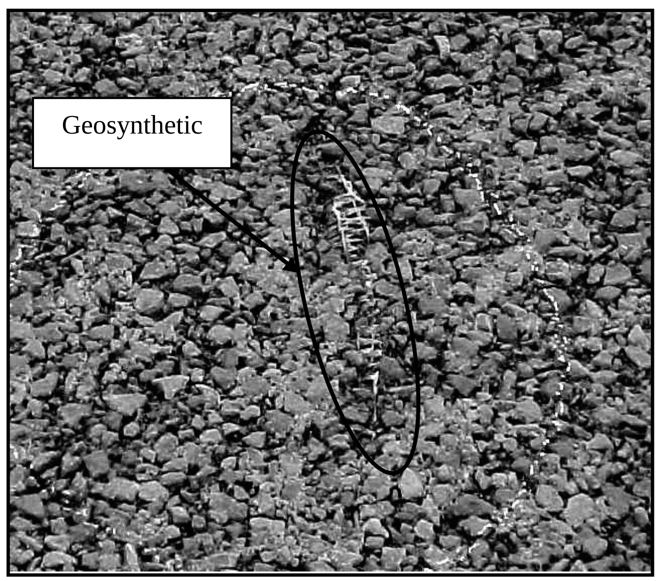

Figure 4.2: Glasgrid 8502® geosynthetic exposed at the surface

Both PavePrep® and GeoTac® were self-adhesive, easy to apply and bonded well to the road surface (*Sposito and Brooks 1999*). Overall, Polygaurd 665™ proved to be the easiest material to install. The placement of Polyguard Cold Flex 2000 SA™, on the other hand, was more difficult and problematic. The general condition of the material was poor as it appeared to have been stored in a hot environment. Most of the adhesive for the Polyguard Cold Flex 2000 SA™ was concentrated at the end of the roll which created problems when unrolling the material. Problems also occurred when removing the backing, which did not peel off in a single sheet but as shredded pieces.

A summary of the installations costs for each test section is calculated in Table 4.1. The expense of filling the cracks was added to the price of the geosynthetic material and all labor costs, then the total was multiplied by the total length of cracks in that section. Note that the length measurements include both travel lanes as well as adjacent shoulders.

Table 4.1: Summary of installation costs for each of the seven test sections

Material Used	MATERIAL ($/M)	LENGTH (M)	CRACK FILL ($/M)	LABOR & EQUIP ($/M)	COST	Cost Per Crack	Cost Per Meter
GLASGRID 8502® + CRACK FILL	$7.41	218.9	$7.28	$8.08	$4,984	$249.22	$22.77
GEOTAC® + CRACK FILL	$7.28	221.4	$7.28	$2.74	$3,830	$212.79	$17.30
PAVEPREP SA® + CRACK FILL	$11.77	246.0	$7.28	$2.47	$5,294	$264.70	$21.52
POLYGUARD COLD FLEX 2000 SA™ + CRACK FILL	$6.42	246.0	$7.28	$2.47	$3,978	$198.89	$16.17
POLYGUARD 665™ + CRACK FILL	$3.90	246.0	$7.28	$2.47	$3,358	$167.90	$13.65
CRACK FILL ONLY	none	297.7	$7.28	none	$2,167	$98.51	$7.28
CONTROL (none)	none	246.0	none	none	$ -	$ -	$0.00

No money was spent on the control sections because nothing was done to them and only crack fill was applied to the crack fill only sections, which amounted to less than $100. Of the materials used on this project, the cheapest geosynthetic material to install was Polyguard 665™, while the most expensive was Glasgrid 8502®, followed by PavePrep SA®.

After all test areas were treated as needed and geosynthetic materials were installed, an overlay was constructed. The overlay material was 50 mm of Class “F” (25 mm max. aggregate size) asphalt concrete mix wearing course, placed full-width. In August of 2000 the roads crew placed a fog seal over the test area.

5.0 RESULTS

Observations were first made in 1999, one year after installation and construction, and continued once a year for eight years until May of 2007. By the end of the study, 132 of 140 transverse cracks had reflected through the pavement overlay (Figure 5.1) (Appendix A). By May of 2007 many of the cracks (99 total) had been filled and sealed over. A few cracks that had not appeared in 2006 such as control cracks 137 and 138 were sealed in 2007. It was assumed that because the cracks were filled, they were visible and thus were given a severity rating of low.

Figure 5.1: Photographic comparison of crack 140 shown before the overlay was constructed (pictured left) and the reflection of crack 140 through the overlay after construction (pictured right)

A summary of field observations from 1999 to 2007 is recorded in Table 5.1. Two main factors were recorded every year: crack length and severity (calculated from crack width). Classification of cracks was subjective and depending on time of day or if the pavement was wet, crack visibilty varried. The length of the reflecting crack was compared to the original crack to see how much had returned or reappeared. The comparison was calculated into a percentage value. The results of these calculations were imputed into a chart that shows the performance of each treatment type from 1999 to 2007 (Figure 5.2).

In 1999, a total of 33 low severity cracks reflected as did one medium severity crack from the control sample. In that same year 55 percent of the total crack length of crack fill only test sections reappeared and 42 percent of Polyguard 665™ reappeared. The three other geotextile test sections each had less that 10 percent crack length reflected. It was clear in the first year of observations that Polyguard 665™ was performing poorly.

In the next year, 2000, four new low severity cracks were observed and were located in the Polyguard 665™ test section. An additional medium severity crack was recorded in 2001 but was located in the crack fill only test sections. Between 2002 and 2003 nine more cracks were reflected totaling 52 cracks. Sixteen of the original 20 cracks in the Polyguard 665™ section were reflected, three of which were rated at medium severity. Over 70 percent of the original crack 1ength of Polyguard 665™ was reflected in 2003, which was the worst of any of the treatment types, including control and crack fill only sections.

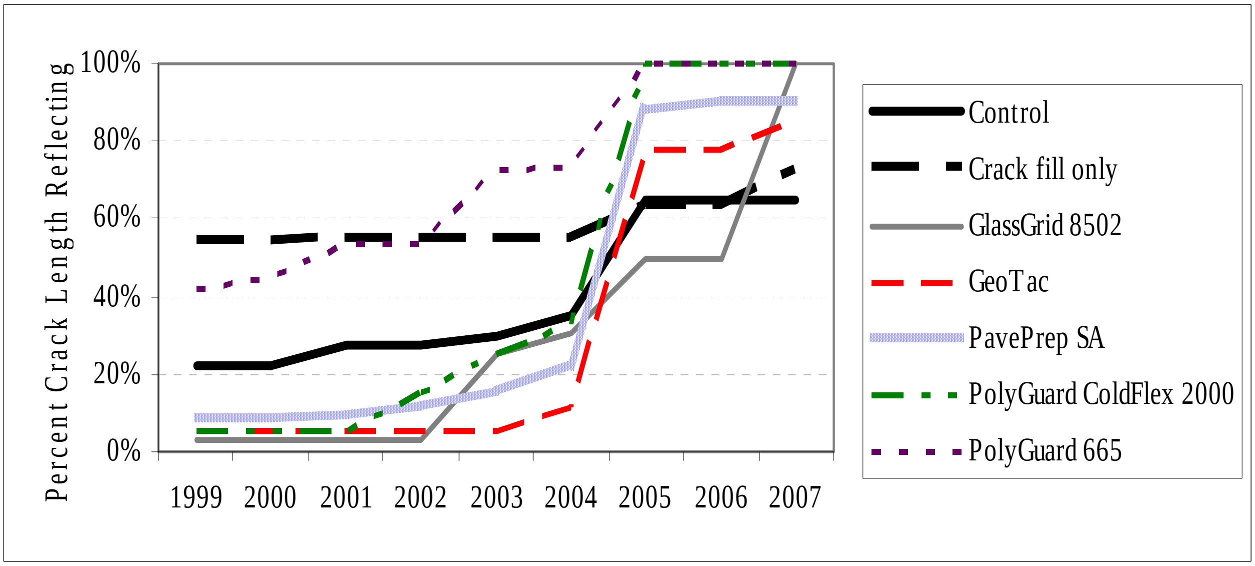

Figure 5.2: Chart showing the percentage of original crack length reflected from 1999 to 2007

Starting in 2005, the geotextile products appear to fail rapidly, causing many cracks to reflect and overall crack severities to worsen (Figure 5.3). All test sections had cracks that reflected over 50 percent of their original length. The total number of cracks nearly doubled from 59 in 2004 to 110 in 2005. One factor that may have contributed to the worsening of road conditions in 2005, was the drop in average temperatures, with an extreme low temperature of -13 degrees. The last time the temperature dropped below -10 degrees was in 1998. Also, according to the Oregon Climate Service at Oregon State University, annual precipitation for 2005 (nearly 30in) exceeded average annual precipitation from 1998 to 2007 (24.7in). Both the decreased temperatures and the increased perception may have accelerated the deterioration of the roadway.

Though PavePrep SA® performed well in the early years of the study, by 2006 five cracks were recorded at a high severity level. The PavePrep SA® test section had the most number of cracks at a high severity level. Both the crack fill only and Glasgrid 8502® test sections were the only areas where no high severity cracks reflected. Glasgrid 8502® also had the least number of cracks that were rated as medium severity. All test sections except the control and crack fill only areas had all cracks return. The least number of reflective cracks and lowest percentage of reflective length occurred in the crack fill only test sections.

Table 5.1: Summary results of the reflective crack prevention project showing crack severity, total cracks appearing, crack length and percentage of original crack reflecting, sorted by year

	ORIGINAL (Before Construction)						1999						2000					
Treatment	L	M	H	sum	length	Δ %	L	M	H	sum	length	Δ %	L	M	H	sum	length	Δ %
CONTROL(NONE)		8	12	20	146		4	1		5	32.8	22%	4	1		5	32.8	22%
CRACK FILL ONLY		9	13	22	160.6		12			12	87.6	55%	12			12	87.6	55%
GLASGRID 8502®		9	11	20	131.2		1			1	3.6	3%	1			1	3.6	3%
GEOTAC®		11	7	18	131.4		1			1	7.3	6%	1			1	7.3	6%
PAVEPREP SA®		10	10	20	146		3			3	12.3	8%	3			3	12.3	8%
POLYGUARD COLD FLEX 2000 SA™		5	15	20	146		1			1	7.3	5%	1			1	7.3	5%
POLYGUARD 665™		14	6	20	146		11			11	61.7	42%	14			14	66.2	45%
TOTAL		66	74	140	1007.2		33	1		34	212.6	x	36	1		37	217.1	x

	2001						2002						2003					
Treatment	L	M	H	sum	length	Δ %	L	M	H	sum	length	Δ %	L	M	H	sum	length	Δ %
CONTROL(NONE)	5	1		6	40.1	27%	5	1		6	40.1	27%	6	1		7	43.7	30%
CRACK FILL ONLY	12	1		13	88.6	55%	11	2		13	88.6	55%	10	3		13	88.6	55%
GLASGRID 8502®	1			1	3.6	3%	1			1	3.6	3%	6			6	33.3	25%
GEOTAC®	1			1	7.3	6%	1			1	7.3	6%	1			1	7.3	6%
PAVEPREP SA®	3			3	13.3	9%	4			4	16.9	12%	4			4	22.2	15%
POLYGUARD COLD FLEX 2000 SA™	1			1	7.3	5%	3			3	21.9	15%	5			5	36.5	25%
POLYGUARD 665™	12	3		15	78.3	54%	12	3		15	78.3	54%	13	3		16	105.7	72%
TOTAL	35	5		40	238.5	x	37	6		43	256.7	x	45	7		52	337.3	x

	2004						2005						2006					
Treatment	L	M	H	sum	length	Δ %	L	M	H	sum	length	Δ %	L	M	H	sum	length	Δ %
CONTROL(NONE)	4	4		8	51	35%	3	8	2	13	94.8	65%	3	8	2	13	94.8	65%
CRACK FILL ONLY	10	3		13	88.6	55%	6	8		14	102.2	64%	5	9		14	102.2	64%
GLASGRID 8502®	7			7	40	30%	11			11	65.5	50%	11			11	65.5	50%
GEOTAC®	2			2	14.6	11%	3	10	1	14	102.2	78%	3	10	1	14	102.2	78%
PAVEPREP SA®	6			6	32.5	22%	7	7	4	18	127.7	87%	7	6	5	18	131.4	90%
POLYGUARD COLD FLEX 2000 SA™	7			7	47.4	32%	8	11	1	20	146	100%	6	13	1	20	146	100%
POLYGUARD 665™	13	3		16	107.1	73%	2	16	2	20	146	100%	2	15	3	20	146	100%
TOTAL	49	10		59	381.2	x	40	60	10	110	784.4	x	37	61	12	110	788.1	x

	2007					
Treatment	L	M	H	sum	length	Δ %
CONTROL(NONE)	6	8	3	17	94.8	65%
CRACK FILL ONLY	8	9		17	116.8	73%
GLASGRID 8502®	19	1		20	131.2	100%
GEOTAC®	6	11	1	18	112.8	86%
PAVEPREP SA®	9	6	5	20	131.4	90%
POLYGUARD COLD FLEX 2000 SA™	6	13	1	20	146	100%
POLYGUARD 665™	2	15	3	20	146	100%
TOTAL	56	63	13	132	879	x

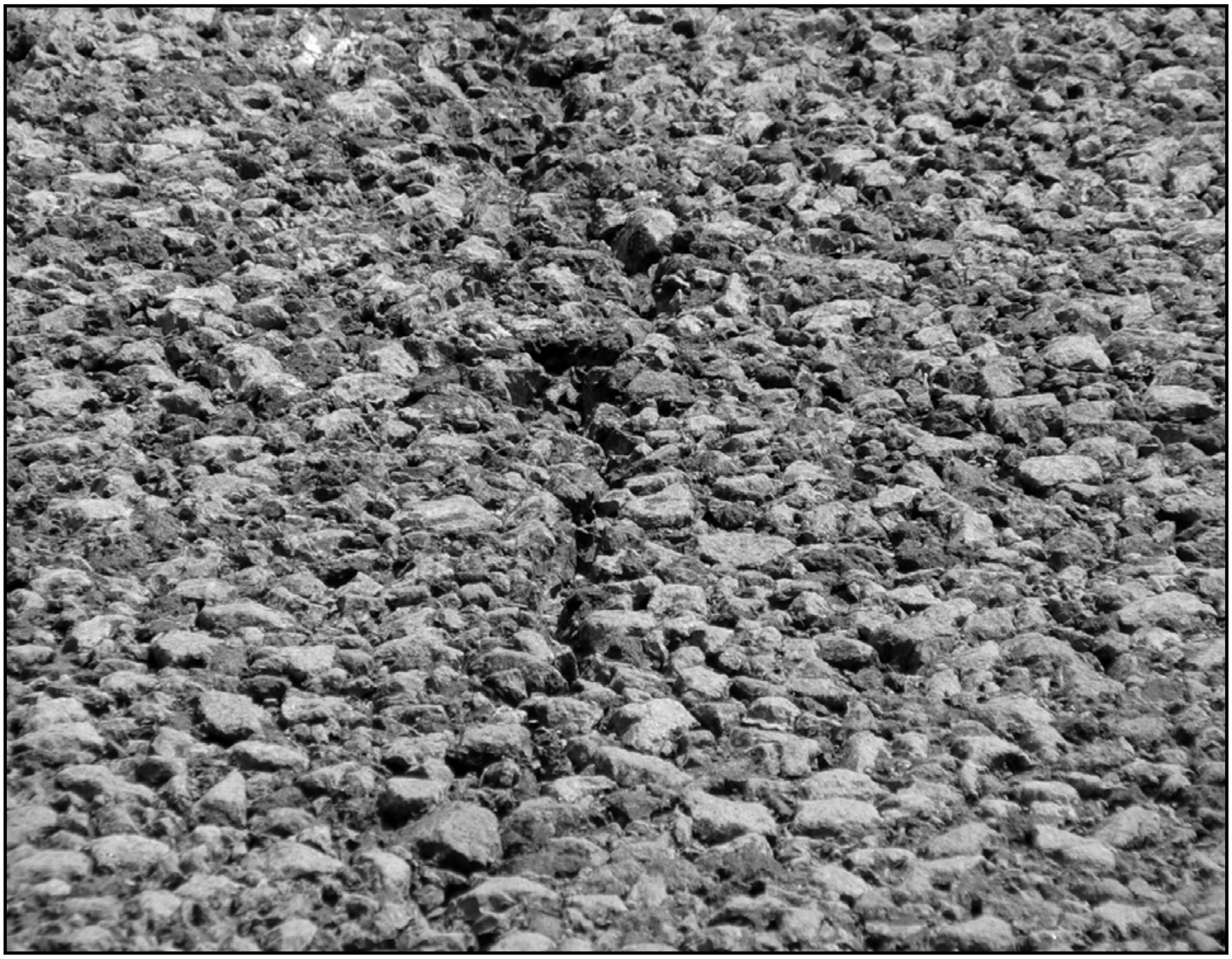

Figure 5.3: Close-up view of transverse crack reflecting through overlay

6.0 CONCLUSION

6.1 SUMMARY

Five geotextile materials were tested on a four mile stretch of US 97 between Milepoint 213.58 and 217.64 from 1999 to 2007. The study investigated the effectiveness of these geosynthetic materials in preventing or retarding reflective transverse cracks through pavement overlays. In 1998 several cracks had reflected through the previous overlay, placed eight years earlier. Of the cracks observed, a total of 140 were chosen for the study. Geosynthetic material was placed over 98 of the cracks, 22 were filled with crack fill only and the remaining 22 were left alone. A pavement overlay was constructed over the material in September of 1998. The total and severity of cracks seen in 2007 can be compared to those recorded prior to the overlay in 1998 and overall conclusions can be drawn (Table 6.1).

Table 6.1: Comparison of transverse crack severity, total number and length in 1998 and 2007

Treatment	1998 Low	2007 Low	1998 Med.	2007 Med	1998 High	2007 High	1998 sum	2007 sum	1998 length	2007 length
CONTROL(NONE)		6	8	8	12	3	20	17	146	94.8
CRACK FILL ONLY		8	9	9	13		22	17	160.6	116.8
GLASGRID 8502®		19	9	1	11		20	20	131.2	131.2
GEOTAC®		6	11	11	7	1	18	18	131.4	112.8
PAVEPREP SA®		9	10	6	10	5	20	20	146	131.4
POLYGUARD COLD FLEX 2000 SA™		6	5	13	15	1	20	20	146	146
POLYGUARD 665™		2	14	15	6	3	20	20	146	146
TOTAL	0	56	66	63	74	13	140	132	1007.2	879

There is no conclusive data to demonstrate that any of the geotextile materials reduced the total number of reflective cracks. Overall crack fill only test sections outperformed geosynthetic material. The least number of cracks reappeared in crack fill only sections (a total of 17 of 22 cracks) and 73 percent of the original crack length reappeared. Geosynthetic material, did however, reduce the percentage of high severity cracks. Prior to test implementation in 1998, there were a total of 98 cracks in the geosynthetic test sections, 49 of the cracks were rated as medium severity and 49 as high severity. In comparison, with the use of geotextiles from 1998 to 2007 all 98 cracks returned but 42 were ranked as low severity, 46 as medium and only 10 as high severity. The geotextile material was effective in reducing the number of high severity cracks by 80 percent.

The best product in reducing reflective crack severity was Glasgrid 8502®. By 2007 all 20 transverse cracks had reflected through the overlay in the Glasgrid 8502® test section but 95 percent of them were of low severity and only one ranked as medium severity (Figure 6.1). The majority of low severity cracks were very narrow and were difficult to trace across the pavement (see Figure 6.1).

Figure 6.1: Example of a low severity crack in the Glasgrid 8502® test section

6.2 COST BENEFIT OF GEOSYNTHETIC MATERIALS

Several factors contribute to the deterioration of a roadway. Once the surface of the road reaches a high level of deterioration, from such things as severe transverse cracking, then the road must be resurfaced. The cost of constructing an overlay is extremely expensive. For example, the expense of placing an overlay on the four-mile test section of this study on US 97 was $220,742 in 1998.

The repaving of the roadway in 1998 was needed because of poor road surface conditions of the previous overlay, placed eight years prior. Thus the cost benefit of geosynthetic materials for this study must determine if the material retards or prevents road deterioration in an eight year period so that the road would not need to be resurfaced.

Labor and equipment costs were most expensive for Glasgrid 8502®. Glasgrid 8502® was the only geosynthetic material that was not self-adhesive and required an adhesive tack to be applied by hand. The in-field application of tack raises the general installation labor and equipment costs to nearly six dollars more than any other of the materials tested.

Though no geosynthetic material was effective at preventing cracks from returning, most stopped or stunted cracks from getting worse (i.e. wider). The geosynthetic material that appeared to be the most effective was Glasgrid 8502®. After eight years, no high severity cracks were recorded, only one medium, and 19 low severity cracks were observed in the Glasgrid 8502® test section.

From 1999 to 2002 only one crack had appeared in the Glasgrid 8502® section. By 2003 a total of seven low severity cracks were evident, and an additional four were observed the following year. All 20 cracks had reflected by 2007, 19 low severity and one of medium severity. In the final year of testing, nine cracks had worsened, eight had appeared for the first time and one had widened to be classified as medium severity. It is difficult to determine how well the Glasgrid 8502® geosynthetic will perform at retarding crack severity in subsequent years.

If reflective transverse cracking is the only factor in road deterioration, then it is economically beneficial to apply Glasgrid 8502® prior to an overlay to improve the life span of the pavement surface. Glasgrid 8502® proved effective in preventing medium and high severity reflective transverse cracks in an eight year period, where as the same section of road eight years prior had needed repaving because of the large number of highly severe transverse cracks that appeared without the geosynthetic material present.

6.3 CONCLUSION

Overall the tested geosynthetic materials performed poorly in coldest years such as 1998, 1999, 2005 and 2006 (Figure 6.2). The trend lines for average crack length of geosynthetic materials and the extreme low temperature per year are almost inverse of one another. These trends show a good correlation between the drop in temperatures and the worsening of the effectiveness of each geotextile. In general this finding is consistent with other studies across the US that concluded geosynthetic materials performed best in warm and mild climates (Cleveland et al. 2002).

In the years 1998, 2005 and 2006 higher than average precipitation amounts were recorded at the nearest station to the test site, Chemult, OR. In those years the annual precipitation level was close to 30in, nearly 6in above the 1998-2006 total average. The increased precipitation in 1998, 2005 and 2006 may have also contributed to the worsening of the effectiveness of the geosynthetic materials.

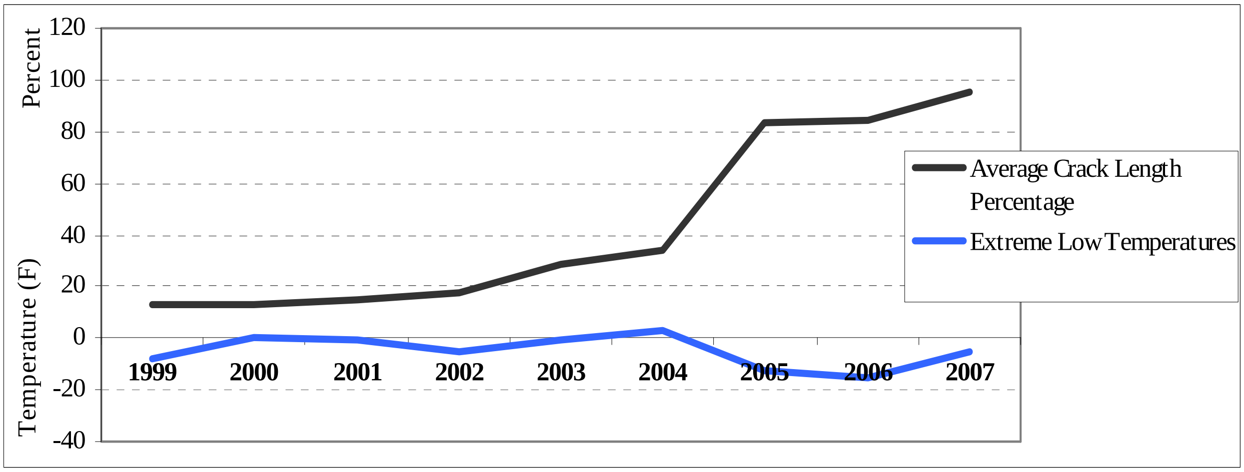

Figure 6.2: Chart showing the correlation of extreme low temperatures and percentage increases in average crack length of geosynthetic test sections

It could not be determined if the average volume of traffic per day created or worsened transverse cracks. The average daily traffic remained fairly steady during the study years. Because there was no significant peak in the number of cars or trucks, it could not be determined what effect they had on the roadway.

Of the five geosynthetic materials tested, it was clear that Glasgrid 8502® performed the best. No geosynthetic material was effective in preventing reflective cracks from returning. Glasgrid 8502® helped to retard the severity of cracks and after eight years all but one crack was still rated as low severity. Placement of a pavement overlay is not necessary on low severity cracks but only high-medium severity and worse. Of the materials tested, select geosynthetics appeared to have stunted road deterioration. However that calculation is made with only one variable, that reflected transverse cracks is the only deterioration factor in the roadway. In the case of US 97, other factors contributed to the deterioration of the overlay surface aside from transverse cracks. The appearance of fatigue cracks, rutting and minimal longitudinal cracking resulted in the need for the test section to be resurfaced after nine years, from 1998 to 2007. If transverse cracking is the only deterioration factor in a roadway, the placement of certain geosynthetic materials appears to be cost effective.

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APPENDIX

INVENTORY OF SURVEY RESULTS OF ALL CRACK LENGTHS AND SEVERITY RATINGS FROM 1998 TO 2007

CRACK #	CRACK STATION METERS	CRACK MP	TREATMENT TYPE	EXISTING CRACK L,M,H	1999		2000		2001		2002		2003		2004		2005		2006		2007	
1	0	213.582	CONTROL(NONE)	M																		
2	40	213.607	CONTROL(NONE)	M	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	**Seal**
3	71	213.626	CONTROL(NONE)	M																		
4	98	213.643	CONTROL(NONE)	M																		
5	131	213.663	CONTROL(NONE)	M									L	3.6	L	3.6	L	3.6	L	3.6	L	3.6
6	145	213.672	CRACK FILL ONLY	M																		
7	168	213.686	CRACK FILL ONLY	H																		
8	204	213.709	CRACK FILL ONLY	H																		
9	249	213.737	CRACK FILL ONLY	M	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3
10	287	213.760	CRACK FILL ONLY	M													L	7.3	M	7.3	M	**Seal**
11	315	213.778	CRACK FILL ONLY	H																		
12	339	213.793	CRACK FILL ONLY	M																		
13	367	213.810	CRACK FILL ONLY	H	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3
14	410	213.837	CRACK FILL ONLY	H					L	1	L	1	L	L 1		1	L	7.3	L	7.3	L	7.3
15	462	213.869	CRACK FILL ONLY	H																	L	7.3
16	486	213.884	GLASGRID 8502®	M													T	7.3	T	7.3	L	7.3
17	536	213.915	GLASGRID 8502®	M									L	4.2	L	7.3	L	7.3	L	7.3	L	7.3
18	578	213.941	GLASGRID 8502®	M													L	7.3	L	7.3	L	7.3
19	614	213.964	GLASGRID 8502®	H																	M	7.3
20	660	213.992	GLASGRID 8502®	H																	L	7.3
21	684	214.007	GLASGRID 8502®	M													L	7.3	L	7.3	L	7.3
22	723	214.031	GLASGRID 8502®	H									L	7.3	L	7.3	L	7.3	L	7.3	L	7.3
23	743	214.044	GLASGRID 8502®	H																	T	7.3
24	776	214.064	GLASGRID 8502®	H									L	7.3	L	7.3	L	7.3	L	7.3	L	7.3
25	803	214.081	GLASGRID 8502®	H																	L	7.3
26	845	214.107	GLASGRID 8502®	M																	L	7.3
27	877	214.127	GLASGRID 8502®	M									L	7.3	L	7.3	L	7.3	L	7.3	L	7.3
28	919	214.153	GLASGRID 8502®	H																	L	7.3
29	933	214.162	GLASGRID 8502®	H																	L	7.3
30	978	214.190	GLASGRID 8502®	H																	L	7.3
31	1003	214.205	GLASGRID 8502®	M																	L	7.3
32	1021	214.216	GLASGRID 8502® (NB only)	M									L	7.3	L	7.3	L	7.3	L	7.3	L	7.3
33	1070	214.247	GLASGRID 8502® (NB only)	M	L	3.6	L	3.6	L	3.6	L	3.6	L	3.6	L	3.6	L	3.6	L	3.6	L	7.3
34	1117	214.276	GLASGRID 8502® (NB only)	H											L	3.6	L	3.6	L	3.6	L	7.3
35	1161	214.303	GLASGRID 8502® (NB only)	H													L	7.3	L	7.3	L	7.3
36	1209	214.333	CRACK FILL ONLY	H	L	7.3	L	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	7.3

CRACK #	CRACK STATION METERS	CRACK MP	TREATMENT TYPE	EXISTING CRACK L,M,H	1999		2000		2001		2002		2003		2004		2005		2006		2007	
37	1257	214.363	CRACK FILL ONLY	H																	L	7.3
38	1289	214.383	GEOTAC®	H													M	7.3	M	7.3	M	**Seal**
39	1334	214.411	GEOTAC®	H																	L	7.3
40	1377	214.438	GEOTAC®	M													M	7.3	M	7.3	M	**Seal**
41	1428	214.469	GEOTAC®	H													L	7.3	L	7.3	L	**Seal**
42	1500	214.514	GEOTAC®	M													M	7.3	M	7.3	M	**Seal**
43	1582	214.565	GEOTAC®	M													M	7.3	M	7.3	M	**Seal**
44	1650	214.607	GEOTAC®	M	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
45	1686	214.630	GEOTAC®	H													L	7.3	L	7.3	L	7.3
46	1723	214.653	GEOTAC®	M													M	7.3	M	7.3	M	**Seal**
47	1804	214.703	GEOTAC®	M																	L	3.3
48	1909	214.768	GEOTAC®	M																	M	7.3
49	1969	214.805	GEOTAC®	M											T	7.3	T	7.3	T	7.3	T	7.3
50	2089	214.880	GEOTAC®	M													H	7.3	H	7.3	H	**Seal**
51	2113	214.895	GEOTAC®	H																	L	7.3
52	2168	214.929	GEOTAC®	M													M	7.3	M	7.3	M	**Seal**
53	2232	214.969	GEOTAC®	H													M	7.3	M	7.3	M	**Seal**
54	2283	215.001	GEOTAC®	H													M	7.3	M	7.3	M	**Seal**
55	2330	215.030	GEOTAC®	M													M	7.3	M	7.3	M	**Seal**
56	2388	215.066	PAVEPREP SA®	M																	L	**Seal**
57	2432	215.093	PAVEPREP SA®	H													L	7.3	L	7.3	L	**Seal**
58	2463	215.112	PAVEPREP SA®	M													M	7.3	M	7.3	M	**Seal**
59	2501	215.136	PAVEPREP SA®	M							L	3.6	L	3.6	L	7.3	H	7.3	H	7.3	H	**Seal**
60	2547	215.165	PAVEPREP SA®	H													L	7.3	L	7.3	L	**Seal**
61	2596	215.195	PAVEPREP SA®	M													H	7.3	H	7.3	L	**Seal**
62	2670	215.241	PAVEPREP SA®	M											L	3.6	H	7.3	H	7.3	H	**Seal**
63	2732	215.280	PAVEPREP SA®	M													L	3.6	L	7.3	L	**Seal**
64	2782	215.311	PAVEPREP SA®	H													L	7.3	L	7.3	L	**Seal**
65	2837	215.345	PAVEPREP SA®	M											L	3	H	7.3	H	7.3	H	**Seal**
66	2895	215.381	PAVEPREP SA®	H																	L	**Seal**
67	2941	215.409	PAVEPREP SA®	H													L	7.3	L	7.3	L	**Seal**
68	3011	215.453	PAVEPREP SA®	M													M	7.3	M	7.3	M	**Seal**
69	3043	215.473	PAVEPREP SA®	H													L	7.3	L	7.3	L	**Seal**
70	3100	215.508	PAVEPREP SA®	H													L	7.3	L	7.3	L	**Seal**
71	3136	215.531	PAVEPREP SA®	H													M	7.3	M	7.3	M	**Seal**
72	3202	215.572	PAVEPREP SA®	H													M	7.3	M	7.3	M	**Seal**
73	3254	215.604	PAVEPREP SA®	M	L	1	L	1	L	2	L	2	L	7.3	L	7.3	M	7.3	H	7.3	H	**Seal**

CRACK #	CRACK STATION METERS	CRACK MP	TREATMENT TYPE	EXISTING CRACK L,M,H	1999		2000		2001		2002		2003		2004		2005		2006		2007	
74	3353	215.665	PAVEPREP SA®	H	L	4	L	4	L	4	L	4	L	4	L	4	M	7.3	M	7.3	M	**Seal**
75	3423	215.709	PAVEPREP SA®	M	L	7.3	L	7.3	L	7.3	L	7.3		N/R	L	7.3	M	7.3	M	7.3	M	**Seal**
76	3482	215.746	CONTROL(NONE)	H													M	7.3	M	7.3	M	**Seal**
77	3574	215.803	CONTROL(NONE)	H	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	7.3	M	**Seal**
78	3611	215.826	CONTROL(NONE)	H													M	7.3	M	7.3	M	**Seal**
79	3642	215.845	CONTROL(NONE)	M													L	3.6	L	3.6	L	**Seal**
80	3685	215.872	CONTROL(NONE)	H					L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	7.3	M	**Seal**
81	3753	215.914	CONTROL(NONE)	H											L	7.3	M	7.3	M	7.3	M	**Seal**
82	3783	215.933	CONTROL(NONE)	M													M	7.3	H	7.3	M	**Seal**
83	3834	215.964	CONTROL(NONE)	H													M	7.3	M	7.3	M	**Seal**
84	3904	216.008	CONTROL(NONE)	H													H	7.3	H	7.3	H	**Seal**
85	3978	216.054	CONTROL(NONE)	H																	L	**Seal**
86	4047	216.097	_YGUARD COLD FLEX 2000 SA	H													M	7.3	M	7.3	M	**Seal**
87	4140	216.154	_YGUARD COLD FLEX 2000 SA	H													M	7.3	M	7.3	M	**Seal**
88	4202	216.193	_YGUARD COLD FLEX 2000 SA	H													M	7.3	M	7.3	M	**Seal**
89	4236	216.214	_YGUARD COLD FLEX 2000 SA	H													M	7.3	M	7.3	M	**Seal**
90	4309	216.259	_YGUARD COLD FLEX 2000 SA	M													L	7.3	L	7.3	L	**Seal**
91	4365	216.294	_YGUARD COLD FLEX 2000 SA	M													L	7.3	L	7.3	L	**Seal**
92	4385	216.307	_YGUARD COLD FLEX 2000 SA	H													L	7.3	M	7.3	M	**Seal**
93	4424	216.331	_YGUARD COLD FLEX 2000 SA	H													L	7.3	M	7.3	M	**Seal**
94	4503	216.380	_YGUARD COLD FLEX 2000 SA	H													M	7.3	M	7.3	M	**Seal**
95	4562	216.417	_YGUARD COLD FLEX 2000 SA	H											L	7.3	L	7.3	L	7.3	L	**Seal**
96	4609	216.446	_YGUARD COLD FLEX 2000 SA	H											L	3.6	L	7.3	L	7.3	L	**Seal**
97	4626	216.456	_YGUARD COLD FLEX 2000 SA	M							L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	**Seal**
98	4667	216.482	_YGUARD COLD FLEX 2000 SA	H													M	7.3	M	7.3	M	**Seal**
99	4715	216.512	_YGUARD COLD FLEX 2000 SA	H													H	7.3	H	7.3	H	**Seal**
100	4760	216.540	_YGUARD COLD FLEX 2000 SA	H													M	7.3	M	7.3	M	**Seal**
101	4793	216.560	_YGUARD COLD FLEX 2000 SA	H	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
102	4819	216.576	_YGUARD COLD FLEX 2000 SA	H									L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
103	4848	216.594	_YGUARD COLD FLEX 2000 SA	H									L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
104	4876	216.612	_YGUARD COLD FLEX 2000 SA	M													L	7.3	L	7.3	L	**Seal**
105	4916	216.637	_YGUARD COLD FLEX 2000 SA	M							L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
106	4939	216.651	POLYGUARD 665™	M									L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
107	4965	216.667	POLYGUARD 665™	H	L	1	L	1	L	1	L	1	L	3.6	L	5	M	7.3	M	7.3	M	**Seal**
108	4994	216.685	POLYGUARD 665™	H	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
109	5037	216.712	POLYGUARD 665™	M	L	1	L	1	L	1	L	1	L	3.6	L	3.6	M	7.3	M	7.3	M	**Seal**
110	5064	216.729	POLYGUARD 665™	M													L	7.3	L	7.3	L	**Seal**
111	5086	216.742	POLYGUARD 665™	M			L	0.5	L	1	L	1	L	7.3	L	7.3	H	7.3	H	7.3	H	**Seal**

CRACK #	CRACK STATION METERS	CRACK MP	TREATMENT TYPE	EXISTING CRACK L,M,H	1999		2000		2001		2002		2003		2004		2005		2006		2007	
112	5115	216.760	POLYGUARD 665™	M					L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	H	7.3	H	**Seal**
113	5141	216.776	POLYGUARD 665™	M	L	5	L	5	L	5	L	5	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
114	5168	216.793	POLYGUARD 665™	M			L	3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
115	5207	216.817	POLYGUARD 665™	H	L	3.6	L	3.6	L	3.6	L	3.6	L	3.6	L	3.6	M	7.3	M	7.3	M	**Seal**
116	5248	216.843	POLYGUARD 665™	H			L	1	L	1	L	1	L	7.3	NR		M	7.3	M	7.3	M	**Seal**
117	5288	216.868	POLYGUARD 665™	M	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
118	5316	216.885	POLYGUARD 665™	M	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
119	5346	216.904	POLYGUARD 665™	M	L	7.3	L	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	**Seal**
120	5414	216.946	POLYGUARD 665™	H													M	7.3	M	7.3	M	**Seal**
121	5463	216.977	POLYGUARD 665™	M	L	7.3	L	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	**Seal**
122	5522	217.013	POLYGUARD 665™	M													L	7.3	L	7.3	L	**Seal**
123	5579	217.049	POLYGUARD 665™	M	L	7.3	L	7.3	M	7.3	M	7.3	M	7.3	M	7.3	H	7.3	H	7.3	H	**Seal**
124	5665	217.102	POLYGUARD 665™	H	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
125	5803	217.188	POLYGUARD 665™	M													M	7.3	M	7.3	M	**Seal**
126	5860	217.223	CRACK FILL ONLY	H	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
127	5926	217.264	CRACK FILL ONLY	M																	L	**Seal**
128	5953	217.281	CRACK FILL ONLY	H	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
129	6010	217.316	CRACK FILL ONLY	M	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	**Seal**
130	6046	217.339	CRACK FILL ONLY	M	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
131	6103	217.374	CRACK FILL ONLY	M	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	**Seal**
132	6158	217.408	CRACK FILL ONLY	M	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	**Seal**
133	6199	217.434	CRACK FILL ONLY	H	L	7.3	L	7.3	L	7.3	L	7.3	NR		NR		M	7.3	M	7.3	M	**Seal**
134	6250	217.466	CRACK FILL ONLY	H	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	NR		L	7.3	L	7.3	L	**Seal**
135	6315	217.506	CRACK FILL ONLY	M	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	L	**Seal**
136	6359	217.533	CONTROL(NONE)	H	L	7.3	L	7.3	L	7.3	L	7.3	L	7.3	M	7.3	M	7.3	M	7.3	M	**Seal**
137	6407	217.563	CONTROL(NONE)	H																	L	**Seal**
138	6452	217.591	CONTROL(NONE)	M																	L	**Seal**
139	6493	217.617	CONTROL(NONE)	H	L	3.6	L	3.6	L	3.6	L	3.6	L	3.6	L	3.6	H	7.3	H	7.3	H	**Seal**
140	6526	217.637	CONTROL(NONE)	H	M	7.3	M	7.3	M	7.3	M	7.3	M	7.3	M	7.3	H	7.3	H	7.3	H	**Seal**