

Rubblization

Making an Impact in Michigan

By Angela S. Wolters, P.E., and Kurt Smith, P.E.

Since 1988, the Michigan Department of Transportation has been using rubblization as a road rehabilitation method. This process has been used across the country for two decades and not only restores structural capacity to the pavement, but also improves functional characteristics of the roadway including ride, noise, splash and spray, friction, and general appearance. Instead of removing the failed Portland cement concrete (PCC) slabs at great cost to the taxpayer and causing long-term traffic delays, the rubblization process breaks the slabs into smaller-sized pieces. The fractured PCC is then overlaid with hot-mix asphalt, and traffic is quickly returned to the roadway. The rubblization process reduces reflection cracking in the HMA overlay caused by slab movements of the underlying PCC pavement. This results in a durable pavement and a smoother ride.

Michigan has been a national leader in the use of this rehabilitation method, rubblizing more than 6 million square yards of pavement over nearly 20 years. A variety of studies have indicated the potential of rubblization as a rehabilitation strategy, and the performance of rubblized pavement projects throughout the U.S. has generally been good. More recently, a study analyzed the performance of 54 pavement projects rubblized in Michigan between 1988 and 2002. The results of that analysis were presented at the 2007 Transportation Research Board Conference in

a paper titled *Evaluation of Rubblized Pavement Sections in Michigan*. The paper presented evidence of good pavement performance for rubblized sections as well as suggested effective control of reflective cracking.

History of rubblization in Michigan

The early MDOT rubblization projects primarily used resonant frequency breakers (RFB). MDOT began rubblizing pavement with the RFB in 1988 and increased its rubblization projects in the mid 1990s. Between 1988 and 2002, a total of 34 rubblization projects using the RFB were constructed on Interstate, U.S., and state trunk highway projects throughout Michigan. In 1997, MDOT conducted its first rubblization project using the multi-head breaker (MHB). Between 1997 and 2002, the MHB was used to construct 20 rubblization projects on Interstate, U.S., and state trunk highway projects in Michigan. Since 1997, both RFBs and MHBs have been used extensively.

Extensive dataset used

To investigate the performance of the rubblized pavement sections in this study, MDOT provided information on the condition of the highway pavement sections that have been rubblized in Michigan for the years 1998 to 2002. A variety of highway section data was provided, including distress index (DI), distress types, international roughness index (IRI), ride quality index (RQI), traffic data, overlay thickness, year of last resurfacing, and pavement

maintenance activities recorded for the pavement section.

Previous research regarding the examination of pavement performance in MDOT had classified the DI into three general categories: low ($DI < 20$), medium ($20 < DI < 40$), and high ($DI > 40$). In addition, MDOT specifies that when a pavement reaches a DI of 50, it is considered to have exhausted its service life and it is ready for rehabilitation because its remaining service life (RSL) is considered to be zero.

MDOT uses a common measure for quantifying road roughness—IRI. In addition to the IRI, MDOT also reports pavement roughness in terms of the RQI. The RQI was developed by MDOT in the 1970s to provide a smoothness statistic that correlates ride quality to the subjective opinions of highway users. RQI measurements between 0 and 30 describe excellent ride quality, values between 31 and 54 reflect good ride quality, values between 55 and 70 indicate fair ride quality, and values greater than 70 reflect poor ride quality.

The DI, RQI, and IRI data were used to examine performance trends of the rubblized pavement sections. Specific distress information was also evaluated for the pavement sections in terms of the amount of transverse and longitudinal cracking included in the DI.

The rubblization dataset used in this study is the largest assembled to date, and the analysis used lends itself to periodic updating and could be used in other states where such data are available.

Performance data

The evaluation of the performance data showed that all but one rubblized pavement subsection of 57 constructed between 1997 and 2002 had a distress index less than 20. Therefore, 98 percent of these sections are categorized as being in good condition according to the DI condition rating scale. In terms of ride quality, according to MDOT's RQI measurement, all subsections are exhibiting excellent or good ride quality. Further, 96 percent of the subsections rubblized since 1997 have IRI values less than 95 inches per mile, which is considered by the Federal Highway Administration (FHWA) as the threshold for classifying pavements with good rideability.

Overall, the pavement sections constructed prior to 1997 have significantly higher DI values than those sections rubblized after 1997. Specifically, 30 percent of those subsections constructed prior to 1997 had a DI condition rating exceeding 20,

indicating either fair or poor condition, as compared to 2 percent of the sections constructed after 1997. Also 7.5 percent of the measured DI values for sections constructed prior to 1997 exceeded the service life threshold of 50. This performance data indicate that the overall performance of pavement sections rubblized in Michigan since 1997 has improved.

These changes in performance did not come as a surprise because several changes occurred in asphalt mix design in the mid to late 1990s. In 1997, changes were made to the calculation of voids in the mineral aggregate (VMA) with MDOT switching to the use of bulk aggregate specific gravity from effective aggregate specific gravity with an assumed absorption. This change, along with a change in target air voids in the asphalt mixes to 4 percent, resulted in mixes with less rutting, less segregation, and overall better performance compared to previous asphalt mixes.

Other thresholds and common distresses evaluated

One of the primary reasons for rubblizing a PCC pavement is to reduce reflection cracks that might occur in the HMA overlay due to movements in the underlying slabs. Therefore, an assessment of the performance of rubblized pavements included an analysis of the transverse cracking in the HMA surface. This was accomplished by using the distress code data provided by MDOT to extract the amount of transverse cracking reported in the DI.

The majority of sections showing significant DI values due to transverse cracking were constructed prior to 1992, which suggests that the rubblization process at that time was not effectively eliminating the causes contributing to transverse cracking. However, the performance of sections rubblized since 1997 indicates that all pavement sections are in good condition based upon the DI, and all sections have low DI

Airfield Rubblization Projects Move Forward

Rubblization and HMA overlay of concrete pavements on highways and streets has become routine in many states. A more recent development has been the rubblization and HMA overlay of thick airfield concrete pavements.

Runway 01-19 at Selfridge Air National Guard Base in Michigan was rebuilt in 2002. Ajax Paving Industries was the HMA paving contractor. The majority of the existing pavement was two layers of concrete – a 10-inch-thick layer over an 11-inch-thick layer.

In order to effectively and efficiently rubblize this thick cross-section, work crews first broke the 96,000 square yards of concrete with a 6-ton, guillotine-style hammer and completed the rubblizing with a 16-hammer multi-head breaker. The overlay consisted of a nominal 4.5 inches of crushed aggregate base course for grade correction and 7 inches of HMA.

"The rubblization and overlay project was a success," said Warren Brown, project engineer at the base. "The runway is still holding up well and the pilots like it for its smooth surface."

More than 100 million square yards of thick concrete airfield pavements over 35 years old exist in the U.S. and will soon require a cost-effective, quickly constructed, and long-term rehabilitation solution.

The success of the Selfridge project and an even larger project at Grand Forks Air Force Base (238,000 square yards of 19 to 24-inch thick concrete rubblized and overlaid in 2005) has demonstrated that the rubblization and HMA overlay option is an excellent choice for the rehabilitation of thick airfield pavements.



Rubblization and repaving completed at Selfridge Air National Guard Base in Michigan.

values associated with transverse cracking (less than 7).

An examination of the occurrence of longitudinal cracking revealed that it is the most significant distress present on the majority of the pavement sections rubblized since 1997. Further review of longitudinal cracking showed that the majority of this distress was concentrated at the pavement joint or at the pavement edge.

Family models used to create performance trends

The information compiled from the MDOT database was also used to evaluate the rubblized (both MHB and RFB) pavement sections in terms

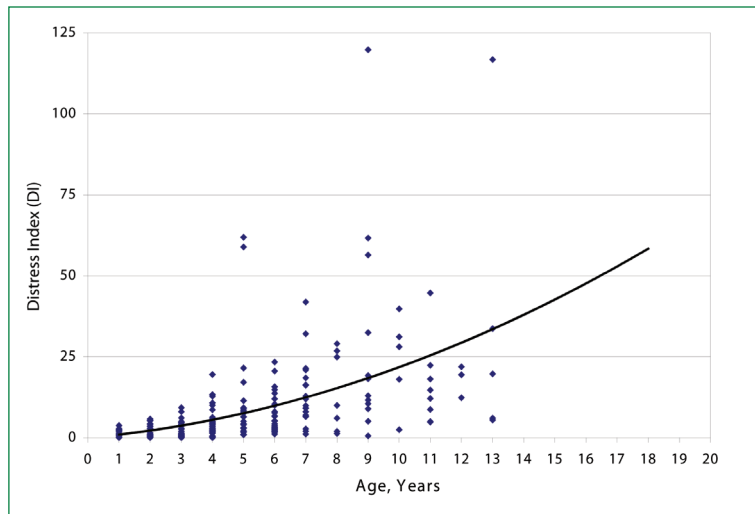


Figure 1. DI data for sections rubblized between 1988 and 2002 in Michigan.

of their performance trends over time. Performance trends of average DI for the MHB and RFB pavement sections from 1997 to 2002 found similar, positive performance for pavement sections rubblized with both types of equipment. A statistical analysis verified that the method of

rubblization (the use of MHB versus RFB) is not a significant factor for predicting DI.

Therefore, using the MHB and RFB data combined for 1988 to 2002, a final regression model was developed that shows an expected average service life of 16.5 years for all rubblized pavement sections in Michigan, as shown in figure 1, based upon a terminal DI of 50 (where the pavement

is assumed to have no remaining service life). The expected service of 16.5 years is based upon the performance of all rubblized sections from 1988 to 2002. If performance trends continue to support the improved performance of pavement sections constructed since 1997 as compared to sections constructed prior to 1997, it is expected that the average service life of the rubblized pavement sections will continue to improve. These expectations will be examined with further monitoring of pavement performance.

Using the MHB and RFB data combined, a regression model was also developed that shows the IRI trends over time for the rubblized pavement sections (see figure 2). As mentioned previously, good ride quality is defined by the FHWA as an IRI value less than 95 in/mile while an acceptable ride quality is defined as an IRI value between 95 in/mile and 170 in/mile. Based upon this standard, on average the rubblized pavement sections in Michigan have maintained a good ride quality for their first 14 years of service. Based upon all collected IRI data, 91 percent of measurements indicate that pavement sections are displaying good ride quality, 8 percent of measurements indicate acceptable ride quality, and only 1 percent of the measurements indicate

Rubblization Helps Contractor Build Quality Highway and Fulfill Warranty

Michigan is home to one of the early design/build/warranty HMA paving projects in the U.S. Thompson-McCully was the contractor on the US-23, Washtenaw County project constructed in 1997. This unique Michigan Department of Transportation (MDOT) project required a 20-year design life and a five-year pavement performance warranty.

Thompson-McCully chose to include rubblization of the existing jointed reinforced concrete pavement and a four-lift HMA overlay in its proposed design. Variable lift thicknesses produced a 7 to 10.5-inch thick overlay that included a wearing course of stone-matrix asphalt (SMA). The crew rubblized the 25 lane miles of divided four-lane highway using the multi-head breaker.

The contractors and MDOT worked closely together to maximize quality construction in order to meet the strict initial and annual pavement performance requirements of the warranty. For example, MDOT measures ride quality for each 0.1-mile section of highway with its ride quality index (RQI). The warranty required initial RQI values no greater than 45 and individual sections not increasing more than 10 RQI points over the five-year warranty period.

Historical values, generally collected every other year for a given highway, can be found in the MDOT pavement management system database. The average RQI values for this project's pavement were 22.1 in 1998, one year after construction, and 28.2 in 2003, one year after the completion of the warranty period. This rubblization and HMA overlay project has provided continued excellent ride quality.

unacceptable ride quality on the rubblized pavement sections.

The development of expected service life estimates was based on limited performance data, and in fact the majority of the pavement sections are less than 6 years old. As more data becomes available in the future, improved estimates of performance lives can be made. Therefore, future performance data for the pavements will provide the needed information to better define the performance trends and expected service life of rubblized pavements.

Conclusion

Michigan has an extensive history of rubblization. MDOT start-

ed using rubblization followed by a HMA overlay as a rehabilitation technique for deteriorated concrete pavements in 1988 to reduce the occurrence of reflective cracking in the overlay. While some projects constructed prior to 1992 exhibited higher levels of

reflective transverse cracking, pavements constructed since then have had reduced amounts. Specifically, those sections constructed since 1997 have shown very good overall performance with little to no occurrence of reflective cracking, indicating that rubblization has done a sufficient job of providing the breakage of the underlying concrete pavement. **HMAT**

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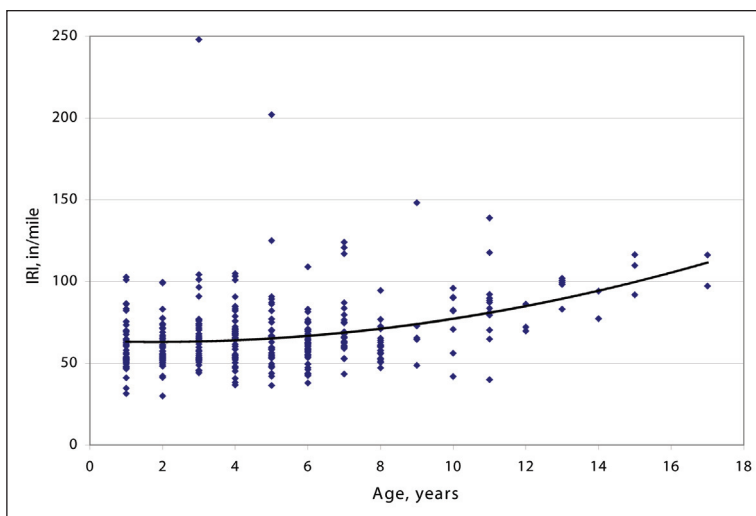
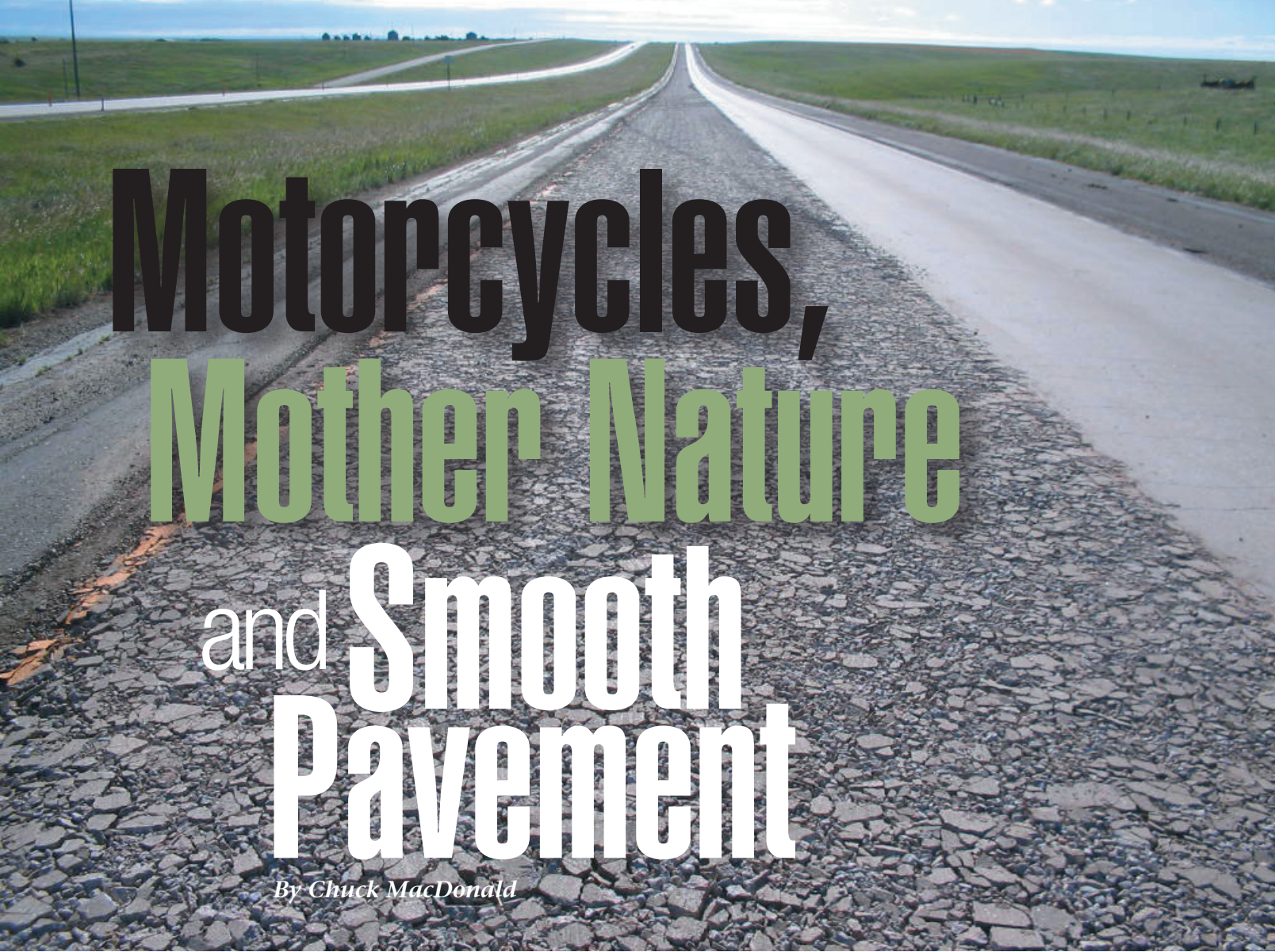


Figure 2. IRI data for sections rubblized between 1988 and 2002 in Michigan.



Motorcycles, Mother Nature and Smooth Pavement

By Chuck MacDonald

Work crews rubblized eastbound lanes of I-90 in South Dakota in preparation for a 6-inch surface course of asphalt.

When it comes to highway projects in South Dakota, two things must be considered. Don't mess with Mother Nature and don't mess with the Sturgis Motorcycle Rally. Border States Paving, based in Fargo, N.D., kept both these ideas in mind as it worked with a team of contractors and the South Dakota DOT to complete paving on I-90 between Presho and Kennebec on time and on budget. I-90 carries a large portion of the state's traffic and is one of the nation's major east-west highway corridors.

The project was to be finished by July, 2006, prior to the annual Motorcycle Rally, which nearly doubles the state's population each August,

and well before cold weather clamps down on paving operations. In order to meet the aggressive schedule, the contractors would have to rubblize the old roadway, cover the rubblized concrete with a gravel bond breaker, then lay down a 6-inch surface course of asphalt. In addition, eight bridge structures had to be rehabilitated.

Like a good motorcycle racer who builds up a big lead then coasts to the finish line, Border States Paving took some unusual steps during the 2005 paving season to be in good position to finish the massive project by the July 2006 deadline. "We decided early in the project that after moving traffic head-to-head while we were paving the eastbound

lanes, we needed to move the traffic again head-to-head onto the freshly paved lanes," said Dan Thompson, president of Border States Paving. With the traffic moved safely away from the bridge work, the subcontractors deployed large crews to work on several structures at once rather than nibbling at the project a little at a time. This allowed subcontractors to remove delaminated concrete on the eight bridge structures and complete the deck overlays before seasonal work closed down in October 2005.

When paving season started up in 2006, the Border States crews again put traffic head-to-head on the newly paved eastbound section and worked on the nine miles

of roadway westbound. With the bridge work already finished, the Border States team completed the paving by the deadline, including installing edge drains. The project required approximately 100,000 tons of hot mix produced at Border State's portable asphalt plant located just two miles off I-90.

The contract with the SDDOT included two, not three, head-to-head alignments. "The project was on a fast track schedule," said

Thompson. "We decided that the only way to get it done on time was to schedule a third head-to-head alignment of traffic. So we picked up the cost of it."

Rubblization used

Another key part of making the project a success was the rubblization of the failed pavement. Instead of hauling away the old road, the construction planners brought in a contractor to rubblize the con-

crete creating a solid foundation for the road and extra protection against reflective cracking. "This is the third rubblization project that we've done and we're happy with the way this one turned out," said Jay Peppel, Winner area project engineer for South Dakota's DOT. In addition to rubblization, project planners called for the contractor to place a gravel layer on top of the rubblized surface to absorb the frost heave activity created by South Dakota's brutal winter temperatures followed by the spring thaws. "This gravel layer serves as a bond breaker to prevent the frost-heave movement from cracking the new asphalt on top and keeping the road on grade."

The close cooperation between the DOT and contractors saved the project. Prior to beginning of the work, project designers decided that in order to get proper air voids, the binder content needed to be increased from a traditional mix. However, after the first three days of paving, the crew detected moderate rutting occurring in the bottom lift of asphalt. Immediately representatives from the state DOT, Dakota Asphalt Pavement Association, and Border States met to try to solve the problem. "There was no finger pointing, we simply worked together on how to fix the problem," said Doug Sherman Winner Area Engineer for the DOT. "We decided to make some adjustments to the mix design, and got the crews back paving."

The result of the teamwork, good problem solving, and outside-the-box planning, resulted in a smooth new stretch of asphalt pavement on the Interstate. The contractor received incentive payments for QC/QA quality and for the good profilograph readings.

"The newly placed pavement is performing great," said Sherman. "It also saved several million dollars from what the cost would have been if we had used more conventional methods."

HMAT