



# Monitoring Geosynthetics in Local Roadways (LRRB 768) 10-Year Performance Summary

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Minnesota Department of Transportation

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# **Monitoring Geosynthetics in Local Roadways (LRRB 768) 10-Year Performance Summary**

## **Final Report**

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# Table of Contents

Chapter 1.	Introduction.....	1
	Background .....	1
	Project Objective.....	1
	Scope of Work .....	1
	Report Organization.....	1
Chapter 2.	Test Sections .....	2
Chapter 3.	2010 Pavement Performance Data Collection .....	5
	Pathways Van Description .....	5
	Pavement Ride Quality .....	6
	Pavement Rutting Performance .....	8
	Pavement Cracking Performance .....	9
Chapter 4.	Long-Term Trends in Pavement Performance.....	14
	Caveat to the Discussion of Performance Trends .....	14
	Long-Term Pavement Performance Trends .....	14
	IRI Performance Trends .....	30
	RQI Performance Trends.....	31
	Rutting Performance Trends.....	31
	SR Performance Trends.....	31
	Geosynthetics Performance Summary .....	32
Chapter 5.	Conclusions and Recommendations .....	39
	Conclusions .....	39
	Recommendations .....	40
References	.....	41

## List of Figures

Figure 1. Geosynthetic Test Section Locations .....	2
Figure 2. MnDOT Pavement Management Pathways Van.....	5
Figure 3. 2010 International Roughness Index Results .....	6
Figure 4. 2010 Ride Quality Index Results.....	7
Figure 5. 2010 Rutting Data.....	9
Figure 6. 2010 Surface Rating Data.....	10
Figure 7. 2010 Transverse Cracking Data .....	11
Figure 8. 2010 Longitudinal Cracking Data .....	12
Figure 9. 2010 Longitudinal Joint Cracking Data .....	13
Figure 10. IRI Performance Trend – Type V Fabric .....	15
Figure 11. IRI Performance Trend – Geogrid.....	16
Figure 12. IRI Performance Trend – Control.....	17
Figure 13. IRI Performance Trend – Saw & Seal .....	18
Figure 14. RQI Performance Trend – Type V Fabric .....	19
Figure 15. RQI Performance Trend – Geogrid .....	20
Figure 16. RQI Performance Trend – Control .....	21
Figure 17. RQI Performance Trend – Saw & Seal .....	22
Figure 18. Rutting Performance Trend – Type V Fabric.....	23
Figure 19. Rutting Performance Trend – Geogrid.....	24
Figure 20. Rutting Performance Trend – Control.....	25
Figure 21. Rutting Performance Trend – Saw & Seal .....	26
Figure 22. SR Performance Trend – Type V Fabric.....	27
Figure 23. SR Performance Trend – Geogrid .....	28
Figure 24. SR Performance Trend – Control.....	29
Figure 25. SR Performance Trend – Saw & Seal .....	30
Figure 26. IRI Performance Summary – All Test Sections .....	33
Figure 27. RQI Performance Summary – All Test Sections.....	34
Figure 28. Rutting Performance Summary – All Test Sections.....	35
Figure 29. SR Performance Summary – All Test Sections.....	36
Figure 30. Transverse Cracking Performance Summary – All Test Sections .....	37
Figure 31. Longitudinal Cracking Performance Summary – All Test Sections .....	38

## **List of Tables**

Table 1. Geosynthetic Test Section Descriptions .....	3
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## Executive Summary

Geosynthetics have been used for many years in northwestern Minnesota for the reconstruction of several asphalt and aggregate surfaced roads. Different types of geosynthetics, including Type V fabrics and geogrids, have been used as a separator layer as a means to stabilize poor subsoils and subgrades in order to provide a stable construction platform. They have also been used as part of the typical roadway design (without reducing the layer thicknesses), anticipating improved strength and reduced future maintenance activities. Although the use of geosynthetics has been fairly widespread, the pavement performance on these sections has not been well documented. Therefore, this project aims to obtain field data that would indicate whether these types of installations have any benefit to extending the roadway life or reducing maintenance as is believed.

The main objective of this 10-year project was to identify and quantify any pavement performance benefits resulting from the installation of geosynthetics in pavement base and subbase layers. Potential benefits would include a reduction in longitudinal and transverse cracking, decreased rutting, and improved ride quality.

Pavement performance was measured on several paved county state aid highway (CSAH) roads in northeastern Minnesota by MnDOT's Pathways digital inspection vehicle, which performed annual condition surveys of each road segment each fall since 2001. The Pathways data were analyzed for ride quality, rutting, and cracking over a 10-year period. Several test sections (covering approximately 44 miles) incorporating type V fabrics, geogrids, and saw & seal treatments were monitored and compared to control sections (approximately 12 miles) without these treatments to determine what, if any, benefits could be derived from geosynthetics.

A snapshot of pavement performance in 2010 was provided, as were long-term performance trends for each individual test section as well as average behavior. The data showed that type V fabric sections had decreased ride quality, rutting resistance, and surface rating when compared to control sections. Geogrid sections had increased ride quality, rutting resistance, and surface rating when compared to control sections. The saw & seal section generally had better pavement performance than the control sections, but there was only one such section in this study.

Based on the results of this study, type V geosynthetic fabrics are not recommended to be used in cases where increased pavement performance or longer pavement life are expected. The use of fabrics did not provide the added strength or decreased cracking resistance that was expected at the outset of this study. However, geogrids did provide better ride quality, structural capacity, and cracking resistance than pavements without geogrids. The use of geogrids to provide strong, long-lasting pavements is warranted.

# Chapter 1. Introduction

## Background

Geosynthetics have been used for many years in northwestern Minnesota for the reconstruction of several asphalt and aggregate surfaced roads (1). Installations have been on low and medium volume paved county roads as well as one state trunk highway. Different types of geosynthetics, including Type V fabrics and geogrids, have been used as a separator layer as a means to stabilize poor subsoils and subgrades in order to provide a stable construction platform. They have also been used as part of the typical roadway design (without reducing the layer thicknesses), anticipating improved strength and reduced future maintenance activities.

Although the use of geosynthetics has been fairly widespread, the pavement performance on these sections has not been well documented. Therefore, this project aims to obtain field data that would indicate whether these types of installations have any benefit to extending the roadway life or reducing maintenance as is believed.

## Project Objective

The main objective of this 10-year project is to identify and quantify any pavement performance benefits resulting from the installation of geosynthetics in pavement base and subbase layers. Potential benefits would include a reduction in longitudinal and transverse cracking resulting in more efficient maintenance activities. In addition a stronger road could result in less rutting allowing for less costly future fixes.

## Scope of Work

Pavement performance was measured on several paved county state aid highway (CSAH) roads in northeastern Minnesota by MnDOT's Pathways digital inspection vehicle, which performed annual condition surveys of each road segment each fall since 2001. The Pathways data were analyzed for ride quality, rutting, and cracking over a ten-year period. Several test sections (covering approximately 44 miles) incorporating type V fabrics, geogrids, and saw-and-seal treatments were monitored and compared to control sections (approximately 12 miles) without these treatments to determine what, if any, benefits could be derived from geosynthetics.

## Report Organization

This report is organized into five main sections. The Introduction will briefly discuss the background, project objectives, and scope. Test Sections will provide information in visual and tabular format on the location of the geosynthetic sections. Then will come a discussion of the pavement performance data collected in 2010, followed by a section detailing the trends in performance of each section over time. The report closes with final conclusions and recommendations.

## Chapter 2. Test Sections

The geosynthetic test sections are located on County State Aid Highways (CSAHs) in Lake of the Woods, Roseau, Polk, Pennington, and Hubbard counties. This region in Northwestern Minnesota is notorious for its swamps and silty-clay soil. The installations are in heavy clay soils with the exception of one installation in granular soils in Hubbard County. The test section locations are shown in Figure 1 and described in Table 1. The geofabric used in section GS13 was different from the others in that it was a non-woven fabric.

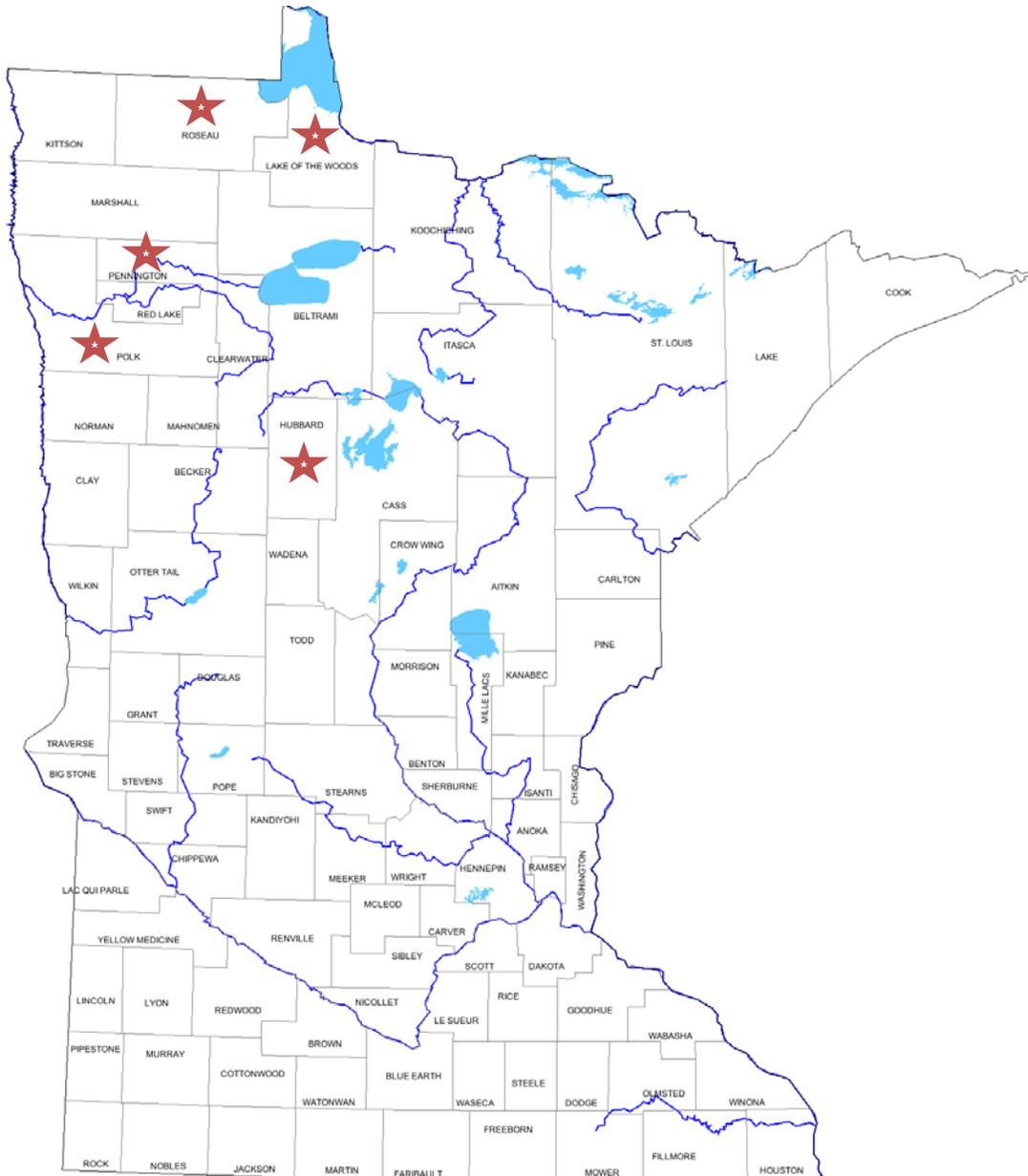


Figure 1. Geosynthetic Test Section Locations

**Table 1. Geosynthetic Test Section Descriptions**

Section	County	CSAH	F-fabric G-geogrid C-control S-sawseal	Length (miles)	Begin Description	End Description	Year Constructed
GS01	LAKE OF THE WOODS	1	F	3.98	CSAH-1 TURNS	TH 72	1993
GS02	LAKE OF THE WOODS	3	C	1.29	CSAH 6	1.29 mi. East of CSAH 6	1993
			F	3.64	1.29 mi. East of CSAH 6	CSAH 1	
GS03	LAKE OF THE WOODS	35	F	1.61	CSAH 3	1.61 mi East of CSAH 3	1996
			C	0.39	1.61 mi East of CSAH 3	CSAH 1	
GS04	LAKE OF THE WOODS	39	F	2.14	TH 11	TH 172	1997
GS05	ROSEAU	13	C	0.36	County Road 137	0.36 mi East of CR 137	1982
			F	0.28	0.36 mi East of CR 137	0.64 mi East of CR 137	1992
			C	0.27	0.64 mi East of CR 137	0.91 mi East of CR 137	1982
			F	0.32	0.91 mi East of CR 137	1.23 mi East of CR 137	1992
			F	0.42	1.23 mi East of CR 137	1.65 mi East of CR 137	1982
			F	0.17	1.65 mi East of CR 137	1.82 mi East of CR 137	1992
			C	1.12	1.82 mi East of CR 137	2.94 mi East of CR 137	1982
			F	0.30	2.94 mi East of CR 137	3.24 mi East of CR 137	1982
			F	0.30	3.24 mi East of CR 137	3.54 mi East of CR 137	1992
			F	0.47	3.54 mi East of CR 137	4.01 mi East of CR 137	1982
			C	1.94	4.01 mi East of CR 137	TH 313	1982
GS06	ROSEAU	12	C	3.10	From CSAH 9	CSAH 13	1995
GS07	ROSEAU	20	F	5.95	TH 89	CSAH 9	1995
GS08	ROSEAU	15	F	4.40	CSAH 2	4.40 mi North of CSAH 2	1997
			C	0.61	4.40 mi North of CSAH 2	TH 11	
GS09	PENNINGTON	16	F	2.39	TH 32	US 59	1999
GS10	POLK	18	G	5.68	US 2	5.68 mi North of US 2	2000
			C	0.19	5.68 mi North of US 2	5.87 mi North of US 2	

			G	2.15	5.87 mi North of US 2	CSAH 17	
GS11	POLK	59	G	4.03	TH 220	4.03 mi East of TH 220	1997
			F	0.78	4.03 mi East of TH 220	4.81 mi East of TH 220	
			C	0.29	4.81 mi East of TH 220	5.10 mi East of TH 220	
			G	0.91	5.10 mi East of TH 220	CSAH 15	
		58	G	2.55	Township Road 131	County Road 225	
GS12	HUBBARD	3	C	0.11	North Junction of County Road 95	0.11 mi North of N Jct CR 95	1996
			G	0.70	0.11 mi North of N Jct CR 95	0.81 mi North of N Jct CR 95	
			C	0.11	0.81 mi North of N Jct CR 95	0.92 mi North of N Jct CR 95	
			G	0.55	0.92 mi North of N Jct CR 95	1.47 mi North of N Jct CR 95	
			C	1.05	1.47 mi North of N Jct CR 95	2.52 mi North of N Jct CR 95	
GS13	HUBBARD	6	S	0.36	CSAH 47	0.36 mi North of CSAH 47	2000
			F	0.18	0.36 mi North of CSAH 47	0.54 mi North of CSAH 47	
			C	0.12	0.54 mi North of CSAH 47	0.66 mi North of CSAH 47	
			G	0.09	0.66 mi North of CSAH 47	0.76 mi North of CSAH 47	
			C	0.02	0.76 mi North of CSAH 47	0.78 mi North of CSAH 47	
			G	0.08	0.78 mi North of CSAH 47	0.86 mi North of CSAH 47	
			C	1.15	0.86 mi North of CSAH 47	County Road 109	

## Chapter 3. 2010 Pavement Performance Data Collection

### Pathways Van Description

MnDOT routinely collects pavement condition data using a Pathways Services, Inc. Video Inspection Vehicle (VIV) as shown in Figure 2. Several lasers mounted across the front bumper measure the pavement longitudinal profile (used to calculate ride quality) as well as rutting. They take a measurement at short intervals as the van travels down the roadway at highway speed. There are also four digital cameras mounted on top of the van. The cameras are used to capture the pavement distress (cracking, patching, etc.) and help assess the overall condition of the pavement (2).



**Figure 2. MnDOT Pavement Management Pathways Van**

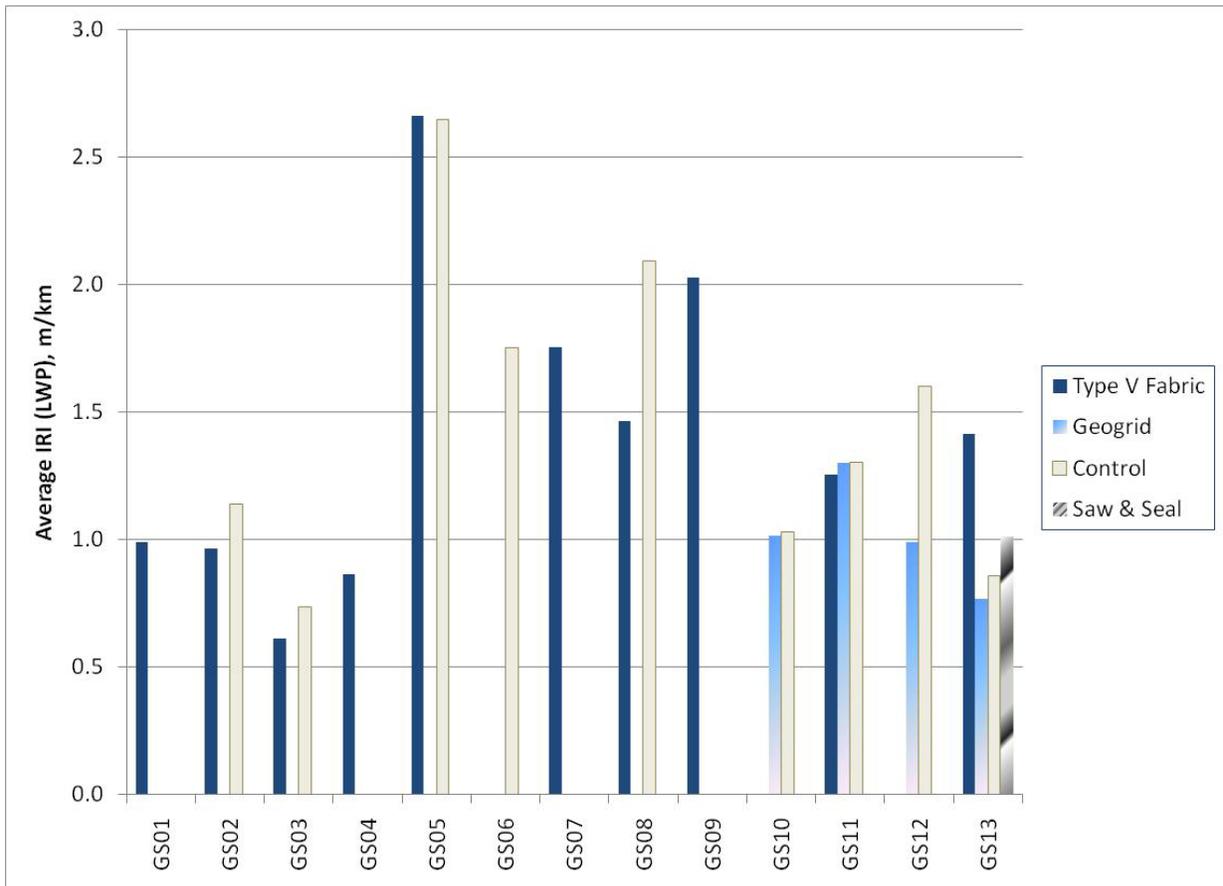
The MnDOT Pavement Management Unit used the Pathways van to collect pavement performance data in July and August 2010 for each of the geosynthetic test sections. The technician drove each of the geosynthetic test sections in the course of testing other highways in the area. The data were then brought back to the office to be processed and summarized according to each section. The reported rutting value is an average rut depth of right and left wheelpaths over a 1-mile section. The roughness or ride quality data are also analyzed over a 1-mile section and reported in the left wheel path. Videos are taken over the first 528 feet of each mile to gather representative distress data for that mile. The following sections summarize the pavement performance data collected with the Pathways van in 2010.

### Pavement Ride Quality

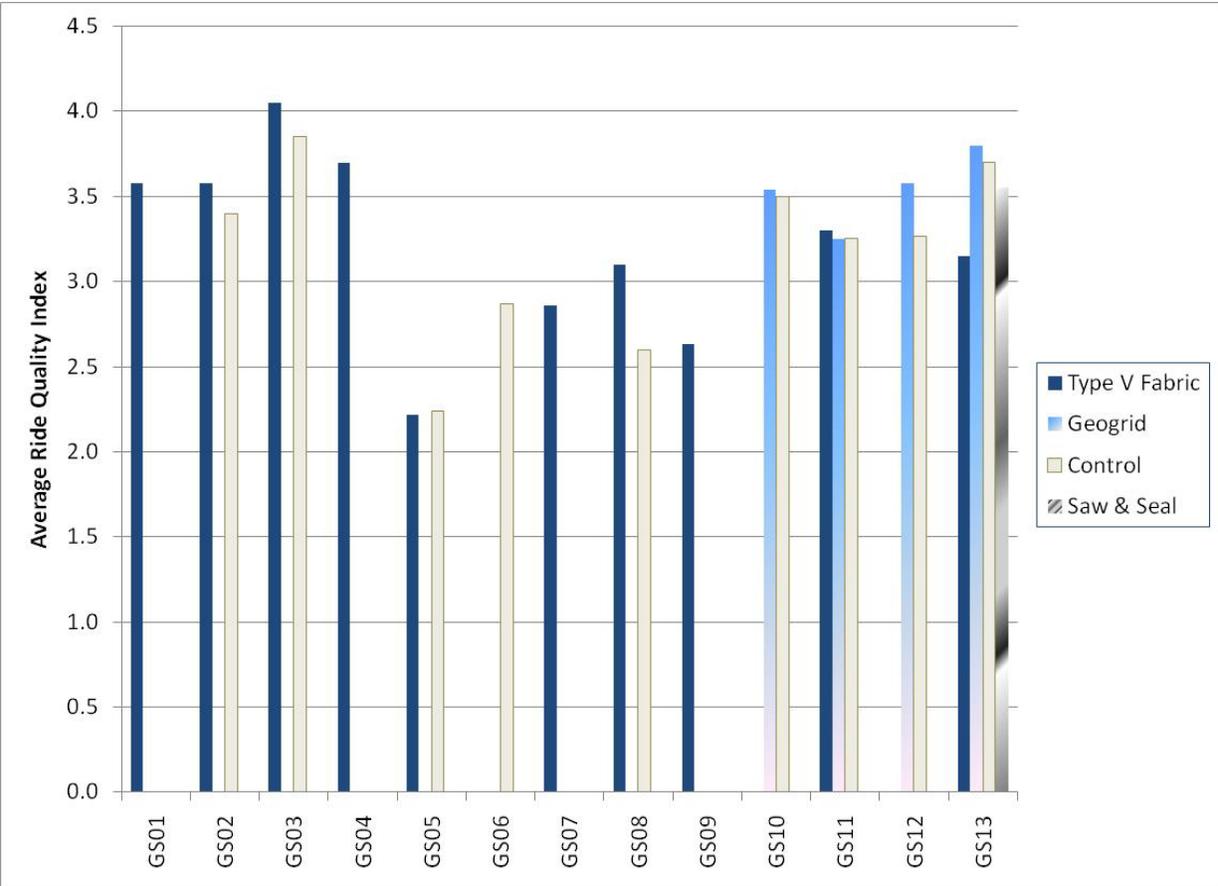
The roughness or ride quality of the geosynthetic sections was reported using two related methods. Each index captures a different aspect of the pavement’s performance and can be used to rank pavement sections and to predict future maintenance and rehabilitation needs. The International Roughness Index (IRI) is an indication of a pavement’s smoothness or “seat-of-the-pants” ride quality. The higher the IRI value, the rougher the ride. An IRI of approximately 2.3 m/km is seen as the target value where a road has deteriorated to a point where most people feel that the ride is uncomfortable and a major rehabilitation is needed. The Ride Quality Index (RQI) is MnDOT’s standard smoothness index. It uses a zero to five rating scale, rounded to the nearest tenth. The higher the RQI, the smoother the road is. IRI and RQI are related by the following equation (2):

$$RQI = 5.697 - (2.104) \cdot \sqrt{IRI}$$

Plots for IRI and RQI, are shown in Figure 3 and Figure 4, respectively.



**Figure 3. 2010 International Roughness Index Results**



**Figure 4. 2010 Ride Quality Index Results**

Sections GS01, GS02, GS03, GS04, GS10, and GS13 all had similarly low IRI values and correspondingly high RQI values. Sections GS05, GS08, and GS09 had the highest IRI values and therefore the lowest RQI values among the sections. Section GS05 was the worst performing section, and Section GS03 was the best performing section overall. The control and fabric sections in GS03 went from some of the worst performing sections in 2009 to the best performing section in 2010. It is likely that this section was reconstructed recently, although that has not been confirmed by Lake Of The Woods County. While Section GS05 is still the worst performing section, it did make some moderate improvements in terms of ride quality from the previous year. It is possible that a surface treatment was placed on this section sometime in the past year, although again this has not been confirmed by Roseau County.

Averaging all of the like sections, the geogrid and saw & seal sections were the smoothest, followed by the geofabric and control sections as indicated by both the IRI and RQI.

A direct comparison can be made of geosynthetic vs. control sections in several of the test sections. In almost all of the cases the control section had a rougher ride than the geosynthetic section, in some instances quite significant. This is somewhat contrary to what the data has shown in several recent years. The 2010 data showed that in most cases the geosynthetic sections were smoother than the control sections, while in previous years the performance was mixed.

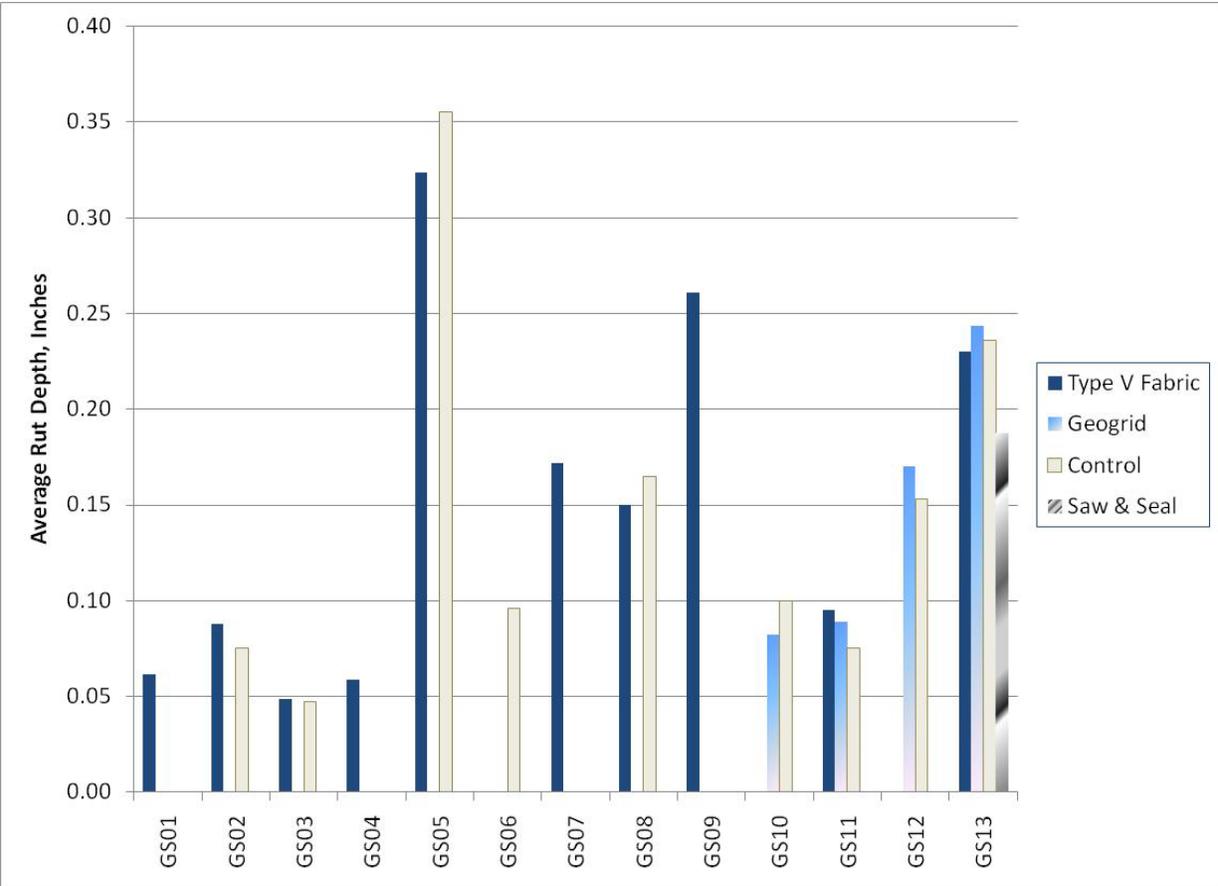
A direct comparison can be made between geofabric and geogrid on only two test sections and with mixed results. In section GS11 the geogrid section was slightly rougher than the geofabric section, but in section GS13 the geofabric is significantly rougher than the geogrid. This trend is consistent with the previous year's data.

#### *Pavement Rutting Performance*

Rutting data were collected by the Pathways van for each geosynthetic test section, and the results are shown in Figure 5. Sections GS05, GS09, and GS13 had the highest rut depths, while Sections GS01, GS02, GS03, and GS04 all had quite low rut depths.

The geofabric, geogrid, and control sections all had virtually the same average rut depth near 0.15 inches. The one saw & seal section was slightly higher at 0.19 inches. The average rut depths actually decreased slightly from the previous year. Some of this decrease in rut depth may be because of reconstruction or maintenance activities, and some may be due to general variation in the measurements.

In two out of six sections the geofabric sections had lower rut depths than the control sections. In two sections the geofabric section had greater rut depth than the control section, and in the other two sections the rut depths were similar. In addition, in three out of four sections the geogrid sections showed greater rut depths than the control, which is contrary to what you would expect, although this performance is consistent with the previous year. In the two head-to-head comparisons between fabric and geogrid, each treatment had a lower rut depth in one of the cases. No clear trend was seen in the data in terms of the effects of geosynthetics on rutting performance.

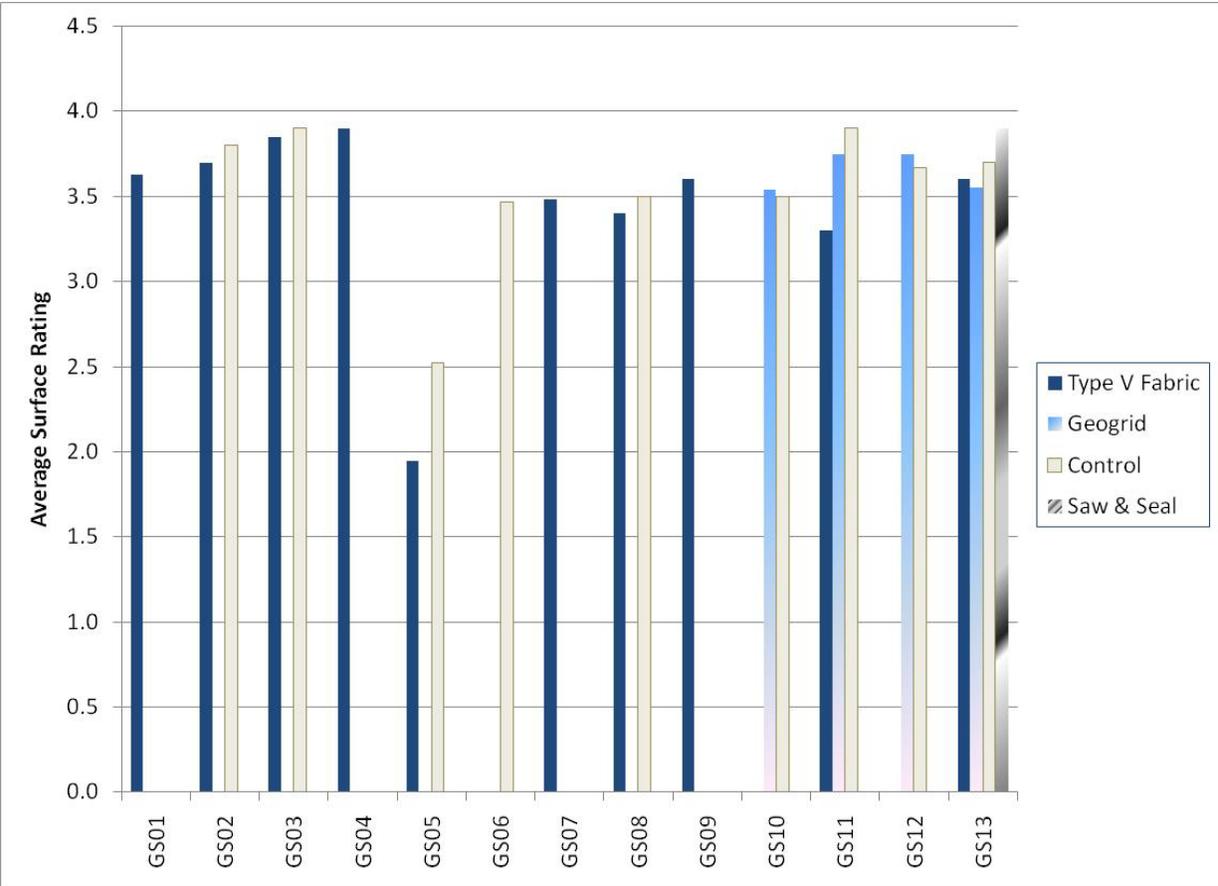


**Figure 5. 2010 Rutting Data**

*Pavement Cracking Performance*

MnDOT (and by extension, many local agencies) uses the Surface Rating (SR) to quantify pavement distress. The percentage of each distress in the 500-foot sample is determined and multiplied by a weighting factor to give a weighted percentage. The weighting factors are higher for higher severity levels of the same distress and higher for distress types that indicate more serious problems exist in the roadway such as alligator cracking. A perfect SR is 4.0, and a lower SR indicates a higher amount of surface distress in the pavement.

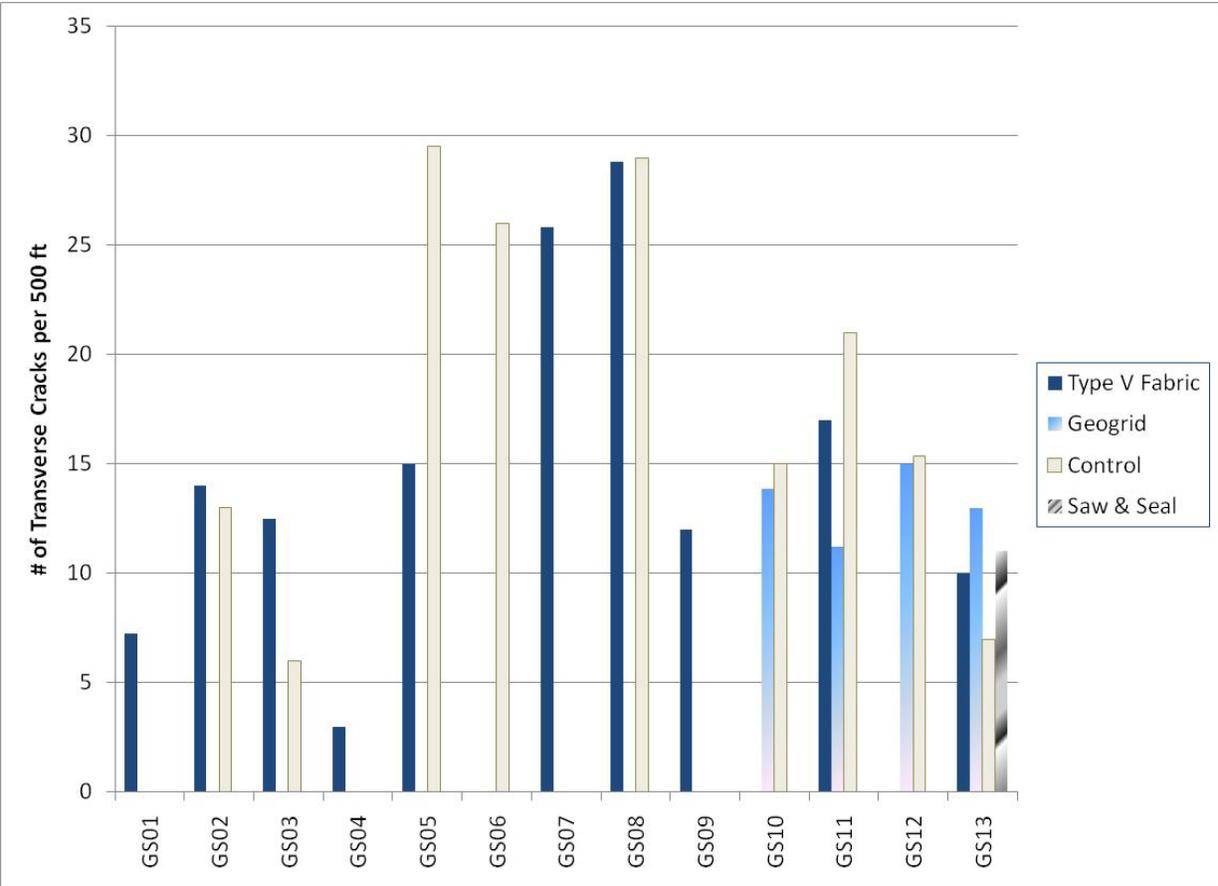
Figure 6 shows the surface rating performance of all the test sections in 2010. Section GS05 has SR values considerably lower than the other sections, which is reflected in the previous rutting and ride quality data. Sections GS02, GS03, and GS04 have exceptionally high SR values, and the other sections have SR values around 3.5.



**Figure 6. 2010 Surface Rating Data**

Figure 7 shows a summary of transverse cracking for each test section. It is interesting to note that overall the amount of cracking is about double that of the previous year, and similar to that of 2008 and earlier. The cracking data from 2009 seems to be an anomaly. The author is not sure if this resulted from a change in how the pavement management data were evaluated, a chip seal or other surface treatment placed on many of the test sections, or some other explanation.

The resulting data are highly variable with respect to the amount of transverse cracking in each section. Sections GS01, GS03, and GS04 had the least amount of transverse cracking, while sections GS05, GS06, GS07, and GS08 had the most cracking. When comparing the fabric vs. control sections, in three out of six cases the geofabric sections had more transverse cracking than the control sections, while in another three cases the geofabric sections had less transverse cracking than the control sections. In three of the four cases, the control sections had more transverse cracking than the geogrid sections. The two fabric vs. geogrid comparisons were split between which section showed less transverse cracking.

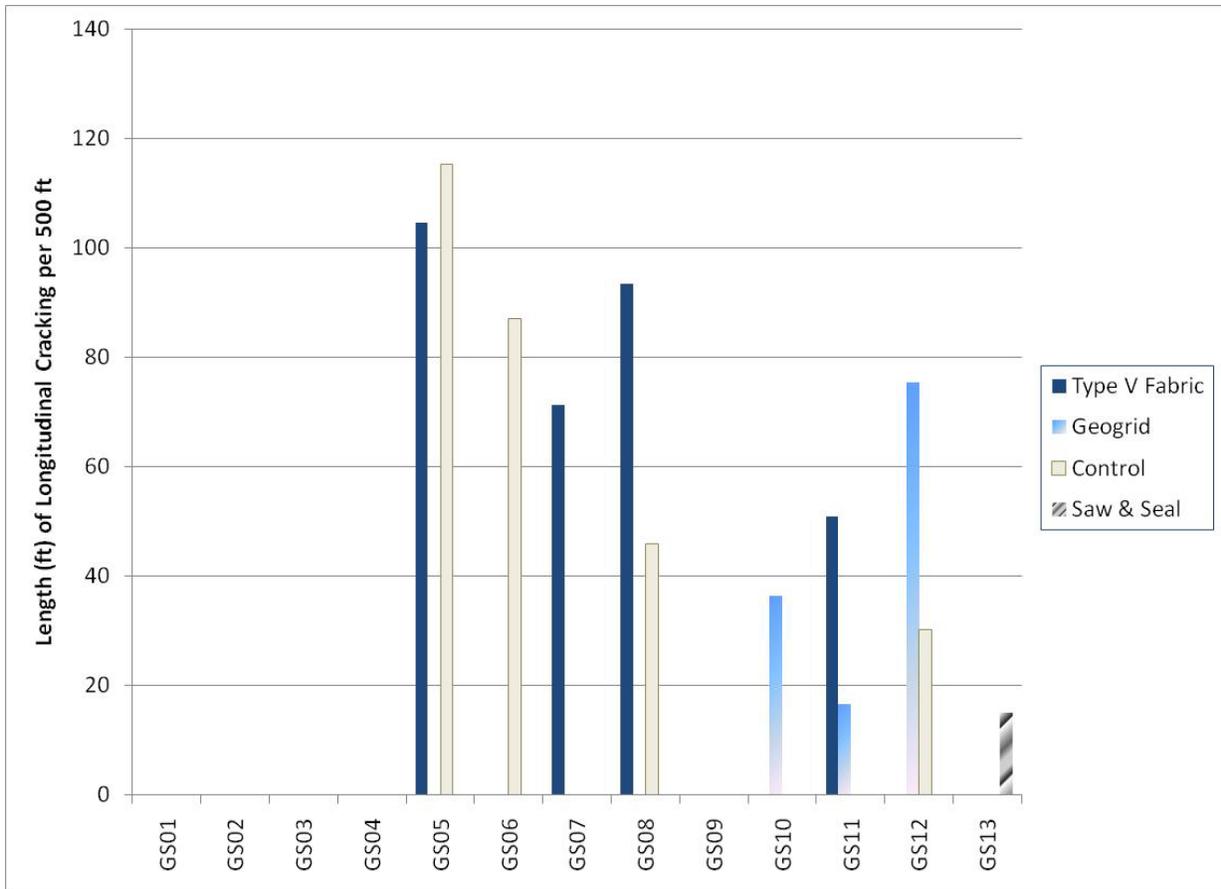


**Figure 7. 2010 Transverse Cracking Data**

Figure 8 shows the longitudinal cracking data from the test sections. Interesting trends in the data were again observed. The sections are showing overall about twice as much longitudinal cracking as compared to 2009, which is back to levels seen in 2008 and previous years.

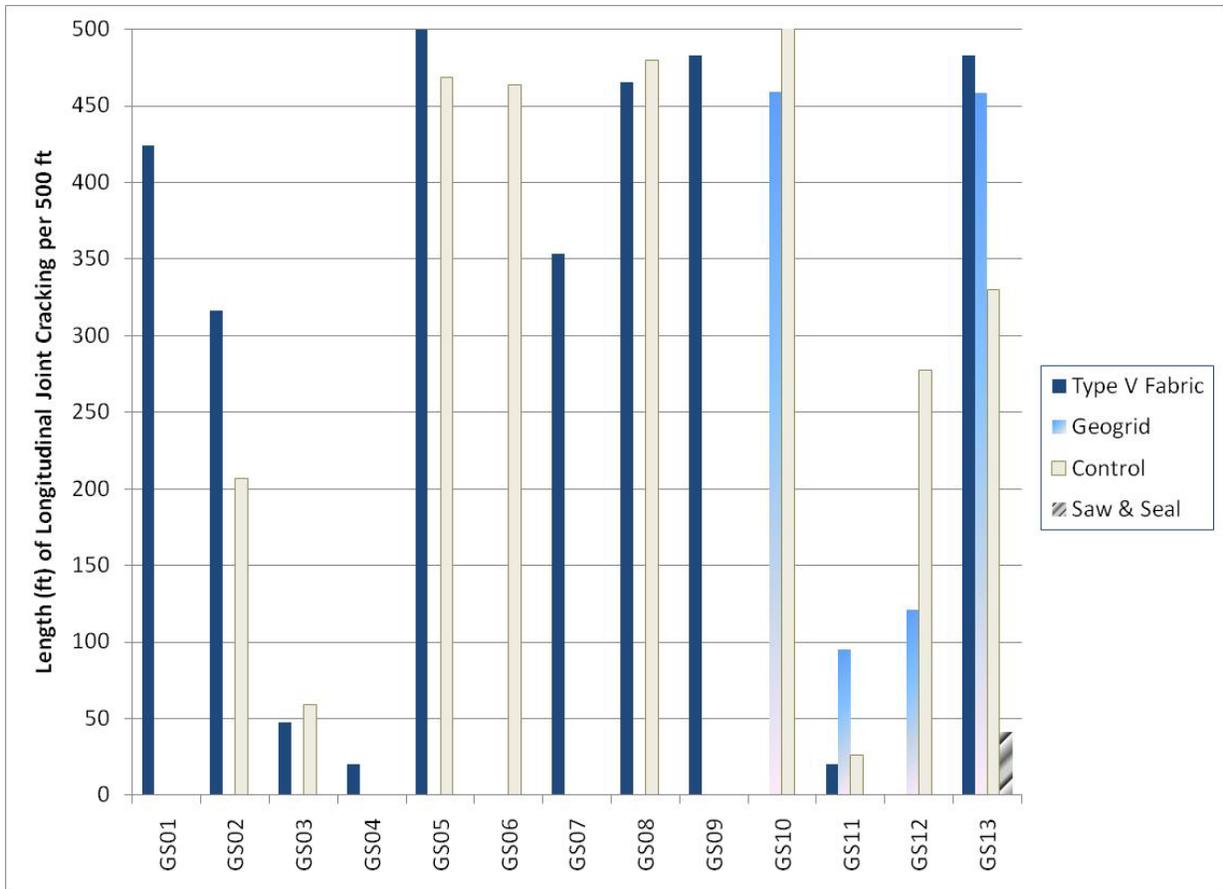
On average the geofabric, geogrid, and control sections all show about the same amount of longitudinal cracking, at 32 feet of cracking per 500-foot section. The one saw & seal section is about half that, at 15 feet of cracking per 500-foot section. Sections GS05, GS06, GS07, and GS08 exhibit extensive longitudinal cracking. Sections GS01, GS02, GS03, GS04, GS09, and GS10 show no longitudinal cracking whatsoever.

In two sections the fabric has more longitudinal cracking than the control, while in one section the opposite is true. Three paired sections do not have any cracking. Comparisons of geogrid vs. control sections also showed that in three out of four cases the geogrid sections had more longitudinal cracking than the control sections (in the fourth case neither section had cracking). In one case, the fabric had more cracking than the geogrid section, while in another case neither section had any cracking. This data seems to show that geosynthetic sections performed worse than control sections in terms of longitudinal cracking.



**Figure 8. 2010 Longitudinal Cracking Data**

The Pathways van also collected cracking along the longitudinal (centerline) joint, shown in Figure 9. Again, this plot shows about twice as much cracking as the previous year and at similar levels as 2008 and previously. Sections GS03, GS04, and GS11 had very little joint cracking while sections GS01, GS05, GS06, GS08, GS09, GS10, and GS13 were cracked rather extensively. In three out of six cases the geofabric sections showed more centerline cracking than the control sections, while in the other three cases the opposite was true. The geogrid vs. control sections were also split in half in terms of longitudinal joint cracking. Comparisons of the fabric vs. geogrid sections were also similarly mixed. The centerline joint cracking may be more related to materials and pavement construction issues rather than structural design, so one might not expect to see an effect here from the use of geosynthetics.



**Figure 9. 2010 Longitudinal Joint Cracking Data**

## **Chapter 4. Long-Term Trends in Pavement Performance**

### **Caveat to the Discussion of Performance Trends**

The reader should be made aware that in the early stages of this project there was much confusion about the specific locations of the geosynthetic test sections. Researchers located the appropriate highways correctly, but the geosynthetic and control subsections within each highway were often incorrectly located. As a result, the data presented in the first few years of the study was likely erroneous.

In 2005 researchers accurately located the start and end points of each geosynthetic and control section, both on the road and within the Pavement Management software. Since that time there is a high degree of confidence in the data that has been presented. The author does not see a clear-cut benefit in going back to the first few years of data and recalculating the performance numbers. Therefore, only data collected in 2004 through 2010 is presented in the following pages. While even the 2004 data may not be correctly located, no obviously erroneous trends were seen in the data plots. At any rate, data between 2005 and 2010 gives six year's worth of pavement performance, which seems adequate to discern any trends.

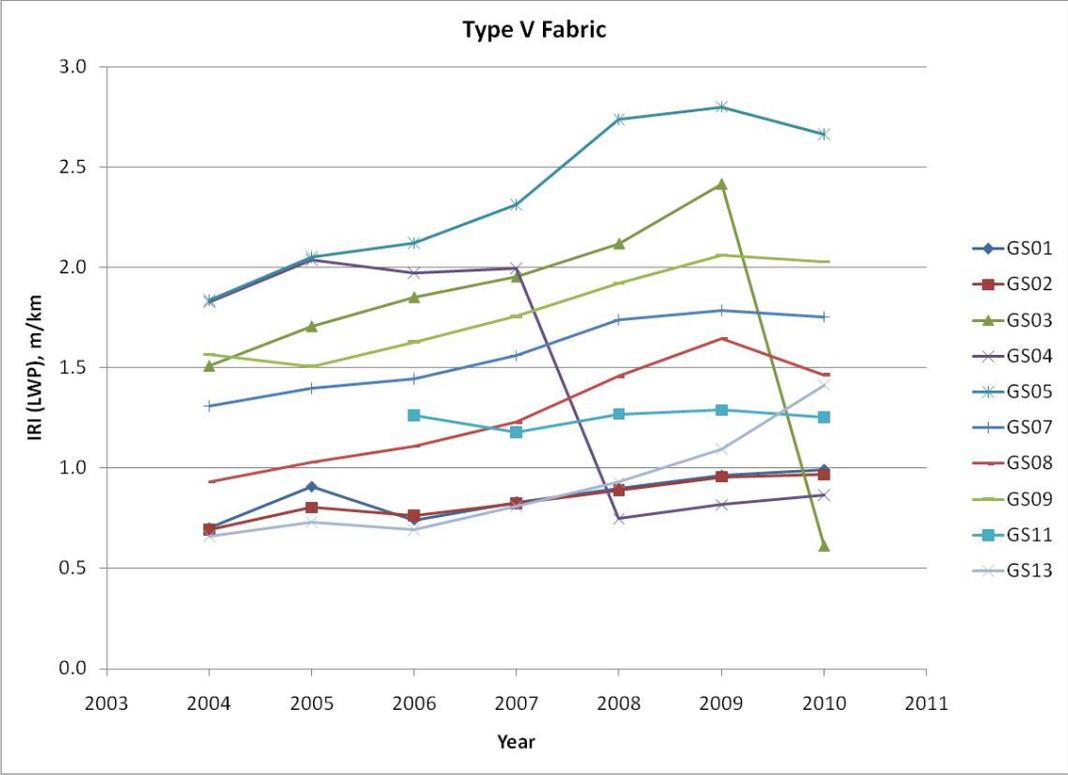
One last item to note before looking in detail at the long-term performance trends is that the IRI and rutting performance data are present all the way from 2004 through 2010. The RQI and SR data have only recently been reported by Pavement Management, beginning in 2007.

### **Long-Term Pavement Performance Trends**

The following pages present a series of plots showing the trends in various performance over time for each of the 13 geosynthetic test sections. Each plot is organized by the type of treatment (type V fabric, geogrid, control, saw & seal) and the performance indicator (IRI, RQI, Rutting, SR). These plots are as follows:

- Figure 10 to Figure 13 – IRI performance
- Figure 14 to Figure 17 – RQI performance
- Figure 18 to Figure 21 – Rutting performance
- Figure 22 to Figure 25 – SR performance

These figures are simply presented on the following pages and then discussed afterward.



**Figure 10. IRI Performance Trend – Type V Fabric**

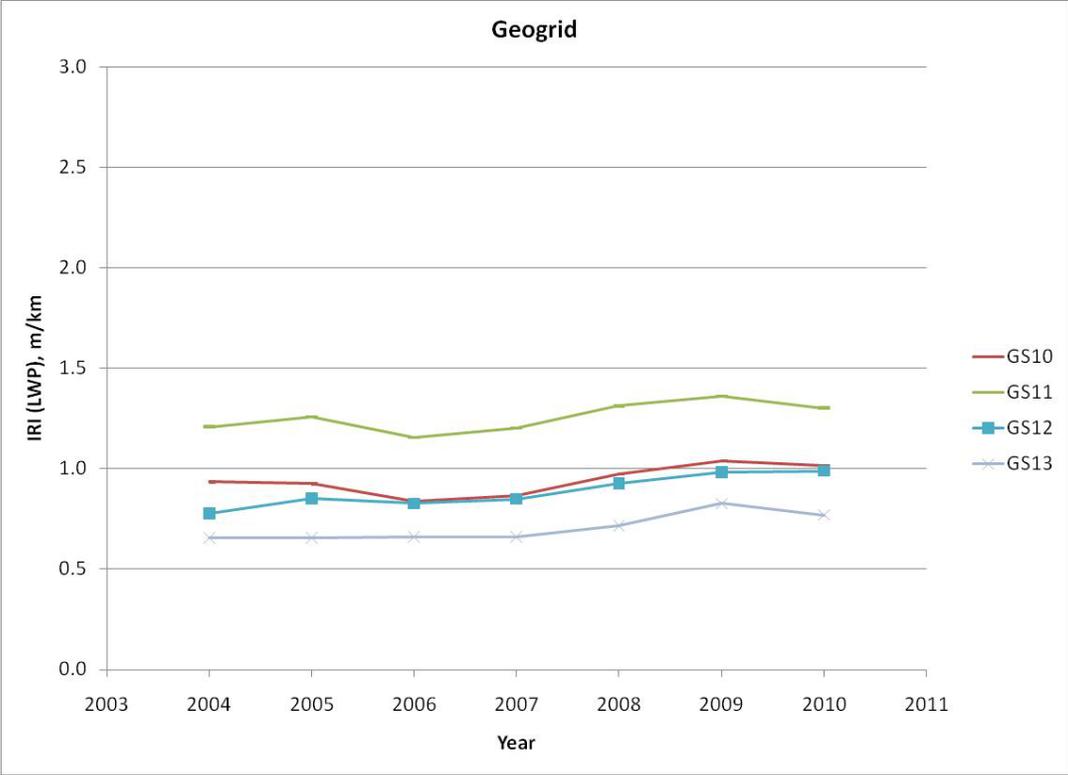
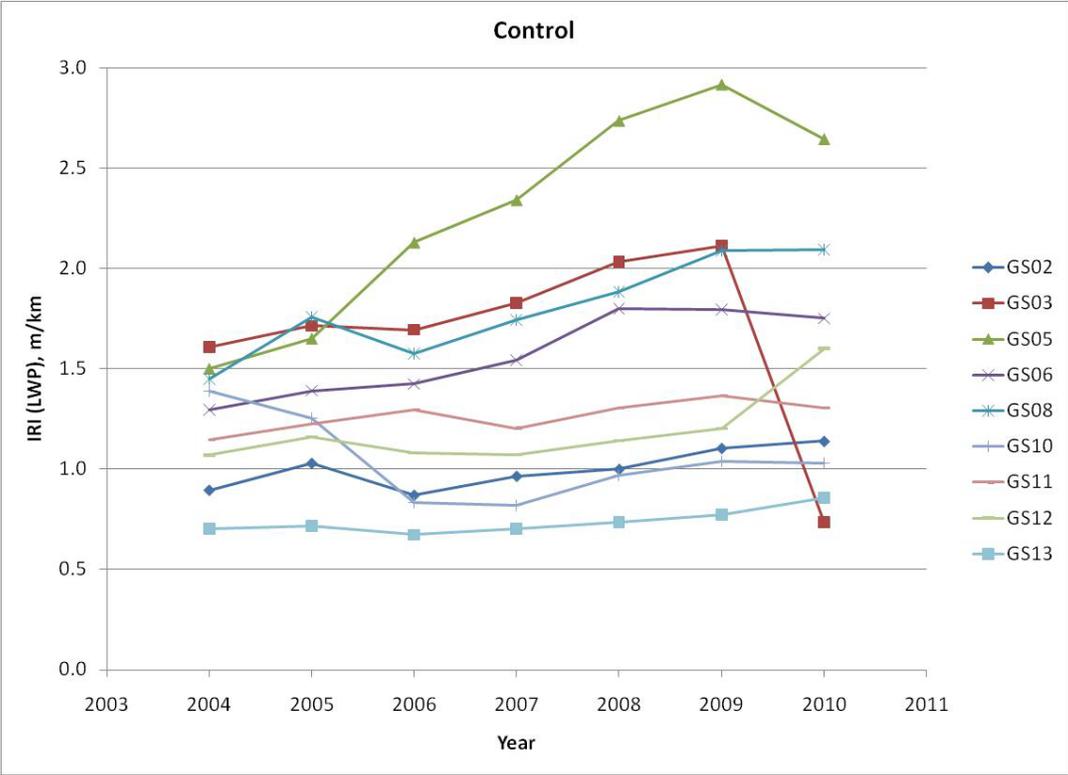
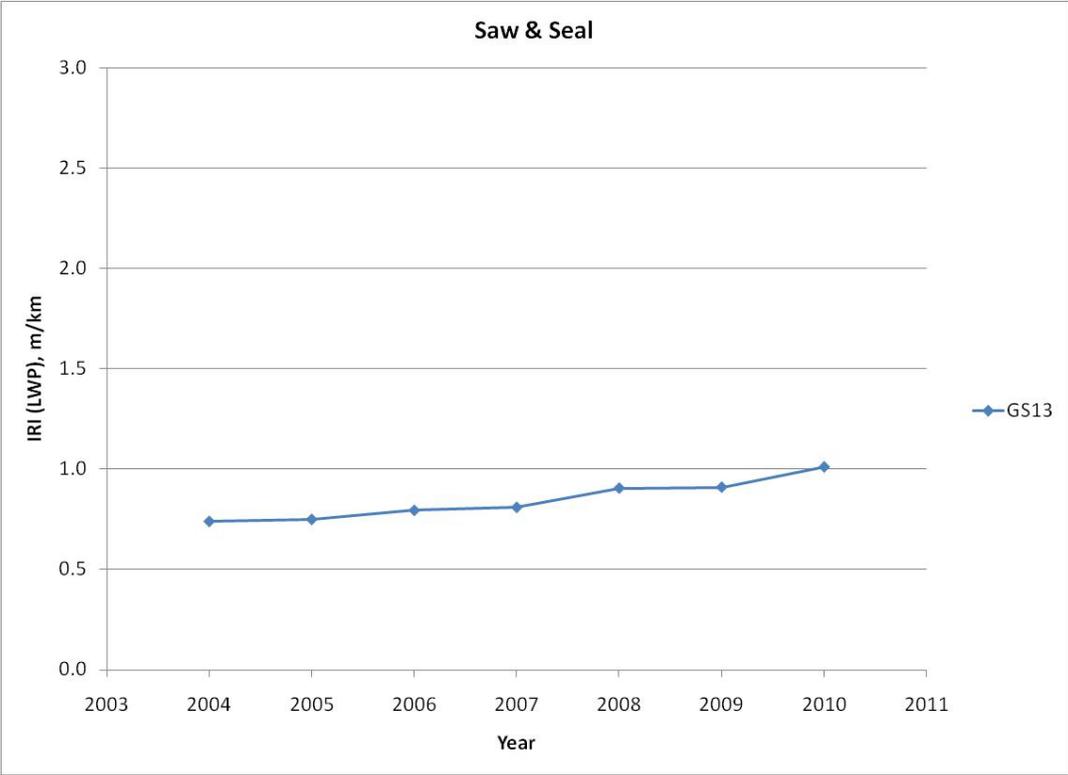


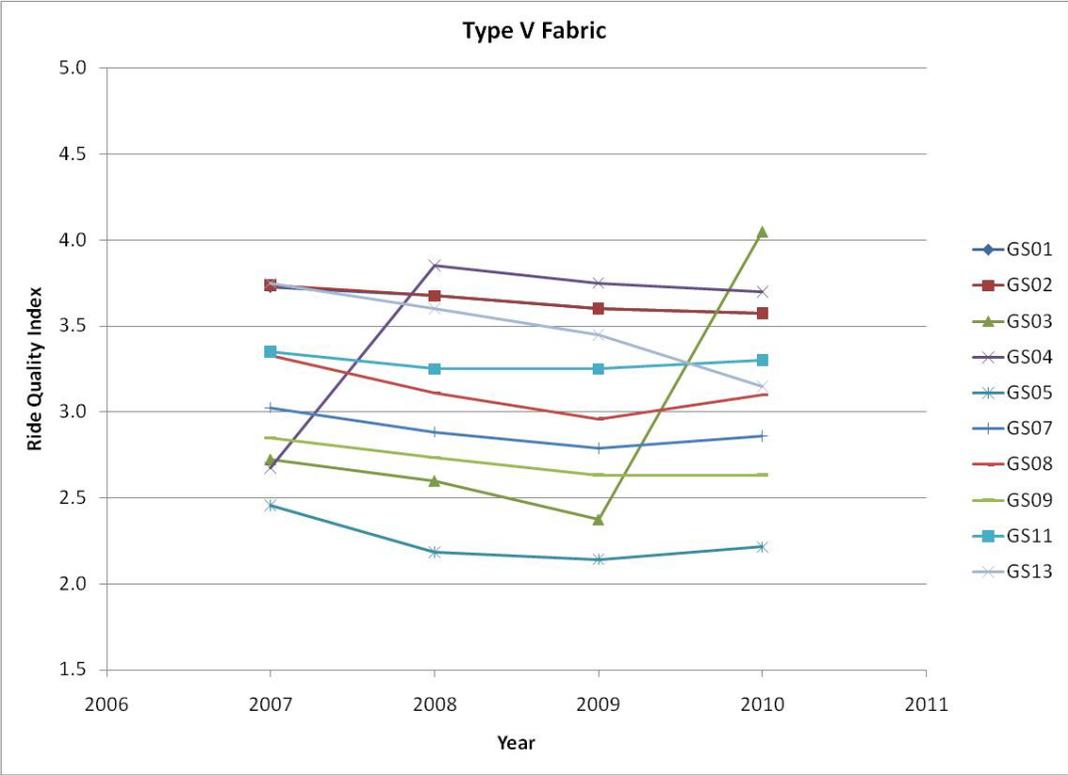
Figure 11. IRI Performance Trend – Geogrid



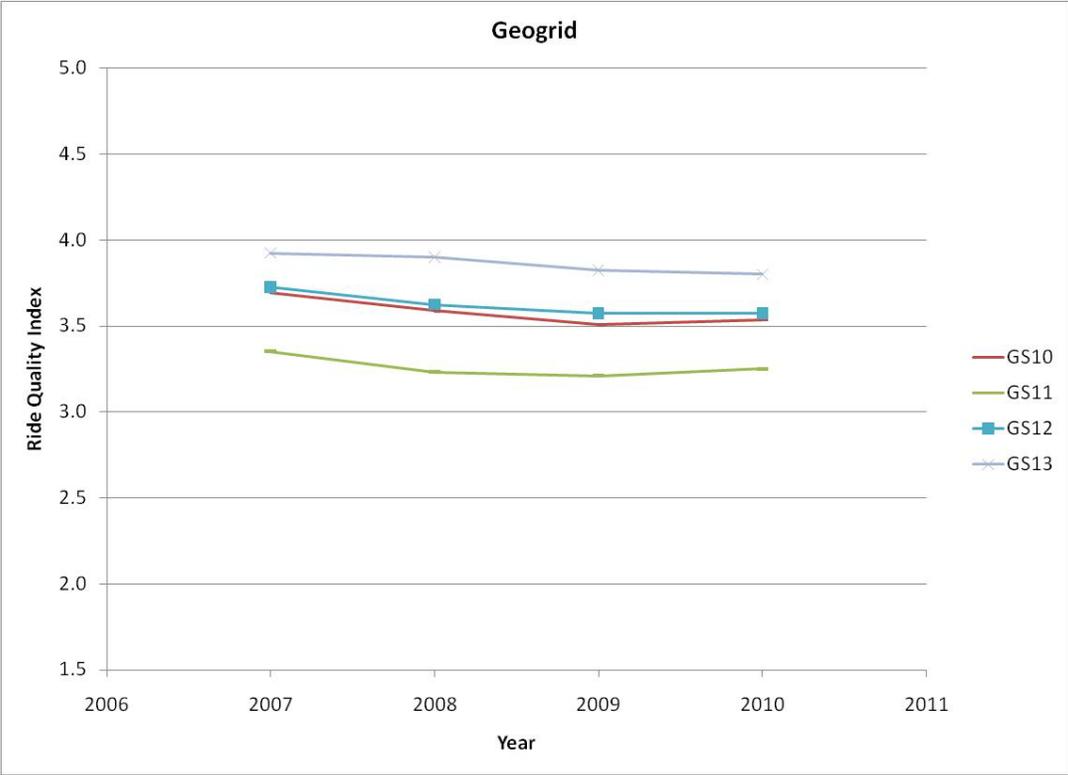
**Figure 12. IRI Performance Trend – Control**



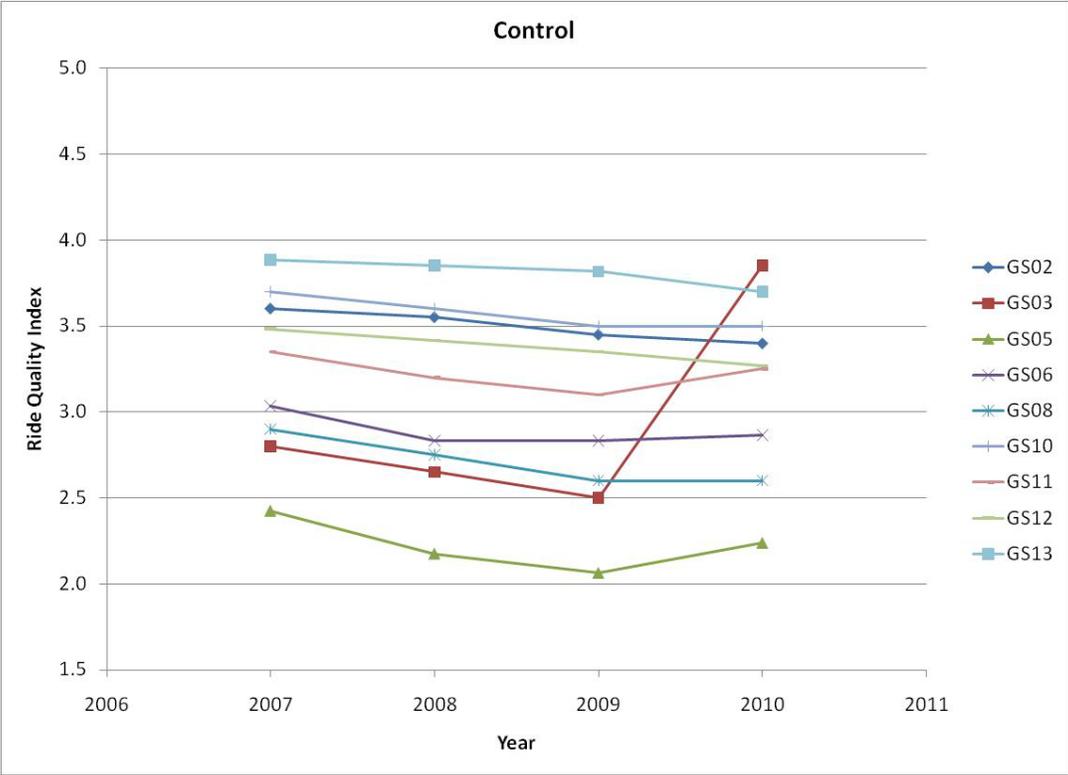
**Figure 13. IRI Performance Trend – Saw & Seal**



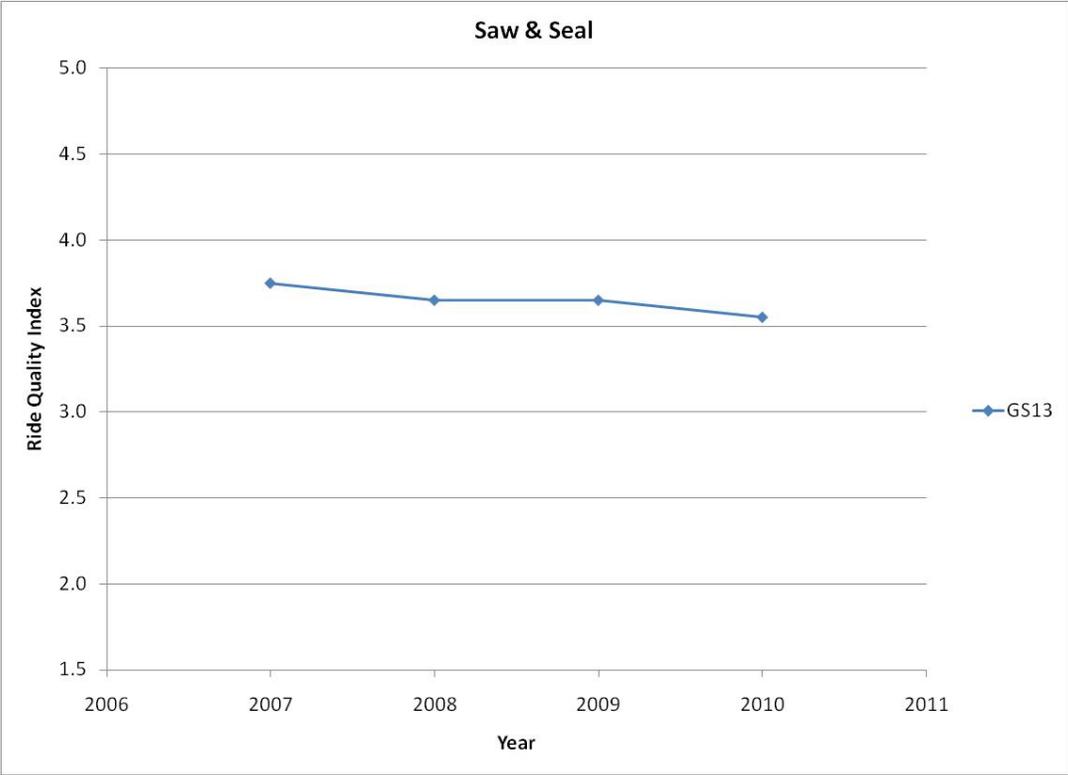
**Figure 14. RQI Performance Trend – Type V Fabric**



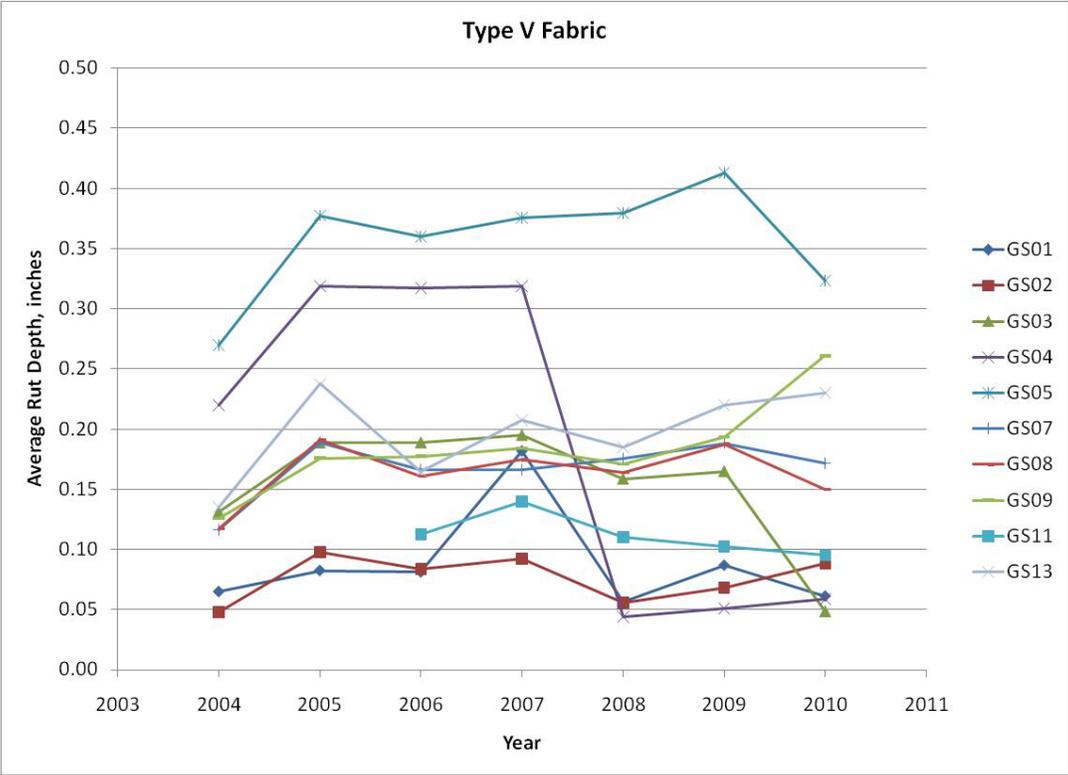
**Figure 15. RQI Performance Trend – Geogrid**



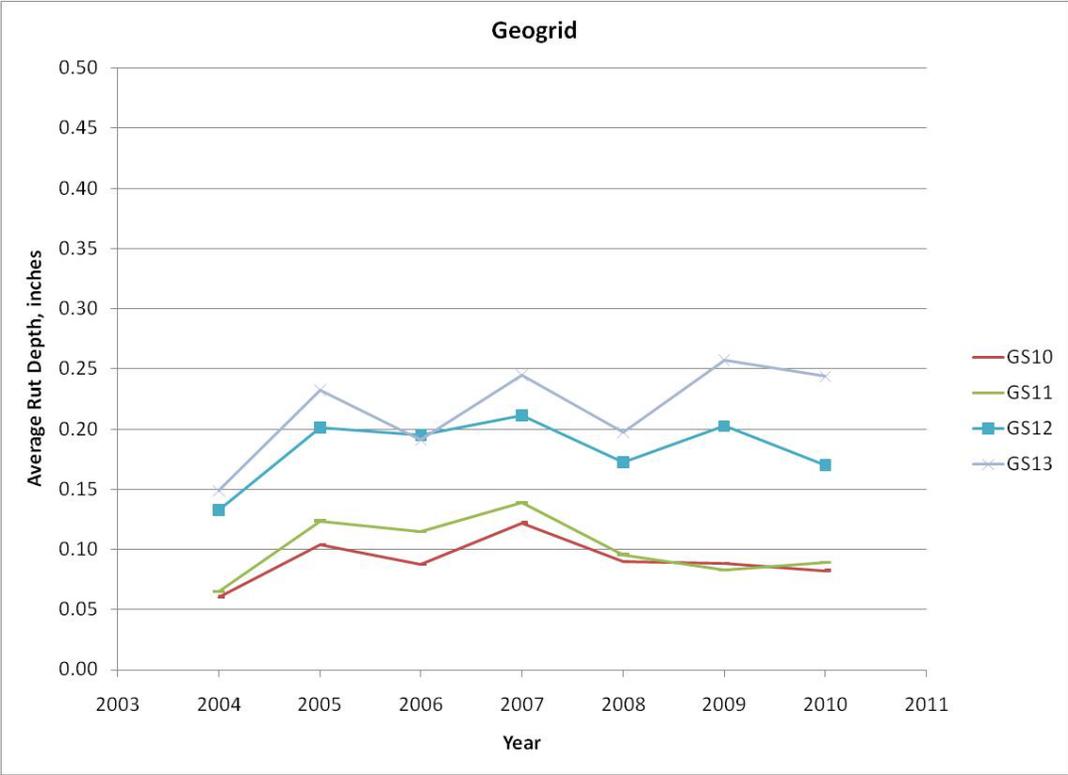
**Figure 16. RQI Performance Trend – Control**



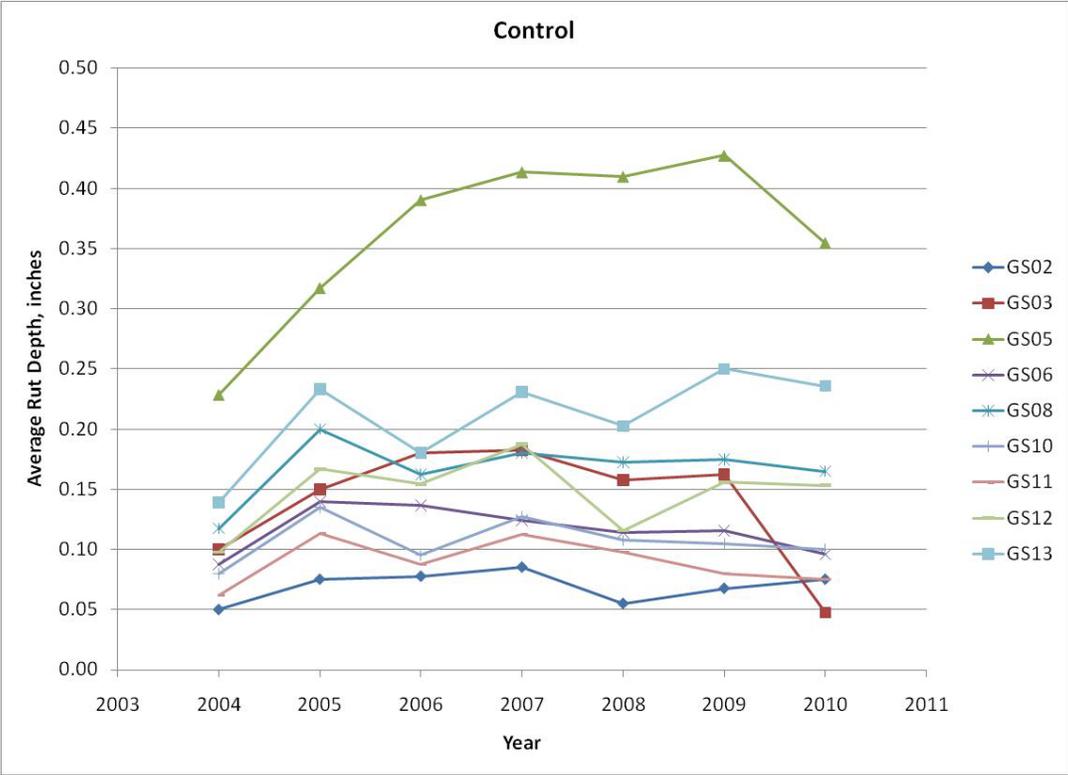
**Figure 17. RQI Performance Trend – Saw & Seal**



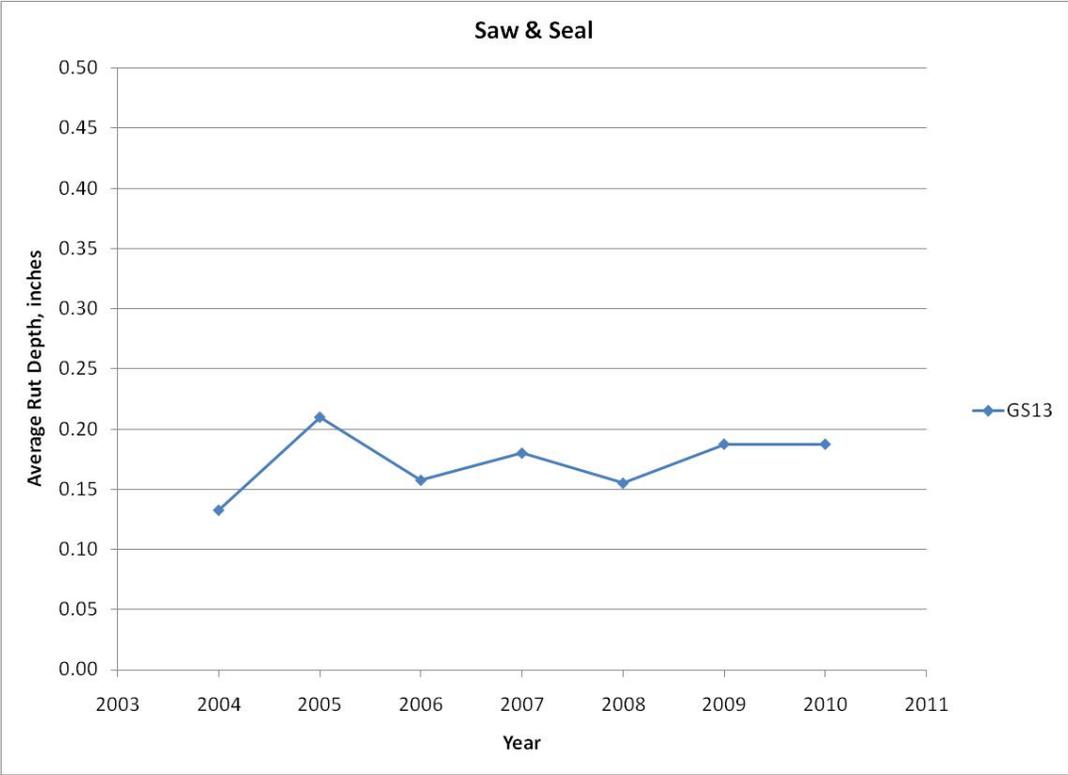
**Figure 18. Rutting Performance Trend – Type V Fabric**



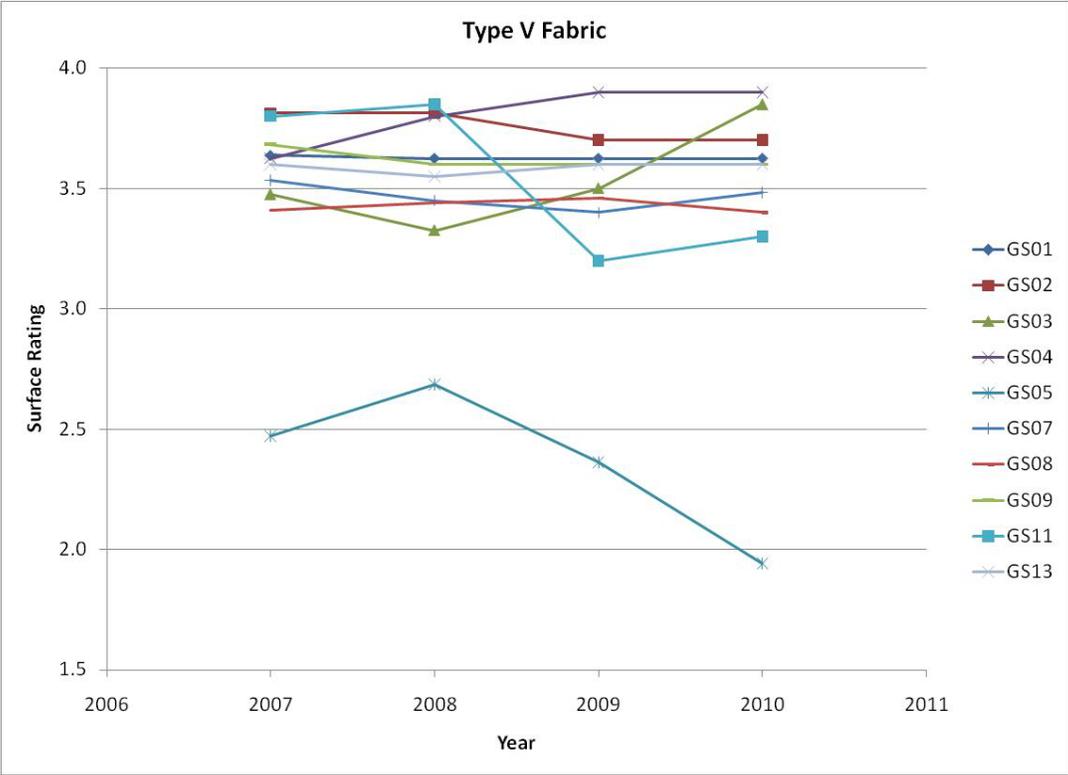
**Figure 19. Rutting Performance Trend – Geogrid**



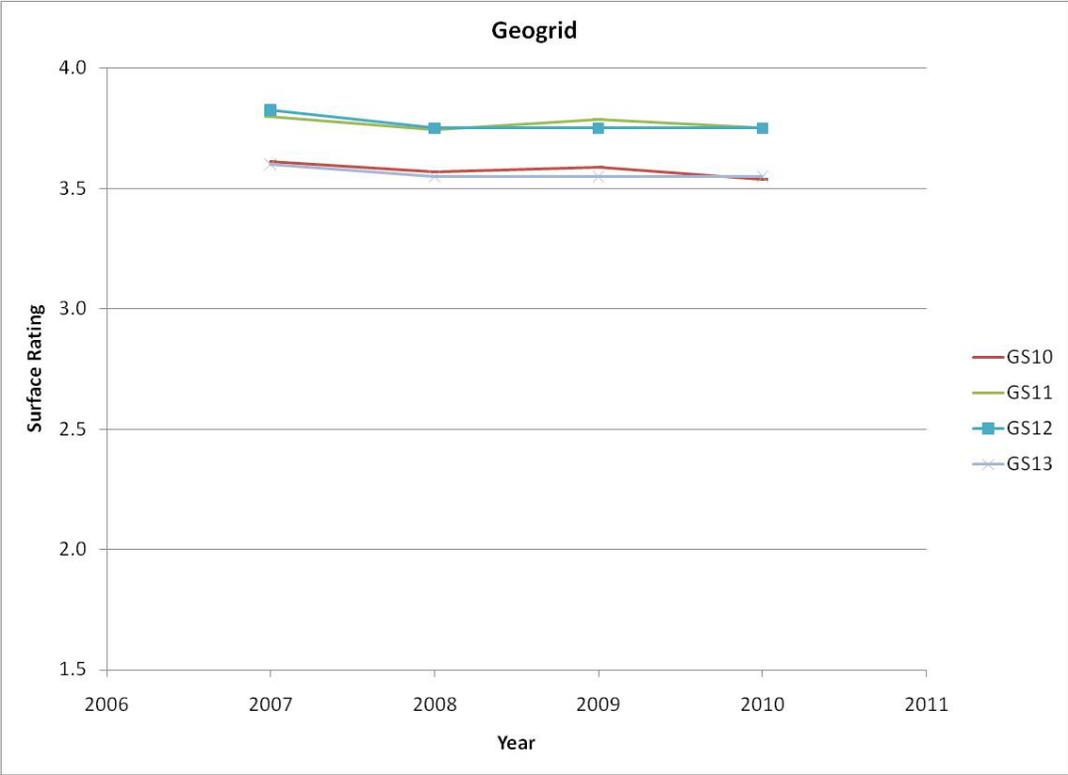
**Figure 20. Rutting Performance Trend – Control**



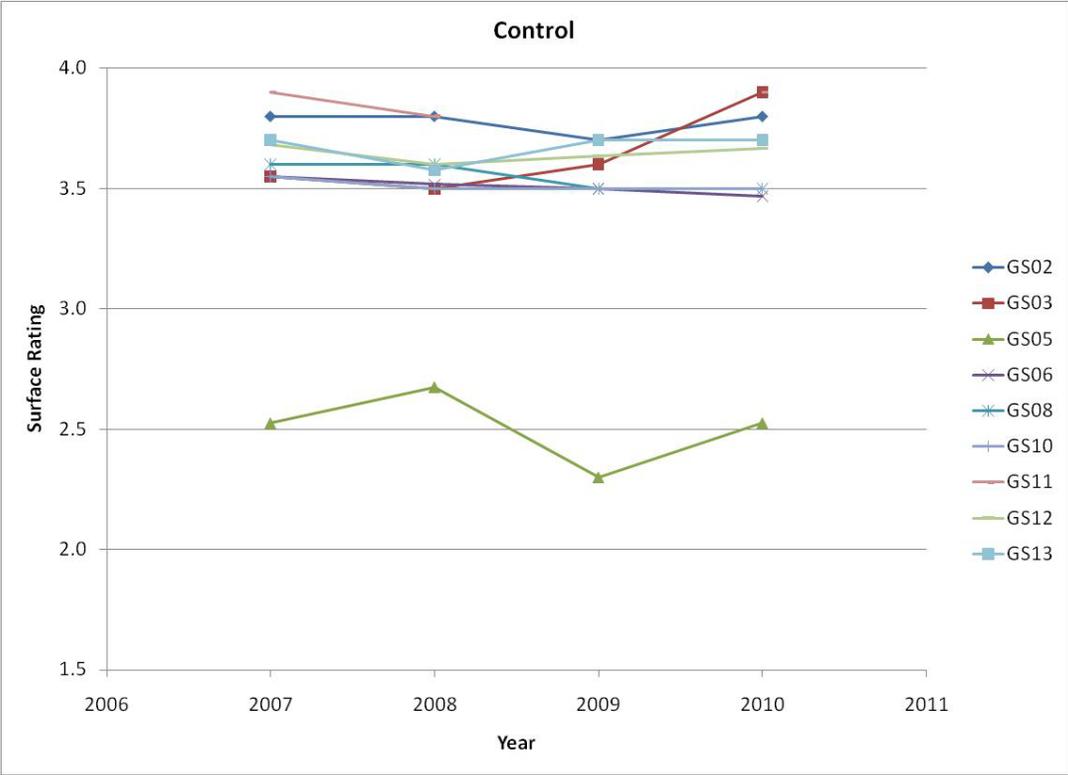
**Figure 21. Rutting Performance Trend – Saw & Seal**



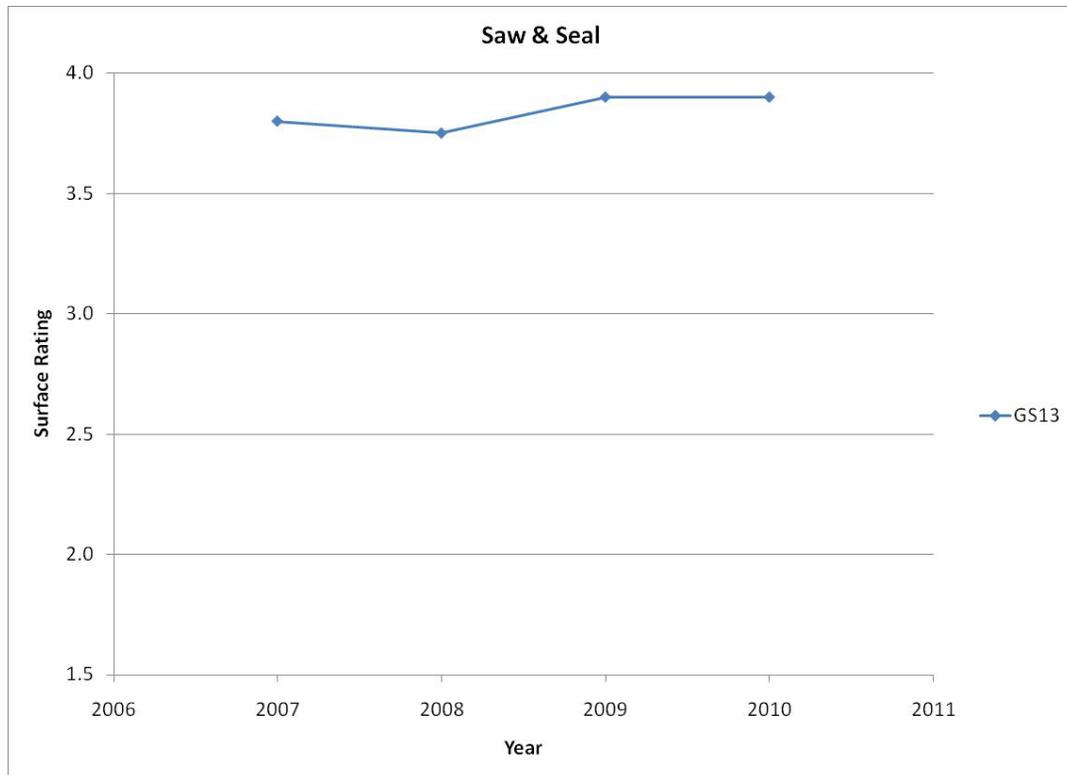
**Figure 22. SR Performance Trend – Type V Fabric**



**Figure 23. SR Performance Trend – Geogrid**



**Figure 24. SR Performance Trend – Control**



**Figure 25. SR Performance Trend – Saw & Seal**

*IRI Performance Trends*

The first group of figures shows the trends over time in International Roughness Index (IRI) of the various geosynthetic test sections. As a first step, a few general observations can be noted. Each of the curves slope upward, which means that the pavement sections are getting rougher over the course of time. Some sections deteriorate more rapidly than others, and it is not immediately apparent if the overall rate of deterioration for the geosynthetic sections is any different than that of the control sections. In addition some of the test sections (i.e., GS03, GS04, and GS05) show drastic reductions in IRI values from one particular year to the following year. This is likely because of reconstruction or maintenance being performed on the pavements at some point in time.

From the figures it can be deduced that roads that are built smooth stay smooth longer, and conversely roads that have built-in roughness get rough quicker. The pavements with IRI values down around 1.0 m/km tend to have a flatter slope than the pavements with initial IRI values around 2.0.

The fabric and control sections have the widest range of IRI values across all test sections, ranging from about 0.7 to about 2.9 m/km. The geogrid sections are in a tighter cluster with IRI values between about 0.6 to 1.4 m/km, and of course there is only one saw & seal section. It is also generally true that within a particular section (i.e., GS05 or GS13) the various geosynthetic or control treatments are in a similar range. This may indicate that the local conditions of the

road itself are more indicative of pavement performance than whether or not a geosynthetic was used.

### *RQI Performance Trends*

The next group of figures shows the trends over time in Ride Quality Index (RQI) of the different geosynthetic test sections. These plots are basically mirror images of the IRI plots, which is to be expected since IRI and RQI are mathematically related. The same trends that were shown in the IRI plots are seen in the RQI plots. The pavements that begin smooth stay smooth longer. No clear distinctions can be made between treatment times on the rate of deterioration of ride quality. Reconstruction or maintenance can be readily seen in the RQI plots. Finally, the fabric and control sections have a wide range of RQI values while the geogrid sections are more closely grouped.

### *Rutting Performance Trends*

The third group of figures shows the trends over time in rutting performance of the various geosynthetic test sections. These figures do not show a very clear picture of performance. This may be because the nature of the Pathways van is geared more towards network level analysis than project-specific analysis.

Nevertheless, a few pieces of information can be gleaned from the figures. It is apparent that pavement rutting increases rapidly the first few years after construction and then flattens out over long periods of time. Some pavements have continued rutting from year to year (i.e., GS05), while others (i.e., GS02) remain relatively constant. Sections GS05 and GS04 exhibited rather high rut depths over time (greater than 0.3 inches), which likely explains why some sort of maintenance or construction was performed on those roads. Most of the other test sections have stayed below 0.2 inches of rutting, which is acceptable for a low volume road in these situations. Again, the fabric and control sections show the greatest spread in rutting data, while the geogrid sections are more closely grouped together.

### *SR Performance Trends*

The final group of figures in the above section shows the trends over time in Surface Rating (SR) of the various geosynthetic test sections. The SR data encompasses rutting, cracking, and other surface distress data types, so the SR plots can be seen as an overall assessment of the condition of the pavement surface.

Several curious observations can be made from looking at the plots. First, Section GS05 is the lone section that has appreciably more distress than any of the other sections. Next, the fabric section in GS11 has shown much more distress than the geogrid and control sections on the same highway. In this case, the fabric sections have the most spread in SR values, while both the geogrid and control (with the exception of GS05) sections are more closely grouped together.

Another interesting observation with the SR data are that while in many of the sections the SR value decreases over time (which is to be expected) in some of the other sections the SR value increases with time. It is unclear whether or not pavement distresses are actually disappearing, being reclassified into different categories, or some other phenomenon is occurring.

A final discussion point is worth noting. The data gathered in this project on geosynthetics is consistent with a much larger body of data that was discussed at a recent research seminar by Erland Lukanen of the MnDOT Pavement Management section (3). During the seminar Lukanen presented data from the MnDOT Pavement Management system, which collects pavement performance data annually on 12,000 miles of trunk highways owned by the state of Minnesota. He presented data that clearly showed that new BAB (bituminous over aggregate base) pavements are exhibiting shorter RQI lives but longer SR lives compared to pavements built in earlier decades. Improvements have been made in the mix design, materials selection, and construction that have reduced the amount of distress in asphalt pavements that develop over time. Lukanen postulated that one reason this may be occurring is because while a lot of attention has been given to the asphalt surface layers in recent years, it has come at the expense of attention being paid to the underlying base and subgrade layers. While ride quality is determined in large part by the amount of pavement surface distress, that is obviously not telling the whole story.

### **Geosynthetics Performance Summary**

Perhaps the clearest picture of the performance of geosynthetic test sections compared to control sections can be seen in the following six figures. For each of these figures, all of the pavements that include a particular geosynthetic treatment (type V fabric, geogrid, control, saw & seal) are averaged together for a particular year. For example, there are ten different fabric sections in which their performance values are averaged to achieve a single fabric value. The saw & seal curves on the figures only come from a single test section, so any conclusions drawn from this data must be taken with caution. In addition, this saw & seal section was constructed over subgrade soils with soil factor = 75, while most of the other geosynthetic sections had soil factor =130.

Figure 26 shows the IRI performance over time on each of the four types of test sections. In this figure the geogrid and saw & seal sections are clearly smoother than both the fabric and geogrid sections. In fact, the performance curves for the fabric and control sections are virtually indistinguishable. This indicates that little if any benefit in ride quality can be gained by using geofabrics, although some benefit is clearly gained by using geogrids.

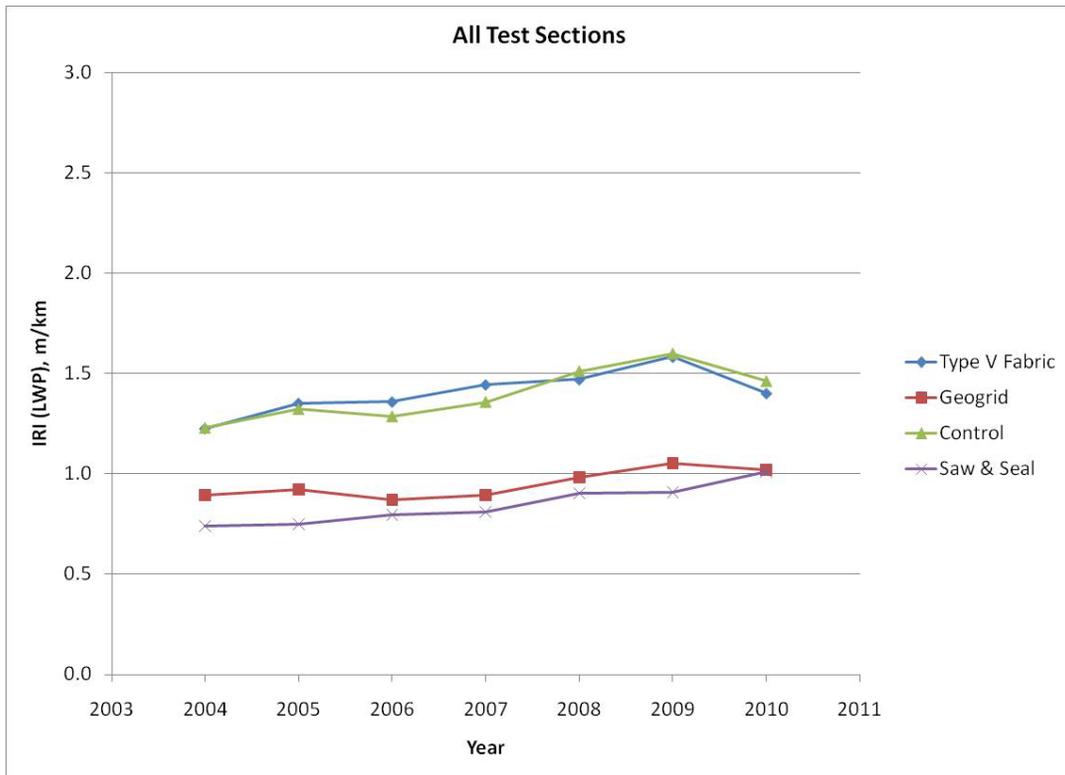
Figure 27 shows the RQI performance over time of the four types of geosynthetic treatments. Again, this figure is essentially a mirror image of the IRI plot. It shows that fabric and control sections are equivalent and that the geogrid and saw & seal sections have superior ride quality.

Figure 28 shows the rutting performance over time of the four types of test sections. It appears that the geogrid sections have slightly less rutting (and therefore greater structural capacity) than the control sections, while the fabric and saw & seal sections have slightly more rutting than the control sections. The performance curves are bunched closely together and somewhat difficult to decipher, but it does appear that slight differences in rutting performance can be observed.

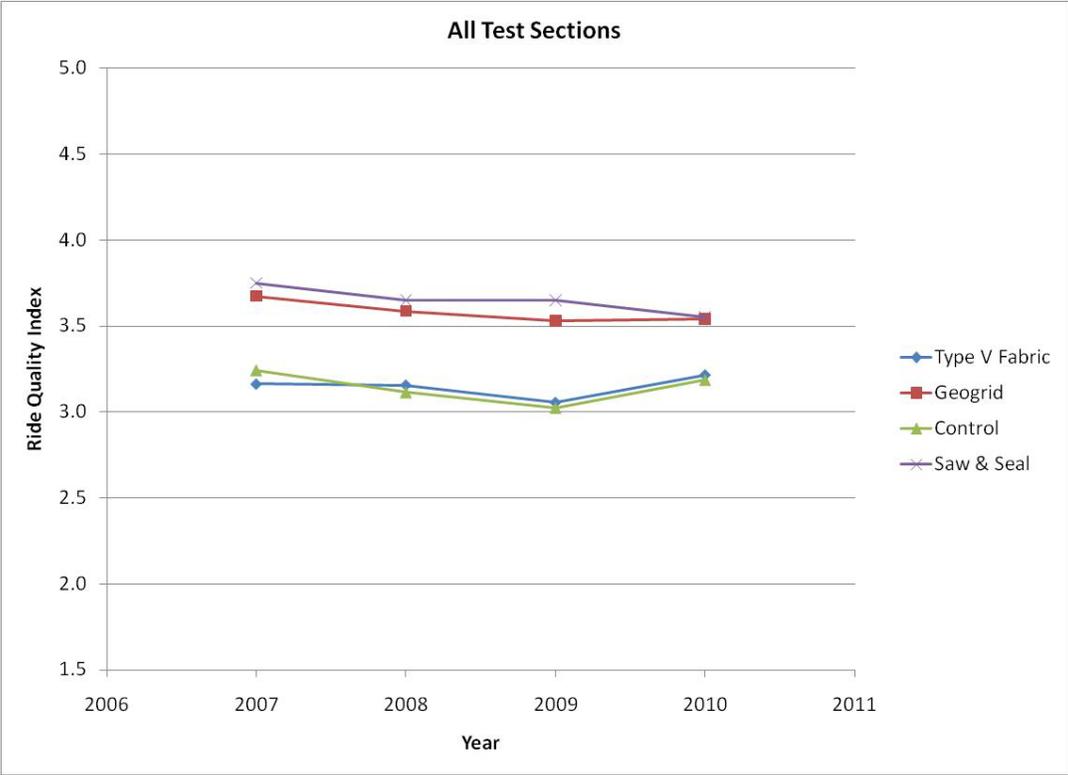
Figure 29 shows the SR performance over time of the four types of geosynthetic treatments. The saw & seal section is clearly the best performer in terms of surface distress, while the geogrid sections follow closely behind. The fabric and control sections follow the same low track, with the control sections outperforming the fabric sections in the most recent year. The improvement

in cracking performance hoped for by using geosynthetic fabrics has clearly not been attained in this project.

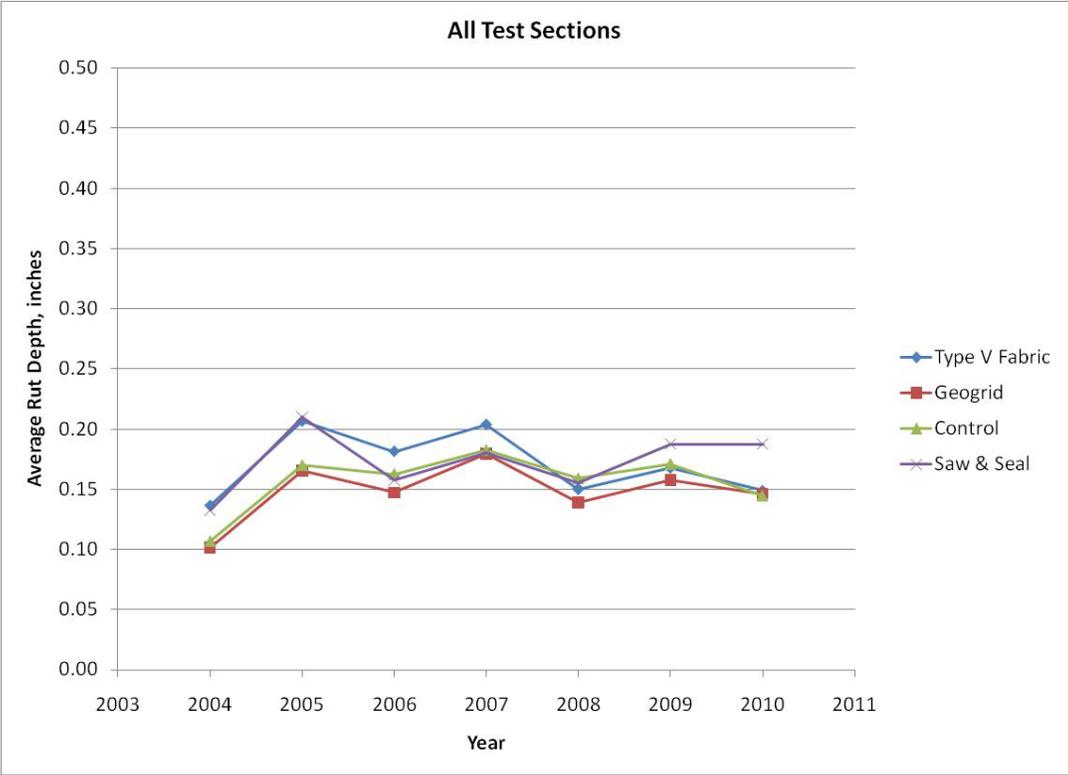
The final two figures show the transverse and longitudinal cracking performance over time of the four types of test sections. Figure 30 shows that on average the control sections have the highest number of transverse cracks, closely followed by the fabric sections. The geogrid and saw & seal sections have much less transverse cracking on average. In Figure 31 we see that the fabric sections have the largest extent of longitudinal cracking, with the control sections having less. Again the geogrid and saw & seal sections have the lowest extent of longitudinal cracking, although the rate of cracking is increasing more rapidly in recent years.



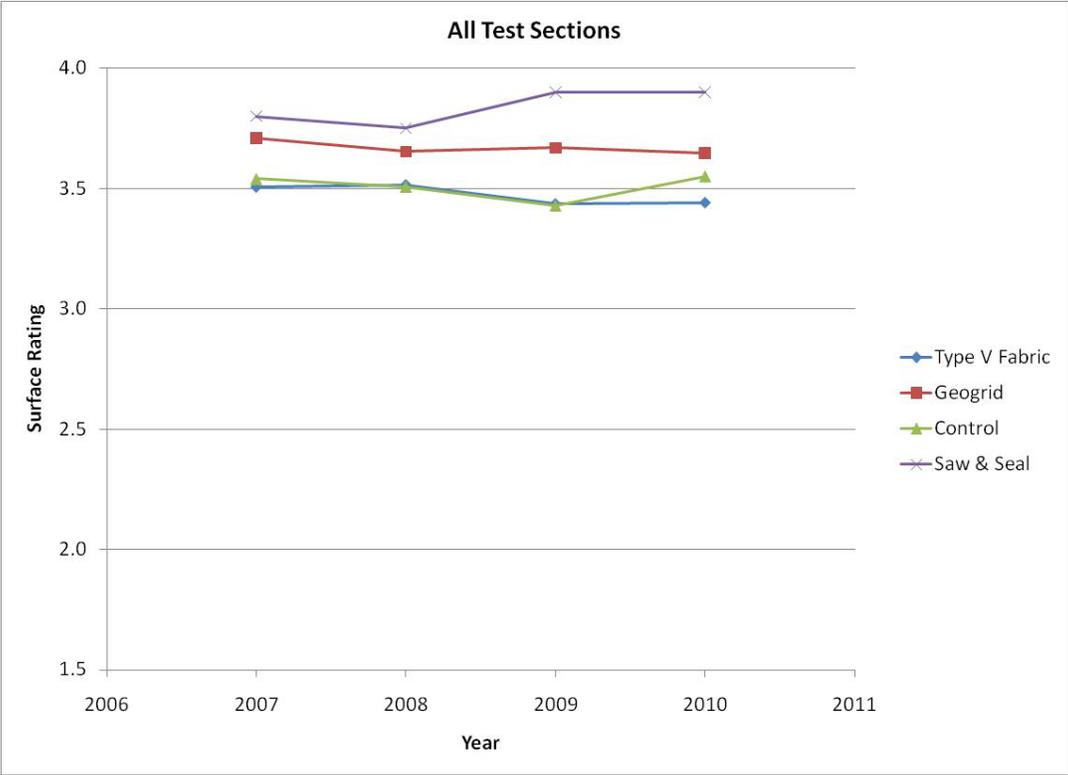
**Figure 26. IRI Performance Summary – All Test Sections**



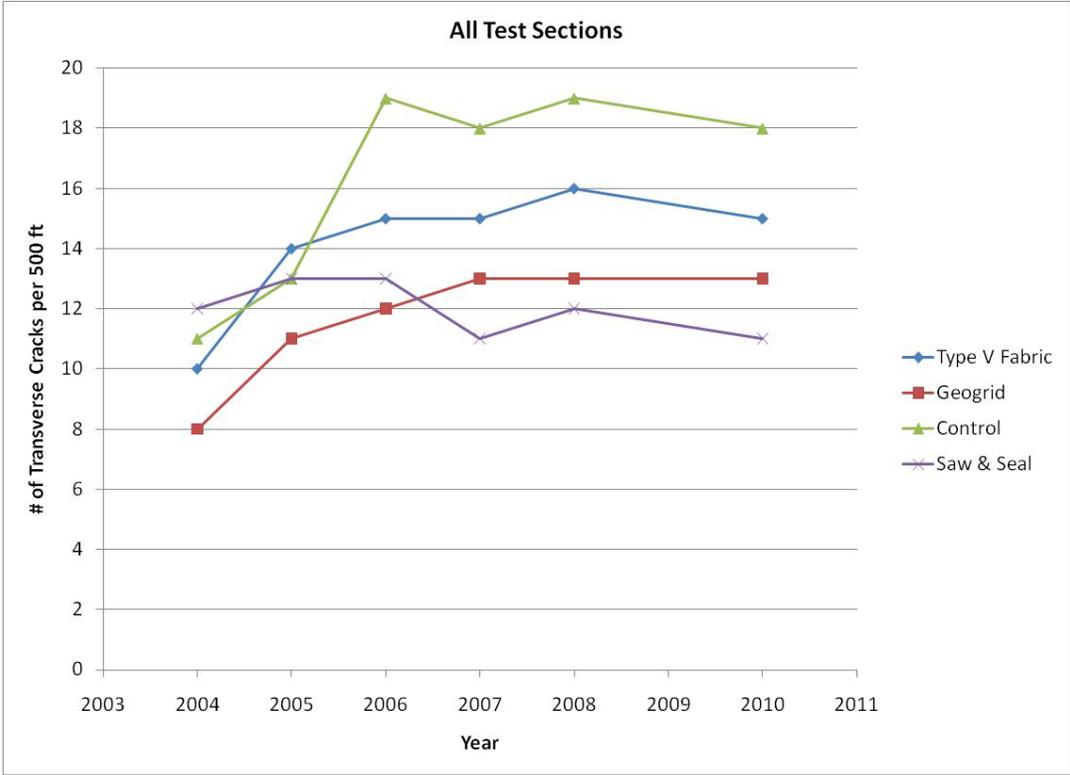
**Figure 27. RQI Performance Summary – All Test Sections**



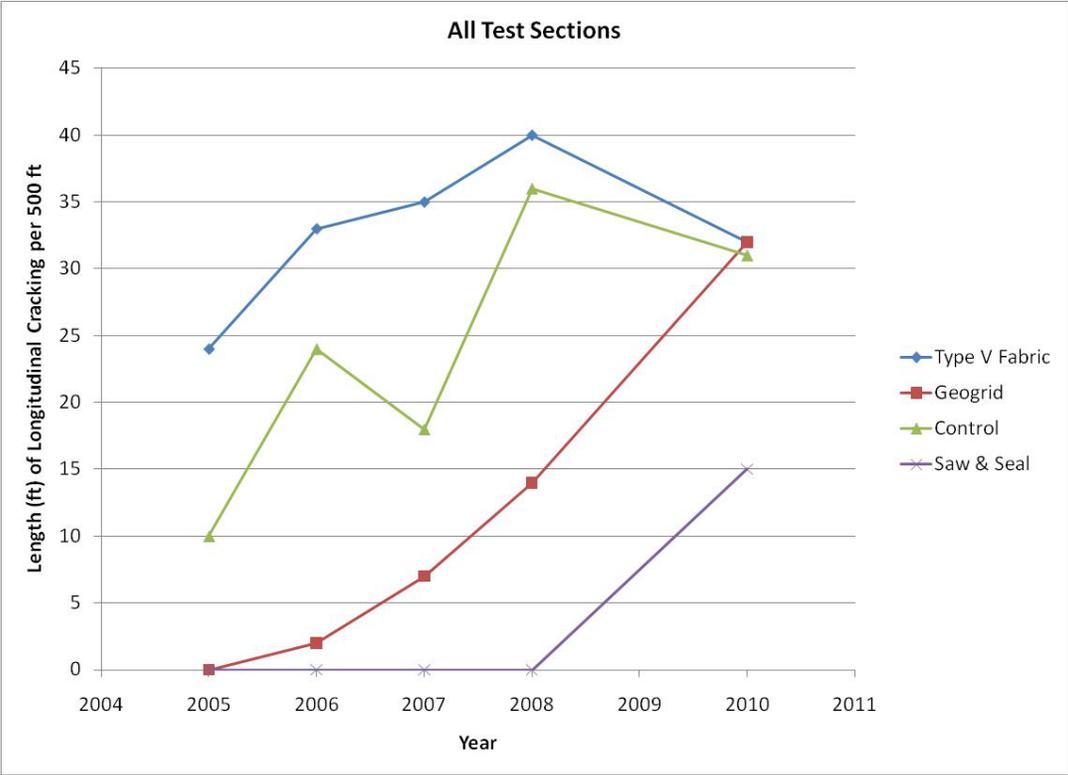
**Figure 28. Rutting Performance Summary – All Test Sections**



**Figure 29. SR Performance Summary – All Test Sections**



**Figure 30. Transverse Cracking Performance Summary – All Test Sections**



**Figure 31. Longitudinal Cracking Performance Summary – All Test Sections**

## Chapter 5. Conclusions and Recommendations

### Conclusions

Geosynthetics (geofabrics and geogrids) have been used in several test sections on 13 county state aid highways in northwestern Minnesota. The sections were constructed between 1993 and 2000, and data collection started in 2001 via the Pathways van and continued through 2010.

For this project, the data were analyzed in detail in terms of pavement smoothness, rutting, and cracking behavior. A snapshot of pavement performance in 2010 was provided, as were long-term performance trends for each individual test section as well as average behavior. Based on the data collected and analyzed for this project, the following conclusions were drawn:

1. The type V fabric and control sections have the widest range of pavement performance over time. Some sections perform quite well while others perform poorly. The geogrid sections are more closely grouped together.
2. The pavements that were constructed smooth at the outset tend to stay smooth over time. Pavements that are comparatively rougher initially increase in roughness more rapidly.
3. The ride quality (measured by ride quality index) decreases more rapidly than the distress index (measured by surface rating). This is consistent with pavement management data measured throughout the state of Minnesota.
4. Geosynthetic type V fabric sections exhibited the same roughness values as the control sections. The geogrid and saw & seal sections had better ride quality than the control sections.
5. The geogrid sections had slightly less rutting than the control sections, which indicates an increase in structural capacity. The type V fabric and saw & seal sections had more rutting than the control sections, indicating a lower structural capacity.
6. The saw & seal section had the highest surface rating, followed by the geogrid sections. The fabric and control sections had equally low surface rating. SR is a composite measure of surface distresses including rutting, cracking, and other distresses; using type V fabric did not show any benefit in this regard.
7. All of the geosynthetic treatments did lead to less transverse cracking than the control sections, which may lead to lower maintenance costs over time. However, the type V fabric sections exhibited much more longitudinal cracking than the control sections. The geogrid showed less longitudinal cracking than the control sections, but the rate of cracking has been increasing rapidly in recent years.
8. Type V fabric geosynthetics did not provide for the increased strength or better pavement performance that was expected at the beginning of this project. Unfortunately, the pavements in this study constructed with fabrics performed only as good as, and sometimes worse than, those without geosynthetics.

9. The use of geogrids did provide added strength, increased smoothness, and less cracking compared to pavements without geogrids. This type of treatment clearly did show a benefit to pavement performance.

## **Recommendations**

The following recommendations are made as a result of this project:

1. Type V fabrics may provide a benefit for construction operations in terms of providing a stable foundation and separating fine from course materials. However, they are not recommended in typical situations where increased performance or long-life, low-maintenance pavements are expected.
2. Geogrids, however, are recommended in situations where increased pavement strength is needed or where better pavement performance is expected.
3. Saw & seal can be a good technique used by pavement designers to control transverse cracking. The limited investigation of this treatment in this study makes it difficult to draw any strong conclusions. Further study of saw & seal sections on additional roadways with various subgrade soil types may be warranted.

## References

1. W. Leu and L. Tasa, "Applications of Geotextiles, Geogrids, and Geocells in Northern Minnesota," *Geosynthetics Conference 2001*, Portland, OR, 2001.
2. D. Janisch, *An Overview of Mn/DOT's Pavement Condition Rating Procedures and Indices*, Minnesota Department of Transportation, 2006.
3. E. Lukanen, *Luke's Ramblings*, Seminar Presented to Road Research, Maplewood, MN, May 5, 2011.