NOVACHIP™ SURFACE TREATMENT
Six Year Evaluation

Theriot Canal Bridge – St. Charles Bridge
Route LA 308
Lafourche Parish

LOUISIANA TRANSPORTATION RESEARCH CENTER
Technical Assistance Report Number 04-2TA

State Project No. 407-04-0034
Theriot Canal Bridge – St. Charles Bridge
Route LA 308
Lafourche Parish

By

Samuel B. Cooper, Jr., P.E.
Senior Asphalt Research Engineer

Louay N. Mohammad, Ph.D.
Associate Professor
Manager, EMCRF

Louisiana Transportation Research Center
4101 Gourrier Ave.
Baton Rouge, LA 70808

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The NOVACHIP^{TM} Surface Treatment process was developed by SCREG Routes STP in France in 1986 [1, 2]. NOVACHIP^{TM} is a registered trademark of Societe Internationale Routiere, which is a subsidiary of SCREG Routes STP [2]. This process was developed to increase skid resistance and to seal old pavement surfaces [2] and, since 1986, has been used widely in Europe [3, 4]. It is used as a surfacing on high-speed, high-volume auto routes and the national route systems. It is also successfully used in curb and gutter sections in cities.

Engineers from the United States were first introduced to the NOVACHIP^{TM} process through a demonstration given during a European Asphalt Study Tour in 1990 [1].

The first NOVACHIP^{TM} projects in the United States were constructed in the state of Alabama in the fall of 1992, with a machine imported from France [1]. Test sections were also constructed in Mississippi and Texas in the same time frame using the same machine from France used in Alabama [1].

Louisiana's first NOVACHIP^{TM} project was completed in September 1997 [4]. The initial NOVACHIP^{TM} paving process used in the United States and Louisiana was proprietary and licensed through KOCH Materials Company, Inc. [2]. Louisiana, partnering with KOCH Pavement Solutions, has since developed a non-proprietary special provision specification using this process [5]. No longer described as NOVACHIP^{TM} in Louisiana, it is now an Ultrathin HMAC Wearing Course.

This report presents a six-year evaluation of Louisiana's first project using this process.

OBJECTIVE

This report documents the six-year performance of the NOVACHIP^{TM} Surface Treatment Process when compared to conventional mill and overlay systems with similar Average Daily Traffic (ADT) and age. The performance evaluation period considered were from 1997 through 2003.

SCOPE

Two mill-and-overlays and one NOVACHIP^{TM} project were selected for this evaluation. They are all located on Route LA 308 in Lafourche Parish. The performance indicators considered in the evaluation included rutting, alligator cracking, random cracking, transverse cracking, and smoothness which were secured through the Pavement Management Section. A Life-Cycle Cost analysis was also used to compare the NOVACHIP^{TM} Surface Treatment project with the conventional mill and overlay projects used in this evaluation.

NOVACHIP™ Surface Treatment Process

The NOVACHIP™ Surface Treatment Process has the capability of placing a thin lift (½ inch – ¾ inch) of gap-graded hot mix wearing course over a polymer-modified tack coat/membrane using only one piece of equipment [1, 2, 3, 4, 6]. This specialized equipment/paver can evenly distribute the polymer-modified membrane immediately in front of the paver augers and apply/level the wearing course concurrently at a rate of 30 to 92 feet per minute. This specialized paver incorporates a hopper to accept hot mix from trucks, a storage tank to hold the polymer-modified tack coat/membrane, emulsion spray bar, heated vibratory screed, auger system, and electronic controls for surface tolerance.

Hot mix asphalt is delivered and laid at the specified lift thickness within 5 seconds of the polymer-modified membrane application. Because the polymer-modified emulsion is applied almost simultaneously with the hot mix, the emulsion rate can be increased. The typical application range for the polymer-modified membrane is 0.23 ± 0.07 gallons per square yard. The thicker emulsion seals the entire surface, including small cracks, and ensures bonding to the existing surface. The heat from the hot mix causes the emulsion to break quickly and wick upward into the bottom portion of the hot mix lift [2]. The hot mix is smoothed over the full lane width in one pass using a heated screed to ensure an even mat. Lift thicknesses of ½ - inch to 1 inch are typical.

Compaction of the wearing course is carried out using 2 passes of a double drum roller of sufficient weight to properly seat the aggregate without crushing it. Density is not an issue since this gap-graded mix seats quickly and completely in 2 passes. No vibration is allowed except at the transverse joints.

PROJECT DESCRIPTION

The 1997 project constructed by T. L. James & Co., Inc., located in Lafourche Parish, began at the Theriot Canal Bridge (C.S. Log Mile 3.130), north of Raceland, and proceeded westward along LA 308 to the St. Charles Bridge (C.S. Log Mile 8.390) for a distance of 5.26 miles. The geometrical features of the existing highway are a 22-foot wide pavement with unimproved shoulders. This highway parallels Bayou Lafourche. This site has moderate to heavy traffic with an estimated 1996 ADT of 4776 [4]. Heaviest truck traffic is seasonal and runs concurrent with the sugar cane harvest during the months of October through December.

Prior to the 1997 project, the existing surface was a plant mix seal that was completed in 1978. There were areas along this roadway that had greater than ¼-inch wide longitudinal cracks. Under the plant mix seal, there is approximately 7 inches of hot mix on top of a sand-shell base [4].

Figure 1 is a map of Lafourche Parish illustrating the project location.

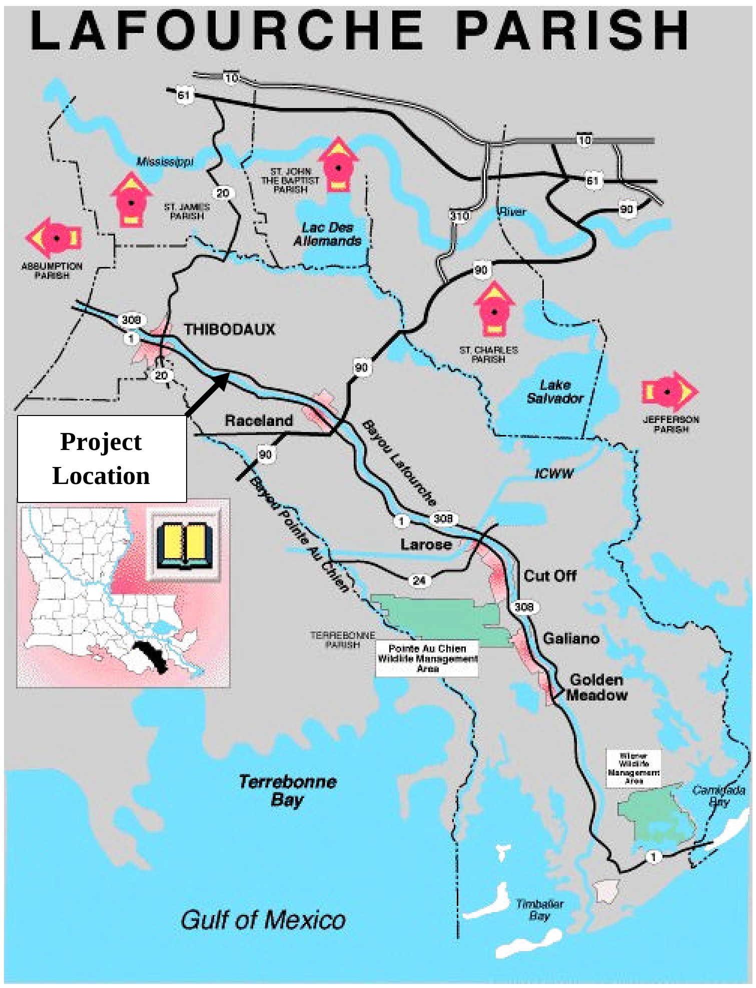

Figure 1
Project Location

Materials

Asphalt Cement

Elastomeric polymer-modified asphalt cement was specified for this project, meeting the Louisiana Department of Transportation and Development (LADOTD) specification for PAC 40HG [7]. The PAC 40HG asphalt cement was supplied by Eagle Asphalt[1]. The optimum polymer-modified asphalt cement content was incorporated at a mix percent of 5.7 by weight as required by the mix design [4]. The Performance Grade (PG) of the PAC 40HG was not measured as required by current specifications [8]. Historically the PAC 40HG from Eagle Asphalt would classify as a PG73-22. Since there is no designation for a PG73-22, the PAC 40HG meets all polymer modification requirements of a PG70-22M typically specified today [8].

Aggregates

The final aggregate blend was composed of 70.7% - #8 siliceous limestone and 23.6% - ¼x0 siliceous limestone (table 1) [4]. The siliceous limestone was supplied by Vulcan Materials Company[2]. The aggregates complied with the requirements set forth in Subsection 1003.06(b) of the Standard Specifications and Special Provisions of the contract for State Project Number 407-04-0034 [7, 9]. Table 1 also presents the field data of the gradation, percent asphalt cement content, and calculated film thickness.

[1] Eagle Asphalt Company, Donaldsonville Louisiana
[2] Vulcan Materials Company, Gilbertsville Kentucky

Table 1
Job Mix Formula

Sieve Size (inch)	Specification Percent Passing	Job Mix Formula	Field Data
½	100	100	100
3/8	90-100	97	95
¼	55-75	64	65
No.4	35-50	43	43
No. 10	15-25	20	25
No. 40	-----	11	12
No. 80	-----	9	9
No. 200	2-8	7.3	7.5
% Asphalt Cement	5.3 minimum	5.7	5.6
Film Thickness (microns)	For Information	11.5	11.0

Antistrip

The contractor was required to evaluate the hot mix asphalt mixture's susceptibility to moisture damage by performing the Boil Test (DOTD TR 317). An Ad-Here LA 2 from Arr-Maz Products, Inc.[3] was added to the hot mix asphalt mixture at a rate of 0.6 percent by weight of mix. Louisiana specifications require an antistrip to be added at a design minimum of 0.6 percent by weight of mix in all hot mix asphalt mixtures [8, 9].

Polymer-Modified Emulsion Tack Coat/Membrane

A polymer-modified cationic emulsion was required to meet the NOVACHIP™ recommendations and LADOTD specifications [7]. The specifications require that the Saybolt Furol viscosity limits for the polymer-modified emulsion be between the limits of 20 and 100 at 77 ^{o}F and have a set time between three and seven minutes at an application temperature of 170 ^{o}F. A minimum force ductility ratio of 0.15 was also required by specification on the polymer-modified emulsion residue. The force ductility ratio is defined as the ratio of force at 30 centimeters elongation to the peak force. The polymer-modified

[3] Arr-Maz Products, Inc., Winter Haven Florida

emulsion was manufactured using Marathon asphalt cement and an Ultrapave polymer. The polymer-modified emulsion was supplied by Asphalt Products Unlimited, Inc. [4] The application rate of the polymer-modified emulsion was 0.15 gallons per square yard [4].

Mix Design

The optimum asphalt cement content was determined from hot mix asphalt compacted with the Marshall Hammer at 75 blows per face. Upon determining the optimum asphalt cement content and aggregate gradation blend, the hot mix asphalt mixture design was then submitted to the representatives of NOVACHIP™ by T.L. James & Co., Inc. for evaluation. The final hot mix design, asphalt content, and gradation, were adjusted based on the recommendations by Jean Claude Roffe, Screg Routes STP, France [4]. The mixture consisted of 70.7% - #8 siliceous limestone and 23.6% - ¼ x 0 siliceous limestone (table 1). Furthermore the final composite blend was classified as a coarse graded 3/8-inch nominal maximum size material. Furthermore, the final recommended design asphalt content of 5.7 percent produced air voids of five ± 1 percent when using 75 blows per face of a Marshall Hammer [4].

An asphalt draindown test was performed in accordance with ASTM D 6390. The results of this test indicated an asphalt draindown of 0.1 percent [4].

Film thickness was also calculated based on surface area of the aggregate using the extracted gradations and effective asphalt content. The calculated film thickness for the asphaltic concrete hot mix material used on this project was 11.5 microns [4].

Construction

A "small" NOVACHIP paver was used during construction of this project. Figure 2 provides an illustration of a NOVACHIP Paver. The capacity of this paver was approximately 100 to 125 tons of mix per hour with a traveling speed of up to 10 miles per hour [4]. This paver was capable of distributing the emulsion between the rates of 0.1 and 0.28 gallons per square yard [4]. The NOVACHIP™ surface treatment for this project was completed in two and a half days. Approximately 4.5 miles were completed on the first day of production. During construction, hot mix materials could be delivered directly into the paver's hopper from the delivery truck; however, the distance from the tailgate of the truck to the back of the truck's rear tires was too short for the paving machine to accept [4]. A Materials Transfer Vehicle (MTV) was used to aide in the delivery of the hot mix materials into the paver's hopper. The

[4] Asphalt Products Unlimited, Inc., Port Allen Louisiana

MTV facilitated quicker truck exchanges and probably aided in the improved profile index [4]. There was no smoothness specification required for the construction of this project; however, a one mile section was profiled with the Ames Profilograph before and after construction to demonstrate the ability of a thin lift overlay to improve surface profile [4]. The profile index before construction and after construction was 14 inches per mile and 2.4 inches per mile, respectively [4]. There were 2611.09 tons of hot mix materials delivered to construct this 67,486.2 square yard project. The average yield for this project was 77.4 pounds per square yard.

Figure 2
NOVACHIP Paver

Six Year Performance Evaluation

Control Section 407-04, Route LA 308, beginning at Log Mile 0.000 to ending Log Mile 14.890, with the exception of the Theriot Canal Bridge, was rehabilitated between 1997 and 1998. There were three projects constructed in this control section during that time period. As a result of the low bid process, the prime contractor for all three projects was T.L. James & Co., Inc. The three projects are listed below with their corresponding state project numbers, beginning and ending construction log mile locations, type construction, ADT, and year constructed. In this report, each state project will be referred to as Section 1, Section 2, or Section 3 as listed below.

1. Section 1
   S.P. No. 407-04-0032
   Begin Construction Log Mile 0.000
   End Construction Log Mile 3.100
   Type of Construction: Mill 2 in. with 3.5 in. Hot Mix Overlay
   ADT: 4900
   Year Constructed: 1998

2. Section 2
   S.P. No. 407-04-0034
   Begin Construction Log Mile 3.130
   End Construction Log Mile 8.390
   Type of Construction: NOVACHIP™, ¾ in. thickness
   ADT: 4776
   Year Constructed: 1997

3. Section 3
   S.P. No. 407-04-0033
   Begin Construction Log Mile 8.370
   End Construction Log Mile 14.890
   Type of Construction: Mill 1.5 in. with 3.5 in. Hot Mix Overlay
   ADT: 5200
   Year Constructed: 1998

Abadie reported that Section 2 was selected for the NOVACHIP™ surface treatment because of its sound base, Average Daily Traffic (ADT), and level of truck traffic [4].

It should be noted that the Theriot Canal Bridge is located at approximate Log Mile 3.100, and there was no work performed between Log Mile 3.100 and Log Mile 3.130. In addition, there is a project overlap where Section 3 begins and Section 2 ends. Section 2 ended at the intersection of the St. Charles Bridge and LA 308 at Log Mile 8.390. The beginning of Section 3 was shifted to Log Mile 8.370 to provide for proper construction of the intersection.

The entire length of Control Section 407-04, 14.890 miles, was visually inspected in the Fall of 2003. Visual inspection of Section 2 revealed low severity cracking widths that were less than 1/8 in. In addition, LADOTD Pavement Management's 2002 visual inspection data for this section indicate the presence of approximately 86 feet of longitudinal cracking (low severity). Abadie reported there was up to 250 feet of longitudinal cracking greater than ¼ in. before the NOVACHIP™ surface treatment application [4]. There were also some areas of corrugation, fatigue cracking, and base failures in Section 2. Visual inspection for Sections 1 and 3 also revealed fatigue cracking and base failures.

The six-year performance of Section 2, constructed in 1997, was then evaluated against the five-year performance of Sections 1 and 3, constructed in 1998. Data used for the analysis were obtained through Pavement Management's visual data for the years of 1997, 2000, and 2002 for Control Section 407-04.

Since no visual data was obtained for 1996, an assumption was made that the International Roughness Index (IRI), alligator cracking, random cracking, transverse cracking, and rut depth values for Sections 1 and 3 would be no worse than the visual data indicated for 1997. Therefore, for Sections 1 and 3, the data point values used for 1996 have the same values as for 1997. Likewise, for Section 2, it was assumed that the 1996 IRI, alligator cracking, random cracking, transverse cracking, and rut depth values would be somewhere between the IRI values for Sections 1 and 3 during that time period. Therefore, an average IRI value was computed using Pavement Management's 1997 visual data. This average IRI value was subsequently used in the analysis for 1996. Moreover, since no visual data was available for the year 1998, an assumption was made that for Sections 1 and 3, completed in year 1998, the IRI value would be no worse than Pavement Management's 2000 IRI visual data value indicated. Therefore, that data was subsequently used for 1998. Since no data was available for 1998, an assumption was made that for Sections 1 and 3, completed in that year, there would be no alligator cracking, no random cracking, no transverse cracking, and no rut depth values reported. Similarly, Section 2 would show no alligator cracking, no random cracking, no transverse cracking, and no rut depth values for 1997.

Figure 3 presents the average IRI for Control Section 407-04. At the time of initial construction for all sections, a decrease in the overall IRI value of approximately 125 inches per mile or 65 percent was experienced as shown in figure 3. Also, in Sections 1 and 3 there is no increase in the IRI values for the time period evaluated. For Section 2, figure 3 demonstrates a slight increasing trend in the IRI value for this same time period. The 2002 IRI data indicates that the increase in the IRI value was approximately 20 percent above that found in the initial construction year, 1997. Nevertheless, less than 100 inches per mile were considered "good" as defined by the Pavement Management System Guidelines. Sections 1 and 3 are also less than 100 inches per mile and are considered "good".

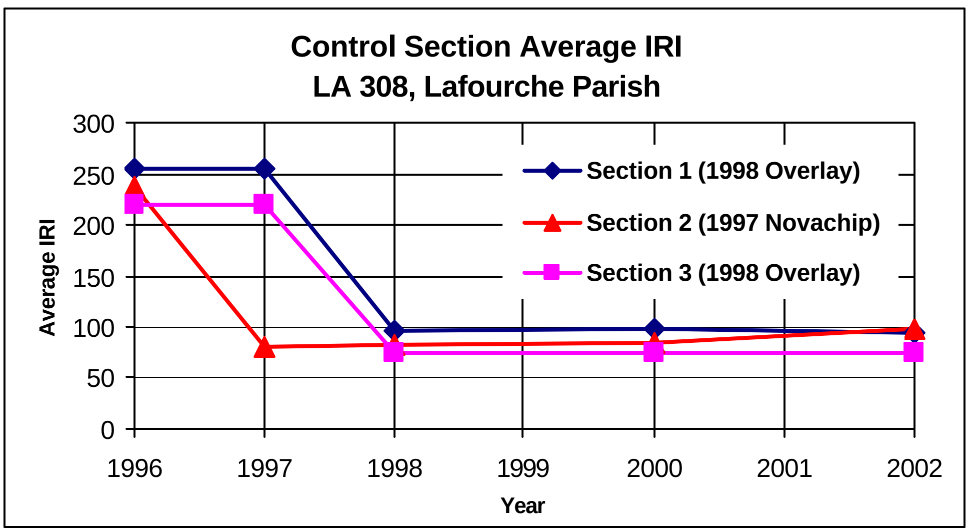

Figure 3
Control Section 407-04, Average IRI

Figure 4 shows the average alligator cracking for Control Section 407-04. As stated previously, visual observation of these projects indicated fatigue cracking and base failures for this control section. With the exception of the urban sections within this control section, the existing shoulders were unimproved. The fatigue cracking and base failures began at the outside wheel path and continued to the edge of shoulder. It is suspected that the fatigue cracking and base failures were due to moisture intrusion into the untreated sand shell base and/or subgrade [4]. Unimproved shoulders in addition to the lack of maintenance of the cross-slope of the existing shoulder may allow moisture to infiltrate the pavement structure.

As indicated in figure 4, before initial construction of all sections there was an excess of 390 square feet of alligator cracking for each section. There was an increasing trend in the square feet of alligator cracking for the time period evaluated. Furthermore, figure 4 shows that there was a substantial increase in the alligator cracking in 2000 and then a decrease in 2002 for Section 3. The decrease in the alligator cracking was the result of several skin-patched distressed areas in 2002.

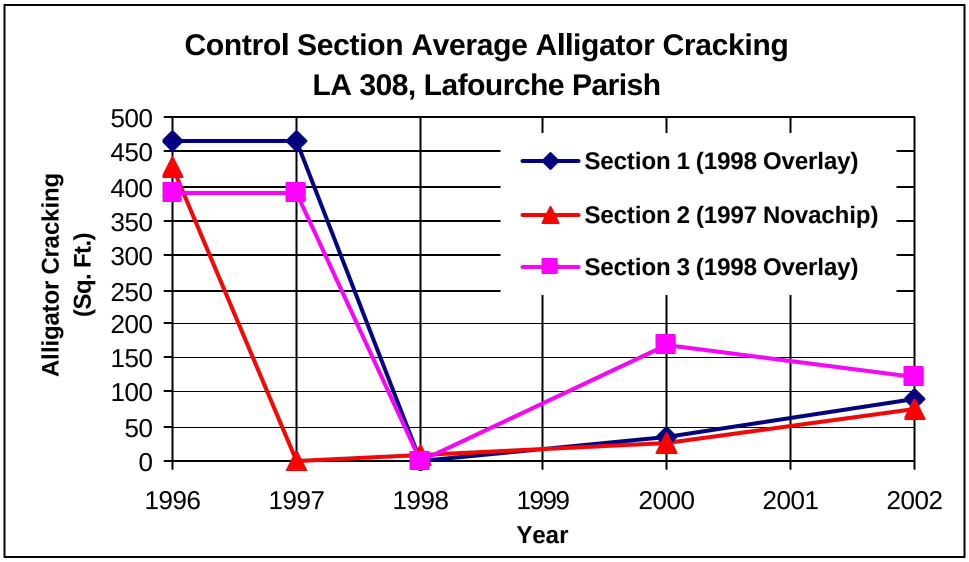

Figure 4
Control Section 407-04, Average Alligator Cracking

Figure 5 presents the average random cracking for Control Section 407-04. As indicated in figure 5, before initial construction of all sections there was an excess of 850 linear feet of random cracking for each section. There was an increasing trend of random cracking in all sections with Section 2 increasing at a faster rate for the time period evaluated. The data indicated that random cracking for Sections 1 and 3 was increasing at approximately 3.5 feet per year whereas Section 2 was increasing at approximately 14.5 feet per year. The 2002 visual data indicated that Section 1 experienced a low-severity level of cracking. On the other hand, Sections 2 and 3 portrayed low, medium, and high-severity levels of random cracking.

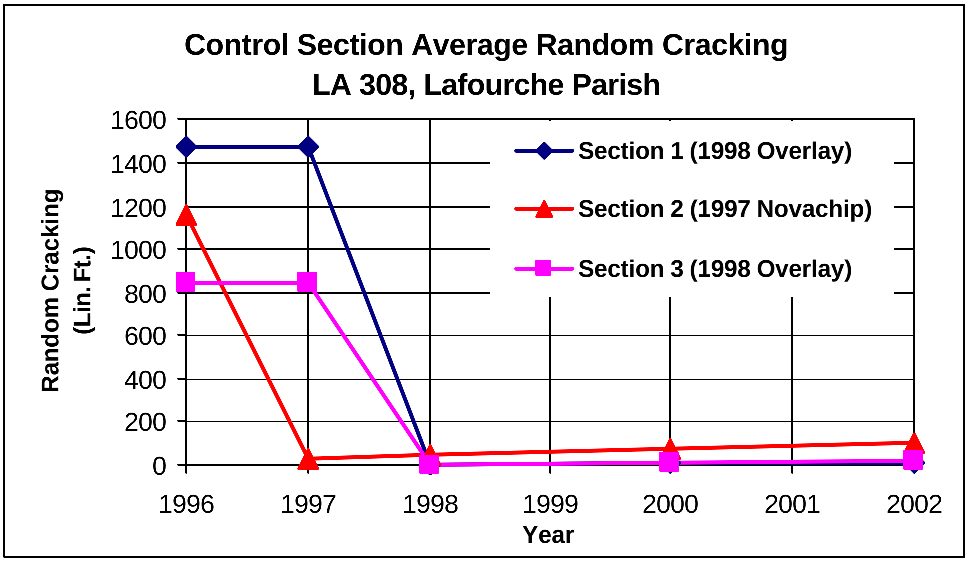

Figure 5
Control Section 407-04, Average Random Cracking

Figure 6 presents the average transverse cracking for Control Section 407-04. As indicated in figure 6, before initial construction of all sections there was an excess of 550 linear feet of transverse cracking for each section. There was an increasing trend of transverse cracking in all sections with Section 2 increasing at a faster rate for the time period evaluated. The data indicated transverse cracking for Sections 1 and 3 increased at approximately 2 feet per year whereas Section 2 increased at approximately 14.5 feet per year. The 2002 visual data indicated that Section 3 experienced low, medium, and high-severity levels of transverse cracking. Visual data for Sections 1 and 2 indicate low-severity levels of transverse cracking.

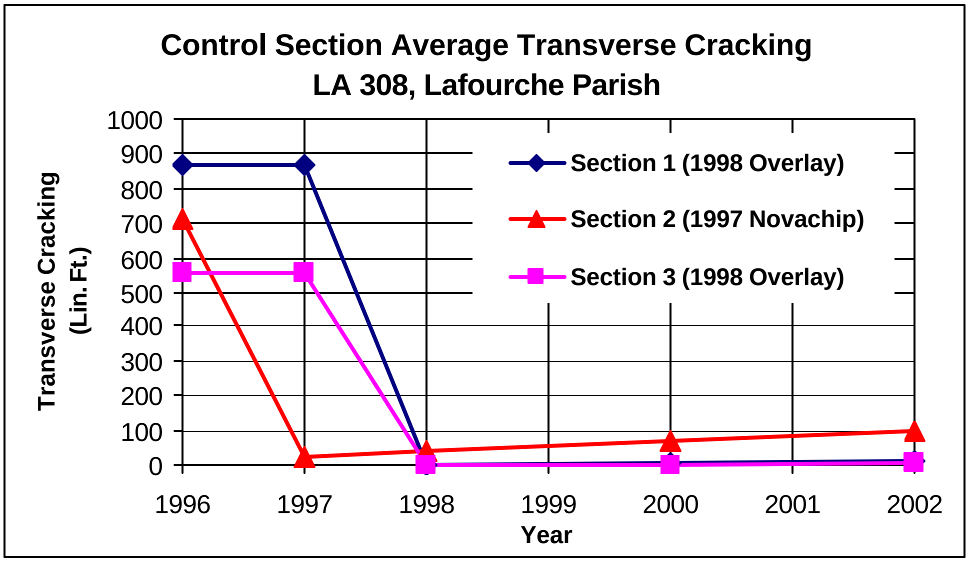

Figure 6
Control Section 407-04, Average Transverse Cracking

Figure 7 shows the average rut depth for Control Section 407-04. As indicated in figure 7, before initial construction of all sections there was an excess of 0.4 inches of rut depth for each section. Also, figure 7 shows that the Rut Depth for all sections remained constant since 2000. The visual data for all sections indicate that the rut depth was at 0.1 inches.

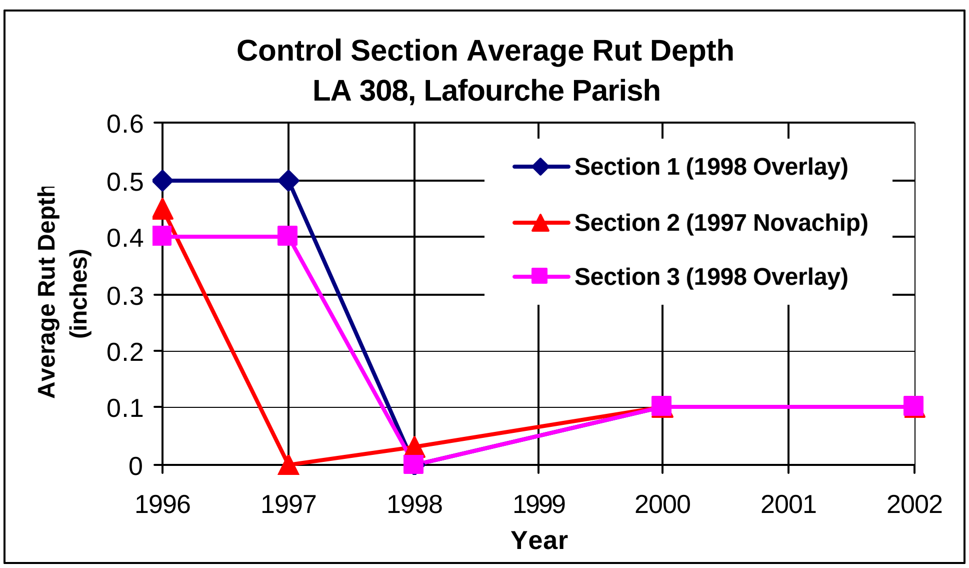

Figure 7
Control Section 407-04, Average Rut Depth

Project Cost

The final as-built cost for Section 2 was $337, 866.08 as constructed by T.L. James, Inc. in 1997. There was a total of 67, 486.20 square yards of NOVACHIP^{TM} material placed in this section. The approximate total cost per mile, including all construction items, was $65, 000 per mile. When computing the total price per square yard of NOVACHIP^{TM} and hot mix items only, the calculated as-built price per square yard was $3.67.

A life cycle cost comparison of Section 2 versus Sections 1 and 3 was performed. The unit price per square yard for the milling and hot mix items, excluding any other contract items, for Sections 1 and 3 was calculated using as-built quantities. The computed price per square yard for each of these sections was then averaged. The average as-built unit price was $10.68/yd^2 for Sections 1 and 3.

Before comparing the life cycle cost of each alternate section some assumptions were made. It was assumed that the interest rates would be constant for the entire 20-year life cycle evaluated. Furthermore, there would be no maintenance costs and no salvage value, and the cost of construction would also be equal during the evaluation period. Also, there is no end-of-service life rehabilitation included in this life cycle cost evaluation. At the end of the 20-year life cycle, it is assumed that Sections 1 through 3 will undergo the same type rehabilitation. The future cost was calculated using the same interest rate, i, equal to 4%. A 10-year expected life for Section 2 was selected because the expected surface life was estimated at 10-years [3]. It was also assumed that Sections 1 and 3 would reach its end-of-service life at 20 years. Section 2 would receive a re-application of the NOVACHIP^{TM} surface treatment at 10 years to achieve the 20-year life cycle need for evaluation.

Figure 8 presents the Life Cycle Cost Diagram used in the computational analysis for Sections 1 and 3.

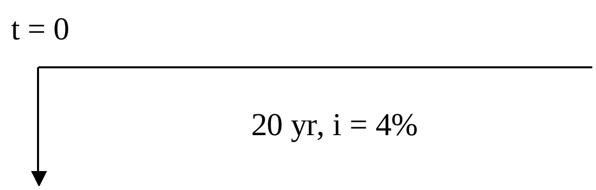

Figure 8
Life Cycle Cost Diagram, Sections 1 and 3

The capitalized cost, or life cycle cost, was determined as Present Worth at t = 0 in figure 8 as follows:

Life Cycle Cost = $\$10.68/yd^2$

Figure 9 shows the Life Cycle Cost Diagram used in the computational analysis for Section 2.

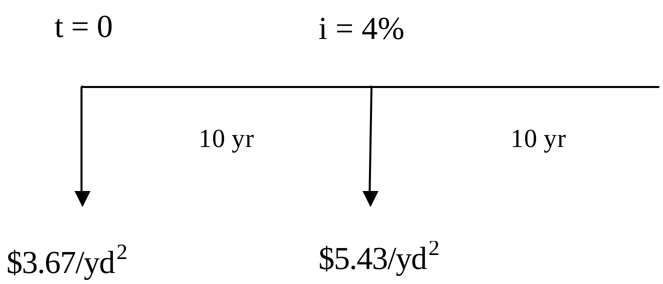

Figure 9
Life Cycle Cost Diagram, Section 2

The capitalized cost, or life cycle cost, was determined as Present Worth at t = 0 in figure 9 as follows:

$$
\begin{aligned}
\text{Life Cycle Cost} &= 3.67 + 5.43(P/F, 4\%, 10) \\
&= 3.67 + 5.43(0.6756) \\
&= \$7.34/yd^2
\end{aligned}
$$

Although the life cycle cost analysis is very basic with these assumptions, it indicates that routine maintenance/overlays such as the NOVACHIP™ surface treatment result in cost savings for LADOTD. In the above calculations, based on the assumptions made, savings of approximately $\$3.34/yd^2$ result.

Comments

It was previously stated that the expected surface life of the NOVACHIP™ process is 10 years. The first projects of this type completed in the United States, if they are still in existence, are just 11 years old. Based on the life cycle cost analysis of this project compared to the overlays, the NOVACHIP™ surface treatment results in a cost savings to LADOTD, provided that the appropriate roadway and rehabilitation technique are selected.

The NOVACHIP™ project indicates a rut resistance mix for the ADT and truck traffic level selected. The rut resistance may be the result of the composite aggregate gradation selected, which is coarse graded.

This NOVACHIP™ project is performing satisfactorily in regard to IRI, rutting, and longitudinal, random, and transverse cracking. This can be attributed to the selection of the appropriate roadway for this type application. Fatigue cracking was not project specific and cannot be attributed to any type of overlay process selected in the control section. It is suspected that the fatigue cracking on the three projects constructed in this control section is due to moisture intrusion from the top and bottom into the pavement structure, including moisture from the subbase material as this control section is in close proximity to Bayou Lafourche.

RECOMMENDATIONS

It is recommended that NOVACHIP^{TM} surface treatment or the Louisiana designated non-proprietary Ultrathin HMAC Wearing Course be considered for evaluation of the following:

1. New construction and/or pavement surface rehabilitation projects on all volumes of traffic.

2. Placement on new concrete pavements or rehabilitated concrete pavements with stable joints, which would serve to enhance roadway drainage and reduction of splash and spray that occurs because of the nature of a hot mix combined with a coarse graded aggregate structure. It is anticipated that the coarse graded hot mix would reduce roadway glare. This could be an added safety enhancement for the motoring public.

3. An alternative method to mill and fill type projects when bases are in sound condition.

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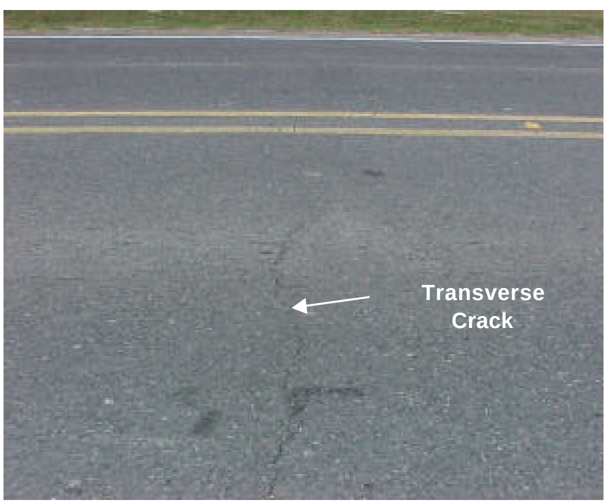
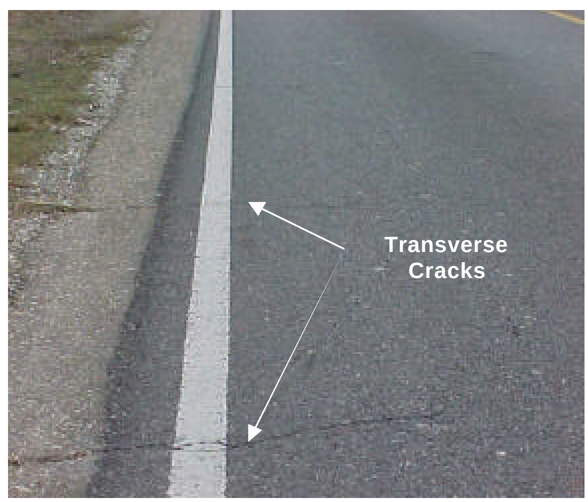
APPENDIX

S.P. No. 407-04-0034
LA 308 – NOVACHIP Surface Treatment
Fall 2003





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