Research Record

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Thin Whitetopping: Rehabilitation Alternative

MDOT Investigates Whitetopping for Rehabilitation of Low-Volume Flexible and Composite Routes

Thin and ultra-thin whitetopping is the term used for paving with Portland cement concrete over an existing bituminous pavement.[1] As a rehabilitation alternative, whitetopping may offer increased durability and savings over traditional, bituminous rehabilitation. The service life of bituminous resurfacing is typically seven to 15 years, whereas some whitetopping projects have performed for over 20 years. This report describes one of Michigan's investigations into whitetopping as an alternative to bituminous rehabilitation.

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.

Other states have constructed whitetopping and ultra-thin whitetopping concrete rehabilitation designs, but until 1999, concrete whitetopping had not been used on any Michigan trunklines. The first whitetopping project dates from 1918 in Terre Haute, Indiana. Since then, nearly 200 projects have been constructed nationally in at least 28 states.

Many states report satisfactory results with whitetopping. Some western states have reported whitetopping projects with over 20 years of service. In particular, Iowa has many miles of whitetopping that provide excellent service with low maintenance needs after 25 years. A recent cost comparison study in Iowa showed:

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

There are three locations in Michigan where whitetopping had been used on local or private roads before 1999:

- 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.

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.

Michigan's first trunkline whitetopping project investigated thin and ultra-thin whitetopping on M-46 between Carsonville and Port Sanilac in 1999. This trial project studied whitetopping as an alternative to the Michigan Department of Transportation's (MDOT) standard bituminous fixes for rehabilitating deteriorated bituminous pavements.

MDOT selected M-46 from east of Carsonville to Port Sanilac for 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. The neighboring M-46 sites would provide similar existing pavement cross sections, pavement conditions, and traffic conditions for later evaluations of both materials. The average annual daily traffic for this trunkline is 2800 with 12 percent commercial traffic. The standard-method fix project, herein referred to as the bituminous project, was applied in three sections using different bituminous fixes for comparison purposes. The bituminous projects start at the west village

[1] *Whitetopping - State of the Practice*, EB210P, American Concrete Paving Association, 1998.
[2] *No Longer an Experiment,* Roads & Bridges, April 1997.

limits of Carsonville and continue east approximately 2.5 mi. 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 4.5 mi. to the junction of M-46 and M-25 in the village of Port Sanilac. The locations, descriptions, and expected design lives of each section are listed in Table 1.

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.

Figure 1. Typical pavement condition in Port Sanilac village limits

Design

MDOT consulted with the Michigan Concrete Paving Association during the whitetopping test section design. Originally, there were to be two 5 in. thick sections outside the village limits of Port Sanilac, and to better compare design performance, one section was designed with reinforcing fibers and one without. Several other states have reported better performance of their whitetopping pavements when fibers are used.

After further consultation with the Michigan Concrete Paving Association, the thickness was increased to 6 in. To evaluate the original 5 in. design, a small 5 in. section with fibers was included between the 6 in. sections and the 3 in. inlay.

The 4 mi. of open farmland outside village limits has only four intersections and few driveways. This area lent itself to a straight overlay. Within the village limits, the number of driveways, intersections, curbs, and gutters limited the changes in pavement elevations possible. Engineers therefore decided to mill off 2 in. of the bituminous surface and replace it with 3 in. of whitetopping with fibers. This would provide 3 in. of concrete over approximately 2 in. of bituminous on top of 8 in. of old concrete pavement.

The original 1924 concrete pavement is just 20 ft. wide. The new concrete surface was designed to be 24 ft. wide with 3 ft. shoulders, except in the curb and gutter area where it would be 40 ft. wide (curb to curb). Outside the area of the 20 ft. original concrete, the whitetopping would be supported by a variable thickness of bituminous (2 in. down to 0 in.) and a gravel shoulder. To provide adequate support, designers designated a thickened section where the bituminous and gravel would be excavated an additional 4 in. Outside the original concrete, contractors would pave monolithically with the inner portion, resulting in a 7 in. (3 in. plus 4 in.) section.

The American Concrete Paving Association designated traverse joints at 10 ft. and longitudinal joints spaced at 12 ft. in the 6 in. and 5 in. sections. In the inlay section, joints were spaced at 3-4 ft. in both the transverse and longitudinal directions. The variable spacing was intended to ensure a longitudinal joint would be placed over the edge where the normal inlay section meets the thickened edge. Engineers designated a low-modulus, hot-poured rubber joint

Section	Location	Fix	Present construction	Base	Expected Design Life
1	Village of Carsonville	mill 1.5 in. (minimum) of existing bituminous and resurface with 3.5 in. of bituminous	4 in. of bituminous over 8in. non-reinforced concrete	12 to 28 in. of sand, or in some spots the pavement was constructed directly on the clay subgrade	10 years (control for section 7 inner lanes)
2	East village limits to Loree Road	minor surface repair with 3 in. bituminous overlay	4 in. of bituminous	8 in. of gravel and about 12 in. of sand	15 years (control for section 7 outer lanes and section 6)
3	Loree Road to Goetze Road	crush and shape with new 3.5 in. bituminous pavement	4 in. of bituminous	8 in. of gravel and about 12 in. of sand	15 years (control for sections 4 and 5)
4	Goetze Road to Ridge Road	6 in. whitetopping without reinforcing fibers	4 in. of bituminous	8 in. of gravel and about 12 in. of sand	15 years
5	Ridge Road to 1000 ft. west of west village limits of Port Sanilac	6 in. whitetopping with fibers	4 in. of bituminous	8 in. of gravel and about 12 in. of sand	15 years
6	1000 ft. west of west village limits of Port Sanilac to the west village limits	5 in. whitetopping with reinforced fibers	4 in. of bituminous	8 in. of gravel and about 12 in. of sand	8 years
7	West village limits to M-25	millexisting bituminous 2 in. and overlay (inlay) with 3 in. whitetopping with fibers	Inner lanes composite & outer lanes flexible: avgerage 5 in. bituminous over 8 in. concrete	7 in. of gravely sand	8 years

Table 1. Test sections in the whitetopping project

Figure 2. Rutting in existing pavement (note lane tie placement on the right shoulder)

sealant in the 6 in. and 5 in. sections. The Michigan Concrete Paving Association recommended an unsealed inlay, citing numerous examples of successful unsealed ultra-thin whitetopping pavements in other states. MDOT required a three-year warranty on materials and workmanship on both the whitetopping and the bituminous fixes.

Pre-Construction Evaluation

Figures 1, 2, and 3 show examples of the pre-existing pavement conditions. All sections had rutting, potholes, and alligator cracking of various severity levels. To evaluate the existing roadbed, MDOT conducted falling weight deflectometer testing, soil borings, Ride Quality Index (RQI) measurements, and a Distress Index (DI) evaluation.

Michigan's RQI has four ride quality levels: Excellent (0 to 30), Good (31 to 54), Fair (55 to 70), and Poor (greater than 70). RQI ratings ranged from 62 (fair) to 117 (poor) in this project's seven test sections.

MDOT videotapes pavement sections every two years to create an average Distress Index (DI). Distress seen in the videotape is logged according to extent and severity levels. The DI scale ranges from 0 (no distress) to infinity. Pavement with DI values over 50 is no longer suitable for preventive maintenance. The 1998 DI values for the test sections ranged from 23 to 311.

Figure 3. Typical edge deterioration

Construction

Bituminous Project

Work on the bituminous project began in May 1999. Following sewer pipe and water main upgrading, the contractor began bituminous work. All three test sections used Michigan 4E3 mix design for the leveling course and Michigan 5E3 for the surface course in the mainline. Some 4E3 was used for wedging, as needed. 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. No specific problems were encountered during construction.

Concrete Project

The whitetopping project began in late May 1999 with some shoulder work, ditch work, and driveway culvert improvements. The existing asphalt surface did not have ruts greater than 2 in., open potholes, or shoving present, so no preparation repairs were required prior to paving.

Contractors began concrete paving on June 19, 1999, near Goetze Road on the west end of the project. The entire 30 ft. width was paved in one pass. In areas where widths were tight (e.g. at guardrails), the shoulder was not paved. These gapped areas and lane turning tapers were formed and poured at a later date.

Figure 4. Shoulder joint lane tie detail (note lane-side offset)

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 4. One spike was typically placed in the aggregate shoulder and one in the existing asphalt. In some cases, a pilot hole needed to be drilled in order to place the spike into the asphalt. The 30 in. long deformed No. 5 bars were offset so that 21 in. 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.

Contractors mixed concrete in a mobile mix plant with a 60 ft.^{3} per minute capacity. The mix design is

Component	Quantity
Portland Cement	683 lbs.
2NS fine aggregate	1865 lbs.
6AA coarse aggregate	2141 lbs.
Water	311 lbs.
Air Entrainment admixture	1.7-2.0 oz./100 lb.
Water-Reducing admixture	2.0 oz./100 lb.

Table 2. Whitetop mixture design

shown in Table 2. The contractor developed and designed the mix and performed quality control approval by MDOT.

Agitor-type trucks carried the whitetop mixture from the plant and placed it on the pavement in front of the spreader. The elapsed time from batch plant to pavement placement was generally less than 10 minutes. Immediately in front of the paving train, a water truck cooled the existing asphalt pavement. The paving train consisted of a spreader, paver, and finisher. Workers hand-finished the pavement following the paving train and applied a curing compound.

Engineers faced several localized issues:

- 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 60 ft. length of removed concrete was located at the Church Street intersection.
- After milling off 3 in. of the bituminous surface in the ultra-thin inlay section, the edge was severely deteriorated. This could be a potential support problem for the ultra-thin whitetopping.
- The planned pavement thickness was held on the shoulder joint of the eastbound lane. At some locations, truck traffic had flattened and deformed the existing westbound pavement. Crown correction references in these locations led to 12-14 in. of whitetopping in the westbound shoulder.
- Random cores taken from shoulder to shoulder along the length of the project showed that the 6 in. proposed sections were paved at 8 in. (average of 15 cores), and the proposed 3 in. inlay was paved at 4 in. (average of 3 cores).

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. On jobs such as this one, existing surface preparation is minimal, traffic detours minimized, and the contractor may pave full-width, including both shoulders.
- Finishing and texturing concrete containing fibers requires a little more effort because of fiber pulling and dragging.
- Whitetopping test sections on this project 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. Observing pavement performance on a test route with whitetopping thickness according to original specifications would better show how whitetopping performs as a pavement rehabilitation alternative.

Reference Material

Much of the text within this Research Record was used with permission from the following report:

Author: Michael J. Eacker, PE

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