

Letter Report

Construction Engineering in State Highway Projects

May 2009



Legislative Audit Bureau

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Janice Mueller
State Auditor

May 12, 2009

Senator Kathleen Vinehout and
Representative Peter Barca, Co-chairpersons
Joint Legislative Audit Committee
State Capitol
Madison, Wisconsin 53702

Dear Senator Vinehout and Representative Barca:

In response to a complaint reported to the Fraud, Waste, and Mismanagement Hotline established by 2007 Wisconsin Act 126, we have completed a limited-scope review of the role of construction engineers in the Department of Transportation's (DOT's) quality assurance process on state highway projects. Construction engineers, who include both DOT staff and private consultants, ensure that construction contractors build highways according to contractual requirements. In fiscal year (FY) 2007-08, construction engineering expenditures totaled an estimated \$56.8 million, including \$20.8 million in spending related to state staff and \$36.0 million paid to private consultants.

Our analysis is focused on state highway projects built with concrete pavement. We reviewed in detail projects begun from FY 2006-07 through FY 2007-08. None of 20 projects we reviewed had any measurements that indicated unacceptable concrete pavement thickness. However, documentation for 11 of the 20 projects indicated that contractors measured the concrete pavement's thickness less frequently than contractually required. State staff served as the lead construction engineer on 7 of the 11 projects, while consultants served in that role on the remaining 4. It is possible the measurements were actually taken but not documented, but we cannot independently confirm this.

To help ensure state highway projects are appropriately constructed, DOT recently modified a number of its quality assurance practices for contractors and construction engineers. However, we provide several additional recommendations to help ensure that highways are consistently constructed according to contractual requirements. This is particularly important because the American Recovery and Reinvestment Act of 2009 will provide Wisconsin with \$529.1 million in federal transportation funds, much of which will be used for state highway projects.

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

Sincerely,

Janice Mueller
State Auditor

JM/DS/ss

Enclosure

CONSTRUCTION ENGINEERING IN STATE HIGHWAY PROJECTS

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 miles of the state highway system, which includes interstate highways and the state highways on which most travel occurs.

In fiscal year (FY) 2007-08, DOT's state highway program was appropriated \$1.5 billion, including \$658.7 million in federal funds, \$519.0 million in state funds, and \$335.3 million in bond proceeds. The program includes five components:

- the major highway development program, which funds projects that are specifically enumerated in statutes by the Legislature and includes the construction of new or significantly improved highways;
- 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 work that includes reconstruction of Interstate 94 and the Marquette Interchange;
- the maintenance and traffic operations program, which funds snow removal, repair work, traffic signals, pavement marking, and road signs; and
- administration.

DOT has implemented a quality assurance process that is intended to ensure construction projects on the state highway system are completed according to applicable standards, which are reflected in construction contracts it executes. Under this process:

- Construction contractors construct the highways and are required by DOT to complete various tests of construction materials to ensure highways are built according to DOT's contractual requirements.
- Construction engineers, who include both DOT staff and private consultants, oversee the contractors and ensure they follow the contractual requirements, review and verify the contractors' tests, and perform their own tests of the materials. Each construction project has a project leader. One or more inspectors, who are typically entry-level engineers, may assist a project leader.

- Independent assurance staff, who are always DOT construction engineers, are not assigned to specific projects. Instead, they observe the tests completed by the contractors and the construction engineers, validate the accuracy of the testing equipment, and complete their own tests of the construction materials.

Staff in DOT's five regions, which are shown in Figure 1, are directly responsible for managing most state highway projects.

Figure 1

DOT Regions



A complaint reported on the Fraud, Waste, and Mismanagement Hotline established by 2007 Wisconsin Act 126 questioned whether DOT was ensuring that contractors consistently met standards for the thickness of concrete pavement on state highways. In December 2008, we released the results of our review of DOT's response to allegations it had received in 2004 against one contractor that was alleged to have used less concrete than DOT required, falsified its thickness measurements, and purposely provided false measurements of concrete pavement roughness.

In this review, we analyzed the role of construction engineers in DOT's quality assurance process, particularly as it pertains to state highway projects built with concrete. In addition, as a result of findings in the Audit Bureau's single audit reports for the State of Wisconsin for FY 2005-06 through FY 2007-08, we expanded our review to include an analysis of DOT's electronic system for tracking and monitoring the results of tests conducted on construction materials.

To complete our review, we interviewed staff in DOT's central office and the Southwest Region, associations that represent contractors and construction engineers, and the Federal Highway Administration. We analyzed DOT's construction engineering expenditure and staffing data from FY 2003-04 through FY 2007-08, information related to consultants hired to serve as construction engineers, and quality assurance data and documentation for projects let from FY 2006-07 through FY 2007-08. Appendix 1 lists the projects we reviewed. In addition, we contacted transportation officials in Illinois, Indiana, Iowa, Michigan, Minnesota, and Ohio.

Expenditures and Staffing

Although DOT does not separately track construction engineering expenditures, it does track each state highway project's expenditures, which typically include 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; on-site construction engineers, including project leaders and inspectors; and independent assurance staff. 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, estimated total expenditures for construction engineering increased from \$48.5 million in FY 2003-04 to \$56.8 million in FY 2007-08, which is 17.1 percent. As a proportion of total expenditures, expenditures related to state staff declined steadily from FY 2003-04, when they represented 39.3 percent of the total, to FY 2006-07, when they represented 30.0 percent. In FY 2007-08, expenditures related to state staff increased to 36.6 percent.

Table 1

Estimated Construction Engineering Expenditures

| | FY 2003-04 | FY 2004-05 | FY 2005-06 | FY 2006-07 | FY 2007-08 |
|--------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| State Staff | \$19,072,200 | \$17,402,500 | \$17,769,600 | \$17,676,400 | \$20,818,800 |
| Consultants | 29,474,100 | 32,315,200 | 36,849,300 | 41,180,900 | 36,000,300 |
| Total | \$48,546,300 | \$49,717,700 | \$54,618,900 | \$58,857,300 | \$56,819,100 |

State Staff

Construction engineering expenditures related to state staffing include:

- salaries and fringe benefits;
- travel, which typically includes fleet charges for traveling to and from project sites;
- administration, which includes rent, postage, utilities, telephone expenditures, and miscellaneous services; and
- materials and supplies, which include paper, printing, and miscellaneous supplies.

Table 2 details construction engineering expenditures incurred by state staff. Salaries and fringe benefits represent almost all of the expenditures. DOT indicated that the increase in FY 2007-08 reflects additional work completed on state highway rehabilitation projects.

Table 2

Estimated Construction Engineering Expenditures Incurred by State Staff

| | FY 2003-04 | FY 2004-05 | FY 2005-06 | FY 2006-07 | FY 2007-08 |
|------------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Salaries and Fringe Benefits | \$17,735,300 | \$16,196,900 | \$16,490,100 | \$16,451,200 | \$19,413,900 |
| Travel | 1,196,600 | 1,030,000 | 1,167,000 | 1,129,900 | 1,292,100 |
| Administration | 101,800 | 127,800 | 100,000 | 62,800 | 72,600 |
| Materials and Supplies | 32,000 | 31,500 | 10,900 | 30,700 | 39,900 |
| Other ¹ | 6,500 | 16,300 | 1,600 | 1,800 | 300 |
| Total | \$19,072,200 | \$17,402,500 | \$17,769,600 | \$17,676,400 | \$20,818,800 |

¹ Includes data processing and training expenditures.

As shown in Table 3, estimated construction engineering staffing levels for state employees declined from FY 2003-04 through FY 2006-07, but they then increased to 264.2 full-time equivalent positions in FY 2007-08.

Table 3
Estimated Construction Engineering Staffing Levels for State Employees
 Full-Time Equivalent Positions

| Employee Type | FY 2003-04 | FY 2004-05 | FY 2005-06 | FY 2006-07 | FY 2007-08 |
|---------------|--------------|--------------|--------------|--------------|-------------------|
| Permanent | 278.3 | 263.4 | 249.7 | 220.4 | 245.2 |
| Limited-Term | 27.3 | 26.9 | 21.4 | 19.3 | 19.0 ¹ |
| Total | 305.6 | 290.3 | 271.1 | 239.7 | 264.2 |

¹ Includes 0.4 full-time equivalent project staff positions.

Consultants

As noted, DOT hires private consultants to serve as construction engineers, including as project leaders or the inspectors who assist them. Consultants' duties and responsibilities are identical to those of DOT staff serving in similar positions.

DOT regional office officials annually identify projects to be completed in the coming year. They first assign state staff to serve as construction engineers, based on staff availability, experience, and expertise. After state staff are assigned, DOT's regions contract with consulting firms for construction engineering services, either because staffing levels are insufficient to complete all work that has been scheduled or because consultants have expertise that DOT staff do not possess. Consultants are selected from a list of firms that have formally indicated their interest in working for DOT by submitting written documents listing their qualifications.

Under federal law, selection of consultants must be based on their ability to provide quality services, including the skill level and expertise of personnel who will work on the project, the amount and type of resources the firm will make available for the project, and the firm's past record of producing quality work for a reasonable price. After a firm has been selected, federal law prescribes that DOT must negotiate the amount payable for the firm's services.

For the 2009 construction season, 74 of 88 firms that indicated an interest in providing construction engineering services were selected to work on at least one project. We found that 71 of the 74 firms have an office in Wisconsin, including 44 based exclusively in the state. The other three firms are based in Illinois, Iowa, and Minnesota.

Table 4 shows the ten firms paid the most for construction engineering services on state highway projects from FY 2003-04 through FY 2007-08.

Table 4

Largest Payments for Construction Engineering
(in millions)

| Firm | FY 2003-04 | FY 2004-05 | FY 2005-06 | FY 2006-07 | FY 2007-08 | Total |
|--|---------------|---------------|---------------|---------------|---------------|----------------|
| Consoer Townsend Envirodyne Engineers, Inc. | \$ 0.0 | \$ 0.0 | \$ 3.0 | \$ 6.2 | \$ 6.6 | \$ 15.8 |
| Ayers & Associates, Inc. | 2.4 | 3.1 | 2.8 | 2.0 | 1.5 | 11.8 |
| Gremmer & Associates, Inc. | 2.1 | 2.3 | 1.6 | 1.7 | 1.9 | 9.6 |
| Short Elliott Hendrickson, Inc. | 1.2 | 2.1 | 2.2 | 2.0 | 1.3 | 8.8 |
| Figg Bridge Inspection, Inc. | 0.0 | 2.2 | 3.4 | 1.9 | 1.2 | 8.7 |
| Mead & Hunt, Inc. | 1.8 | 1.7 | 1.6 | 1.3 | 1.4 | 7.8 |
| R.A. Smith & Associates, Inc. | 1.1 | 0.8 | 1.2 | 1.7 | 2.1 | 6.9 |
| Earthtech, Inc. | 0.0 | 0.3 | 1.0 | 2.5 | 1.9 | 5.7 |
| Strand Associates, Inc. | 1.8 | 1.6 | 1.2 | 0.6 | 0.4 | 5.6 |
| Kapur & Associates, Inc. | 1.3 | 1.2 | 1.0 | 1.1 | 0.9 | 5.5 |
| All Other Firms | 17.8 | 17.0 | 17.8 | 20.2 | 16.8 | 89.6 |
| Total | \$29.5 | \$32.3 | \$36.8 | \$41.2 | \$36.0 | \$175.8 |

Illinois and Michigan reported to us that they regularly employ consultants as construction engineers on state highway projects, typically when state staff are unavailable. Illinois estimated that consultants are involved in approximately 30.0 percent of all projects, while Michigan estimated that they are involved in approximately 50.0 percent of all projects. In contrast, four other states reported to us that they hire consultants infrequently:

- Iowa seldom uses consultants and hires them only when they have specialized expertise that state staff do not possess.
- Indiana believes that state staff are more knowledgeable about procedures and are better trained than consultants, who account for no more than 10.0 percent of all construction engineers on its projects.
- Minnesota uses consultants on approximately 5.0 percent of all projects, and typically only on simple projects with minimal contract administration duties.
- Ohio believes consultants are more costly than state staff and therefore seldom hires them, and only to support state staff who are the lead engineers of projects.

As shown in Table 5, the best available information indicates that the proportion of Wisconsin's state highway projects involving consultants as construction engineers increased from 39.2 percent in FY 2003-04 to 64.9 percent in FY 2006-07, then declined to 44.3 percent in FY 2007-08. During the entire five-year period, consultants were involved with 48.2 percent of all projects.

Table 5

State Highway Projects Involving Consultants as Construction Engineers

| Fiscal Year | State Highway Projects | Projects Involving Consultants as Construction Engineers | |
|--------------|------------------------|--|-------------|
| | | Number | Percentage |
| 2003-04 | 390 | 153 | 39.2% |
| 2004-05 | 311 | 145 | 46.6 |
| 2005-06 | 289 | 153 | 52.9 |
| 2006-07 | 225 | 146 | 64.9 |
| 2007-08 | 287 | 127 | 44.3 |
| Total | 1,502 | 724 | 48.2 |

There have been longstanding concerns by some groups over the extent to which DOT hires consultants as construction engineers. In 1997 (report 97-4), we noted that the proportion of total construction engineering expenditures paid to consultants increased from 8.2 percent in FY 1987-88 to 34.3 percent in FY 1996-97. As was shown in Table 1, this proportion increased to 70.0 percent in FY 2006-07 before decreasing to 63.4 percent in FY 2007-08.

The precise proportion of construction engineering work that can be completed by consultants without hindering DOT's oversight ability is unknown, but some believe that consultants should complete no more than one-half of all work. We note that in January 2008, the federal Government Accountability Office found that as state staff become further removed from the day-to-day management of highway construction projects, they are less able to develop the experience, skills, and expertise needed to effectively oversee construction contractors and consultants.

We attempted to determine the exact tasks that consultants were hired to perform but were unable to do so. DOT's central office tracks consultants' involvement in projects, but its electronic information does not indicate whether they were hired as project leaders or the inspectors assisting them. In addition, we were sometimes unable to reconcile this information with other project-related information that DOT provided us. Complete information is maintained in project files in each regional office, but this information is not readily available to officials in DOT's central office.

☑ Recommendation

We recommend the Department of Transportation electronically track the extent to which consultants serve as construction engineers on each state highway project, including whether they serve as the project leader or as inspectors.

Cost-Benefit Analyses

2005 Wisconsin Act 89, which was enacted in January 2006, requires state agencies to conduct a uniform cost-benefit analysis of each proposed procurement of contractual services involving estimated expenditures greater than \$25,000. It does not require agencies to use the results of the analyses to decide whether to contract for services.

DOT provided us with copies of all 214 cost-benefit analyses it completed for construction engineering services from March 2007 through June 2008. Analyses completed before March 2007 are maintained in project files in the regional offices and could not be readily obtained. We found that:

- 125 analyses indicated DOT staff could complete the work at a lower cost than consultants could;
- 84 analyses indicated consultants could complete the work at a lower cost than DOT staff could; and
- 5 analyses indicated that state staff did not have the requisite expertise for the projects and, therefore, the analyses could not be completed.

Although 125 of the 214 analyses indicated that DOT staff could have completed the work at a lower cost, DOT nevertheless hired consultants in all 125 instances because it reported that it did not have engineering staff available to complete the work.

Consultant Performance Evaluations

For each consultant contract of \$10,000 or more, DOT's policies require the project manager to formally evaluate the consulting firm within three months of the contract's completion. Firms are evaluated on their project management; human relations; engineering, inspection, and survey skills; quality of work; cost control; and timeliness. They receive scores from 1.00 (unacceptable) to 5.00 (outstanding). Although DOT staff who are involved with hiring consultants are generally aware of individual firms' strengths and weaknesses, they sometimes refer to the evaluations in order to obtain more detailed information.

Table 6 shows the scores of the 742 performance evaluations completed by DOT staff from FY 2003-04 through FY 2007-08. During this period, 69.8 percent of the consultants received scores of 3.50 or higher, indicating satisfaction with the quality of the consultants' construction engineering work.

Table 6

Scores of Consultant Performance Evaluations
FY 2003-04 through FY 2007-08

| Score | Evaluations | Percentage of Total |
|--------------|-------------|---------------------|
| 1.00 to 1.99 | 0 | 0.0% |
| 2.00 to 2.49 | 10 | 1.3 |
| 2.50 to 2.99 | 33 | 4.5 |
| 3.00 to 3.49 | 181 | 24.4 |
| 3.50 to 3.99 | 163 | 22.0 |
| 4.00 to 4.49 | 234 | 31.5 |
| 4.50 to 4.99 | 99 | 13.3 |
| 5.00 | 22 | 3.0 |
| Total | 742 | 100.0% |

Quality Assurance Process

Federal regulations require DOT to operate a quality assurance program that ensures construction practices and materials meet minimum standards. Although the federal regulations apply only to federally funded projects on the National Highway System, which includes interstate and other key highways, DOT's policies apply them to all state highway projects.

Under DOT's quality assurance program, contractors are contractually required to perform a variety of tests on concrete pavement, such as measuring its thickness and roughness, which are key factors in a highway's quality and durability. Construction engineers are responsible for ensuring projects are constructed according to the contractual requirements. They review the contractors' test results and perform additional tests to verify the contractors' test results.

Construction engineers in Illinois, Minnesota, and Ohio also use contractors' test results to assess construction practices and materials, and they also conduct their own tests. In contrast, construction engineers in Indiana, Iowa, and Michigan rely solely on their own tests to ensure highways are constructed according to their states' standards.

Thickness of Concrete Pavement

Project contracts specify the thickness of the concrete pavement and require contractors to follow DOT's standards for measuring thickness. Contractors are required to randomly select one location for every 250 feet per lane of poured concrete, measure the thickness in each of the two tire paths at that location, and then average the two measurements.

There are various methods for measuring the thickness of concrete pavement. Since 1998, DOT's primary method has been probing, which involves placing a metal plate on the roadbed before the concrete is poured, inserting a metal rod into freshly poured concrete, and measuring the distance between the metal plate and the concrete pavement's surface.

Through December 2008, DOT required construction engineers to verify the contractors' measurements approximately twice for every lane mile of poured concrete. Construction engineers were to observe contractors' measurements and record the results, but they were not required to take their own measurements. If the thickness on a given 250-foot section was:

- no more than 0.375 inches less than the contractually stipulated thickness, the section was considered to be conforming, and no further action was to be taken;
- from 0.375 to 1.0 inch less than the contractually stipulated thickness, the section was considered to be nonconforming, but no further action was to be taken as long as the thickness of the next section was conforming; however, if the next section's thickness was also found to be nonconforming, the construction engineer was required to assess the contractor a financial penalty equivalent to a percentage of the amount DOT paid for both sections; and
- more than 1.0 inch less than the contractually stipulated thickness, the section was considered unacceptable, and the construction engineer was required to instruct the contractor to either remove and replace the section or not be paid for that section.

Within 60 working days of a project's completion, DOT requires contractors to submit the documentation of all thickness measurements. Although DOT has an electronic system for tracking the results of some contractor-performed tests, such as those that measure pavement roughness, the system does not record and track thickness measurements, which are instead maintained in project files in each regional office.

We reviewed the thickness measurements completed by contractors and verified by construction engineers for a sample of state highway construction projects. We requested that DOT provide us with the relevant documentation for all state highway construction projects let from FY 2006-07 through FY 2007-08 that involved at least enough concrete to construct one mile of a two-lane highway and had documentation available at the time of our review. Twenty projects met these criteria.

None of the 20 projects had any measurements that indicated the thickness of concrete pavement was unacceptable. Four projects had at least one measurement that indicated a section's thickness was nonconforming, but no financial penalties were assessed because the adjacent sections were acceptably thick.

As shown in Table 7, documentation for 11 of the 20 projects indicated that contractors had measured the concrete pavement's thickness less frequently than required, including 1 project for which it appears that less than one-half the required measurements were taken, and 1 project for which it appears that no measurements were taken. State staff served as the lead construction engineer on 7 of the 11 projects, while consultants served in that role on the other 4. It is not known whether the measurements were actually taken but not documented or

whether they were never taken. On average, each of the 11 projects required 265 measurements to be taken. Appendix 2 provides additional information on each project we reviewed.

Table 7

**Extent to Which Construction Contractors Measured
the Thickness of Concrete Pavement on 20 State Highway Projects¹**

| Percentage of Required Measurements Documented | Lead Construction Engineer | | Total |
|---|----------------------------|-------------|-----------|
| | State Staff | Consultants | |
| 100.0 | 5 | 4 | 9 |
| 75.0 to 99.9 | 2 | 2 | 4 |
| 50.0 to 74.9 | 4 | 1 | 5 |
| 0.1 to 49.9 | 0 | 1 | 1 |
| 0.0 | 1 | 0 | 1 |
| Subtotal | 7 | 4 | 11 |
| Total | 12 | 8 | 20 |

¹ According to DOT's documentation for projects let from FY 2006-07 through FY 2007-08 that involved at least enough concrete to construct one mile of a two-lane highway.

DOT's documentation also indicated that construction engineers did not verify contractors' measurements as frequently as required on 7 of the 20 projects, including 5 projects with no indication that any verification had occurred. State staff served as the lead construction engineer on four of the seven projects, while consultants served in that role on three projects. DOT does not penalize contractors or consultant construction engineers for not documenting or verifying the measurements.

Our review of the 20 projects also indicated other apparent violations of the standards, including:

- 7 projects for which contractors listed each of the two measurements taken at a given location but did not calculate an average;
- 5 projects for which contractors did not randomly select the locations of their measurements, but instead measured the thickness at regular intervals; and
- 4 projects for which contractors calculated average thicknesses for multiple lanes, rather than calculating separate averages for each lane.

Through December 2008, construction engineers typically were not permitted access to contractors' paving equipment and, therefore, were unable to closely observe the probing

measurements. Instead, they typically watched from the roadside and waited for contractors either to bring them the probing rods, which they inspected to verify the concrete pavement's thickness, or to inform them of the measurements.

This process has limitations because a contractor could use less concrete than contractually required, thereby increasing profits and harming the highway's durability and quality. For example, a contractor could intentionally insert a probing rod into the roadbed next to the metal plate, thereby making the pavement appear thicker than it really was. A contractor could also pour an inadequate amount of concrete for much of the project's length but increase the amount to the contractually stipulated thickness when the paving machine passed over the metal plates used in the probing measurements. If a construction engineer did not ride on the paving machine, it could be more difficult to detect such deceptions.

In part to address these concerns, DOT recently modified its quality assurance practices. Beginning in the 2009 construction season:

- Concrete pavement must be within 0.125 inches of the contractually stipulated thickness, rather than the former 0.375 inches, in order to be conforming.
- Construction engineers must randomly select one location every 2,500 feet of poured concrete and measure the thickness themselves. They will be able to take additional measurements if the thickness is nonconforming, and to order a contractor to remove and replace concrete pavement if the thickness is unacceptable.
- Construction engineers will be allowed to ride on the paving machines and more closely observe contractors taking thickness measurements.
- DOT's independent assurance staff will, for as many projects as is feasible, evaluate the probing equipment and procedures used during individual measurements.

Even with these modifications, it is possible for contractors to measure the thickness of the concrete pavement less frequently than is contractually required and for construction engineers not to verify the measurements that are taken, as we found in our review of the 20 projects. If measurements are not documented, DOT cannot ensure they were taken or assess the pavement's thickness. Thus, DOT could consider both requiring contractors to document their measurements in the electronic system it uses to track other quality assurance tests, and requiring construction engineers to electronically record their verification of the tests. DOT could also consider assessing financial penalties on contractors that do not document their measurements and on consultant construction engineers who do not verify the measurements.

Recommendation

We recommend the Department of Transportation ensure that contractors measure the thickness of concrete pavement on state highway projects as frequently as required and that construction engineers verify the contractors' measurements.

Comparisons with Other Midwestern States

We analyzed whether DOT's standards for measuring the thickness of concrete pavement are comparable to those of other states. In contrast to Wisconsin, state-employed construction engineers, not contractors, determine the thickness in the six other midwestern states we contacted.

Table 8 compares thickness standards as of 2009. Construction engineers in each of the six states other than Wisconsin are required to measure the thickness more frequently than DOT requires. However, only Minnesota has a stricter standard than Wisconsin's for determining whether a given highway section's thickness is nonconforming. All seven states have similar standards for determining whether a given section's thickness is unacceptable.

Table 8
Concrete Pavement Thickness Standards in Midwestern States
2009

| State | Distance Between Construction Engineers' Thickness Measurements (in feet) | Extent to Which Thickness Is Less than Contractually Stipulated | |
|------------------|--|---|--------------------|
| | | Nonconforming | Unacceptable |
| Illinois | 500 | 2.0% ¹ | 10.0% ¹ |
| Indiana | 1,800 ² | 0.2" | 1.0" ³ |
| Iowa | 1,500 ² | n/a | 1.0" |
| Michigan | 1,000 | 0.2" | 1.0" |
| Minnesota | 1,000 | 0.08" | 1.0" ³ |
| Ohio | 1,500 ² | 0.2" | 1.0" ³ |
| Wisconsin | 2,500 | 0.125" | 1.0" |

¹ Standards are expressed as a percentage of the contractually stipulated thickness.

² Approximately.

³ If the thickness is 0.5" to 1.0" less than contractually stipulated, construction engineers may require contractors to remove and replace the concrete pavement or not be paid for it.

All six other midwestern states measure the thickness by coring the concrete pavement, which involves drilling, removing, and measuring a cylindrical sample of hardened concrete. Minnesota indicated that it is considering measuring the thickness by both coring and probing but that it has no plans to rely solely on probing, as Wisconsin does.

DOT changed its primary method for measuring thickness from coring to probing in 1998, in part because probing costs less, is less destructive to the highway, and allows contractors to immediately address inadequate thicknesses. In addition, DOT indicated that it has insufficient staff to core all projects. One advantage of coring is that because the measurements are taken after the concrete has hardened, contractors do not know where construction engineers will measure the pavement's thickness. In addition, because construction engineers perform the measurements, contractors are not able to provide false measurements.

DOT does not routinely core state highway projects because probing is its primary method of measuring thickness. However, to determine whether contractors' probing measurements are accurate, it selected ten projects that were completed from 2006 through 2007 and took cores of the concrete pavement at various locations on each one. UW-Madison researchers measured the cores and compared the results to the probing measurements contractors had taken when the projects were constructed. Based on the researchers' December 2008 report, DOT accepted the researchers' conclusion that probing and coring are comparable methods of measuring pavement thickness. However, we believe the results should be interpreted with caution because only ten projects were examined and few cores were taken on many of them.

DOT subsequently took concrete cores from two projects completed in 2008. The available documentation indicates that:

- the thicknesses of 4 of 28 cores taken on one project were nonconforming, but none of the contractor's 32 probing measurements taken in the same areas of the project was nonconforming; and
- the thicknesses of 3 of 110 cores taken on another project were nonconforming, but none of the contractor's 20 probing measurements taken in the same areas of the project was nonconforming.

Although DOT believes that probing measurements are as accurate as coring measurements, we believe additional data should be collected to definitively support this assertion. As noted, probing measurements can be subject to manipulation by contractors, and all surrounding midwestern states use coring to determine the thickness of concrete.

Recommendation

We recommend the Department of Transportation:

- *conduct additional tests to definitively support the use of probing; and*
- *use coring to verify concrete thickness on at least a sample of state highway projects annually.*

Roughness of Concrete Pavement

DOT requires contractors to measure the roughness of concrete pavement on projects that are at least one mile long and involve highways with a speed limit of 45 miles per hour or more. In October 2006, it began requiring them to measure roughness by using the International Roughness Index, which determines the amount of vertical motion a vehicle absorbs over a mile-long section of highway. Roughness is measured with a specialized piece of equipment that calculates a numerical rating from 0 to more than 250. A lower number indicates a smoother highway. DOT switched to 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 Transportation Officials, which is a nonprofit, nonpartisan association involving all 50 states. Michigan, Minnesota, and Ohio also use the index, and Iowa indicated that it intends to implement it in the near future.

Projects on roads with speed limits of less than 45 miles per hour are considered urban projects. Construction engineers inspect the concrete pavement of urban projects but do not use the International Roughness Index. Likewise, the index is not used on projects involving interchanges and weigh stations.

DOT requires construction engineers to review contractors' roughness measurements and determine whether the contractors should receive financial bonuses or be assessed financial penalties. Contractors:

- receive bonuses for each 500-foot highway section with a roughness rating lower than 55;
- are paid the contractually required amount for each section with a roughness rating from 55 to 85;
- are assessed penalties for each section with a roughness rating greater than 85; 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 2007, the most recent year for which data were available. As shown in Table 9, Wisconsin had a higher proportion of state highways rated as smooth (under 95) and lower proportions rated as fair (95 to 144) or rough (145 or more) compared to most of the six other states.

Table 9
International Roughness Index Rating¹
2007

| | Percentage of Highway Miles | | |
|------------------|-----------------------------|-------------|-------------|
| | Smooth | Fair | Rough |
| Illinois | 42.2% | 33.4% | 24.4% |
| Indiana | 59.0 | 28.5 | 12.5 |
| Iowa | 44.9 | 31.9 | 23.2 |
| Michigan | 57.0 | 25.4 | 17.6 |
| Minnesota | 52.1 | 35.8 | 12.1 |
| Ohio | 59.6 | 26.8 | 13.6 |
| Average | 51.9 | 30.6 | 17.5 |
| Wisconsin | 58.2 | 28.5 | 13.3 |

¹ Includes concrete and asphalt state highways.

We requested that DOT provide roughness measurements and supporting documentation for 28 projects that were let from October 2006 through June 2008, involved at least enough concrete to construct one mile of a two-lane highway, and had documentation available at the time of our review. In contrast to thickness measurements, roughness measurements are required to be documented by contractors in DOT's electronic system. Of these 28 projects, 18 were urban projects or otherwise exempted from roughness measurement, and 1 did not have any roughness measurements because DOT did not include this requirement in its contract with the contractor.

We examined the remaining nine projects and found that:

- Contractors for four projects were awarded a total of \$60,500 in bonuses because of roughness ratings of 55 or lower. However, at the time of our audit, contractors had actually been paid only \$37,200. DOT indicated that one contractor had submitted incorrect ratings, which was detected only after the bonus was calculated. DOT will re-measure the pavement this year and determine whether the contractor actually earned a bonus.
- Contractors for five projects should have been penalized a total of \$32,000 because of roughness ratings greater than 85. At the time of our audit, DOT had assessed two contractors a total of \$9,800, but it had not assessed penalties on the other three, in part because two contractors' projects had not been entirely completed. DOT was unable to provide us with information on the other contractor.
- None of the projects had roughness ratings greater than 140, which means that all were at least in fair condition.

In September 2008, DOT began to independently verify contractors' roughness measurements. To do so, it contracted with a West Allis engineering firm to measure the roughness of 32 projects completed from 2007 through 2008. DOT believes verification should ideally be performed within 48 hours of a contractor's measurements and under similar weather conditions. Because the verification in fall 2008 involved projects that had been completed months earlier, and the pavement condition may have changed in the intervening months, DOT did not examine the roughness of individual highway sections. Instead, it calculated an overall roughness rating for each project. At the time of our audit, DOT had not yet completed its analyses of the verification measurements.

DOT subsequently purchased equipment that will allow it to measure the roughness of concrete pavement. At the time of our audit, it was considering additional action, including:

- using the equipment to annually measure the roughness of at least one project completed by each contractor statewide, as soon as possible after a contractor has measured the roughness;
- improving its electronic system used by contractors to record roughness measurements and by construction engineers to verify those measurements; and
- requiring contractors to use the International Roughness Index to measure the roughness of urban projects.

If implemented, these actions would provide DOT with additional assurances that contractors and construction engineers are appropriately measuring the roughness of concrete pavement.

☑ Recommendation

We recommend the Department of Transportation report to the Joint Legislative Audit Committee by August 31, 2009, on the improvements it plans for measuring and verifying the roughness of concrete pavement on state highway projects.

Materials Testing

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 a supplier that the material meets specified requirements;
- pre-approval, based on the results of prior tests of the material; and
- visual inspection of the material at the project site, a procedure that is permitted for materials used in small quantities.

Contractors are contractually required to test a variety of characteristics of concrete pavement. DOT requires construction engineers to conduct their own tests to verify the concrete's strength and air content, which are the characteristics DOT considers the most critical to its integrity and durability. In addition, construction engineers are required to ensure contractors have submitted the appropriate certifications for various materials used to make concrete mixtures and concrete pavement.

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

Our recent single audit reports for the State of Wisconsin have found that construction engineers failed to electronically document approximately 20 percent of tests and from 10 to 20 percent of the required certifications, indicating that the tests and certifications either were not completed or were completed but not documented. In response to these findings, DOT has:

- reminded construction engineers of the testing and documentation requirements;
- reviewed selected projects to evaluate compliance with the requirements;

- developed an online system to help construction engineers determine testing and certification requirements for specific projects; and
- required all electronic documentation to be completed within 60 working days of project completion.

We reviewed documentation of the test results and certifications for concrete and related materials used on 20 projects that were let from FY 2006-07 through FY 2007-08, involved enough concrete to construct at least one mile of a two-lane highway, and had applicable documentation available. The 20 projects included 3 local road projects, for which DOT oversees testing and certification when federal funds are involved.

Because determining testing requirements for specific projects requires engineering expertise, we asked DOT to review the 20 projects and determine the number of tests that construction engineers should have completed and electronically documented. Based on the quantities of materials involved in the projects, DOT determined that four types of tests should have been completed a total of 432 times. However, 158 of the 432 tests, or 36.6 percent, were not documented electronically. Because the documentation was also not in the project files when we examined them, it appears that the tests were not performed.

A total of 149 of the 158 undocumented tests involved one type of test. This test is conducted on the concrete companion cylinders that construction engineers use to validate contractors' testing methods and results, but not to approve the concrete's use. Five of the six other midwestern states we contacted do not test concrete companion cylinders. Because DOT does not consider these tests to be an integral part of its process for verifying concrete quality, it plans to modify its standards and, beginning no later than 2010, remove these tests from its quality assurance process. However, it plans to continue conducting the tests, which it believes are useful for validating contractors' testing methods.

The other three types of tests involved characteristics important to the concrete's quality. We found that:

- the first test was not documented 6 of the 27 times it should have been conducted, which is 22.2 percent;
- the second test was not documented 2 of the 49 times it should have been conducted, which is 4.1 percent; and
- the third test was not documented 1 of the 2 times it should have been conducted, which is 50.0 percent.

Consultants and state staff each served as the lead construction engineer for 10 of the 20 projects. We found that:

- the ten consultant-led projects should have involved a total of 276 required tests, but only 64.1 percent of them were documented; and
- the ten state staff-led projects should have involved a total of 156 required tests, but only 62.2 percent of them were documented.

Although DOT considers air content to be a key factor in deciding whether concrete should be approved for use, it does not require construction engineers to electronically document most air content test results. Instead, documentation is in the project files. Air content tests appear to have been completed as frequently as required for 16 of the 20 projects, but we noted concerns with the other 4 projects:

- documentation of the air content tests on 3 projects was incomplete; and
- documentation indicated that construction engineers failed to perform one-half of the required air content tests on 1 project because of miscommunication with the contractor.

We also reviewed documentation of the certifications on the 20 projects. DOT determined on our behalf that construction engineers should have electronically documented 70 certifications. We found that 35 of the 70 certifications, or 50.0 percent, were not electronically documented. Consultants electronically documented 52.6 percent of the 38 certifications on their projects, while state staff electronically documented 46.9 percent of 32 certifications on their projects. However, when we reviewed the project files, 62 of the 70 certifications, or 88.6 percent, were documented.

If the required quality assurance tests on construction materials are not completed, or if construction engineers review the required certifications but do not electronically document them, DOT officials cannot easily verify that these quality assurance activities were completed or identify problems with particular construction engineers, contractors, or construction materials.

Recommendation

We recommend the Department of Transportation report to the Joint Legislative Audit Committee by August 31, 2009, on the steps it has taken to ensure construction engineers complete the required tests on concrete materials, review the necessary certifications, and electronically document the results of these quality assurance activities.

Nonconforming Materials

Construction materials that do not meet contractual requirements are considered to be nonconforming, and construction engineers may:

- accept the materials from the contractor at the contractually stipulated prices;
- accept the materials at reduced prices; or
- direct the contractor to replace the materials at no cost to DOT.

DOT's standards specify situations in which nonconforming materials should be accepted at reduced prices, depending on such factors as the degree to which the materials do not meet the standards, whether highway durability is affected, and whether DOT's future highway

maintenance costs might increase. They also specify how reduced prices should be calculated for various materials. However, they do not provide clear guidance about when construction engineers should direct contractors to replace materials at no cost to DOT.

DOT does not maintain centralized information on how often construction engineers accept nonconforming materials at contractually stipulated prices or direct contractors to replace materials, but it indicated that these options are seldom taken. In contrast, DOT does track how often contractors are paid reduced prices for materials.

DOT's data indicate that from FY 2003-04 through FY 2007-08, there were 1,163 instances in which contractors were paid reduced prices for nonconforming materials on state highway projects. Asphalt-related pay reductions were most common, while concrete-related pay reductions occurred less frequently because concrete is used less often. We attempted to quantify the pay reductions but were unable to do so because construction engineers used different methods to calculate reductions.

In December 2008, the Federal Highway Administration reviewed DOT's policies for handling nonconforming materials and was also unable to quantify the pay reductions. It recommended that DOT establish a standard method for calculating pay reductions and provide construction engineers with additional guidance on when contractors should be directed to replace nonconforming materials. At the time of our audit, DOT was preparing its response to the Federal Highway Administration.

☑ Recommendation

We recommend the Department of Transportation report to the Joint Legislative Audit Committee by August 31, 2009, on the actions it has taken in response to the Federal Highway Administration's December 2008 review of its policies regarding nonconforming construction materials.

Future Considerations

It will be important to ensure that the \$529.1 million in federal transportation funds Wisconsin will receive under the American Recovery and Reinvestment Act of 2009 are spent effectively. A significant portion of these funds will be used for state highway projects that DOT will let and oversee. 2009 Wisconsin Act 2, which was enacted in February 2009, requires DOT to construct 46 state highway projects that have an estimated total cost of \$298.6 million, all of which will be paid for with the federal funds. DOT plans to let these projects before June 30, 2009.

Construction-related costs account for most costs of state highway projects, and construction engineers play a critical role in ensuring that contractors adhere to contractual requirements, including those relating to quality assurance standards. If construction engineers do not ensure that contractors appropriately measure concrete pavement thickness, or if they do not appropriately test the quality of construction materials used, project quality can be adversely affected. If the required measurements and quality assurance tests are completed but not documented, DOT officials cannot be certain that contractual requirements and quality assurance standards were followed.

Finally, if completing state highway projects financed by the significant amounts of available federal transportation funds requires DOT to hire additional consultants as construction engineers, it will become more challenging for state staff to effectively oversee the consultants. Given that the federal funds are to be spent as quickly as possible in order to maximize their economic impact, we believe it is important for DOT to be diligent in ensuring its quality assurance process is consistently followed. We will follow up on DOT's efforts in future audits.

■ ■ ■ ■

Appendix 1

Description of Projects We Reviewed

We asked the Department of Transportation (DOT) to identify all state highway projects that were let from FY 2006-07 through FY 2007-08 and involved at least enough concrete to construct one mile of a two-lane highway. DOT identified 39 such projects, plus 6 local road projects that met these criteria and that it was responsible for overseeing because the projects involved federal funding, for a total of 45 projects. Through December 2008, some of these projects had not yet been completed. As a result, only 34 projects could be used for our analyses of concrete pavement thickness, concrete pavement roughness, and materials testing.

Reviewed Projects

| Highway/Road | Corridor | County | Thickness Analysis | Roughness Analysis | Materials Testing Analysis |
|-------------------------|---|-------------------|--------------------|--------------------|----------------------------|
| Interstate 39/90 | Illinois State Line to Madison | Rock | ■ | ■ | ■ |
| Interstate 43 | Rock Freeway | Waukesha | | ■ | |
| U.S. Highway 10 | Stevens Point to Waupaca | Portage | ■ | ■ | ■ |
| | Interstate 39 to River Road | Portage | ■ | | |
| | River Road to Long Road | Portage | ■ | ■ | |
| U.S. Highway 14 | County Highway YY to Coon Valley | La Crosse, Vernon | ■ | | ■ |
| U.S. Highway 18 | City of Jefferson | Jefferson | | ■ | |
| U.S. Highway 45 | County Highway G to County Highway YY | Winnebago | ■ | ■ | ■ |
| U.S. Highway 51 | City of Janesville | Rock | ■ | ■ | ■ |
| | U.S. Highway 51/State Highway 29 Corridor | Marathon | ■ | ■ | ■ |
| U.S. Highway 61 | City of Fennimore | Grant | ■ | ■ | ■ |
| U.S. Highway 151 | City of Madison | Dane | ■ | ■ | ■ |
| | Madison to Fond du Lac | Fond du Lac | ■ | ■ | ■ |
| State Highway 11 | Interstate 90 to State Highway 89 | Rock | ■ | | ■ |
| State Highway 19 | Waunakee to Sun Prairie | Dane | | ■ | |
| State Highway 21 | City of Sparta | Monroe | ■ | ■ | |
| State Highway 26 | City of Watertown | Dodge, Jefferson | ■ | ■ | ■ |
| State Highway 32 | City of Port Washington | Ozaukee | | ■ | |
| State Highway 33 | City of Beaver Dam | Dodge | ■ | ■ | ■ |
| State Highway 35 | City of La Crosse | La Crosse | ■ | ■ | ■ |

| Highway/Road | Corridor | County | Thickness Analysis | Roughness Analysis | Materials Testing Analysis |
|--------------------------|-------------------------------------|------------|--------------------|--------------------|----------------------------|
| State Highway 38 | City of Racine | Racine | | ■ | |
| State Highway 44 | City of Oshkosh | Winnebago | | ■ | |
| State Highway 50 | Delavan to Lake Geneva | Walworth | | ■ | |
| State Highway 55 | City of Kaukauna | Outagamie | ■ | ■ | ■ |
| State Highway 57 | City of Milwaukee | Milwaukee | ■ | ■ | ■ |
| | Green Bay to Sturgeon Bay | Door | ■ | ■ | ■ |
| State Highway 60 | City of Hartford | Washington | | ■ | |
| State Highway 74 | Sussex to Menomonee Falls | Waukesha | | ■ | |
| State Highway 95 | Hixton to Alma Center | Jackson | | ■ | |
| State Highway 96 | State Highway 76 to U.S. Highway 41 | Outagamie | | ■ | |
| State Highway 140 | Village of Clinton | Rock | ■ | ■ | ■ |
| County Highway LP | City of Appleton | Calumet | | | ■ |
| Local Street | W. Villard Ave., City of Milwaukee | Milwaukee | | | ■ |
| Local Street | S. Commercial St., City of Neenah | Winnebago | | | ■ |

Summary of Our Review of 34 Projects

| | |
|-------------------------|------------------------------------|
| Interstate 39/90 | Construction Engineer: State Staff |
|-------------------------|------------------------------------|

Illinois State Line to Madison
Rock County

Concrete pavement thickness

- Contractor electronically documented all required measurements
- Construction engineer electronically documented all required verifications of the contractor's measurements
- Electronic documentation indicates that the contractor did not measure the thickness at random locations, as is required
- Electronic documentation indicates that the contractor did not calculate an average thickness, as is required

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Construction engineer electronically documented 9 of 19 required tests and 1 of 3 required certifications; all 3 certifications were documented in the project file

| | |
|----------------------|------------------------------------|
| Interstate 43 | Construction Engineer: State Staff |
|----------------------|------------------------------------|

Rock Freeway
Waukesha County

Concrete pavement thickness

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement thickness

- Contractor electronically documented all required measurements
- Construction engineer electronically documented all required verifications of the contractor's measurements
- Electronic documentation indicates that the contractor did not measure the thickness at random locations, as is required
- Electronic documentation indicates that the contractor did not calculate an average thickness, as is required

Concrete pavement roughness

- No problems noted with the measurements

Materials testing

- Construction engineer electronically documented 42 of 52 required tests and all 5 required certifications

Concrete pavement thickness

- Contractor electronically documented 72 of 123 required measurements, or 58.5 percent
- Construction engineer electronically documented all required verifications of the contractor's measurements
- Electronic documentation indicates the contractor inappropriately calculated average thicknesses

Concrete pavement roughness

- We did not analyze roughness data because this project did not meet our criteria for inclusion in our analysis

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

U.S. Highway 10
River Road to Long Road
Portage County

Construction Engineer: Consultant

Concrete pavement thickness

- Contractor electronically documented 71 of 187 required measurements, or 38.0 percent
- Construction engineer electronically documented fewer verifications of the contractor's measurements than required

Concrete pavement roughness

- No problems noted with the measurements

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

U.S. Highway 14
County Highway YY to Coon Valley
La Crosse County and Vernon County

Construction Engineer: State Staff

Concrete pavement thickness

- Contractor electronically documented 448 of 529 required measurements, or 84.7 percent
- Construction engineer electronically documented all required verifications of the contractor's measurements

Concrete pavement roughness

- We did not analyze roughness data because this project did not meet our criteria for inclusion in our analysis

Materials testing

- Construction engineer electronically documented 25 of 31 required tests and 2 of 4 required certifications; 3 of 4 certifications were documented in the project file

U.S. Highway 18

City of Jefferson
Jefferson County

Construction Engineer: State Staff

Concrete pavement thickness

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

U.S. Highway 45

County Highway G to County Highway YY
Winnebago County

Construction Engineer: State Staff

Concrete pavement thickness

- Contractor electronically documented 220 of 366 required measurements, or 60.1 percent
- Construction engineer electronically documented fewer verifications of the contractor's measurements than required
- Electronic documentation indicates that the contractor did not measure the thickness at random locations, as is required
- Electronic documentation indicates that the contractor did not calculate an average thickness, as is required

Concrete pavement roughness

- No problems noted with the measurements

Materials testing

- Construction engineer electronically documented 10 of 11 required tests and 2 of 4 required certifications; all 4 certifications were documented in the project file

U.S. Highway 51

City of Janesville
Rock County

Construction Engineer: State Staff

Concrete pavement thickness

- Contractor electronically documented none of the required measurements
- Construction engineer electronically documented none of the required verifications of the contractor's measurements

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Construction engineer electronically documented 5 of 13 required tests and 1 of 3 required certifications; 2 of 3 certifications were documented in the project file
- Documentation of air content tests was incomplete

U.S. Highway 51

U.S. Highway 51/State Highway 29 Corridor
Marathon County

Construction Engineer: Consultant

Concrete pavement thickness

- Contractor electronically documented all required measurements
- Construction engineer electronically documented all required verifications of the contractor's measurements
- Electronic documentation indicates the contractor inappropriately calculated average thicknesses

Concrete pavement roughness

- No problems noted with the measurements

Materials testing

- Construction engineer electronically documented 18 of 52 required tests and all 5 required certifications
- One-half of the required air content tests were not performed

U.S. Highway 61

City of Fennimore
Grant County

Construction Engineer: State Staff

Concrete pavement thickness

- Contractor electronically documented all required measurements
- Construction engineer electronically documented all required verifications of the contractor's measurements

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Construction engineer electronically documented 8 of 24 required tests and all 3 required certifications

U.S. Highway 151

City of Madison
Dane County

Construction Engineer: Consultant

Concrete pavement thickness

- Contractor electronically documented all required measurements
- Construction engineer electronically documented all required verifications of the contractor's measurements

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Construction engineer electronically documented 18 of 40 required tests and all 3 required certifications

Concrete pavement thickness

- Contractor electronically documented 270 of 273 required measurements, or 98.9 percent
- Construction engineer electronically documented all required verifications of the contractor's measurements
- Electronic documentation indicates that the contractor did not measure the thickness at random locations, as is required
- Electronic documentation indicates that the contractor did not calculate an average thickness, as is required

Concrete pavement roughness

- No problems noted with the measurements

Materials testing

- Construction engineer electronically documented 30 of 51 required tests and 0 of 4 required certifications; 3 of 4 certifications were documented in the project file

Concrete pavement thickness

- Contractor electronically documented 39 of 53 required measurements, or 73.6 percent
- Construction engineer electronically documented none of the required verifications of the contractor's measurements

Concrete pavement roughness

- We did not analyze roughness data because this project did not meet our criteria for inclusion in our analysis

Materials testing

- Construction engineer electronically documented 3 of 5 required tests and 2 of 3 required certifications; all 3 certifications were documented in the project file

Concrete pavement thickness

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement roughness

- No problems noted with the measurements

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement thickness

- Contractor electronically documented 16 of 31 required measurements, or 51.6 percent
- Construction engineer electronically documented none of the required verifications of the contractor's measurements
- Electronic documentation indicates that the contractor did not calculate an average thickness, as is required

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

State Highway 26

City of Watertown
Dodge County and Jefferson County

Construction Engineer: Consultant

Concrete pavement thickness

- Contractor electronically documented all required measurements
- Construction engineer electronically documented all required verifications of the contractor's measurements
- Electronic documentation indicates the contractor inappropriately calculated average thicknesses

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Construction engineer electronically documented 2 of 5 required tests and 2 of 3 required certifications; all 3 certifications were documented in the project file

State Highway 32

City of Port Washington
Ozaukee County

Construction Engineer: State Staff

Concrete pavement thickness

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

State Highway 33

City of Beaver Dam
Dodge County

Construction Engineer: State Staff

Concrete pavement thickness

- Contractor electronically documented all required measurements
- Construction engineer electronically documented all required verifications of the contractor's measurements
- Electronic documentation indicates the contractor inappropriately calculated average thicknesses

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Construction engineer electronically documented 13 of 14 required tests and 0 of 3 required certifications; 2 of 3 certifications were documented in the project file

State Highway 35

City of La Crosse
La Crosse County

Construction Engineer: State Staff

Concrete pavement thickness

- Contractor electronically documented 118 of 137 required measurements, or 86.1 percent
- Construction engineer electronically documented all required verifications of the contractor's measurements
- Electronic documentation indicates that the contractor did not calculate an average thickness, as is required

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Construction engineer electronically documented 11 of 15 required tests and 0 of 3 required certifications; 2 of 3 certifications were documented in the project file

State Highway 38City of Racine
Racine County

Construction Engineer: State Staff

Concrete pavement thickness

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

State Highway 44City of Oshkosh
Winnebago County

Construction Engineer: Consultant

Concrete pavement thickness

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

State Highway 50Delavan to Lake Geneva
Walworth County

Construction Engineer: State Staff

Concrete pavement thickness

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement roughness

- No problems noted with the measurements

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement thickness

- Contractor electronically documented all required measurements
- Construction engineer electronically documented none of the required verifications of the contractor's measurements
- Electronic documentation indicates that the contractor did not measure the thickness at random locations, as is required
- Electronic documentation indicates that the contractor did not calculate an average thickness, as is required

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Construction engineer electronically documented 3 of 7 required tests and 2 of 3 required certifications
- Documentation of air content tests was incomplete

Concrete pavement thickness

- Contractor electronically documented 27 of 47 required measurements, or 57.4 percent
- Construction engineer electronically documented all required verifications of the contractor's measurements

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Construction engineer electronically documented 5 of 13 required tests and 2 of 3 required certifications

State Highway 57
Green Bay to Sturgeon Bay
Door County

Construction Engineer: Consultant

Concrete pavement thickness

- Contractor electronically documented 886 of 960 required measurements, or 92.3 percent
- Construction engineer electronically documented none of the required verifications of the contractor's measurements

Concrete pavement roughness

- No problems noted with the measurements

Materials testing

- Construction engineer electronically documented all 38 required tests and 0 of 6 required certifications; all 6 certifications were documented in the project file

State Highway 60
City of Hartford
Washington County

Construction Engineer: State Staff

Concrete pavement thickness

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

State Highway 74
Sussex to Menomonee Falls
Waukesha County

Construction Engineer: State Staff

Concrete pavement thickness

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

State Highway 95
Hixton to Alma Center
Jackson County

Construction Engineer: State Staff

Concrete pavement thickness

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement roughness

- No measurements were taken because DOT neglected to include the relevant contract provisions

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

State Highway 96
State Highway 76 to U.S. Highway 41
Outagamie County

Construction Engineer: State Staff

Concrete pavement thickness

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

Concrete pavement roughness

- No problems noted with the measurements

Materials testing

- Complete documentation did not exist for this aspect of the project at the time of our audit fieldwork

State Highway 140
Village of Clinton
Rock County

Construction Engineer: State Staff

Concrete pavement thickness

- Contractor electronically documented all required measurements
- Construction engineer electronically documented all required verifications of the contractor's measurements

Concrete pavement roughness

- DOT exempted the project from measurement

Materials testing

- Construction engineer electronically documented 8 of 9 required tests and 2 of 3 required certifications; all 3 certifications were documented in the project file

County Highway LP
City of Appleton
Calumet County

Construction Engineer: Consultant

Concrete pavement thickness

- DOT is not responsible for overseeing the thickness of local projects

Concrete pavement roughness

- DOT is not responsible for overseeing the roughness of local projects

Materials testing

- Construction engineer electronically documented 16 of 17 required tests and all 3 required certifications

Local Street
W. Villard Avenue, City of Milwaukee
Milwaukee County

Construction Engineer: Consultant

Concrete pavement thickness

- DOT is not responsible for overseeing the thickness of local projects

Concrete pavement roughness

- DOT is not responsible for overseeing the roughness of local projects

Materials testing

- Construction engineer electronically documented 7 of 11 required tests and 0 of 3 required certifications; 2 of 3 certifications were documented in the project file
- Documentation of air content tests was incomplete

Local Street
S. Commercial St., City of Neenah
Winnebago County

Construction Engineer: Consultant

Concrete pavement thickness

- DOT is not responsible for overseeing the thickness of local projects

Concrete pavement roughness

- DOT is not responsible for overseeing the roughness of local projects

Materials testing

- Construction engineer electronically documented 3 of 5 required tests and 0 of 3 required certifications; all 3 certifications were documented in the project file