



RESEARCH

2007-18

Performance of Ultra-Thin Bonded Wearing Course (UTBWC) Surface Treatment on US-169 Princeton, Minnesota

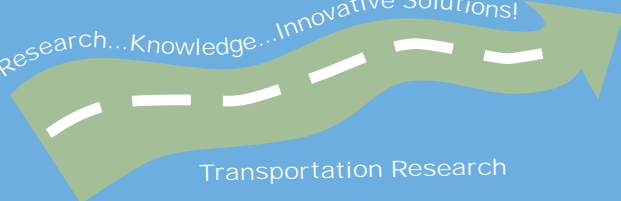


Take the



steps...

Research... Knowledge... Innovative Solutions!



Transportation Research

Technical Report Documentation Page

1. Report No. MN/RC – 2007-18	2.	3. Recipients Accession No.	
4. Title and Subtitle Performance of Ultra-Thin Bonded Wearing Course (UTBWC) Surface Treatment On US-169 Princeton, MN		5. Report Date May 2007	
		6.	
7. Author(s) Malaki Musa Ruranika & Jerry Geib		8. Performing Organization Report No.	
9. Performing Organization Name and Address Office of Materials 1400 Gervais Avenue Maplewood, MN 55109		10. Project/Task/Work Unit No.	
		11. Contract (C) or Grant (G) No.	
12. Sponsoring Organization Name and Address Minnesota Department of Transportation 395 John Ireland Boulevard Mail Stop 330 St. Paul, Minnesota 55155		13. Type of Report and Period Covered Final Report	
		14. Sponsoring Agency Code	
15. Supplementary Notes http://www.lrrb.org/media/reports/200718.pdf			
16. Abstract (Limit: 250 words) <p>The purpose of this report is to evaluate the performance of 1999 and 2000 ultra-thin bonded wearing course (UTBWC) surface treatment on US-169 in Princeton, Minnesota. The UTBWC consisted of gap graded course aggregate hot mix asphalt over a heavy asphalt emulsion layer and it was placed at an average thickness of 3/8". For comparison purposes, a control section was established to assess the performance of the overlay. This section continues to be maintained using standard sealing and patching techniques. The surface roughness and condition of these sections have been monitored on yearly basis.</p> <p>The overall performance of the UTBWC sections has been very good, while the control section is currently in need of major rehabilitation. The UTBWC appears to provide an economical choice for pavements in need of minor rehabilitation. In addition, UTBWC may prove beneficial as a preventive maintenance option. It should be considered for all sections with minor cracking and roughness distresses that do not stem from subgrade problems.</p> <p>Nationwide research has shown that UTBWC reduces deterioration caused by weathering, oxidation, traffic and provides good skid resistance, reduced rolling noise, reduction of hydroplaning, and back spray from roadway. UTBWC does not increase the structural capacity of the pavement, however, the use of UTBWC on new pavements as a wearing course could be considered.</p>			
17. Document Analysis/Descriptors Novachip, UTBWC, Pavement, Preventive Maintenance, Performance, Ultra-thin, Hot mix asphalt, Ride Quality Index, RQI		18. Availability Statement No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages XXX	22. Price

Performance of Ultra-Thin Bonded Wearing Course (UTBWC) Surface Treatment on US-169 Princeton, MN

Final Report

Prepared by:

Malaki Musa Ruranika

&

Jerry Geib

Minnesota Department of Transportation
Office of Materials

May 2007

Published by:

Minnesota Department of Transportation
Research Services Section
395 John Ireland Boulevard, MS 330
St. Paul, Minnesota 55155-1899

This report represents the results of research conducted by the authors and does not necessarily represent the views or policies of the Minnesota Department of Transportation. This report does not contain a standard or specified technique.

The authors and the Minnesota Department of Transportation does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to this report.

Acknowledgements

The authors gratefully acknowledge the help of several individuals, including:

Dan Wegman with SemMaterials for providing cost data.

Randy Reznicek and Pat Wallin Johnson with Mn/DOT District 3 for their support in obtaining data and more information.

Tom Nordstrom and Tom Wood with Mn/DOT for their information and assistance with Mn/DOT Pavement Management system.

The authors would also like to express their appreciation to Peter Davich with Mn/DOT for his ideas and vital contribution.

Table of Contents

Chapter 1: Introduction	1
Chapter 2: Project Description.....	2
Chapter 3: Performance of UTBWC on US-169	4
Chapter 4: Conclusion and Recommendation.....	11
References.....	12
Appendix A: Index Performance Graphs	

List of Tables

Table 1 Rate of RQI Change for UTBWC Sections4

List of Figures

Figure 1 Texture of UTBWC on US-169.1
Figure 2 Project Location.....2
Figure 3 Pathway Services, Inc Video Inspection Vehicle (VIV)3
Figure 4 Ride Quality Index Performance for UTBWC and Cracks Sealed Sections.....5
Figure 5 UTBWC Overlay Section.....6
Figure 6 Cracks Sealed Section6
Figure 7 Longitudinal Edge Crack.....7
Figure 8 Transverse Cracks Reflecting Through the UTBWC Overlay7
Figure 9 Transverse Cracks Reflecting Through the UTBWC Overlay8
Figure 10 UTBWC Pavement Located on the Left and Control Section on the Right.....8
Figure 11 Rehabilitation Strategy versus Performance10

Executive Summary

Ultra-thin bonded wearing course (UTBWC) pavement treatment was introduced to Minnesota in 1999. This technique, in which hot mix asphalt (HMA) is laid over a heavy asphalt emulsion layer or membrane, can be used as a preventive maintenance option or surface rehabilitation technique. One of the first highways to be overlaid with UTBWC was US-169 near Princeton. This was done in two phases, September 1999 and August 2000, and made use of the Novachip® brand. For comparison purposes, a control section was established to assess the performance of the overlay. This section was sealed and pothole patched and has been maintained using standard techniques.

Pavement condition data were collected yearly using the Pathway Services Inc. video inspection vehicle (VIV). The average ride quality index (RQI) of the UTBWC overlay section was 3.3 in 2002 and 3.2 in 2006, which indicates an RQI change of 4.5 percent. The RQI on the control section was 2.5 in 2002 and 1.9 in 2006, which is a 24 percent change.

There have been no maintenance costs on the UTBWC overlay section since its construction. Some transverse cracks have reflected through; however, they are still tight. Mn/DOT's Pavement Management System predicts that the UTBWC overlay section will perform well for at least 5 more years, while the control section is currently in need of major rehabilitation.

On the basis of these observations, ultra-thin bonded wearing courses appear to provide an economical choice for pavements in need of minor rehabilitation. In addition, they may provide benefits as a preventive maintenance option. It is recommended that they be considered for all sections with minor cracking and roughness distresses that do not stem from subgrade problems.

Chapter 1 Introduction

Ultra-thin bonded wearing course (referred as Novachip®) is a surface treatment process developed in France in 1980s. UTBWC involves the placement of a thin $\frac{3}{8}$ " to $\frac{3}{4}$ " gap graded course aggregate hot mix asphalt over a membrane called Novabond®. Novabond® is a polymer modified asphalt emulsion designed to seal the existing roadway and bond with UTBWC asphalt materials.

Some of the advantages of the UTBWC treatment as reported by Koch Materials Company are:

- Can be placed without milling.
- Minimum lane closure time.
- Placed in one pass.
- Reduce rolling noise (especially in urban use).
- Finished lift is $\frac{3}{8}$ " to $\frac{3}{4}$ " thick.
- Fewer curb and minimal clearance adjustments.
- Coarse aggregate matrix- no loose chips.
- Uses a special asphalt membrane (Novabond®) for superior bonding.
- Wear resistant for longer life.
- Thinner lift means lower costs (1) and no shoulder overlay

The performance limitations for UTBWC are that the treatment should be used on structurally sound pavements, only cracks greater than $\frac{1}{4}$ " should be sealed. It should not be used on rutted pavements exceeding $\frac{1}{2}$ " or above overband crack filling or new seal patch due to the likelihood of bleed through (2,3).



Figure 1: Texture of UTBWC on US-169. Photo Taken at RP 182 NB on February 14th, 2007. UTBWC was placed in August 2000.

Chapter 2 Project Description

The Minnesota Department of Transportation (District 3) constructed two projects on highway US-169 Northbound using Ultra-thin bonded wearing course (UTBWC) near the city of Princeton. The first project involved paving lanes between reference post 183 and 185.3 in September 1999. The second project extended this section from RP 180.845 to RP 183 in August 2000. The section from RP 185.3 to 187 was unmodified and has been used as a control section.

US-169 was constructed in 1977 as a bituminous aggregate over base pavement (BAB). In 1993 a thin bituminous overlay was added to the original structure.

The existing road had transverse cracks, which affected the roughness. This portion of US-169 carries an Average Annual Daily Traffic (AADT) of approximately 15,900 vehicles, of which 4 percent are trucks.



Figure 2: Project Location in Princeton, Minnesota (US-169 Northbound)

Surface Preparation and UTBWC Placement

It was necessary to seal the cracks in the pavement with crumb rubber before the UTBWC was placed. $\frac{3}{8}$ " gap graded aggregates (granite), PG70-28 binder, and Novabond® were used. Mn/DOT supplied labor and equipment except for the paver, which was supplied by Koch Pavement Solution. The material was laid using a special paver, which spread both the asphalt emulsion and hot mix asphalt in a single pass. Compaction was done to seal the asphalt into the Novabond® membrane.

Data Collection

Mn/DOT currently collects pavement condition data annually using the Pathway Services, Inc Video Inspection Vehicle (VIV) shown in Figure 3. Prior to 2000, Mn/DOT collected data every 2 years.



Figure 3: Pathway Services, Inc Video Inspection Vehicle (VIV) (4).

Pavement condition data from 1977 to 2006 were obtained from Mn/DOT's Pavement Management System. Visual inspection was done on February 14th, 2007.

Chapter 3 Performance of UTBWC on US-169

Pavement Roughness

To assess the effectiveness of the Ultra-thin bonded wearing course, the ride quality index from the UTBWC treated section was compared with the RQI from the crack sealed (control) section. Table 1 contains RQI data from 2002 to 2006 as well as the predicted year at which rehabilitation will become necessary. A RQI value of 2.5 is often regarded as the point at which rehabilitation is necessary (5). The average change of RQI on the UTBWC section from 2002 to 2006 is 4.5 percent while the change on the control section over the same time period is 24 percent. This indicates that the control section deteriorated more than 5 times faster than the UTBWC section.

Appendix A contains the graphs of RQI plotted against time from the Mn/DOT Pavement Management System, which predict how long the pavement will still be sound. Figure 4 shows the RQI from the UTBWC and crack sealed sections from 1990 to 2006. It can be seen that the ride quality index increased after the UTBWC placement in 1999 and 2000. There was a smaller increase in the RQI for the crack sealed (control) section as well. The average ride quality index for the UTBWC overlay section is 3.2, which is in good condition as categorized by Mn/DOT (4). However, the RQI for the crack sealed section is 1.9, which indicates that the pavement is in poor condition and needs major rehabilitation or reconstruction. Figures 5 and 6 contain pictures of the UTBWC overlay and crack sealed sections. The small change in the RQI trend in 2005 was mostly likely due to introduction of new video inspection vehicles.

Table 1: Rate of RQI Change for UTBWC Sections

UTBWC Location	Reference Point	RQI 2002	RQI 2006	RQI Change %	Year Predicted for RQI =2.5
US-169 NB	180.845 – 182 Paved Aug 2000	3.5	3.4	2.9	2021
	182 – 183 Paved Aug 2000	3.6	3.4	5.6	2017
	183 – 184 Paved Aug 1999	3.0	2.9	3.3	2013
	184 - 185.3 Paved Aug 1999	3.2	3.0	6.3	2012
	185.3 – 187 (Control Section)	2.5	1.9	24.0	2002

US-169 Ultra-Thin Bonded Wearing Course Performance

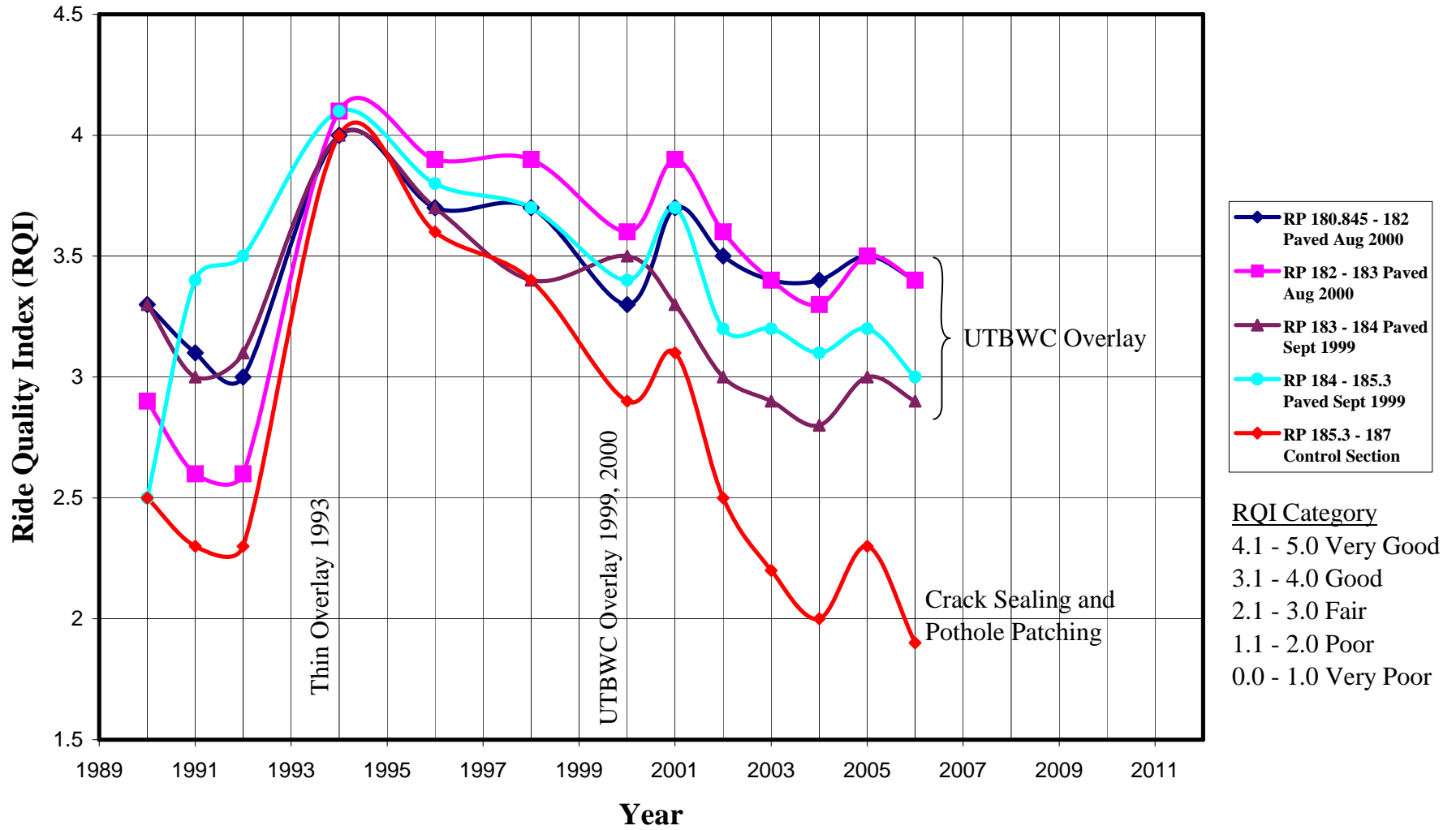


Figure 4: Ride Quality Index Performance for UTBWC and Cracks Sealed Sections.



Figure 5: UTBWC Overlay Section (Paved in August 2000). Photo taken at RP 181.00 NB on February 14th, 2007



Figure 6: Cracks Sealed Section. Photo taken at RP 185.4 NB on February 14th, 2007.

Distress Performance

Figures 7, 8, and 9 show longitudinal edge crack and transverse cracks reflecting through the UTBWC overlay after 7 years. It can be seen that the transverse cracks reflecting through the UTBWC overlay are still tight. The longitudinal cracks between the mainline and shoulder are wider in the area where the UTBWC overlay was not extended past the existing longitudinal

edge crack (Figure 7). Figure 10 shows the interface between the UTBWC overlay on the left and crack sealed section on the right.



Figure 7: Longitudinal Edge Crack - after 7 years.
Photo Taken at RP 184 NB on February 14th, 2007.



Figure 8: Transverse Cracks Reflecting Through the UTBWC Overlay.
Photo Taken at RP 183.5 NB on February 14th, 2007.



Figure 9: Transverse Cracks Reflecting Through the UTBWC Overlay. Photo Taken at RP 183 NB on February 14th, 2007.



Figure 10: UTBWC Pavement Located on the Left and Control Section on the Right- February 14th, 2007.

UTBWC Cost Comparison

The estimated in-place cost of the UTBWC for the US-169 project in 1999-2000 was \$2.90 per square yard. The latest costs for UTBWC in Minnesota (2007) is estimated at \$4.00 per square yard by SemMaterialsSM, which includes material and placement costs. The actual price will depend on the quantity of UTBWC to be placed. No costs relating to the maintenance or rehabilitation of the UTBWC overlay sections have yet been incurred.

None of the UTBWC overlay sections were near the terminal RQI value of 2.5 at the time of rating in 2006. The control section had a ride quality index of 2.5 in 2002 and 1.9 in 2006. Therefore, the control section is due for major rehabilitation. The estimated cost for the control section rehabilitation ranges from \$12 to \$15 per square yard, which includes a 3" mill and overlay. Figure 11 shows different performance curves for likely rehabilitation strategies. This indicates that UTBWC can be used as a cost effective alternative and should have long-term benefits.

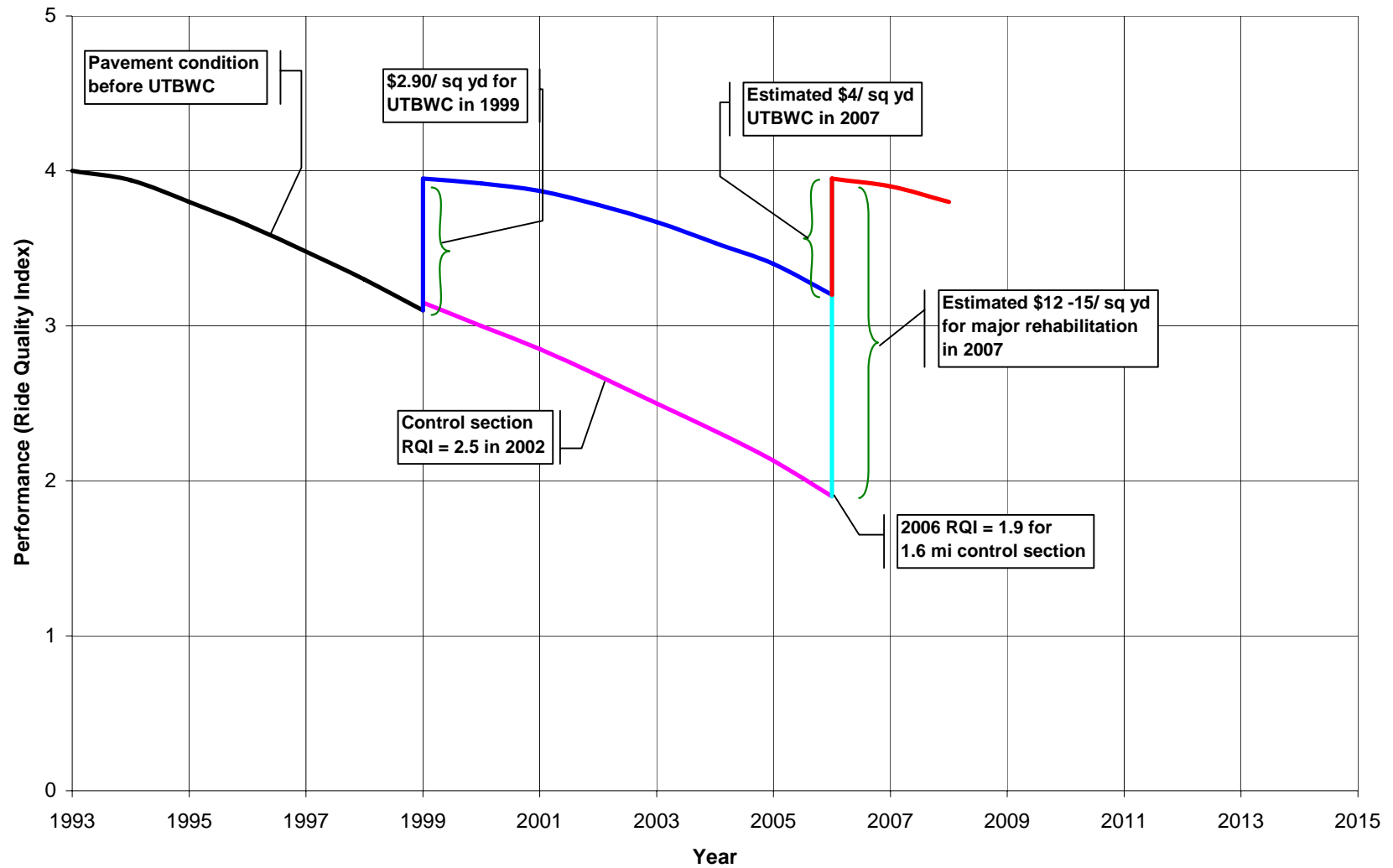


Figure 11: Rehabilitation Strategy versus Performance

Chapter 4

Conclusion and Recommendations

The field performance of the UTBWC after 7 years is excellent: no weathering or edge deterioration is evident on any of the sections. Furthermore, the UTBWC appears to be adhering to the existing surface well: no raveling is evident

This project is also performing well in regards to ride quality and transverse cracking. The average ride quality index on the UTBWC overlay section is 3.2 and the Mn/DOT Pavement Management System predicts the UTBWC overlay section will not reach an RQI of 2.5 for more than 5 years. The transverse cracks reflecting through the UTBWC overlay are still tight.

Ultra-thin bonded wearing courses (UTBWC) appear to be durable: no maintenance costs have been incurred since 1999/2000. However, crack sealing should be considered in the future to extend the life of the overlay.

The US-169 control section deteriorated very quickly despite annual maintenance. The ride quality index was 1.9 at the time of rating in 2006, which is well below the rehabilitation trigger value of 2.5. Major rehabilitation should be done on this section.

Nationwide research has shown that UTBWC reduces deterioration caused by weathering, oxidation, traffic and provides good skid resistance, reduced rolling noise, reduction of hydroplaning, and back spray from roadway (2,6). UTBWC does not increase the structural capacity of the pavement, however, the use of UTBWC on new pavements as a wearing course could be considered.

In order to reduce the effect of longitudinal cracks between the mainline and shoulder, the UTBWC overlay should extend past the existing longitudinal edge cracks.

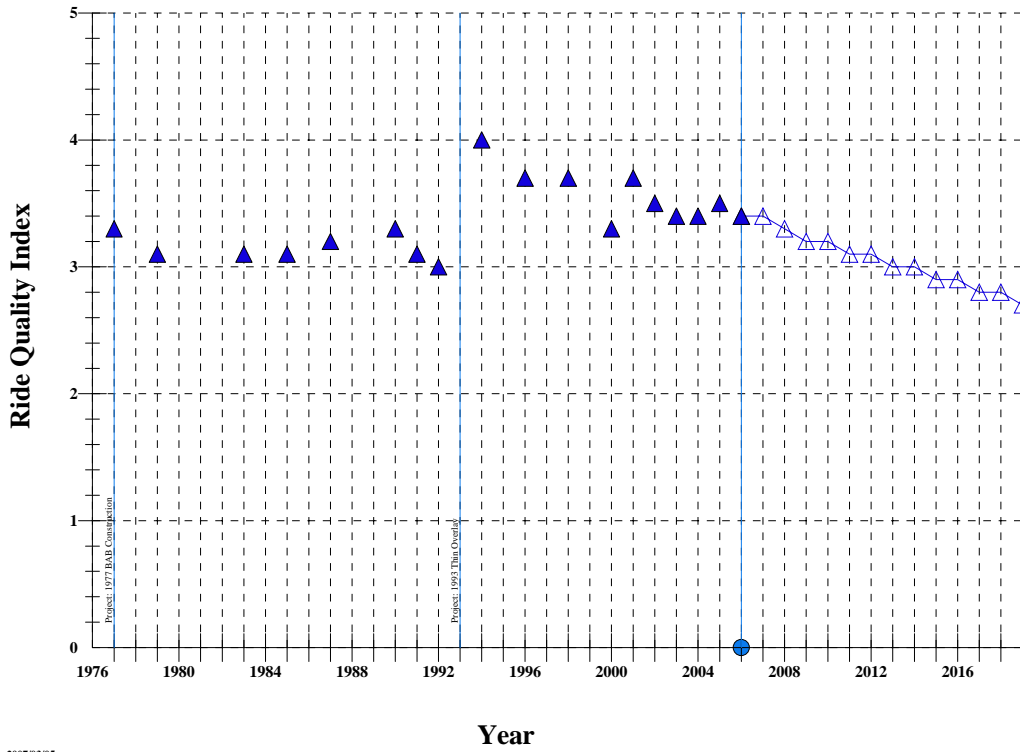
Evaluation of the US-169 UTBWC project should be continued on a yearly basis in order to have a better understanding of UTBWC performance and its life cycle costs.

References

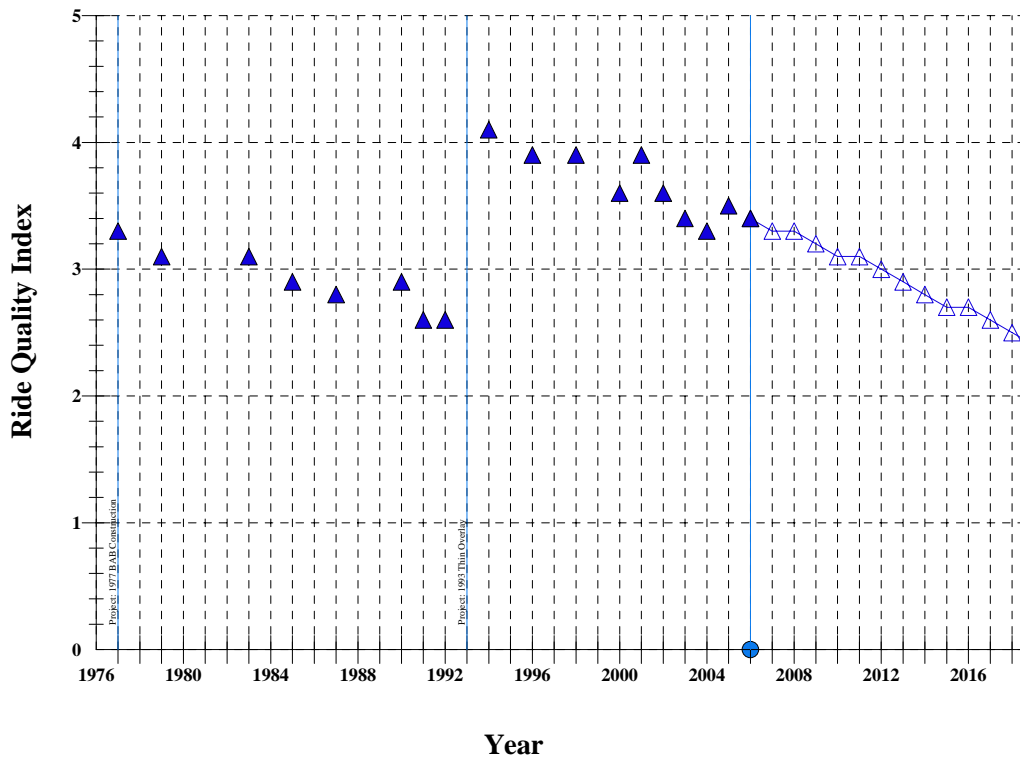
1. *Novachip® - Moving Performance*, (Wichita: Koch materials Company, 1998).
2. *Technical Note: The Use of Novachip® as Surface Treatment*, (Olympia, Washington; Washington State Department of Transportation, June 2003).
3. *Pavement Preventative Maintenance Program - Guidelines*, (Saint Paul, Minnesota; Department of Transportation, January, 2001).
4. *An Overview of Mn/DOT's Pavement Condition Rating Procedures and Indices*, (Saint Paul, Minnesota; Minnesota Department of Transportation, March 2003.)
5. *Mn/DOT Distress Identification Manual*, (Saint Paul, Minnesota; Minnesota Department of Transportation, February 2003).
6. *Performance of Novachip® in New Mexico*, (Santa Fe, New Mexico; New Mexico State Highway & Transportation Department, 2003).

Appendix A

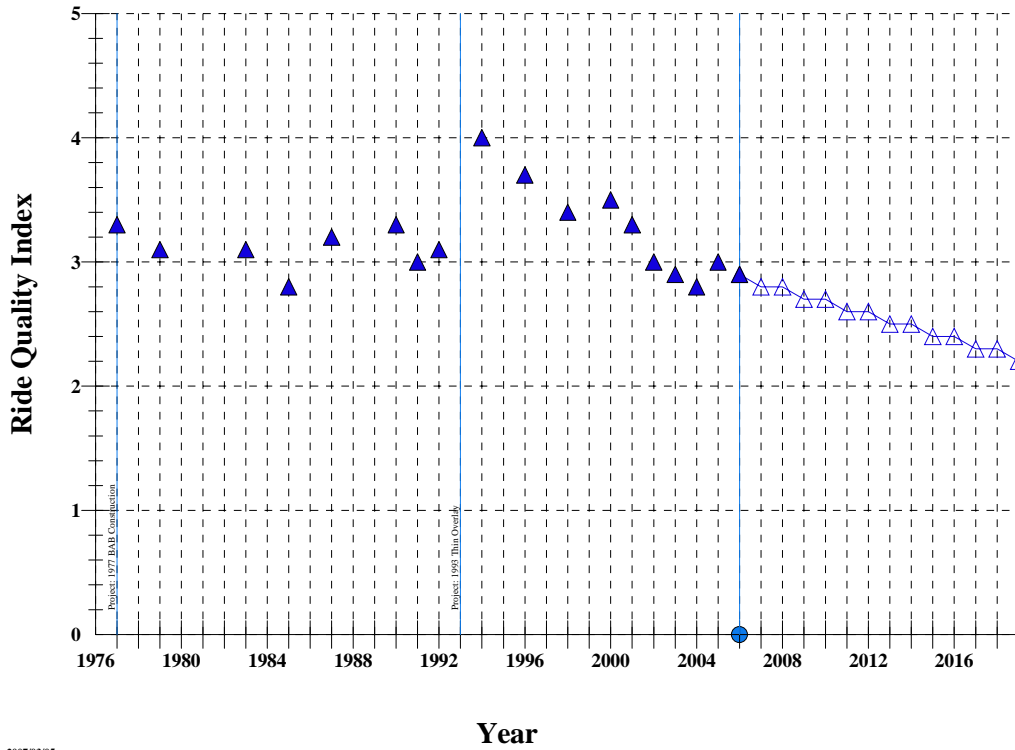
Index Performance Graphs



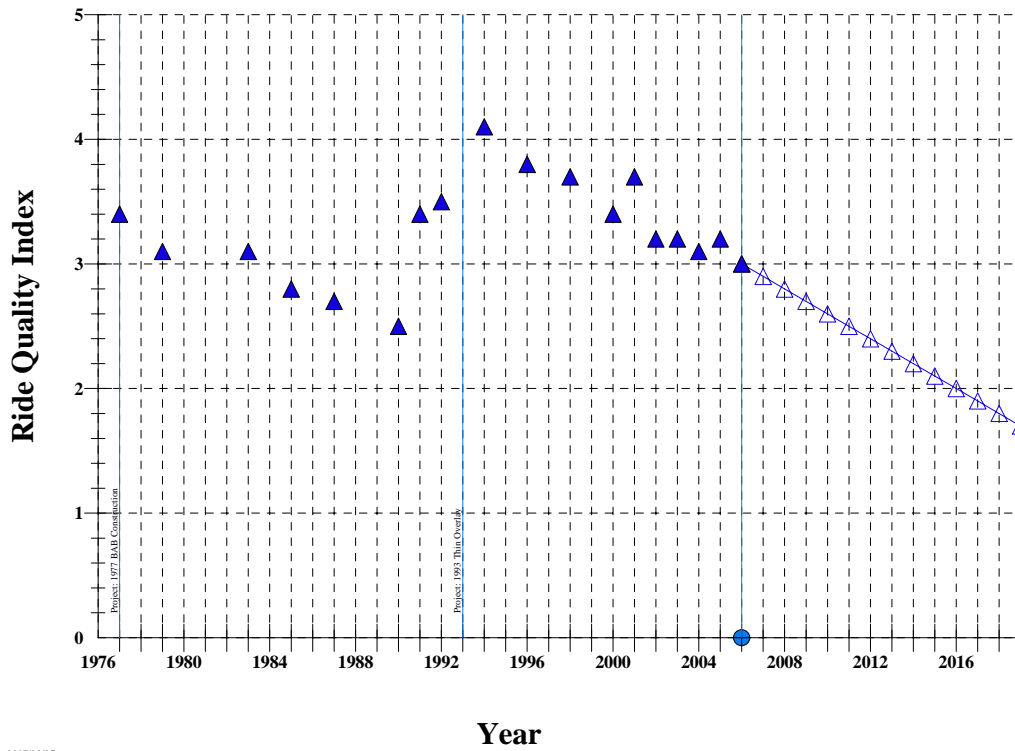
Index Performance Plot for UTBWC (US-169 NB RP 180.845 – 182.00)



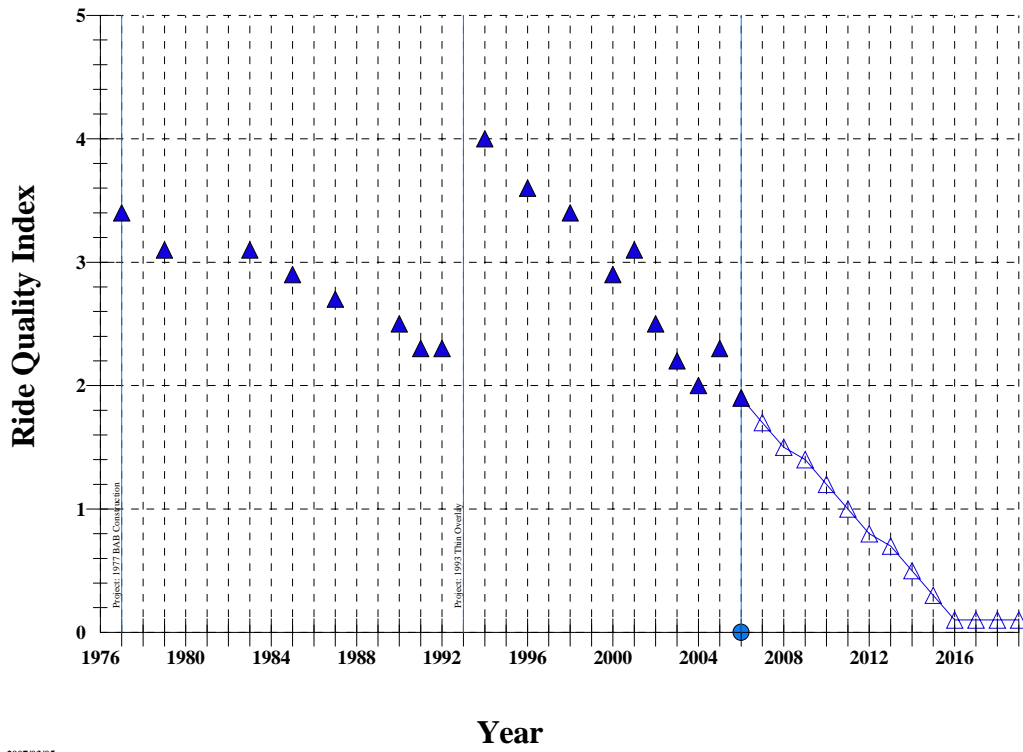
Index Performance Plot for UTBWC (US-169 NB RP 182.00 – 183.00)



Index Performance Plot for UTBWC (US-169 NB RP 183.00 – 184.00)



Index Performance Plot for UTBWC (US-169 NB RP 184.00 – 185.30)



2007/03/05

Section: US 169 0 0 10 186+0.000 - 187+0.000

Index Performance Plot for Cracks Sealed Section (US-169 NB RP 185.30 – 187.00)