WHITETOPPING PROJECT ON M-46 BETWEEN CARSONVILLE AND PORT SANILAC

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MICHIGAN DEPARTMENT OF TRANSPORTATION
MDOT

WHITETOPPING PROJECT ON M-46 BETWEEN CARSONVILLE AND PORT SANILAC

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16. Abstract: In 1999, The Michigan Department of Transportation (MDOT) constructed its first whitetopping project. The whitetopping consisted of 150 mm thick sections with and without fibers, a 125 mm thick section with fibers, and a 75 mm thick inlay section with fibers. The locations are on M-46 outside Carsonville to Port Sanilac.

Adjacent to the whitetopping (from Carsonville to the whitetopping) a bituminous project was built, which consisted of three standard fixes: milling and resurfacing; overlay only; and a crush and shape with overlay. The performances of these fixes will be compared to the whitetopping project to judge long term cost effectiveness.

This report summarizes the construction of both projects.

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EXECUTIVE SUMMARY

This report summarizes the construction of thin and ultra-thin concrete overlays (a.k.a. whitetopping) on M-46 between Carsonville and Port Sanilac. This is the first whitetopping project constructed in Michigan by the Michigan Department of Transportation (MDOT). The purpose of this trial project is to study whitetopping as an alternative to our standard bituminous fixes for rehabilitating deteriorated bituminous pavements. A project to the west of the whitetopping project was constructed using several of MDOT's standard bituminous methods.

The test sections are as follows:

<u>Bituminous Fixes</u>

Section 1. Mill and resurface with 90 mm of bituminous.
Section 2. Minor surface repair with 75 mm bituminous overlay.
Section 3. Crush and shape and overlay with 90 mm of bituminous.

<u>Concrete Whitetopping Fixes</u>

Section 4. 150 mm whitetopping without fibers.
Section 5. 150 mm whitetopping with fibers.
Section 6. 125 mm whitetopping with fibers.
Section 7. Mill and overlay (inlay) with 75 mm whitetopping with fibers.

Section 1 is the control for section 7, section 2 is the control for section 6, and section 3 is the control for sections 4 and 5.

Construction went per plan with no significant changes to report for either fix type. The only deviation from plan was thickness of the whitetopping sections. The 150 mm proposed sections were paved at 203 mm (average of 15 cores), and the proposed 75 mm inlay was paved at 106 mm (average of 3 cores). The increase was due to necessary grade and crown corrections.

INTRODUCTION

Historically, when flexible or composite pavements require rehabilitation, the selected fix results in a new bituminous surface. These fixes typically consist of three alternatives: (1) existing pavement repair and bituminous overlay, (2) milling with a bituminous overlay, or (3) crushing and shaping the existing pavement followed by a bituminous overlay. These rehabilitation fixes typically have varying service lives of seven to fifteen years depending on the pavement's existing condition and deterioration rate.

Nationally, other states have constructed alternative concrete rehabilitation designs, such as whitetopping and ultra-thin whitetopping. Until 1999, concrete whitetopping had not been used on any Michigan trunklines. Whitetopping is the term used for paving with Portland cement concrete (PCC) over an existing bituminous pavement[1]. The first whitetopping project occurred in 1918 in Terre Haute, Indiana. Since then, nearly 200 projects have been constructed nationally in at least 28 states.

Many states are reporting satisfactory results with whitetopping. Some western states have reported that whitetopping projects have performed for more than 20 years. In particular, Iowa has many miles of whitetopping, which are providing excellent service with low maintenance needs after 25 years[2]. A recent cost comparison study in Iowa showed:

> "...a 5 to 6 in. (127 to 152 mm) concrete overlay costs up to 50 percent more than a 2 or 3 inch (51 to 76 mm) asphalt overlay, but that the concrete pavement can last twice as long as asphalt."[2]

There are three locations in Michigan where whitetopping was previously used on local or private roads:

- September 1996 - An entrance drive to a steel company and concrete redi-mix plant in Traverse City.
- October 1996 - A short portion of Schaefer Hwy. at the Coolidge Yard bus terminal in Detroit.
- October 1997 - The intersection of Ann Arbor-Saline Road and Pleasant Lake Road in Washtenaw County.

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[1]*Whitetopping - State of the Practice*, EB210P, American Concrete Paving Association, 1998.

[2]*No Longer an Experiment,* Roads & Bridges, April 1997.

A visual evaluation of each location in September 1998 indicated that the Washtenaw County and Traverse City sites are performing well, while the bus terminal section had extensive panel cracking.

A site on M-46 from east of Carsonville to Port Sanilac was selected to try the whitetopping because a project on M-46 from the Village of Carsonville to the east was already being designed using a standard method of rehabilitation. This site would provide similar existing pavement cross sections, pavement conditions, and traffic conditions for both materials. Average Annual Daily Traffic is 2800 with about 12 percent being commercial. The standard-method fix project (herein referred to as the bituminous project), was changed to three sections using bituminous fixes. The bituminous project starts at the west village limits and continues east from Carsonville for approximately 4 km to just west of Goetze Road. The whitetopping project (Control Section 74062, Job Number 47172A) begins where the bituminous project ends and continues east for approximately 7.3 km to the junction of M-46 and M-25 in the village of Port Sanilac. A location and test section map are shown in Figure 1.

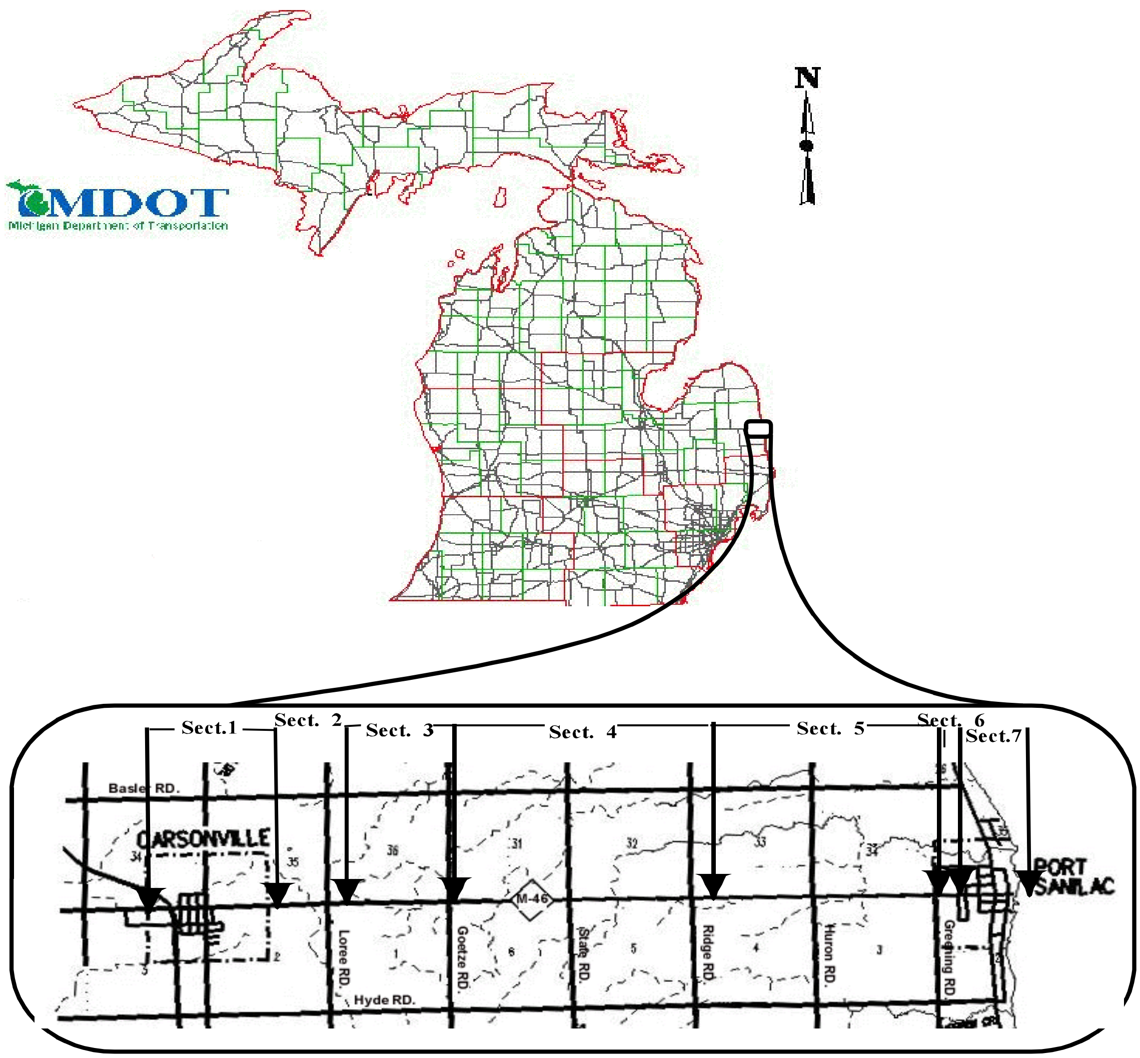

Figure 1. Project and Test Section Locations

The study sections are as follows:

Bituminous Fixes

Section 1. Village of Carsonville - mill 40 mm (minimum) of existing bituminous and resurface with 90 mm of bituminous - existing pavement is composite.

Section 2. East village limits to Loree Road - minor surface repair with 75 mm bituminous overlay - existing pavement is flexible.

Section 3. Loree Road to Goetze Road - crush and shape with new 89 mm bituminous pavement - existing pavement is flexible.

Concrete Whitetopping Fixes

Section 4. Goetze Road to Ridge Road - 150 mm whitetopping without reinforcing fibers - existing pavement is flexible.

Section 5. Ridge Road to 305 m west of west village limits of Port Sanilac - 150 mm whitetopping with fibers - existing pavement is flexible.

Section 6. 305 m west of west village limits of Port Sanilac to the west village limits - 125 mm whitetopping with reinforced fibers - existing pavement is flexible.

Section 7. West village limits to M-25 - mill 50 mm of existing bituminous and overlay (inlay) with 75 mm whitetopping with fibers - existing inner lanes are composite & outer lanes are flexible.

In test section 1, the existing pavement was 100 mm of bituminous over 200 mm non-reinforced concrete. The base consisted of anywhere from 300 to 700 mm of sand or in some spots the pavement was constructed directly on the clay subgrade. In test sections 2 through 6, the existing pavement was 100 mm of bituminous over 200 mm of gravel and about 300 mm of sand. In test section 7, the existing pavement averaged 123 mm of bituminous over 203 mm of concrete. The subbase averaged 170 mm of gravely sand.

Expected design lives of the various fixes are found in Table 1. Section 1 is the control for section 7, section 2 is the control for section 6, and section 3 is the control for sections 4 and 5.

The project objectives and future evaluation timetable are described in Work Plan 146, under Research Project 98 G-0322, *Evaluation of Concrete Rehabilitation Alternatives on Low-Volume Michigan Routes*.

Table 1. Expected Design Lives

Concrete fix	Design Life	Bituminous Fix (control)	Design Life
Section 7, inner lanes	8 yrs.	Section 1	10 yrs.
Section 7, outer lanes	8 yrs.	Section 2	15 yrs.
Section 6	8 yrs.		
Section 4	15 yrs.	Section 3	15 yrs.
Section 5	15 yrs.		

DESIGN

Originally, the limits of the bituminous job were within the village limits of Carsonville and the scope of work involved only coldmilling and resurfacing. The whitetopping would then be constructed from the east village limits of Carsonville to M-25 in Port Sanilac. However, two more standard bituminous fixes were added to compare performance with the whitetopping. Standard AASHTO design procedures were used to determine overlay thicknesses. Examples of pavement cross-sections can be found in the Appendix.

Design of the concrete whitetopping test sections was initiated in consultation with the Michigan Concrete Paving Association. Originally, there were to be two 125 mm thick sections outside the village limits of Port Sanilac, one with reinforcing fibers and one without. Several other states have reported better performance of their whitetopping pavements when fibers are used. Michigan decided to try a section without fibers to verify this.

After further consultation with the Michigan Concrete Paving Association, the thickness was increased to 150 mm. A small 125 mm section with fibers to judge the original 125 mm design, was included between the 150 mm sections and the 75 mm inlay.

Outside of the village limits is very open farmland with only four intersections and few driveways spaced over 6.4 kilometers. This area lent itself to a straight overlay. However, within the village limits it was desirable to limit changes in pavement elevations due to the number of driveways and intersections, plus curb and gutter in one section. Therefore, it was decided to mill off 50 mm of the bituminous surface and replace it with 75 mm of whitetopping with fibers. This would provide 75 mm of concrete over approximately 50 mm of bituminous on top of 207 mm of old concrete pavement.

The original 1924 concrete pavement is just 6 meters wide. The new concrete surface was designed to be 7.2 meters wide with 1 meter shoulders, except in the curb and gutter area where it would be 12 m wide (curb to curb). This meant that outside the area of the 6 meter original concrete, the whitetopping would be supported by a variable thickness of bituminous (50 mm down to 0) and a gravel shoulder. This would provide insufficient support, so a thickened section was adopted where the bituminous and gravel would be excavated an additional 100 mm. The area outside the original concrete would then be paved monolithically with the inner portion. This resulted in a 175 mm (75 mm plus 100 mm) section.

Joint spacing was designed using the recommendations of the American Concrete Paving Association. In the 150 mm and 125 mm sections, transverse joints were spaced at 3 meters with the longitudinal joints spaced at 3.6 meters. In the inlay section joints were spaced at 1.0 to 1.25 meters in both the transverse and longitudinal directions. This range was used so that spacing could be adjusted to ensure that a longitudinal joint would be placed over the edge where the normal inlay section meets the thickened edge. Low-modulus, hot-poured rubber would be used as the joint sealant in the 150 mm and 125 mm sections. The inlay would be unsealed based on the recommendation of the Michigan Concrete Paving Association, which cited numerous examples of successful unsealed ultra-thin whitetopping pavements in other states.

A three-year warranty on materials and workmanship was required on both the whitetopping and the bituminous fixes. Details on the warranty can be found in the Appendix.

PRE-CONSTRUCTION EVALUATION

Examples of the existing condition of the pavement prior to construction can be found in Figures 2 through 5. As can be seen from the figures, all sections had rutting, potholes, and alligator cracking of various severity levels.

Figure 2. Typical pavement condition between Carsonville and Port Sanilac.

Figure 3. Typical pavement condition between Carsonville and Port Sanilac.

Figure 4. Typical edge deterioration.

Figure 5. Typical pavement condition in Port Sanilac village limits.

Falling weight deflectometer (FWD) testing was conducted in the eastbound lane prior to construction in order to backcalculate layer moduli. The department's KUAB FWD was used to collect the data every 100 meters. These data were then run through the MICHBACK computer program to backcalculate the layer moduli. Existing layer thicknesses were required as input for the backcalculation. These thicknesses were taken from the log of soil borings (in the Appendix). The cross-section of the pavement was consistent in three different areas: within the village limits of Carsonville, between Carsonville and Port Sanilac, and within the village limits of Port Sanilac. The layer thicknesses from the soil boring log were averaged for each of these three areas. Each of the test sections is located in one of these three areas, so that area's average layer thickness was used for the backcalculation. Average layer moduli for each of the test sections can be found in Table 2. Due to sewer work occurring in the village of Carsonville, test section 1 could not be tested.

Table 2. Layer Moduli for Each Test Section			
Section	**Pavement**	**Agg. Base**	**Subgrade**
1	No tests	No tests	No tests
2	3311 MPa	112 MPa	135 MPa
3	4153 MPa	149 MPa	169 MPa
4	4267 MPa	136 MPa	168 MPa
5	3724 MPa	130 MPa	134 MPa
6	3920 MPa	134 MPa	118 MPa
7	3141 MPa	146 MPa	143 MPa

Ride quality was also measured prior to construction. Michigan uses its own Ride Quality Index (RQI). Table 3 has the average RQI numbers before construction. An RQI of 0 to 30 is considered excellent, 31 to 54 is considered good, 55 to 70 is considered fair, and greater than 70 is considered poor.

Table 3. Pre-Construction Ride Quality Numbers		
	Direction	
Section	**Eastbound**	**Westbound**
1	114	95
2	70	62
3	56	68
4	62	66
5	73	67
6	63	63
7	81	84

Table 4 contains the average Distress Index (DI) numbers for each test section from our Pavement Management System (PMS). Each pavement within the jurisdiction of MDOT is videotaped every two years. These videotapes are reviewed and all visual distresses are logged. Points are assigned to each distress based on its extent and severity levels. The points for a 160 meter section were totaled and then averaged to arrive at a DI for each section. The DI scale starts at 0 (no distress) and increases with no upper limit. A DI over 50 is treated as a pavement that is no longer suitable for preventative maintenance. Videotaping for all test sections was done in the spring of 1998. The next taping is scheduled for late in 2000.

Table 4. Distress Index Numbers for Each Section

Section	Dist. Index
1	311
2	111
3	132
4	61
5	46
6	23
7	111

CONSTRUCTION

Bituminous Project

Work on the bituminous project began in May 1999. The project called for sewer pipe and water main upgrading, which was completed first. Once this work was completed, the contractor then began work on the bituminous fixes in July. All three test sections used Michigan 4E3 mix design for the leveling course and Michigan 5E3 for the surface course, in the mainline. The asphalt mix design properties and aggregate gradations can be found in Tables 5 and 6. Some 4E3 was used for wedging where needed. No specific problems were encountered during the construction of this job.

Table 5. Asphalt mix design properties.

Property	4E3	5E3
Asphalt Cement grade	PG 58-28	PG 58-28
Asphalt Cement content, %	5.6	5.9
Air Voids, %	4.0	4.0
V.M.A., %	14.6	15.5
Aggregate angularity	42.5	42.8

Table 6. Asphalt mix aggregate gradations.		
Sieve Size	4E3	5E3
19 mm	100	100
12.5 mm	95.2	100
9.5 mm	87.5	96.4
No. 4	80.8	84.4
No. 8	57.5	60.3
No. 16	40.2	42.5
No. 30	29.9	31.9
No. 50	18.9	20.3
No. 100	6.8	7.3
No. 200	4.8	5.3

To facilitate faster construction on both M-46 projects, a detour route was used on a parallel county road. Local traffic was allowed to drive on the shoulders.

Concrete Project

Work on the concrete whitetopping began in late May, 1999 with some shoulder work, ditch work, and driveway culvert improvements. Once this work was completed, the contractor began paving the whitetopping. The existing asphalt surface did not have ruts greater than 50 mm, open potholes, or shoving present, so no preparation repairs were required prior to paving.[3]

Concrete paving began on June 19, 1999, near Geotze Road on the west end of the project. The intersection was gapped out for maintaining traffic. The entire 9.2 meter width was paved in one pass. In areas where widths were tight (at guardrail, etc.) the shoulder was not paved. These gapped areas were formed and poured at a later date. Lane turning tapers were also formed and poured at a later date.

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[3] *Whitetopping - State of the Practice,* EB210P, American Concrete Paving Association, 1998

The whitetopping design called for no reinforcement and no dowels at the joints. However, lane ties at the shoulder joint and the centerline joint were specified. The lane ties at the shoulder joint were held in place with spikes like those shown in Figure 6. One spike was typically in the aggregate shoulder and one was in the existing asphalt. In some cases, a pilot hole needed to be drilled in order to place the spike into the asphalt. The 760 mm long deformed No. 16 bars were offset so that 530 mm were embedded in the lane. The lane ties at the centerline joint were placed with a "rocket launcher" tie bar inserter attachment on the paving machine (Figure 7).

Figure 6. Tie bars setup used at shoulder joints.

Figure 7. Method for placing tie bars at centerline.

The concrete was mixed in a mobile mix plant set up on site. It had the capacity to mix 6.8 m^3 every four minutes. The concrete was then dumped into agitor-type trucks (Figure 8), which then placed it on the pavement in front of the spreader. The time from batch plant to placement on the pavement was generally less than 10 minutes.

Figure 8. Trucks used for hauling the concrete.

Following is the concrete mix design used per cubic meter. The mix design was developed by the contractor and approved by the department since this was a contractor quality control project.

Portland Cement	310 kg
2NS fine agg.	846 kg
6AA coarse agg.	971 kg
Water	141 kg
Air Entrainment adm.	110-130 ml/100 kg
Water-Reducing adm.	130 ml/100 kg

Immediately in front of the paving train, the existing asphalt pavement was sprayed with water from a water truck to cool it off as seen in Figure 9. The paving train consisted of a spreader, paver, and finisher. Following the paving train the concrete was hand-finished and a curing compound was applied.

Figure 9. Water on bituminous just prior to paving. Note the rutting.

A few problems were encountered during construction. Traffic was being maintained on the gravel shoulders during construction. One morning, construction workers returned to find about a kilometer of stringline had been knocked down. It took most of the day to get it back to the correct level. Fortunately, it was ahead of where the paving was taking place so that operation was not held up.

On several occasions, the plant went down and paving was held up. This was never usually more than a half-hour in duration, so paving could continue per the progress schedule.

A section of the existing composite pavement in the ultra-thin inlay in Port Sanilac was so badly deteriorated that it was totally removed and replaced with only concrete. The length of the removed concrete was 18 meters and was located at the Church Street intersection.

After milling off 75 mm of the bituminous surface in the ultra-thin inlay section, the edge was severely deteriorated as seen in Figure 10. This could be a potential support problem for the ultra-thin whitetopping.

Figure 10. Edge condition after milling.

Another problem was the need for cross slope correction. The planned pavement thickness was held on the shoulder joint of the eastbound lane. Crown correction was referenced from that point. At some locations, the existing westbound pavement was severely flattened and deformed from truck traffic. This resulted in the whitetopping being 300 to 350 mm thick in the westbound shoulder, as seen in Figure 11 (150 mm test sections only). Random cores were taken from shoulder to shoulder along the length of the project. These cores showed that the 150 mm proposed sections were paved at 203 mm (average of 15 cores), and the proposed 75 mm inlay was paved at 106 mm (average of 3 cores).

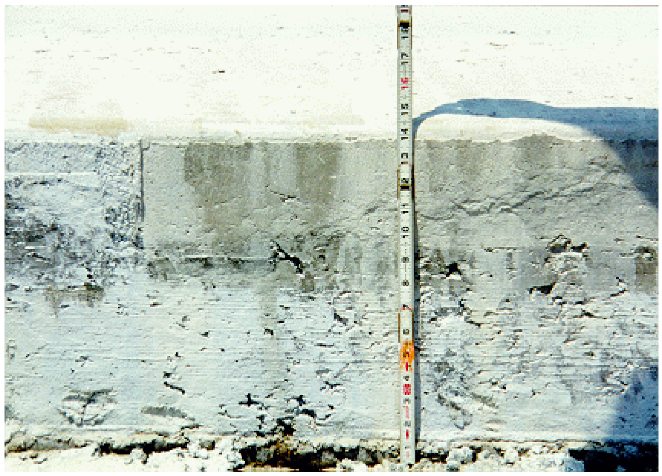

Figure 11. Example of a thick shoulder due to grade correction (not typical).

CONCLUSIONS

Based on observations made during construction, the following conclusions were drawn:

- The construction of both the bituminous project and the whitetopping project went very well.
- Rehabilitation of a deteriorated bituminous pavement can be done quickly with whitetopping. This was especially true on this job since there was no prep work done on the pavement, traffic was detoured, and the contractor chose to pave full-width, including both shoulders.
- Finishing and texturing the concrete containing fibers requires a little more effort because the fibers tend to pull and drag.
- The whitetopping test sections were paved much thicker than planned, which will likely help provide a longer fatigue life for the pavement. Because this is not a typical design for this whitetopping, another test site should be chosen where the pavement will see more traffic and the cross-section is typical thickness. This will better judge the cost effectiveness of whitetopping as a pavement rehabilitation alternative.