

Letter Report

# **Construction and Inspection of Asphalt State Highways**

*March 2011*



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**STATE OF WISCONSIN**

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Janice Mueller  
State Auditor

March 8, 2011

Senator Robert Cowles and  
Representative Samantha Kerkman, Co-chairpersons  
Joint Legislative Audit Committee  
State Capitol  
Madison, Wisconsin 53702

Dear Senator Cowles and Representative Kerkman:

In response to a complaint reported on the Fraud, Waste, and Mismanagement Hotline established by 2007 Wisconsin Act 126, we have completed a limited-scope review of the Department of Transportation's (DOT's) warranty program for asphalt state highways. Concerns were raised about the quality of asphalt highways constructed under warranties. From 1995 through 2009, 184 such highways were constructed under warranties that guarantee pavements will meet contractually specified performance standards, typically for five years. If DOT determines that these standards have not been met, contractors can be required to perform and pay for repairs.

We reviewed all warranted asphalt state highway projects constructed from 2002 through 2004. Pavements on 12 of these 34 projects did not meet some performance standards during their warranty periods. However, because many inspection results were provided to DOT regional offices after warranties had expired, it is unclear whether contractors can now be required to repair identified problems.

We also compared the quality of 33 asphalt pavement projects constructed under warranties to that of all 215 asphalt pavement projects constructed on state highways during the same three-year period. We found that the warranted projects generally show less distress—such as cracks, potholes, and ruts—and are smoother than those without warranties. However, some DOT engineers are concerned that warranted pavements constructed since 2004 are deteriorating more quickly than anticipated, particularly in northwest Wisconsin.

Because our May 2009 review of concrete state highways and several recent single audit reports for the State of Wisconsin found that DOT did not always follow its quality assurance program, we examined quality assurance procedures for asphalt state highways. We found that construction engineers performed 181 of the 193 tests (93.8 percent) required by DOT to measure the density of asphalt pavement on 41 projects constructed in 2009. We also found that DOT has improved its documentation of contractors' roughness measurements.

We appreciate the courtesy and cooperation extended to us by DOT in completing this review.

Sincerely,

Janice Mueller  
State Auditor

JM/DS/ss



## **CONSTRUCTION AND INSPECTION OF ASPHALT STATE HIGHWAYS**

The Department of Transportation (DOT) plans, promotes, and provides financial support to road, air, water, and other transportation programs statewide. It is funded through the Transportation Fund, a segregated fund that receives revenue primarily from state, federal, and local sources and from bond proceeds. Under the state highway program, DOT is responsible for planning, designing, constructing, and maintaining the 11,800-mile system of state highways in Wisconsin. Two-thirds of the system, or 7,800 miles of highways, is paved with asphalt.

The state highway program was appropriated \$1.6 billion in fiscal year (FY) 2009-10, including \$648.3 million in state funds, \$612.5 million in federal funds, and \$293.1 million in bond proceeds. The program has five components:

- the major highway development program, which funds projects involving new construction or significant highway improvements that are specifically enumerated in statutes by the Legislature;
- the rehabilitation program, which funds resurfacing projects that maintain a smooth ride and protect the underlying base of state highways, reconditioning projects that include both resurfacing and minor improvements such as adding turn lanes at intersections, and reconstruction projects that involve rebuilding existing highways;
- the southeast Wisconsin highway rehabilitation program, which funds projects such as reconstruction of Interstate 94 and the recently completed Marquette Interchange;
- the maintenance and traffic operations program, which funds snow removal, repair work, traffic signals, pavement marking, and road signs; and
- administration.

As required by federal regulations, DOT operates a quality assurance program for certain federally funded projects, and it applies the same quality standards to all state highways. Under DOT's quality assurance program:

- Construction contractors are required to complete various tests of construction materials and pavements to ensure that highways are built according to contractual requirements.
- Construction engineers—who may be either DOT staff or private consultants—provide oversight, ensure contractors follow contractual requirements, review and verify contractors' tests, and perform their own tests of materials and pavement.

In August 1995, the Federal Highway Administration began permitting states to include warranties in construction contracts for federally funded highway projects as a means to identify innovative construction practices that improve quality. DOT's pavement warranty program shifts responsibility for ensuring pavement quality from construction engineers to

construction contractors. Contractors are not required to test the quality of materials used in asphalt highways constructed under warranties, and construction engineers do not perform their own tests of the materials and the warranted pavement during construction, but contractors are contractually required to perform and pay for repairs if a DOT inspection determines that a pavement under warranty does not meet performance standards related to certain distress—such as cracks, potholes, and ruts—that indicates deterioration. Contractors are not held responsible for distress caused by factors beyond their control, such as an unstable pavement base. DOT periodically inspects the pavements during the warranty period, which is typically five years.

Staff in DOT’s five regions, which are shown in Figure 1, are directly responsible for managing most state highway projects, including those constructed under warranties.

Figure 1

**Department of Transportation Regions**



Although DOT does not separately track construction engineering expenditures, it does track each state highway project's expenditures, including those related to project design, real estate acquisition, and construction. Projects may also involve other expenditures, such as those related to environmental mitigation, historic preservation, traffic mitigation, insurance, and landscaping. DOT staff working on projects charge their time to various activity codes, a number of which are associated with activities that are typically, although not always, performed by construction engineers.

We obtained and analyzed activity code data maintained by DOT for construction engineering activities for all state highway projects. Time is charged to these codes by project managers who are located in the regional offices and oversee multiple projects, as well as by on-site construction engineers, including inspectors, technicians, and others. We also requested that DOT provide us with its private consultant expenditures for construction engineering activities. In reviewing DOT's information, we identified and removed a number of expenditures unrelated to construction engineering.

As shown in Table 1, DOT's expenditures for construction engineering increased from an estimated \$54.6 million in FY 2005-06 to \$69.8 million in FY 2009-10, or by 27.8 percent during the five-year period we reviewed. Expenditures for state staff declined by 1.5 percent, while expenditures for consultants increased by 42.0 percent. The optimal construction engineering staffing level for state staff is a matter of ongoing disagreement. Over the five-year period we reviewed, estimated construction engineering staffing levels for state staff declined by 15.4 percent, from 271.1 full-time equivalent (FTE) positions in FY 2005-06 to 229.4 in FY 2009-10.

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Table 1  
**Estimated Construction Engineering Expenditures**

	FY 2005-06	FY 2006-07	FY 2007-08	FY 2008-09	FY 2009-10
State Staff	\$17,769,600	\$17,676,400	\$20,818,800	\$17,821,500	\$17,504,900
Consultants	36,849,300	41,180,900	36,000,300	42,619,200	52,341,900
<b>Total</b>	<b>\$54,618,900</b>	<b>\$58,857,300</b>	<b>\$56,819,100</b>	<b>\$60,440,700</b>	<b>\$69,846,800</b>

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In response to a complaint reported on our Fraud, Waste, and Mismanagement Hotline, and to follow up on findings in single audit reports we issued for the State of Wisconsin from FY 2005-06 through FY 2007-08, we reviewed construction engineering issues related to concrete pavement and reported our findings to the Joint Legislative Audit Committee in May 2009. In an August 2009 letter to the Audit Committee and at public hearings in September 2009 and January 2010, DOT indicated that it planned to address those issues. In May 2010, our Fraud, Waste, and Mismanagement Hotline received another complaint questioning the adequacy of DOT's quality assurance program for asphalt highway projects and alleging that DOT has not consistently inspected warranted asphalt pavement in a timely manner, and therefore contract

warranties may not be enforceable and contractors may be constructing substandard highways that deteriorate more quickly than anticipated.

We therefore analyzed DOT's quality assurance program for asphalt highways. We evaluated all 34 asphalt state highway projects constructed under warranties from 2002 through 2004 in order to determine when DOT inspected pavements, pavement quality, and whether contractors had performed and paid for necessary repairs. We also analyzed the extent to which DOT performed key quality assurance tests on 41 large asphalt state highway projects that were constructed without warranties in 2009, and we interviewed staff in DOT's central and five regional offices, as well as Federal Highway Administration and transportation officials in six other midwestern states and associations representing asphalt contractors. We did not review the small number of concrete highway projects that are constructed under warranties.

## **Asphalt State Highway Projects Constructed under Warranties**

Under DOT's warranty program:

- Central office staff, including a 0.4 FTE statewide warranty coordinator position, develop statewide policies, determine performance standards and the provisions to include in all contracts for projects constructed under warranties and monitor the program.
- The central office-based pavement data unit, which includes 6.0 FTE positions and 1.0 limited-term employee, inspects pavement under warranty and provides the results to the regional offices. It also biennially inspects each state highway.
- Regional office staff determine which projects will be built under warranties, analyze inspection results and examine the condition of warranted pavements, and determine whether to require contractors to perform and pay for repair work.

In a June 2009 report, DOT concluded that warranties are cost-effective and typically result in high-quality pavement. Regional offices are therefore encouraged to use warranties when appropriate. DOT policies indicate that warranties are most appropriate on rural highways, which have lower traffic volume and are less likely than urban highways to develop pavement distress because of leaking water and sewer lines or other factors unrelated to pavement quality. Decisions about the use of warranties also take into account the availability of construction engineers to provide oversight.

Over the 15-year period shown in Table 2, 184 asphalt state highway projects were constructed under warranties, and the number of warranted projects increased from 3 in 1995 to 29 in 2009. Warranted work was performed by 24 contractors, including 7 that constructed 157 projects, or 85.3 percent of the total.



Table 2

**Asphalt State Highway Projects Constructed under Warranties**

	Number	Project Length (in miles)
1995	3	17.0
1996	3	21.8
1997	3	29.0
1998	4	19.7
1999	5	51.4
2000	7	43.6
2001	10	83.9
2002	11	66.2
2003	9	45.3
2004	14	81.7
2005	15	103.9
2006	27	224.6
2007	21	148.1
2008	23	146.8
2009	29	226.2
<b>Total</b>	<b>184</b>	<b>1,309.2</b>

The expected lifespan of new or reconstructed asphalt highway pavement ranges from 15 to 20 years. Warranties last from four to seven years after project completion, but five-year warranties are most common. However, DOT indicated that distress such as cracks and potholes generally becomes apparent in the first several years after poor construction. It also indicated that the cost of performance bonds, which contractors purchase and incorporate into their bids, is likely to affect warranty length. The bonds are third-party guarantees that DOT will be compensated if a contractor fails to meet contractual obligations, and DOT believes that performance bonds for warranties lasting longer than seven years are cost-prohibitive.

As shown in Table 3, DOT's Northwest Region, which includes many rural highways with low traffic volume, was responsible for 48.9 percent of the 184 asphalt state highway projects constructed under warranties from 1995 through 2009. In contrast, the Southeast Region was responsible for only 4.3 percent of the total projects.

Table 3

**Asphalt State Highway Projects Constructed under Warranties, by DOT Region**

Region	Number	Percentage of Total	Project Length (in miles)	Percentage of Total
Northwest	90	49.0%	686.4	52.4%
Southwest	40	21.7	226.7	17.3
Northeast	24	13.0	172.0	13.1
North Central	22	12.0	170.8	13.1
Southeast	8	4.3	53.3	4.1
<b>Total</b>	<b>184</b>	<b>100.0%</b>	<b>1,309.2</b>	<b>100.0%</b>

**Quality Assurance and Oversight**

DOT's pavement data unit is contractually required to inspect a pavement during a warranty's first and final years. For each mile of pavement under warranty, the unit inspects two 0.1-mile (528 feet) segments, including one that is selected randomly and another that is always near the middle of the mile, using a vehicle with specialized equipment that records images of the pavement. A regional office may request additional inspections if it suspects certain areas of a pavement do not meet the performance standards.

Before May 2008, a warranty began on the date a pavement opened to traffic and expired precisely five years later. Since May 2008, all construction contracts stipulate that their warranties expire on November 1, regardless of when the pavement opened to traffic. For example, a five-year warranty on pavement that opened to traffic on August 15, 2008, will expire on November 1, 2013.

Inspections completed in a warranty's final year are particularly important because the results are used to determine whether contractors should be required to make any repairs to meet warranty obligations. Standard construction contracts prescribe particular types of repairs contractors can be required to perform for each type of distress covered by the warranty. If a regional office and contractor disagree about the need for repairs, either may invoke a contractually prescribed conflict-resolution process that currently involves DOT and contractor representatives.

Of the 34 warranted asphalt projects we reviewed, 33 had five-year warranties that expired by the time of our review, and 1 had a seven-year warranty that will expire in September 2011. Available information indicates all 34 projects were inspected as frequently as required through 2009, and Appendix 1 summarizes the inspection results.

However, as shown in Table 4, although the inspections were completed, the pavement data unit did not provide the regional offices with inspection results for 18 of the 33 projects until after the warranties had expired. Inspection results for all projects with warranties that expired in 2009 were not provided until 2010. The pavement data unit indicated that this delay was

caused by temporary problems with the software used to extract inspection results from the specialized equipment and that central office officials instructed the unit to complete its analysis of biennial inspections of each state highway, which it is also required to conduct, before analyzing the warranty inspection results.

Table 4

**Delays in Pavement Inspection Results Provided to DOT Regional Offices  
Asphalt Projects in the Final Warranty Year**

Final Warranty Year	Projects	Projects for Which Inspection Results Were Provided after Warranties Had Expired	Percentage of Projects
2007	11	3	27.3%
2008	9	2	22.2
2009	13	13	100.0
<b>Total</b>	<b>33</b>	<b>18</b>	54.5

It should also be noted that the pavement data unit does not systematically receive complete information about all pavements under warranty, including warranty start and end dates, from either DOT's central office or the regional offices. For example, the pavement data unit was unaware until recently that asphalt reconstruction work completed on the Marquette Interchange between 2005 and 2008 is currently under warranty. That project was not included in our analysis because it was constructed after 2004.

A number of central and regional office staff have expressed concern that warranty provisions may no longer be enforceable, and contractors may claim they are not obligated to complete repairs, because warranties had expired before the 2009 inspection results were received. Others believe that a contractor is responsible for repairs as long as the inspection is completed before a warranty expires, even if its results are not provided to the regional office and the contractor is not notified of the need for warranty-related repairs before the warranty expires. Contract warranty provisions related to this issue are unclear.

The pavement data unit's inspection results indicated that 35.3 percent of the 34 projects we reviewed did not meet one or more of DOT's performance standards at some point while under warranty:

- On six projects, contractors were directed to repair pavements at their own expense.
- On five projects, regional offices determined that contractors were not responsible for at least some pavement distress.

- On one 8.8-mile project on State Highway 27 in Chippewa County with a warranty that expired in March 2010, the contractor initially declined to perform repairs after the expiration date. The Northwest regional office did not inform the contractor of the need for repairs until July 2010, when it received the 2009 inspection results. In August 2010, the contractor agreed to perform and pay for the necessary repairs.

Regional offices were able to document their decisions that contractors were not responsible for pavement distress in three of the five projects we reviewed:

- Interstate 94 in Jackson County, a 7.5-mile project constructed in 2002 at a cost of \$4.2 million with a warranty that expired in November 2007, developed a particular type of pavement crack. During construction, DOT had signed a contract change order specifying that because the highway's underlying base was likely to cause this type of crack, the contractor was not responsible for repairing any related distress. In 2010, the Northwest regional office paid that contractor \$4.3 million to repair the pavement, and it plans to completely replace the entire pavement in 2014 and 2016 as part of a larger project it estimates will cost \$34.0 million.
- U.S. Highway 10 in Jackson County, a 10.2-mile project constructed in 2002 at a cost of \$2.3 million with a warranty that expired in June 2007, developed pavement distress that the Northwest regional office determined was caused by a flawed highway design. At the time of our audit, there were no plans to repair the pavement, which is in the early stages of failure, but the regional office is monitoring the pavement's condition.
- State Highway 37 in Buffalo County, a 5.1-mile project constructed in 2003 at a cost of \$4.5 million with a warranty that expired in October 2008, developed pavement cracks that the Northwest regional office determined were caused by the highway's underlying base. At the time of our audit, there were no plans to repair the pavement, but the regional office is monitoring the pavement's condition.

However, on the other two projects, regional offices were unable to provide written documentation supporting their decisions that contractors were not responsible for repairing warranted asphalt pavement:

- State Highway 11 in Racine County, an 8.1-mile project constructed in 2004 at a cost of \$6.0 million with a warranty that expired in November 2009, showed pavement distress in spring 2005. The Southeast regional office indicated to us that the cause of the distress was unclear, and that approximately \$100,000 in repair costs were shared equally by DOT and the contractor.
- State Highway 42 in Kewaunee County, a 9.3-mile project constructed in 2004 at a cost of \$1.6 million with a warranty that expired in November 2009, showed pavement distress from 2006 through 2009. The Northeast regional office indicated to us that inclement winter weather caused the distress, and therefore the contractor was not responsible for repairs.

Moreover, DOT's minimum performance standards for pavements under warranty may not have been sufficiently stringent. When the warranty program was implemented in 1995, the standards were set at levels that required contractors to perform repairs only if a pavement's condition was worse than at least 90.0 percent of all other pavements statewide. Pavement engineers in all five regional offices told us they believe these standards were not stringent enough and that some pavements under warranties are exhibiting distress beyond what would be expected. In December 2010, DOT addressed these concerns by making some existing standards more stringent and requiring contractors to meet a number of new standards relating to pavement distress that had not been previously addressed.

A warranty can be voided if repair or maintenance work is completed on the pavement by either DOT or counties, which contract to maintain state highways. DOT indicated that after a few counties inadvertently performed maintenance work on warranted pavements, it implemented a statewide database to track each pavement under warranty, including its location, the warranty's start and expiration dates, and all warranty work performed by the contractor. However, we found that some regions do not use the database. For example, the Southeast regional office keeps all warranty-related documentation in paper files, while the Northeast regional office uses its own database. No warranties were voided because of inadvertent county maintenance work during our review period.

While we did not find any indication that warranty work had not been completed, regional offices were unable to document that contractors had performed required warranty work on six projects that did not meet DOT's performance standards while under warranty. Similarly, the regional offices also could not document why contractors were not required to perform warranty work on two projects with pavements that did not meet performance standards.

### **Recommendation**

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*We recommend the Department of Transportation improve its management of the pavement warranty program by:*

- *ensuring the pavement data unit has complete information on all projects under warranty, including the dates each warranty begins and expires;*
- *taking steps to ensure contractors are informed of required repair work before a warranty's expiration;*
- *regularly reviewing and updating the minimum acceptable performance standards for pavement under warranty; and*
- *requiring the regional offices to maintain information about all warranted projects, including warranty work completed by contractors and the reasons contractors are not required to repair pavements under warranty, using the statewide tracking database.*

## Quality Comparisons

We compared the quality of asphalt pavement projects constructed under warranties from 2002 through 2004 with that of all 215 asphalt state highway projects constructed during that three-year period. Because pavement deteriorates over time and the rate of deterioration varies depending on the material over which a pavement is built, we compared pavements of the same age and reviewed only those built over a crushed aggregate base, which excluded 1 of the 34 warranted projects.

The pavement data unit measures pavement condition in two ways:

- The pavement distress index summarizes the extent and severity of road distress, including various types of cracking. It takes into account the distress DOT uses to evaluate compliance with warranty-related performance standards, as well as other distress. Scores can range from 0 to 100, with a lower score indicating less distress. DOT measures each mile of pavement.
- The international roughness index determines the amount of vertical motion a vehicle absorbs over a one-mile highway segment. DOT measures roughness with specialized equipment that calculates a numerical rating from 0 to over 300, with a lower score indicating a smoother highway.

As shown in Table 5, warranted asphalt pavement projects generally had better pavement distress index scores than nonwarranted projects during each of the first five years after construction. Appendix 2 includes the pavement distress index scores for each of the 33 warranted pavements we analyzed.

Table 5

**Pavement Distress Index Scores<sup>1</sup>**  
Asphalt Pavement Projects Constructed from 2002 through 2004

Pavement Age (in years)	Average Pavement Distress Index Score for All Asphalt State Highways <sup>2</sup>	Percentage of Pavement Miles with Better-than-Average Scores	
		Warranted Pavements	Nonwarranted Pavements
1	2.57	93.9%	90.3%
2	8.55	78.4	73.3
3	8.91	86.5	70.9
4	12.10	54.7	54.6
5	12.31	55.8	50.9
6	11.24	44.8	54.8

<sup>1</sup> Includes only pavement constructed over a crushed aggregate base, and only those highway segments for which DOT's data included a pavement distress index score.

<sup>2</sup> A lower score indicates less distress.

As shown in Table 6, warranted asphalt pavement projects were also smoother than nonwarranted projects during each of the first six years after construction. Appendix 3 includes international roughness index scores for each of the 33 warranted pavements we analyzed.

Table 6  
**International Roughness Index Scores<sup>1</sup>**  
 Asphalt Pavement Projects Constructed from 2002 through 2004

Pavement Age (in years)	Average International Roughness Index Score for All Asphalt State Highways <sup>2</sup>	Percentage of Pavement Miles with Better-than-Average Scores	
		Warranted Pavements	Nonwarranted Pavements
1	59.4	84.5%	60.5%
2	59.0	72.5	66.8
3	60.2	81.0	62.7
4	62.7	68.5	65.1
5	64.5	82.5	60.9
6	67.0	67.7	67.5

<sup>1</sup> Includes only pavement constructed over a crushed aggregate base, and only those highway segments for which DOT's data included an international roughness index score.

<sup>2</sup> A lower score indicates a smoother highway.

Despite the generally favorable quality of the warranted asphalt pavement projects, DOT pavement engineers are concerned that some pavement constructed under warranty after 2004 is deteriorating more quickly than anticipated and that the full extent of the problems may not become apparent until after the warranties expire. Pavement engineers in the Northwest regional office indicated that 13 of 21 warranted projects constructed in 2005 and 2006 are showing distress that is inconsistent with pavement age. For example:

- U.S. Highway 53 in Chippewa County, a 7.6-mile project constructed in 2006 at a cost of \$5.5 million and with a warranty that expires in July 2011, has unusual cracking and accelerating deterioration. A June 2009 Federal Highway Administration report indicated that the pavement may last 14 years or less, rather than the originally expected 20 years, because of construction quality issues. While the contractor believes that sealing the cracks and patching the distressed areas will be sufficient, the Northwest regional office believes that the distressed areas should be removed and replaced with new pavement. In September 2010, the regional office and contractor initiated the conflict-resolution process.

- State Highway 98 in Clark County, a 9.6-mile project constructed in 2006 at a cost of \$4.0 million and with a warranty that expires in August 2011, has begun to develop some cracks and other distress along pavement edges. Because of concerns with quality, the Northwest regional office asked the pavement data unit to inspect the entire pavement, rather than a sample. At the time of our audit, the regional office had not yet received inspection results.
- State Highway 40 in Rusk County, a 10.3-mile project constructed in 2005 at a cost of \$1.5 million and with a warranty that expired in October 2010, has begun to exhibit pavement distress. Because of concerns with quality, the Northwest regional office asked the pavement data unit to inspect the entire pavement. The inspection revealed that cracks and ruts are developing. The regional office believes portions of the pavement should be replaced, but the contractor proposed to patch the areas that have significantly deteriorated. In October 2010, the regional office and contractor initiated the conflict-resolution process.

The Federal Highway Administration expressed concerns about DOT's warranty program, indicating to us that:

- DOT's recordkeeping and contract supervision during the paving of warranted projects may not always be sufficient, which could reduce DOT's ability to determine why pavement subsequently deteriorates;
- staffing shortages in DOT's regional offices may sometimes result in warranties being used for projects that should be constructed without warranties; and
- DOT's minimum performance standards were not always stringent enough to address certain types of distress.

As a result of its concerns, the Federal Highway Administration inspected a \$7.4 million, 21.0-mile asphalt project on Interstate 94 in Trempealeau and Jackson counties that began to show distress in April 2009, the month construction began. The Federal Highway Administration reported in May 2009 that the distress was associated with reduced pavement quality and lifespan and increased maintenance costs, and in June 2009 that contractors had made repairs after the inspections. The project is under warranty until November 2014.

The Federal Highway Administration has also noted concerns with the westbound lanes of Interstate 94 in Jackson and Monroe counties, an 8.9-mile project constructed in 2009 at a cost of \$10.1 million and under warranty until November 2014. In November 2009, the federal agency reported that the pavement is likely to have future quality issues because the contractor contravened good construction practices by, for example, paving in inclement weather, and that if the project had not been under warranty, the contractor and construction engineer would have tested construction materials, identified quality problems, and corrected them during construction.



We attempted to determine whether pavement projects constructed under warranties cost more or less than nonwarranted projects. We were unable to do so because DOT does not maintain readily available project-specific information on materials testing and project supervision costs and does not track costs associated with administering the warranty program, inspecting pavement during warranty periods, or making repairs after warranties expire.

In June 2009, DOT estimated that warranted pavement projects cost approximately 17.0 percent less than similar nonwarranted projects. However, the estimate did not take into account all costs, including when DOT pays for pavement repairs after a regional office exempts a contractor from performing them, or long-term maintenance costs. Moreover, beginning in December 2009 the pavement data unit has received at least ten requests for more extensive inspections of pavement under warranty, to address regional offices' concerns about pavement quality. The pavement data unit indicates these are costly and time-consuming to perform.

### **☑ Recommendation**

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*We recommend the Department of Transportation report to the Joint Legislative Audit Committee by January 13, 2012, on the cost-effectiveness of asphalt pavement projects constructed with warranties.*

## **Warranty Programs in Other States**

Nationwide, 24 states have used warranties on at least some highway projects they manage. Among six surrounding midwestern states:

- Indiana, Michigan, and Minnesota currently have warranty programs;
- Illinois and Ohio previously had warranty programs but no longer do; and
- Iowa has never had a warranty program.

As shown in Table 7, Wisconsin has constructed more asphalt pavement projects under warranty than four of the five other midwestern states with warranty programs, and DOT appears to provide less oversight than the other states' transportation departments. For example, DOT allows contractors to select the construction materials they prefer, while the other states have established minimum materials requirements, and departments of transportation in Illinois, Michigan, and Minnesota test project materials. In Indiana, Ohio, and Wisconsin they do not. All six states have similar warranty periods.

Table 7

**Asphalt Pavement Warranty Programs in Six Midwestern States**

	Asphalt Pavement Projects Constructed under Warranties	Typical Warranty Period (in years)	Minimum Materials Requirements	Material Testing by State Agency
Illinois	11	5	Yes	Yes
Indiana	14	5	Yes	No
Michigan	1,350	3 and 5	Yes	Yes
Minnesota	20	3	Yes	Yes
Ohio	68	3 and 7	Yes	No
<b>Wisconsin</b>	<b>184</b>	<b>5</b>	<b>No</b>	<b>No</b>

We reviewed information about the quality and cost-effectiveness of warranties in other midwestern states and found mixed results:

- In October 2003, the Indiana Department of Transportation concluded that warranted asphalt pavement costs an estimated 10.0 percent more to build but an estimated 27.0 percent less to maintain over 25 years, which resulted in a net savings.
- A 2006 report by the Minnesota Department of Transportation concluded that two-year warranties provided no added value because of the additional administrative oversight they required and because contractors did not use innovative construction methods. The evaluation was unable to conclude whether five-year warranties provided any added value. Minnesota no longer uses either two- or five-year warranties.
- The Illinois Department of Transportation stopped using warranties after concluding in June 2004 that contractors did not use innovative construction methods, and therefore pavement quality would likely be similar whether or not warranties were used.
- The Ohio Department of Transportation stopped using warranties in 2009 after concluding that their benefit did not clearly exceed the added costs.

### **Quality Assurance for Nonwarranted Asphalt Pavements**

Under DOT's quality assurance program for asphalt pavement that is not constructed under warranty, contractors are contractually required to test for key factors in pavement quality and durability, such as density and roughness. Construction engineers and the technicians they oversee review the contractors' tests and also perform tests to verify the contractors' test results.

## Density of Asphalt Pavement

Adequate density, or compaction, increases the life expectancy of asphalt pavement, as well as pavement strength and stability, and it decreases cracking in low temperatures. According to the American Association of State Highway and Transportation Officials, which is a national nonprofit, nonpartisan organization, compaction is the most important factor in the performance of asphalt pavement.

DOT contracts specify minimum density standards for each of the multiple asphalt layers that make up a pavement. Until 2009, DOT contract specifications stipulated the number of density tests a project required based on the tons of asphalt used. Since 2009, contractors have been required to test each asphalt layer at one random location per 1,500 feet of highway lane. Construction engineers must verify the contractors' test results by conducting their own tests at one random location for every 15,000 feet, which is approximately 2.8 miles. At each location, they complete three tests ten feet apart and average the results. Separate tests are conducted on highway shoulders. If the results measured by the construction engineers vary considerably from those of the contractor, or if they are considerably below DOT's minimum standards, construction engineers conduct additional tests. If a project involves multiple mixes of asphalt, which is typically the case, each mix must be tested at least once. Construction engineers must document all test results in a DOT computer system.

We analyzed the density tests construction engineers performed on 41 state highway projects constructed in 2009 with more than 10,000 tons of asphalt, which is typically enough to pave three miles. Because we found that not all tests were documented electronically, we obtained additional information from the paper files for three projects. As shown in Table 8, 181 of the 193 required tests, or 93.8 percent, were performed on the 41 projects. While all 167 required density tests were performed on 37 projects, only 14 of 26 required tests were performed on the other 4 projects. Appendix 4 summarizes the test results.

Table 8

### Density Tests Completed by Construction Engineering Staff on 41 Asphalt State Highways Projects<sup>1</sup>

Percentage of Required Tests Documented	Projects	Required Tests	Tests Documented
100.0	37	167	167
75.0 to 99.9	1	4	3
50.0 to 74.9	2	9	5
0.0 to 49.9	1	13	6
Subtotal	4	26	14
<b>Total</b>	<b>41</b>	<b>193</b>	<b>181</b>

<sup>1</sup> According to DOT's documentation for 41 state highway projects constructed in 2009 with more than 10,000 tons of asphalt.

Our review of the 41 projects also indicated that other DOT testing policies were not always followed. We found that construction engineers:

- did not test each of the asphalt mixes used on 14 projects;
- did not take samples ten feet apart on 4 projects;
- completed fewer than three samples per location on 1 project; and
- inappropriately combined the test results of traffic lanes and highway shoulders on 1 project.

### **Recommendation**

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*We recommend the Department of Transportation ensure that construction engineers perform asphalt density tests as frequently as required and comply with all testing requirements, such as testing each asphalt mix used on a project at least once.*

Under DOT policies, a contractor may be directed to replace asphalt pavement if results of a density test performed by construction engineers are considerably below the minimum standard established in a project contract. We reviewed density test results for the 41 projects and found that:

- for 25 projects, all of the results met or exceeded DOT's minimum standards; and
- for 16 projects, at least one result was somewhat below the minimum standard, but no result was so far below the standard that pavement replacement was required.

If the result of a contractor-performed density test exceeds DOT's performance standard by a specified margin, the contractor earns a financial bonus, and if the result is under the standard by more than a specified margin the contractor is penalized. DOT considers all bonuses and penalties and calculates the net total for each project. We found that contractors for 39 of 41 projects were awarded a net total of \$241,000, which is an average bonus of \$6,200 per project. Per project net totals ranged from \$50 to \$21,400. Contractors for two projects received neither bonuses nor penalties. We did not review information on the individual bonuses and penalties, which are maintained only in paper files.

### **Roughness of Asphalt Pavement**

DOT contractually requires contractors to measure the roughness of asphalt pavement on most new construction projects of at least 1.0 mile. Before 2010, projects on roads with speed limits of less than 45 miles per hour were considered urban projects, and contractors were not required to measure the roughness of these pavements.

In October 2006, DOT began requiring contractors to measure roughness by using the international roughness index, which is a numerical rating from 0 to more than 300. DOT began

to use this index because new measurement technology was available and because it wanted to be consistent with the standards of the American Association of State Highway and Transportation Officials. Contractors' roughness measurements are reviewed by construction engineers, who determine whether the contractors should receive financial bonuses or be assessed financial penalties. For most asphalt pavements, contractors:

- receive bonuses for each 500-foot highway section with a roughness rating lower than 35;
- are paid the contractually required amount for each section with a roughness rating between 35 and 60;
- are assessed penalties for each section with a roughness rating greater than 60, or for parts of a section that have a roughness rating greater than 175; and
- must resurface each section with a roughness rating greater than 140.

We used summary information compiled by the Federal Highway Administration to compare the roughness of state highways in seven midwestern states in 2008, the most recent year for which data were available. As shown in Table 9, Wisconsin's state highways were fourth among the seven states in the proportion of miles rated as smooth. The proportion of Wisconsin state highways rated as smooth decreased by 1.6 percentage points from 2007 to 2008, while the proportions rated as fair and rough increased by 1.3 and 0.3 percentage points, respectively.

Table 9

**International Roughness Index Rating<sup>1</sup>  
2008**

State	Percentage of Highway Miles		
	Smooth (0 to 94)	Fair (95 to 144)	Rough (145 or more)
Illinois	43.1%	33.0%	23.9%
Indiana	57.7	29.9	12.4
Iowa	47.2	30.6	22.3
Michigan	61.7	20.5	17.8
Minnesota	56.0	32.0	12.0
Ohio	60.2	25.1	14.7
<b>Wisconsin</b>	<b>56.6</b>	<b>29.8</b>	<b>13.6</b>
Average	54.0	28.6	17.5

<sup>1</sup> Includes asphalt and concrete state highways.

We requested roughness measurements and supporting documentation from DOT for the 41 projects constructed in 2009 with at least 10,000 tons of asphalt. Because 16 of these 41 projects were urban projects or otherwise appropriately exempted from roughness measurement, we received information for 25 projects. We found that contractors took all required roughness measurements and that DOT has improved the quality of the roughness measurement information in its computer system since our May 2009 review. In addition, we found that:

- contractors for 18 projects were awarded a total of \$219,400 because of roughness ratings lower than 35;
- contractors for 7 projects should have been assessed \$11,400 in penalties but were actually assessed \$10,800 because one project's construction engineer incorrectly assessed a penalty, which resulted in the contractor receiving an extra \$600; and
- none of the 25 projects we reviewed had sections with roughness ratings greater than 140, which means that none required resurfacing.

A construction engineer may exempt certain areas of newly constructed pavements—such as railroad crossings, intersections, and pavement adjacent to bridges—from penalty calculations because these areas are typically rougher than other pavement areas. Although the exemptions were not always indicated in DOT's computer system, we did not identify any areas that were inappropriately exempted. DOT indicated to us that it plans to improve documentation of these exemptions.

Our 2009 review reported that in September 2008, DOT began to independently verify contractors' roughness measurements by contracting with a West Allis firm. In our current review, we found that DOT subsequently purchased its own measuring equipment. Each year, it tries to verify measurements for at least one project submitted by each contractor that owns measuring equipment. In 2009, DOT verified roughness measurements for nine of ten such contractors. For three projects, we compared the roughness measurements calculated by DOT and the contractors and found that DOT's measurements were always lower, indicating that the pavements were actually smoother than reported by the contractors.

## **Materials Testing**

Under DOT's quality assurance program, all construction materials that contractors use on state highway projects must meet contractual requirements for quality, as approved by construction engineers. Depending on the particular material, approval can be obtained by several methods, including:

- the results of tests that contractors and construction engineers conduct on the material in a DOT or DOT-approved laboratory;
- certification by a contractor or supplier that the material meets specified requirements;

- pre-approval from DOT, based on the results of prior tests of the material; and
- visual inspection of the material by construction engineers at the project site, a procedure that is permitted for materials used in small quantities.

DOT requires construction engineers to electronically document the results of many materials tests they perform and all certifications they review. Electronic documentation standardizes the format of the information and enables DOT officials to ascertain whether the tests were completed or any concerns with materials were identified. However, some test results are documented only in project files.

Our 2009 review found that construction engineers did not complete 36.6 percent of 432 required materials tests on 20 concrete highway projects begun from FY 2006-07 through FY 2007-08 and that they did not document 35 of 70 required certifications. In response to our findings, DOT reviewed 50 state highway projects constructed in 2008 to assess compliance with various materials testing requirements. The review included 14 asphalt pavement projects constructed without warranties. DOT found that 142 of 151 materials tests important to asphalt quality, or 94.0 percent, were appropriately documented. At the time of our audit, DOT was considering how to use these results to improve materials testing.

■ ■ ■ ■





Appendix 1

**Asphalt State Highway Projects Constructed under Warranties**

From 2002 through 2004

**Interstate Highway 94**

Hixton to County Highway F  
Jackson County

Warranty Length: 5 years  
Warranty End Date: November 19, 2007  
Final Inspection: May 7, 2007

**Inspection Results**

- This project did not meet all of DOT's performance standards in 2003, 2005, or 2007.
- After the project contract was executed, DOT modified the standard warranty provisions to exclude the type of distress exhibited by the pavement. Therefore, the contractor was not required to repair the pavement.

**U.S. Highway 10**

West County Line to U.S. Highway 12 North  
Jackson County

Warranty Length: 5 years  
Warranty End Date: June 11, 2007  
Final Inspection: May 9, 2007

**Inspection Results**

- This project did not meet all of DOT's performance standards in 2007.
- DOT indicated that because the distress was caused by design flaws, the contractor was not required to repair the pavement.

**U.S. Highway 53**

Kent Road to U.S. Highway 2  
Douglas County

Warranty Length: 5 years  
Warranty End Date: November 5, 2007  
Final Inspection: May 1, 2007

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 11**

Crossway Road to County Highway C  
Racine County

Warranty Length: 5 years  
Warranty End Date: November 18, 2009  
Final Inspection: May 21, 2009

**Inspection Results**

- This project did not meet all of DOT's performance standards in 2006, 2008, or 2009.
- DOT indicated that the distressed segment was excluded from the warranty but could not provide documentation.

**State Highway 17**

U.S. Highway 8 to Birchwood Drive  
Oneida County

Warranty Length: 7 years  
Warranty End Date: September 6, 2011  
Final Inspection: N/A

**Inspection Results**

- To date, this project has met all of DOT's performance standards.

**State Highway 22**

North Bridge Street to City of Manawa  
Waupaca County

Warranty Length: 5 years  
Warranty End Date: August 2, 2007  
Final Inspection: April 30, 2007

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 23**

Fond du Lac to Sheboygan  
Sheboygan County

Warranty Length: 5 years  
Warranty End Date: July 18, 2008  
Final Inspection: Unknown; DOT was unable to document the inspection date.

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 25**

State Highway 35 to North County Line  
Buffalo County

Warranty Length: 5 years  
Warranty End Date: November 17, 2009  
Final Inspection: May 5, 2009

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 25**

South County Line to 10th Avenue  
Pepin County

Warranty Length: 5 years  
Warranty End Date: November 17, 2009  
Final Inspection: May 5, 2009

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 26**

South County Line to County Highway N  
Winnebago County

Warranty Length: 5 years  
Warranty End Date: October 16, 2007  
Final Inspection: May 9, 2007

**Inspection Results**

- This project did not meet all of DOT's performance standards in 2006 or 2007.
- DOT could not document that the required repairs had been performed.

**State Highway 27**

State Highway 64 to North County Line  
Chippewa County

Warranty Length: 5 years  
Warranty End Date: March 3, 2010  
Final Inspection: May 14, 2009

**Inspection Results**

- This project did not meet all of DOT's performance standards in 2007 or 2009.
- After negotiations with DOT, the contractor agreed in August 2010 to perform the required repairs.

**State Highway 27**  
State Highway 70 to Hayward  
Sawyer County

Warranty Length: 5 years  
Warranty End Date: September 2, 2009  
Final Inspection: May 12, 2009

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 28**  
Theresa to East County Line  
Dodge County

Warranty Length: 5 years  
Warranty End Date: July 26, 2009  
Final Inspection: May 21, 2009

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 28**  
County Highway PPP to Interstate Highway 43  
Sheboygan County

Warranty Length: 5 years  
Warranty End Date: August 22, 2008  
Final Inspection: Unknown; DOT was unable to document the inspection date.

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 32**  
South County Line to Wabeno  
Forest County

Warranty Length: 5 years  
Warranty End Date: November 12, 2008  
Final Inspection: Unknown; DOT was unable to document the inspection date.

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 33**

Wonewoc to LaValle Road  
Sauk County

Warranty Length: 5 years  
Warranty End Date: October 19, 2009  
Final Inspection: August 4, 2009

**Inspection Results**

- This project did not meet all of DOT's performance standards in 2009.
- DOT provided some documentation of repairs, but it was insufficient to determine if the distress identified in the inspection was repaired as required.

**State Highway 35**

Lancaster to State Highway 81  
Grant County

Warranty Length: 5 years  
Warranty End Date: November 4, 2007  
Final Inspection: May 3, 2007

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 37**

Alma to Mondovi  
Buffalo County

Warranty Length: 5 years  
Warranty End Date: October 10, 2008  
Final Inspection: Unknown; DOT was unable to document the inspection date.

**Inspection Results**

- This project did not meet all of DOT's performance standards in 2005, 2007, or 2008.
- DOT documented that part of the pavement was excluded from the warranty because of problems with the ground on which the pavement was built, but it is unclear if the exclusion covers all of the distressed segments.

**State Highway 42**

Village of Sister Bay  
Door County

Warranty Length: 5 years  
Warranty End Date: July 19, 2007  
Final Inspection: May 2, 2007

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 42**

Sister Bay to Northport  
Door County

Warranty Length: 5 years  
Warranty End Date: July 19, 2007  
Final Inspection: May 2, 2007

**Inspection Results**

- This project did not meet all of DOT's performance standards in 2004, 2006, or 2007.
- DOT could not document that the required repairs had been performed.

**State Highway 42**

Kewaunee to Algoma  
Kewaunee County

Warranty Length: 5 years  
Warranty End Date: November 17, 2009  
Final Inspection: May 28, 2009

**Inspection Results**

- This project did not meet all of DOT's performance standards in 2006, 2008, or 2009.
- DOT indicated that the distressed segment was excluded from the warranty but could not provide documentation.

**State Highway 44**

South County Line to State Highway 91  
Winnebago County

Warranty Length: 5 years  
Warranty End Date: October 22, 2008  
Final Inspection: Unknown; DOT was unable to document the inspection date.

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 47**

U.S. Highway 8 to Kildare Road  
Oneida County

Warranty Length: 5 years  
Warranty End Date: November 6, 2007  
Final Inspection: April 30, 2007

**Inspection Results**

- This project did not meet all of DOT's performance standards in 2006 or 2007.
- DOT could not document that the required repairs had been performed.

**State Highway 60**

State Highway 67 to East County Line  
Dodge County

Warranty Length: 5 years  
Warranty End Date: August 26, 2007  
Final Inspection: April 30, 2007

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 60**

West County Line to Hartford  
Washington County

Warranty Length: 5 years  
Warranty End Date: August 26, 2007  
Final Inspection: April 30, 2007

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 64**

County Highway E to WCPL Marinette  
Marinette County

Warranty Length: 5 years  
Warranty End Date: August 11, 2009  
Final Inspection: May 29, 2009

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 67/28**

Theresa to Lomira Road  
Dodge County

Warranty Length: 5 years  
Warranty End Date: July 26, 2009  
Final Inspection: May 21, 2009

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 67**

U.S. Highway 51 to State Highway 140  
Rock County

Warranty Length: 5 years  
Warranty End Date: August 5, 2009  
Final Inspection: May 19, 2009

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 68**

Fox Lake to Waupun Road  
Dodge County

Warranty Length: 5 years  
Warranty End Date: August 26, 2008  
Final Inspection: Unknown; DOT was unable to document the inspection date.

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 69**

Monroe to Monticello Road  
Green County

Warranty Length: 5 years  
Warranty End Date: August 16, 2008  
Final Inspection: Unknown; DOT was unable to document the inspection date.

**Inspection Results**

- This project did not meet all of DOT's performance standards in 2007 or 2008.
- DOT provided some documentation of planned repairs, but the information was insufficient to determine if the distress identified in the inspection was repaired as required.



**State Highway 72**  
Ellsworth to Elmwood  
Pierce County

Warranty Length: 5 years  
Warranty End Date: June 21, 2008  
Final Inspection: Unknown; DOT was unable to document the inspection date.

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 78**  
Illinois State Line to Gratiot  
Lafayette County

Warranty Length: 5 years  
Warranty End Date: August 16, 2008  
Final Inspection: Unknown; DOT was unable to document the inspection date.

**Inspection Results**

- This project did not meet all of DOT's performance standards in 2007 or 2008.
- DOT provided some documentation of planned repairs, but the information was insufficient to determine if the distress identified in the inspection was repaired as required.

**State Highway 113**  
County Highway V to Bellin Street  
Dane and Columbia Counties

Warranty Length: 5 years  
Warranty End Date: July 9, 2009  
Final Inspection: May 20, 2009

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.

**State Highway 141**  
Beecher to Pembine  
Marinette County

Warranty Length: 5 years  
Warranty End Date: August 10, 2009  
Final Inspection: May 29, 2009

**Inspection Results**

- This project met all of DOT's performance standards during the warranty period.



Appendix 2

**Pavement Distress Index Scores**  
Asphalt State Highway Projects Constructed under Warranties  
From 2002 through 2004<sup>1</sup>

Project Description	Pavement Age in Years					
	1	2	3	4	5	6
<b>Average Score for All Projects</b>	<b>2.57</b>	<b>8.55</b>	<b>8.91</b>	<b>12.10</b>	<b>12.31</b>	<b>11.24</b>
<b>Buffalo County</b>						
State Highway 25, State Highway 35 to North County Line	0.70	–	0.00	–	N/A	N/A
State Highway 37, Alma to Mondovi	0.00	2.33	–	3.50	–	N/A
<b>Chippewa County</b>						
State Highway 27, State Highway 64 to North County Line	0.00	–	0.88	–	N/A	N/A
<b>Dane and Columbia Counties</b>						
State Highway 113, County Highway V to Bellin Street	1.40	–	1.40	–	N/A	N/A
<b>Dodge County</b>						
State Highway 28, Theresa to East County Line	0.00	–	0.00	–	N/A	N/A
State Highway 60, State Highway 67 to East County Line	0.64	–	2.17	–	4.33	–
State Highway 68, Fox Lake to Waupun Road	0.00	22.00	–	29.00	–	N/A
State Highway 67/28, Theresa to Lomira Road	0.00	–	5.20	–	N/A	N/A
<b>Door County</b>						
State Highway 42, Village of Sister Bay	0.00	0.00	–	0.00	–	0.00
State Highway 42, Sister Bay to Northport	0.00	14.30	–	14.70	–	16.00
<b>Douglas County</b>						
U.S. Highway 53, Kent Road to U.S. Highway 2	4.56	–	22.50	–	33.10	–
<b>Forest County</b>						
State Highway 32, South County Line to Wabeno	0.00	–	0.00	–	8.50	N/A
<b>Grant County</b>						
State Highway 35, Lancaster to State Highway 81	0.00	–	0.00	–	3.50	–
<b>Green County</b>						
State Highway 69, Monroe to Monticello Road	0.00	7.00	–	10.00	–	N/A
<b>Jackson County</b>						
U.S. Highway 10, West County Line to U.S. Highway 12 North	0.00	–	4.67	–	6.00	–

Project Description	Pavement Age in Years					
	1	2	3	4	5	6
<b>Average Score for All Projects</b>	<b>2.57</b>	<b>8.55</b>	<b>8.91</b>	<b>12.10</b>	<b>12.31</b>	<b>11.24</b>
<b>Kewaunee County</b>						
State Highway 42, Kewaunee to Algoma	-	0.75	-	15.88	N/A	N/A
<b>Lafayette County</b>						
State Highway 78, Illinois State Line to Gratiot	0.00	0.00	-	0.00	-	N/A
<b>Marinette County</b>						
State Highway 141, Beecher to Pembine	-	13.60	-	25.00	N/A	N/A
State Highway 64, County Highway E to WCPL Marinette	-	10.86	-	18.60	N/A	N/A
<b>Oneida County</b>						
State Highway 17, U.S. Highway 8 to Birchwood Drive	-	1.17	-	17.67	N/A	N/A
State Highway 47, U.S. Highway 8 to Kildare Road	0.00	6.00	-	4.27	-	8.00
<b>Pepin County</b>						
State Highway 25, South County Line to 10 <sup>th</sup> Avenue	7.00	-	0.00	-	N/A	N/A
<b>Pierce County</b>						
State Highway 72, Ellsworth to Elmwood	0.00	6.38	-	15.00	-	N/A
<b>Racine County</b>						
State Highway 11, Crossway Road to County Highway C	-	12.57	-	5.71	N/A	N/A
<b>Rock County</b>						
State Highway 67, U.S. Highway 51 to State Highway 140	0.00	-	0.00	-	N/A	N/A
<b>Sauk County</b>						
State Highway 33, Wonewoc to LaValle Road	0.00	-	1.17	-	N/A	N/A
<b>Sawyer County</b>						
State Highway 27, State Highway 70 to Hayward	1.44	-	5.89	-	N/A	N/A
<b>Sheboygan County</b>						
State Highway 23, Fond du Lac to Sheboygan	0.88	-	5.25	-	27.25	N/A
State Highway 28, County Highway PPP to Interstate Highway 43	0.67	-	6.50	-	15.60	N/A
<b>Washington County</b>						
State Highway 60, West County Line to Hartford	0.00	0.00	-	0.00	-	13.00

Project Description	Pavement Age in Years					
	1	2	3	4	5	6

<b>Average Score for All Projects</b>	<b>2.57</b>	<b>8.55</b>	<b>8.91</b>	<b>12.10</b>	<b>12.31</b>	<b>11.24</b>
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**Waupaca County**

State Highway 22, North Bridge Street to City of Manawa	–	6.50	–	3.50	–	3.50
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**Winnebago County**

State Highway 26, South County Line to County Highway N	0.00	13.25	–	18.50	–	22.75
State Highway 44, South County Line to State Highway 91	0.00	–	0.00	–	8.88	N/A

<sup>1</sup> Includes only pavement constructed over a crushed aggregate base. Lower scores indicate less distress. Shaded cells indicate scores that exceed the average for all projects of the same pavement age; dashes indicate the project was not surveyed at that pavement age; and N/A indicates the pavement had not reached the indicated age at the time of our review or that data were unavailable.



Appendix 3

**International Roughness Index Scores**  
Asphalt State Highway Projects Constructed under Warranties  
From 2002 through 2004<sup>1</sup>

Project Description	Pavement Age in Years					
	1	2	3	4	5	6
<b>Average Score for All Projects</b>	<b>59.4</b>	<b>59.0</b>	<b>60.2</b>	<b>62.7</b>	<b>64.5</b>	<b>67.0</b>
<b>Buffalo County</b>						
State Highway 25, State Highway 35 to North County Line	32.1	–	39.8	–	N/A	N/A
State Highway 37, Alma to Mondovi	–	49.5	–	56.7	–	N/A
<b>Chippewa County</b>						
State Highway 27, State Highway 64 to North County Line	34.8	–	41.6	–	N/A	N/A
<b>Dane and Columbia Counties</b>						
State Highway 113, County Highway V to Bellin Street	63.6	–	69.0	–	N/A	N/A
<b>Dodge County</b>						
State Highway 28, Theresa to East County Line	56.0	–	65.0	–	N/A	N/A
State Highway 60, State Highway 67 to East County Line	40.8	–	44.5	–	50.5	–
State Highway 68, Fox Lake to Waupun Road	–	81.0	–	91.0	–	N/A
State Highway 67/28, Theresa to Lomira Road	43.6	–	50.0	–	N/A	N/A
<b>Door County</b>						
State Highway 42, Village of Sister Bay	–	69.0	–	69.0	–	72.0
State Highway 42, Sister Bay to Northport	–	59.5	–	64.1	–	72.4
<b>Douglas County</b>						
U.S. Highway 53, Kent Road to U.S. Highway 2	71.2	–	66.6	–	74.1	–
<b>Forest County</b>						
State Highway 32, South County Line to Wabeno	45.5	–	45.8	–	51.8	N/A
<b>Grant County</b>						
State Highway 35, Lancaster to State Highway 81	54.0	–	57.1	–	55.0	–
<b>Green County</b>						
State Highway 69, Monroe to Monticello Road	–	53.9	–	56.3	–	N/A
<b>Jackson County</b>						
U.S. Highway 10, West County Line to U.S. Highway 12 North	45.0	–	35.2	–	36.8	–

Project Description	Pavement Age in Years					
	1	2	3	4	5	6
<b>Average Score for All Projects</b>	<b>59.4</b>	<b>59.0</b>	<b>60.2</b>	<b>62.7</b>	<b>64.5</b>	<b>67.0</b>
<b>Kewaunee County</b>						
State Highway 42, Kewaunee to Algoma	-	48.8	-	55.4	N/A	N/A
<b>Lafayette County</b>						
State Highway 78, Illinois State Line to Gratiot	-	48.8	-	50.2	-	N/A
<b>Marinette County</b>						
State Highway 141, Beecher to Pembine	-	51.2	-	62.6	N/A	N/A
State Highway 64, County Highway E to WCPL Marinette	-	43.9	-	52.4	N/A	N/A
<b>Oneida County</b>						
State Highway 17, U.S. Highway 8 to Birchwood Drive	-	53.7	-	61.5	N/A	N/A
State Highway 47, U.S. Highway 8 to Kildare Road	-	44.2	-	44.8	-	45.0
<b>Pepin County</b>						
State Highway 25, South County Line to 10 <sup>th</sup> Avenue	30.5	-	37.5	-	N/A	N/A
<b>Pierce County</b>						
State Highway 72, Ellsworth to Elmwood	-	57.1	-	68.4	-	N/A
<b>Racine County</b>						
State Highway 11, Crossway Road to County Highway C	-	84.6	-	88.4	N/A	N/A
<b>Rock County</b>						
State Highway 67, U.S. Highway 51 to State Highway 140	91.0	-	102.0	-	N/A	N/A
<b>Sauk County</b>						
State Highway 33, Wonewoc to LaValle Road	54.3	-	58.0	-	N/A	N/A
<b>Sawyer County</b>						
State Highway 27, State Highway 70 to Hayward	49.9	-	58.6	-	N/A	N/A
<b>Sheboygan County</b>						
State Highway 23, Fond du Lac to Sheboygan	57.0	-	68.2	-	54.3	N/A
State Highway 28, County Highway PPP to Interstate Highway 43	68.7	-	105.0	-	90.8	N/A
<b>Washington County</b>						
State Highway 60, West County Line to Hartford	-	134.0	-	146.5	132.0	113.0
<b>Waupaca County</b>						
State Highway 22, North Bridge Street to City of Manawa	-	78.5	-	75.0	-	74.5



Project Description	Pavement Age in Years					
	1	2	3	4	5	6

<b>Average Score for All Projects</b>	<b>59.4</b>	<b>59.0</b>	<b>60.2</b>	<b>62.7</b>	<b>64.5</b>	<b>67.0</b>
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**Winnebago County**

State Highway 26, South County Line to County Highway N	-	59.6	-	64.2	-	67.6
State Highway 44, South County Line to State Highway 91	43.0	-	51.4	-	51.3	N/A

<sup>1</sup> Includes only pavement constructed over a crushed aggregate base. Lower scores indicate less distress. Shaded cells indicate scores that exceed the average for all projects of the same pavement age; dashes indicate the project was not surveyed at that pavement age; and N/A indicates the pavement had not reached the indicated age at the time of our review or that data were unavailable.



## Appendix 4

### **Pavement Density and Roughness Tests Performed by DOT on 41 Asphalt State Highway Projects Constructed in 2009**

#### **Interstate Highway 43**

Rock County Line to U.S. Highway 12  
Walworth County

##### **Pavement Density**

- Construction engineers performed 6 of 13 required tests, or 46.2 percent.
- Construction engineers tested 3 of 7 asphalt mixes, or 42.9 percent.

##### **Pavement Roughness**

- DOT exempted the project from measurement.

#### **U.S. Highway 8**

Pembine to U.S. Highway 141  
Marinette County

##### **Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

##### **Pavement Roughness**

- No problems noted with the measurements.

#### **U.S. Highway 12**

Whitewater to Elkhorn Road  
Walworth County

##### **Pavement Density**

- Construction engineers performed the required number of tests.
- Construction engineers tested 4 of 5 asphalt mixes, or 80.0 percent.

##### **Pavement Roughness**

- No problems noted with the measurements.

**U.S. Highway 14**

Darien to Walworth  
Walworth County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- DOT exempted the project from measurement.

**U.S. Highway 51**

Hazelhurst to Minocqua  
Oneida County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- DOT exempted the project from measurement.

**State Highway 11**

Main Street to Burlington Bypass  
Racine County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- No problems noted with the measurements.

**State Highway 13**

Wisconsin Dells to Adams  
Adams County

**Pavement Density**

- Construction engineers performed the required number of tests.
- Construction engineers tested 1 of 3 asphalt mixes, or 33.3 percent.

**Pavement Roughness**

- No problems noted with the measurements.

**State Highway 32**

Hiles to Three Lakes  
Oneida County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- DOT exempted the project from measurement.

**State Highway 35**

Prairie du Chien to Genoa Road  
Crawford County

**Pavement Density**

- Construction engineers performed the required number of tests.
- Construction engineers tested 1 of 2 asphalt mixes, or 50.0 percent.
- Construction engineers' density measurements incorrectly mixed traffic lanes and shoulders.

**Pavement Roughness**

- No problems noted with the measurements.

**State Highway 42**

Sheboygan to Howards Grove  
Sheboygan County

**Pavement Density**

- Construction engineers performed the required number of tests.
- Construction engineers tested 2 of 3 asphalt mixes, or 66.7 percent.

**Pavement Roughness**

- No problems noted with the measurements.

**State Highway 52**

Lily to Forest County Line  
Langlade County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- DOT exempted the project from measurement.

**State Highway 57**

Marne Avenue to Good Hope Road  
Milwaukee County

**Pavement Density**

- Construction engineers performed the required number of tests.
- Construction engineers tested 2 of 3 asphalt mixes, or 66.7 percent.

**Pavement Roughness**

- DOT exempted the project from measurement.

**State Highway 64**

Medford to Goodrich Road  
Taylor County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- No problems noted with the measurements.

**State Highway 64**

New Richmond to Bloomer Road  
Dunn County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.
- Construction engineers did not take the samples 10 feet apart, as required.

**Pavement Roughness**

- No problems noted with the measurements.

**State Highway 73**

Pittsville to Neillsville  
Wood County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- DOT exempted the project from measurement.

**State Highway 73**  
Plainfield to Wisconsin Rapids  
Wood County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- DOT exempted the project from measurement.

**State Highway 76**  
U.S. Highway 10 to State Highway 15  
Outagamie County

**Pavement Density**

- Construction engineers performed 3 of 4 required tests, or 75.0 percent.
- Construction engineers tested 1 of 2 asphalt mixes, or 50.0 percent.

**Pavement Roughness**

- No problems noted with the measurements.

**State Highway 76**  
U.S. Highway 41 to U.S. Highway 10  
Winnebago County

**Pavement Density**

- Construction engineers performed the required number of tests.
- Construction engineers tested 2 of 3 asphalt mixes, or 66.7 percent.

**Pavement Roughness**

- No problems noted with the measurements.

**State Highway 144**  
Slinger to West Bend Road  
Washington County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- DOT exempted the project from measurement.

**State Highway 147**

Mishicot to Interstate 43  
Manitowoc County

**Pavement Density**

- Construction engineers performed 2 of 3 required tests, or 66.7 percent.
- Construction engineers tested 1 of 2 asphalt mixes, or 50.0 percent.

**Pavement Roughness**

- No problems noted with the measurements.

**State Highway 147**

Two Rivers to Mishicot  
Manitowoc County

**Pavement Density**

- Construction engineers performed the required number of tests.
- Construction engineers tested 1 of 2 asphalt mixes, or 50.0 percent.

**Pavement Roughness**

- No problems noted with the measurements.

**State Highway 153**

Mosinee to Shawano County Line  
Marathon County

**Pavement Density**

- Construction engineers performed the required number of tests.
- Construction engineers tested 1 of 2 asphalt mixes, or 50.0 percent.

**Pavement Roughness**

- DOT exempted the project from measurement.



**State Highway 181**

Mequon Road to Pioneer Road  
Ozaukee County

**Pavement Density**

- Construction engineers performed 3 of 6 required tests, or 50.0 percent.
- Construction engineers tested asphalt mixes as required.

**Pavement Roughness**

- DOT exempted the project from measurement.

**State Highway 310**

County Highway R to Columbus Street, Two Rivers  
Manitowoc County

**Pavement Density**

- Construction engineers performed the required number of tests.
- Construction engineers tested 1 of 4 asphalt mixes, or 25.0 percent.

**Pavement Roughness**

- No problems noted with the measurements.

**County Highway A**

Hixton to Black River Falls  
Jackson County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.
- Construction engineers did not take the samples 10 feet apart, as required.

**Pavement Roughness**

- No problems noted with the measurement.

**County Highway A**

Markesan to Green Lake  
Green Lake County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- No problems noted with the measurements.

**County Highway A**  
Pittsville to Marshfield  
Wood County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.
- Construction engineers did not take the samples 10 feet apart, as required.

**Pavement Roughness**

- No problems noted with the measurements.

**County Highway C**  
City of Washburn to Cornucopia  
Bayfield County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.
- Construction engineers did not take the correct number of samples.

**Pavement Roughness**

- No problems noted with the measurements.

**County Highway CC**  
U.S. Highway 8 to North 4<sup>th</sup> Street, Tomahawk  
Lincoln County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.
- Construction engineers did not take the samples 10 feet apart, as required.

**Pavement Roughness**

- No problems noted with the measurements.

**County Highway D**  
Interstate 39 to Almond  
Portage County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- No problems noted with the measurements.

**County Highway G**  
Beaver Dam to Randolph Road  
Dodge County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- No problems noted with the measurements.

**County Highway H**  
Main Street to School House Road, Town of La Pointe  
Ashland County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- DOT exempted the project from measurement.

**County Highway J**  
Woodruff to St. Germain  
Oneida County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- No problems noted with the measurements.

**County Highway M**  
State Highway 47 to Oconto County Line  
Menominee County

**Pavement Density**

- Construction engineers performed the required number of tests.
- Construction engineers tested 2 of 3 asphalt mixes, or 66.7 percent.

**Pavement Roughness**

- DOT exempted the project from measurement.

**County Highway NN**

State Highway 107 to U.S. Highway 51  
Marathon County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- No problems noted with the measurements.

**County Highway O**

U.S. Highway 12 to Warrens  
Monroe County

**Pavement Density**

- Construction engineers performed the required number of tests.
- Construction engineers tested 1 of 2 asphalt mixes, or 50.0 percent.

**Pavement Roughness**

- No problems noted with the measurements.

**County Highway Q**

U.S. Highways 41/45 to Pilgrim Road  
Washington County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- DOT exempted the project from measurement.

**County Highway T**

U.S. Highway 41 to State Highway 64, Marinette  
Marinette County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- DOT exempted the project from measurement.

**County Highway W**

County Highway Q to U.S. Highway 8  
Forest County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- No problems noted with the measurements.

**County Highway W**

Kellner to Bancroft  
Portage County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- No problems noted with the measurements.

**Local Street**

West Grange Avenue and South 60<sup>th</sup> Street, Greendale  
Milwaukee County

**Pavement Density**

- Construction engineers performed the required number of tests, including asphalt mixes.

**Pavement Roughness**

- DOT exempted the project from measurement.