FLORIDA'S EXPERIENCE WITH CRACK-AND-SEAT REHABILITATION STRATEGY

Bouzid Choubane[1], Abdenour Nazef[1], James A. Musselman[1], and Bjorn Birgisson[2]
[1] FDOT Materials Research Park, 5007 N.E. 39th Avenue, Gainesville, FL 32609
Phone: (352) 955-6302, E-mail: bouzid.choubane@dot.state.fl.us
[2] Civil Engineering Department, University of Florida, Gainesville, FL 32611
Phone: (352) 846-3429, E-mail: bbirg@ce.ufl.edu

Paper submitted for consideration for presentation at the 2002 Association of Asphalt Paving Technologists (AAPT) Annual Meeting and Publication in the AAPT Journal.

Abstract

In 1993 and 1994, Florida initiated the construction of seven crack-and-seat projects on different parts of I-10. The primary intent was to obtain long-term field performance data to allow for a more rational assessment of the effectiveness of the crack-end-seat technique in minimizing reflection cracking in asphalt overlays. As a supplementary strategy to further reduce reflective cracks, the projects also included an asphalt-rubber membrane interlayer (ARMI). The performance of a total of 14 two-lane sections was monitored, at the time of construction and periodically thereafter. After approximately seven years of service, all the projects still have very good to good ride characteristics while the majority of the sections exhibited less than 6-mm (0.25 in.) of rutting. In addition, the overall performance of the Florida crack-and-seat projects is still highly rated in terms of cracking and patching. Visual surveys indicated that the amount of cracking was still relatively insignificant in most of the tests sections.

All the present performance indications are that the crack-and-seat technique, when used in conjunction with an ARMI as in these projects, could be an effective rehabilitation strategy of PCC pavements.

Introduction

One of the major challenges that highway agencies face today is not how to design and construct new pavements but rather how to evaluate, maintain, and upgrade existing ones to meet today's trends toward heavier traffic loadings, greater traffic volumes, and higher tire pressures. In fact, most reported road-related expenditures are for maintenance, repair and rehabilitation.

A pavement is a highly complex structure from a stress analysis standpoint. It is supported by soil whose physical properties vary greatly from one location to another. It is also constantly subjected to traffic loads as well as to stresses due to variations in temperature and moisture conditions. In addition, materials properties change with aging, affecting accordingly the characteristics and the response of the pavement. Factors such as traffic loads, environment, and aging, tend to decrease the initial high serviceability level of pavements over time. At some point in time, the pavement would degrade to the level that the serviceability becomes unacceptable. At this stage, the pavement must be rehabilitated or reconstructed.

Transportation agencies have used various restoration treatments and strategies over the years in an effort to extend the service lives of the deteriorating pavements. Depending on the volume of traffic, the most prevalent treatment currently is the use of overlays. This paper focuses on hot-mix asphalt (HMA) overlays on portland cement concrete (PCC) pavements using a procedure referred to as the crack-and-seat procedure.

A major concern associated with HMA overlays on PCC pavements is reflection cracking. Reflection cracking is a premature failure mechanism that is detrimental to the ride quality and structural integrity of the pavement system. It is defined as the crack pattern in the overlay surface that originates or reflects off an existing crack or joint in the underlying layer. It is believed that this reflection is primarily induced by both the horizontal and the differential vertical movements occurring at the joints and cracks in the underlying pavement. The differential vertical movement is due to traffic loading while the horizontal movement is the result of temperature and moisture changes. Horizontal movements are generally believed to be more critical *(1)*.

Several methods may be used to potentially minimize the reflection cracking in HMA overlays on PCC pavements, with the crack-and-seat technique being one of the most common. This technique involves cracking the existing pavement into small sections with a gravity or pneumatic type breaker, seating these sections with heavy rollers, and then overlaying them with an asphalt mixture. The intent is to reduce the concrete slabs into sections small enough to minimize their movement but large enough to maintain some structural integrity through aggregate interlock. The cracked sections are approximately 0.35 to 0.55 m^2 (4 to 6 ft^2) in size.

Over the past 30 years, a number of states have experimented with the crack-and-seat method *(2, 3, 4)*. The results of those experiences have been mixed. Building on experiences and practices of other states, the Florida Department of Transportation (FDOT) constructed seven projects to evaluate the ease of construction and field performance of the crack-and-seat technique for Florida conditions. As a supplementary strategy to further reduce reflective cracks, the projects included the use of an asphalt-rubber membrane interlayer (ARMI).

Objective

Nationally, there have been several studies performed on the construction and field performance of HMA overlays on cracked-and-seated sections. However, the findings of these studies have not been all in agreement. Therefore, it was felt there was still a need for long-term field data to define performance that would allow for appropriate decisions in developing improved rehabilitation and reconstruction strategies. Thus, seven projects were planned with a short-term objective of verifying the construction specifications. The long-term objective was to monitor the field performance of the crack-and-seat procedure of overlay for Florida conditions. The results of such a performance evaluation are documented in this paper.

Project Descriptions

In 1993 and 1994, Florida initiated the construction of seven crack-and-seat projects. They were all two-lane rehabilitation projects located on I-10, both in the East and West directions. Therefore, a total of 14 sections were considered. The original pavement on this high volume facility was a 230-mm (9-in.) plain jointed PCC pavement with a 6-m (20-foot) joint spacing on a 300-mm (12-in.) cement stabilized base. On each project, a 4,000 lb. gravity-type breaker was used to crack the original pavement into 0.9-m (36-in.) maximum size pieces. The cracked slabs were seated using a pneumatic tired roller, followed by the placement of 15 mm (0.5 in.) of ARMI layer, 100 mm (4 in.) of typical Florida structural asphalt mixtures, as well as 15 mm (0.5 in.) of an open-graded friction course. The asphalt mixtures used on these projects, with the exception of the project in Gadsen County, contained recycled asphalt pavement (RAP). All the crack-and-seat sections were retrofitted with edgedrains. A summary of key information related to each of these projects is presented in Table 1, while Figure 1 shows schematic drawing of typical pavement cross-sections. Also, traffic data as collected for all the projects are summarized in Table 2.

Data Analysis

The objective of this work was to evaluate the projects such that an analysis could be made to assess the effectiveness of the crack-and-seat technique in minimizing reflection cracking in HMA overlays. The performance of the sections was evaluated at the time of construction and periodically thereafter. This evaluation was performed in terms of varying levels and amounts of specific distresses, namely, (1) rideability, (2) rutting, and (3) cracking and patching.

The trends in the performance data collected during this study are illustrated in Figures 2 through 7. The ride quality was rated in terms of the present serviceability. The latter rating was derived from readings taken with an automated profiler that measures deviations in a pavement surface. These deviations provide a measure of the smoothness or roughness of the pavement. The ride quality is rated on a scale of 0 to 5, with 0 being very poor (undriveable) and 5 being very good (new surface). The ride rating data, summarized in Figures 2 and 3, indicate that all the projects still have very good to good ride characteristics after seven years of service.

The rut depth measurements as plotted in Figure 4 and 5 show presently at most 6 mm rut on the majority of the sections considered in this evaluation. Typically, asphalt pavements in Florida average approximately 2.8 mm (0.11 in.) of rutting after one year of service *(5)*. This is mainly the result of consolidation of the structural layers. The two projects that seem to exhibit relatively higher levels of deformation are those located in Jefferson and Leon (second project) Counties where rut depths averaging approximately 12 mm (0.5 in) were recently recorded. It is likely that this rutting is due to problems with the asphalt mix since a number of problems were encountered during the mix production, and the same mix was placed on both projects. Critically low in-place air voids (ranging from 0.2 to 1.9 percent) were measured on the Leon County project *(6)*. Although this resulted in the removal and replacement of a substantial amount of pavement on this project before its completion in August of 1993, low in-place air voids ranging from 2.5 to 2.9 percent were still measured during a 1994 forensic investigation. It is also probable that the fine graded, 50-blow Marshall designed mixes were inadequate to withstand current loading conditions. Over the past 10-15 years, a significant number of asphalt pavements on Interstate projects in north Florida have experienced premature failures, primarily due to rutting *(7)*.

In any case, the major distress associated with the crack-and-seat technique is primarily reflection cracking. Therefore, a more appropriate measure of crack-and-seat field performance should be in terms of cracking. An earlier investigation elsewhere indicated that the cracking-and-seating method reduced reflection cracking during the first few years after construction, but after 4 to *5* years the cracking increased, thus questioning the effectiveness of such a rehabilitation procedure *(4)*. However, as illustrated in Figures 6 and 7, in combination with visual inspections, the overall performance, in terms of cracking and patching, of the Florida crack-and-seat projects is still highly rated. In most cases, this rating is equal or better than one would expect on asphalt overlays after approximately seven years of service. Although it should noted that, within the last 18 months, an increase in the amount of cracks was observed on the

Gadsen County project (in both directions) and, to a lesser extent, on the second project in Jackson County (westbound side), visual surveys still indicate that the amount of cracking was relatively insignificant in most of the sections.

All these observations cannot be directly associated with the crack-and-seat alone without including the potential performance of the ARMI layer. It has to be acknowledged that Florida has obtained encouraging results on the use of the ARMI as a stress-absorbing membrane in other applications *(8)*.

Conclusions

The present evaluation was initiated with the primary objective of collecting long-term field performance data on the effectiveness of the crack-end-seat technique in minimizing reflection cracking in HMA overlays. As a supplementary strategy to further reduce reflective cracks, the projects also included an asphalt-rubber membrane interlayer (ARMI). The performance of a total of 14 two-lane sections, all located on I-10 in North Florida, was monitored, at the time of construction and periodically thereafter. This performance was evaluated in terms of crack, rut, and ride characteristics. The analysis of the performance data collected on these sections after approximately seven years of service indicated the following:

- All projects still have very good to good ride characteristics on both east and west directions.
- The majority of the sections considered in this experiment exhibited at most 6-mm (0.25 in.) rutting. However, two projects, located in Jefferson and Leon (second project) Counties, showed relatively higher levels of deformation, averaging approximately 12 mm (0.5 in), although this appears to be asphalt mix related.
- Within the last 18 months, an increase in the amount of cracks was observed on the Gadsen County project (in both directions) and, to a lesser extent, on the second project in Jackson County (westbound side). However, the overall performance of the Florida crack-and-seat projects is still highly rated in terms of cracking and patching. Visual surveys indicated that the amount of cracking was still relatively insignificant in most of the sections.
- Performance data indicate that the crack-and-seat technique, when used in conjunction with an ARMI as on these projects, could be an effective rehabilitation strategy of PCC pavements.

Acknowledgments

The authors would like to acknowledge the staff of the FDOT Pavement Systems Evaluation Section for their diligent efforts in collecting all performance data. The assistance of Aubrey Graves, Third District Materials Engineer, and Pat Upshaw, State Materials Office Field Operations Engineer, in obtaining the construction data is also gratefully acknowledged.

References

1. Huang, Y. H. *Pavement Analysis and Design*. Prentice-Hall, Inc., New Jersey, 1993.
2. Thompson, M. R. *NCHRP Synthesis of Highway Practice 144: Breaking/Cracking and Seating Concrete Pavements*. TRB, National Research Council, Washington, D.C., 1989.
3. Wells, G. K., J. B. Hannon, and N. H. Predoehl. California Experience with Cracking and Seating of Concrete Pavements. In *Transportation Research Record 1307*, TRB, National Research Council, Washington, D.C., 1991.
4. *Crack-and-Seat Performance*. Review Report, Demonstration Projects Division and Pavement Division, Federal highway administration, Washington, D.C., 1987.
5. *Annual Rut Depth Survey of Random Projects Let in 1986*. Unpublished Data, Florida Department of Transportation, State Materials Office, Gainesville, FL, 1994.
6. J. A. Musselman, G. C. Page, D. C. Romano, and R. C. West. *Pavement Distress Investigation I-10, Leon County.* Technical Report 94-3, Florida Department of Transportation, State Materials Office, Gainesville, FL, December 1994.
7. J. A. Musselman, B. Choubane, G. C. Page, and P. B. Upshaw. Superpave Field Implementation: Florida's Early Experience. In *Transportation Research Record 1609*, TRB, National Research Council, Washington, D.C., 1998.
8. B. Choubane, G.A. Sholar, J.A. Musselman, and G.C. Page. Ten-Year Performance Evaluation of Asphalt-Rubber Surface Mixes. In *Transportation Research Record 1681*, TRB, National Research Council, Washington, D.C., 1999.

TABLE 1 PROJECTS INFORMATION SUMMARY

Project No.	Completion Date	Location		Primary Contractor
		Milepost Limits	County	
54001-3429	Mar-94	4.920 to 10.007	Jefferson	Anderson Columbia
55320-3435	Jan-95	4.573 to 8.576	Leon	Peavy
55320-3436	Aug-93	15.630 to 19.755	Leon	Anderson Columbia
50001-3437	Mar-94	20.437 to 31.538	Gadsden	C. W. Roberts
53002-3428	Nov-94	8.680 to 10.351	Jackson	White
53002-3439	Nov-94	10.351 to 13.609	Jackson	Anderson Columbia
60002-3418	Nov-93	18.10 to 24.061	Walton	Okaloosa Asphalt

TABLE 2 TRAFFIC DATA SUMMARY

Project No.	County	Survey Year	AADT*	Percent Truck
54001-3429	Jefferson	1994	18,888	20
		1995	19,207	20
		1996	19,873	20
		1997	20,905	21
		1998	21,782	21
		1999	22,803	20
55320-3435	Leon	1995	42,510	11
		1996	44,045	11
		1997	45,776	10
		1998	48,530	11
		1999	52,245	12
55320-3436	Leon	1995	19,207	20
		1996	19,873	20
		1997	20,905	21
		1998	21,782	21
		1999	22,803	20
50001-3437	Gadsen	1995	20,885	26
		1996	21,619	24
		1997	23,116	18
		1998	24,378	17
		1999	26,960	18
53002-3428	Jackson	1994	14,400	18
		1995	16,463	18
		1996	17,296	18
		1997	18,044	14
		1998	18,723	23
		1999	19,968	17
53002-3439	Jackson	1994	14,400	18
		1995	16,463	18
		1996	17,296	18
		1997	18,044	14
		1998	18,723	23
		1999	19,968	17
60002-3418	Walton	1994	14,544	18
		1995	14,424	17
		1996	14,638	18
		1997	15,573	22
		1998	16,315	24
		1999	17,456	21

* Annual Average Daily Traffic.

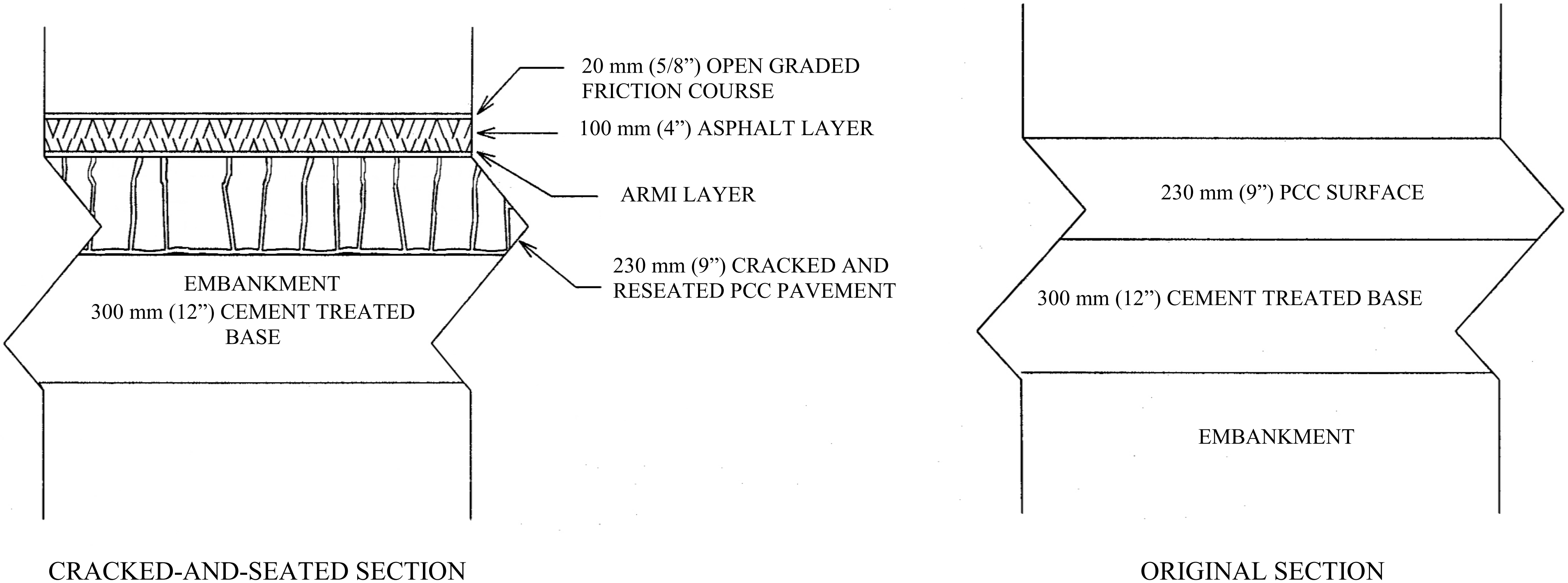

Figure 1 Schematic drawing of typical pavement cross-sections

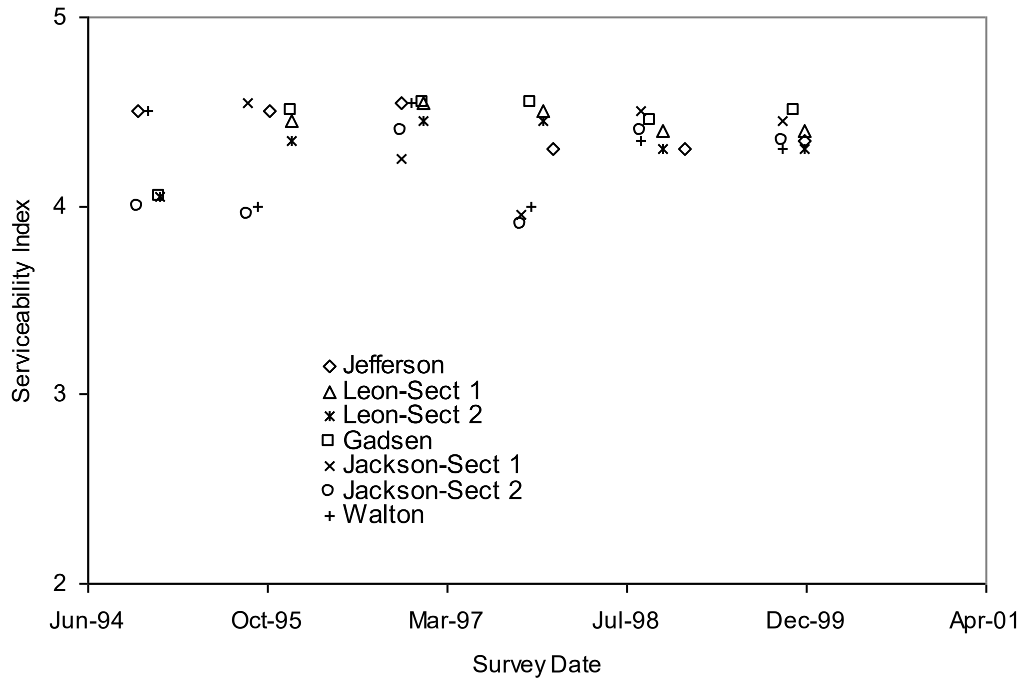

Figure 2 Ride quality vs. time as measured on the eastbound direction

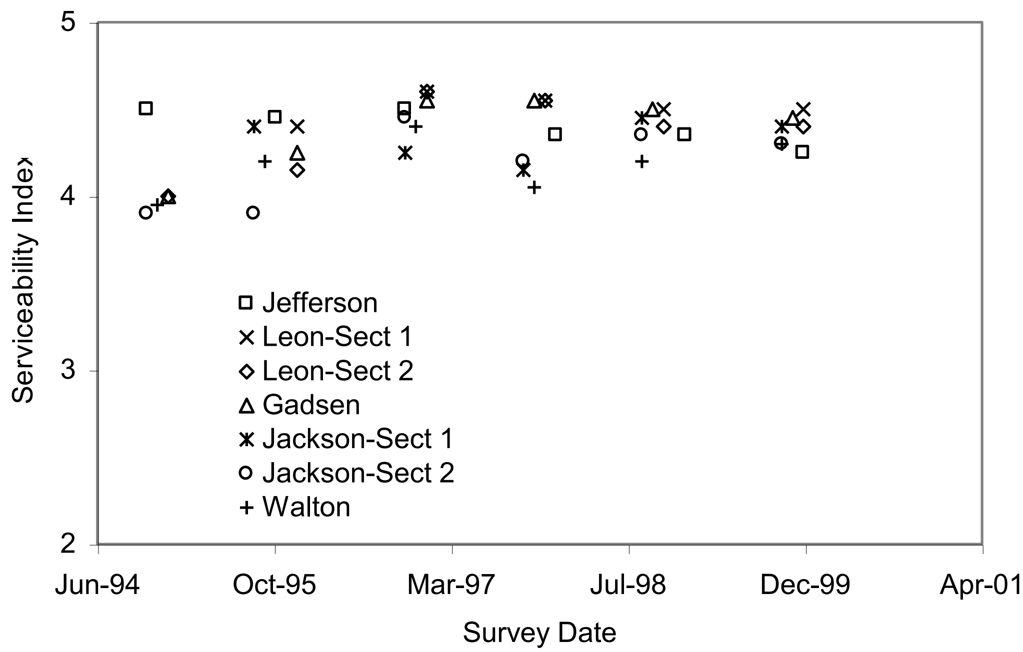

Figure 3 Ride quality vs. time as measured on the westbound direction

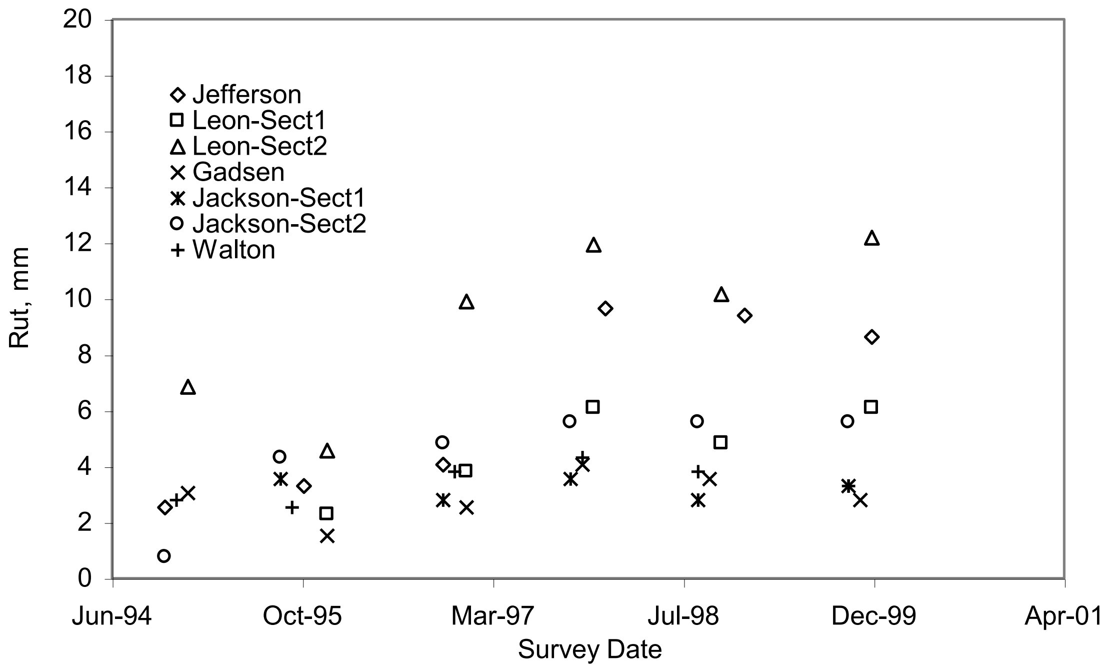

Figure 4 Rut depth vs. time as measured on the eastbound direction

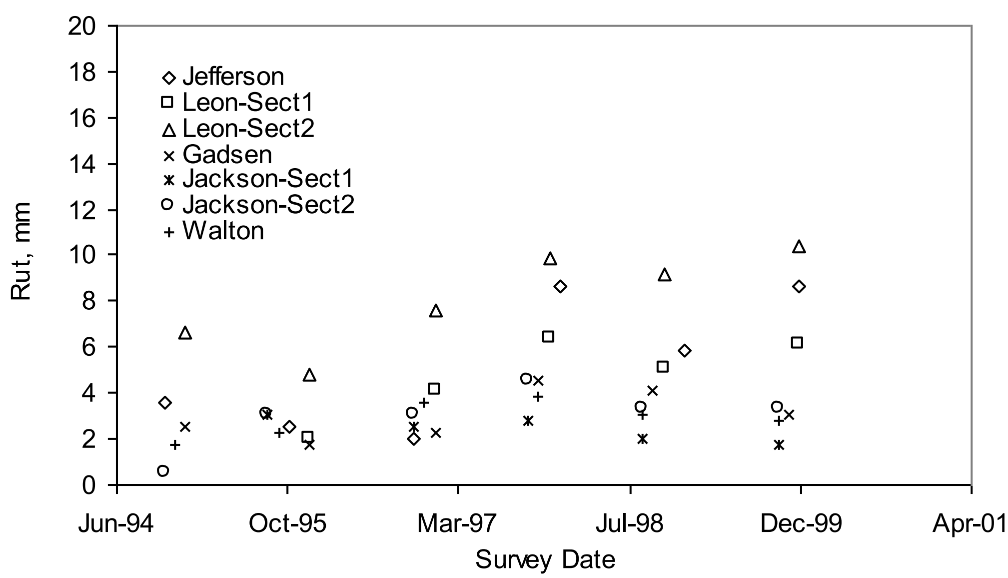

Figure 5 Rut depth vs. time as measured on the westbound direction

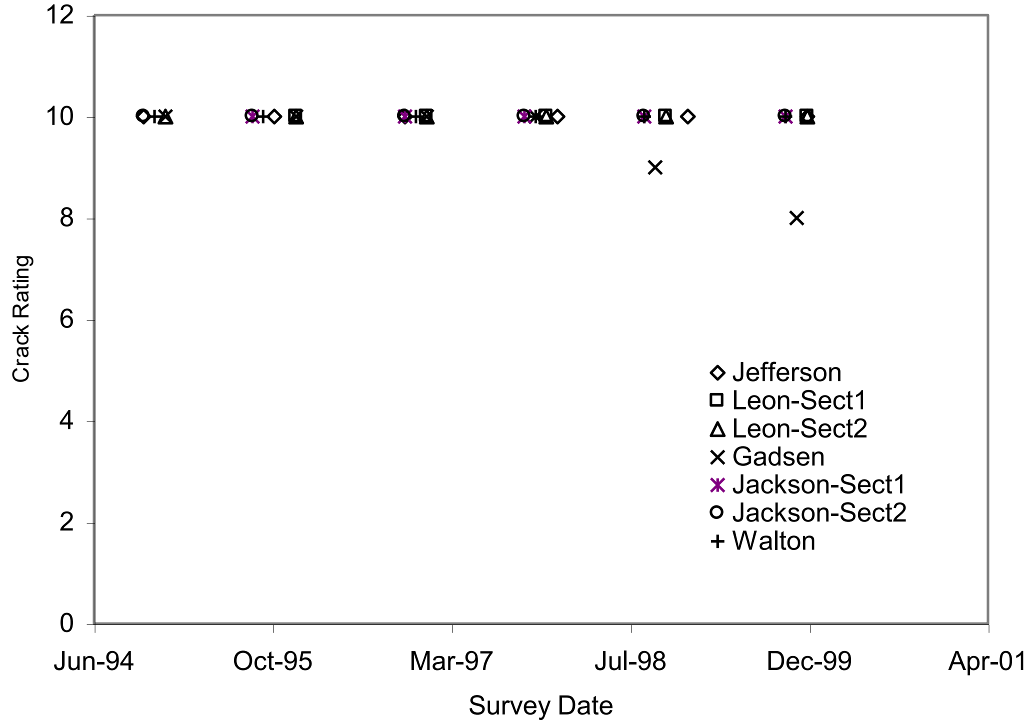

Figure 6 Crack rating vs. time as measured on the eastbound direction

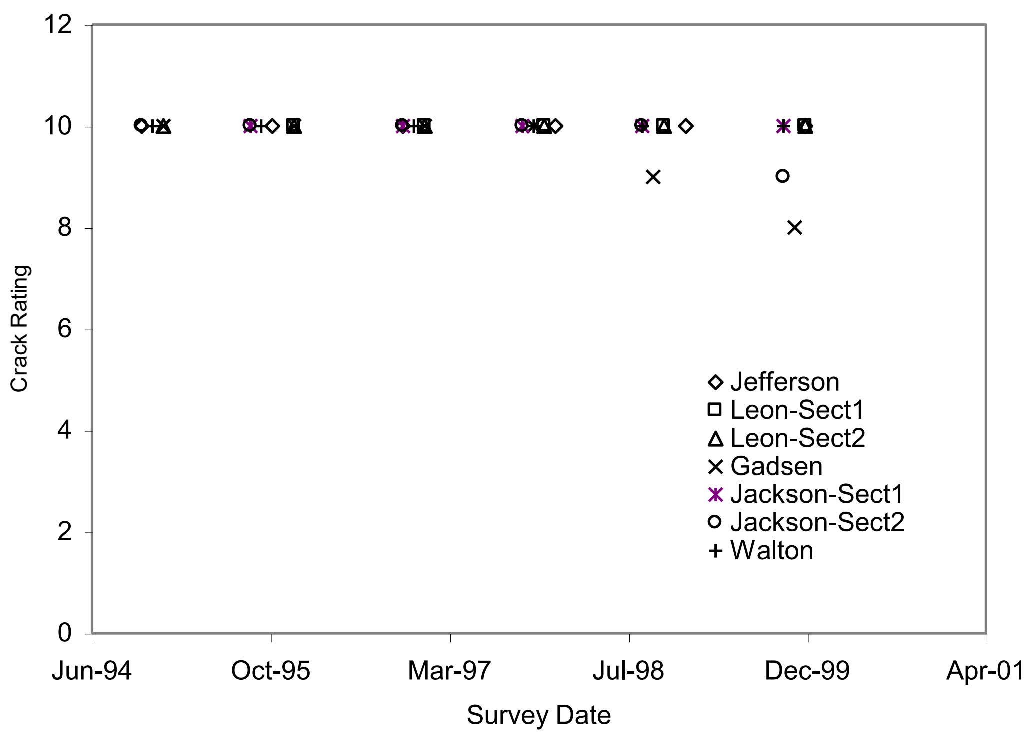

Figure 7 Crack rating vs. time as measured on the westbound direction