Michigan Department of Transportation

Roads Innovation Task Force Report

June 1, 2016
Revised September 8, 2016

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ACKNOWLEDGEMENTS

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SUMMARY

Public Act 175 of 2015, signed by Governor Rick Snyder on November 10, 2015, amends Public Act 51 of 1951 and sets forth the following requirements for the Michigan Department of Transportation (MDOT) regarding the *Roads Innovation Task Force Report*.

Sec. 1j.
(1) No later than December 1, 2015, the Department shall form a special internal task force specifically named the Roads Innovation Task Force. The purpose of the Task Force shall be to create a comprehensive public report that does all of the following:

a) Evaluates road materials and construction methods that, when implemented, could allow the Department to build high-quality roads in this state that last longer than those typically constructed by the Department, with a goal of roads lasting at least 50 years, higher quality roads, and reduced maintenance costs.

b) Focuses on materials and processes that may cost more in initial up-front spending but that still produce life-cycle construction and maintenance savings. The Department shall strive to achieve a reduction of at least 50 percent in its net present value 50-year life cycle costs as compared to the commensurate net present value 50-year life cycle costs for road construction and maintenance costs from 2015, in a manner that results in no state roads being rated in poor condition and has no net degradation from overall 2015 level pavement surface evaluation and rating (PASER) scores within the plan's first 10 years.

c) Focuses on longer-term time frames that seek to maximize value to the taxpayers of this state on a total cost basis, regardless of funding or financing considerations. The report shall not incorporate or reference plans or suggestions regarding bonding, refinancing, or financing innovations.

(2) Not later than March 1, 2016, the Department shall finalize and make public the report described in Subsection (1). The Task Force shall present that report at a public hearing before a joint committee hearing of the standing committees of the Senate and House of Representatives with primary responsibility for transportation issues called by the chairs.

(3) Not later than June 1, 2016, the Task Force shall update the finalized report described in Subsection (2) to provide suggested boilerplate language which coincides with how the Department would execute the plan and attempt to achieve the targets described in Subsection (1). The plan shall include sufficient detail to allow the legislature to monitor and track progress, estimate how long it is expected to take to achieve targets, and project what the inflation adjusted reduction in annual spending will be once fully implemented as compared to the costs associated with 2015.

This report meets the Michigan Department of Transportation's requirements for Sec. 1j (1), (2), and (3) of Public Act 175 of 2015.

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June 1, 2016
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The report is in four major sections:

- "Evaluation of Materials and Processes" (addressing (1) a) above) – This section discusses how MDOT evaluates new materials and processes.
- "Upfront Investment to Reduce Life Cycle Costs" (addressing (1) b) above) – This section provides an assessment of 50-year pavements. It compares current MDOT standards against proposed higher standards to achieve longer lasting pavements with potential reduced life cycle costs. The cost impacts of 50-year pavements is also included.
- "Longer Term Time Frames" (addressing (1) c) above) – This section discusses methods that MDOT currently uses to evaluate longer term time frames as applied to materials and construction methods.
- "Suggested Legislative Language" (addressing (3) above) – This section provides suggested boilerplate language for long life pavements and suggested changes to PA 51 in regards to life cycle cost analysis language and pavement demonstration program language. Furthermore, it is recommended that studded tires not be allowed on MDOT roadways.

Evaluation of Materials and Processes

MDOT continually seeks new materials, technologies, and construction methods that have potential to improve pavement performance. MDOT's method to assess these innovations include the New Materials Evaluation Procedure, Pavement Demonstration Program, and Research Findings and Results. MDOT's technical staff works closely with Michigan universities and other national experts in design, materials selection, and construction methods. MDOT's involvement in national research initiatives related to pavement performance allows for the evaluation of innovations. These initiatives are not specific to developing the protocol for 50-year pavements. Rather, they embrace holistic strategies to provide reductions in life cycle cost through improved performance.

MDOT's evaluation of new products and materials used for transportation focuses on optimizing the overall network pavement performance in an effort to maximize value to taxpayers. This optimization is accomplished by understanding how pavements truly perform over time relative to what affects pavement performance. Understanding the causes and effects of pavement performance allows MDOT to provide pavement designs and specify materials that are both reliable and low in life cycle cost. Any innovation, when implemented, should allow MDOT to deliver high-quality roads that last longer than those typically constructed using conventional methods, with the goal of roads lasting at least 50 years, higher quality roads, and reduced maintenance costs.

Upfront Investment to Reduce Life Cycle Costs

A proven pavement section that would require fewer Capital Preventative Maintenance (CPM) treatments (or no CPM treatments) to meet the noted requirements for a 50-year period has not yet been demonstrated in Michigan. As a consequence, MDOT does not have the historical performance data necessary to accurately forecast the future costs associated with such a pavement. However, proposed strategies that could be considered to reliably increase pavement

service life to 50, or 75, years with a potential reduction in preventive maintenance are listed for each pavement type as detailed within this report.

The table below provides estimated costs of reconstructing one lane-mile of pavement using MDOT's traditional 20-year pavement design, compared with 30- and 50-year design lives.

Estimated Reconstruction Cost versus Design Life

	20-Year Design Life (Current Standard)	30-Year Design Life (50-Year Service Life)	50-Year Design Life (75-Year Service Life)
Estimated Reconstruction Cost Per Lane Mile	$2,000,000	$3,000,000 Rural $4,000,000 Urban	$3,700,000 Rural $5,000,000 Urban

Although the table suggests that building 30-year pavements can provide 50 percent longer pavement life at an estimated 50 percent increase in cost, the decision to invest in longer-lasting pavements has impact across the trunkline system. When more money is invested in higher cost-per-lane mile longer-lasting reconstruction work, fewer lane miles of pavement can be improved overall. Investing more to reconstruct fewer miles would mean more lane miles of roadway would fall into poor condition. MDOT currently employs a mix of fixes and any roads reconstructed are to the current 20-year design standard to maximize pavement condition across the entire network.

Following is a summary of estimated funding projections that would be required to meet and sustain the 90 percent good/fair pavement goal (currently approved by the State Transportation Commission) using today's design standards alongside what would be needed to achieve similarly sustained levels of service for 20-, 30- and 50-year design standards and eliminate poor pavements on state trunkline within 10 years. Funding levels less than these would result in a degradation of the condition level as compared to the 2015 condition level. Any number of lane miles constructed using the 30- and 50-year design standards would result in a degradation of the condition level as compared to the 2015 condition level.

Estimated Funding Projections

Funding Impacts	Investment Needed First 10 Years	Average Investment Needed Next 40 Years
Current Standards 20-Year Design Life with Mix of Fixes	$15 billion	$3.9 billion/year
20-Year Design Standards Reconstruct	$60 billion	$9 billion/year
30-Year Design Standards Reconstruct	$111 billion	$450 million/year
50-Year Design Standards Reconstruct	$140 billion	$560 million/year

Table 2 within the report provides a summary of proposed pavement designs for a 30- and 50-year design life.

The report provides potential life cycle cost savings from constructing enhanced pavement sections based on an additional funding level provided by legislation enacted in 2015. Costs for the enhanced pavement designs and enhancements to materials, specification requirements, and construction methods presented in the report are estimated, as are the potential utility relocations and real estate acquisitions. Actual costs for these items would be project-specific and may be significantly higher than the estimates, which could lead to fewer potential lane miles being constructed using the Roads Innovation Fund.

State Law 247.651h, Act 51, requires that ". . . the Department shall develop and implement a life-cycle- cost analysis for each project for which total pavement costs exceed $1,000,000 funded in whole, or in part, with state funds. The Department shall design and award paving projects utilizing material having the lowest life-cycle costs." This law also requires that ". . . life cycle cost shall compare equivalent designs and shall be based upon Michigan's actual historic project maintenance, repair, and resurfacing schedules and costs as recorded by the pavement management system, and shall include estimates of user costs throughout the entire pavement life." Furthermore, the law states that, "For pavement projects for which there are no Michigan actual historic project maintenance, repair, and resurfacing schedules and costs as recorded by the pavement management system, the department may use actual historical and comparable data for equivalent designs from states with similar climates, soil structures, or vehicle traffic." MDOT has considered and continually seeks out performance data from other states that could be used in the life cycle costs analysis (LCCA) process. MDOT is aware of states that have constructed long life pavements and are monitoring their progress. Once these pavements have been in place long enough and actual performance data can be obtained MDOT may be able to translate the data for use in long life pavement LCCA in Michigan.

MDOT has no historic performance or maintenance data on these proposed long-life pavements, and therefore, a life cycle cost analysis (based on actual costs) cannot be performed. Any long life pavements undertaken through use of the Roads Innovation Fund would not conform to the above requirements and, thus, would need to be exempt from the current life cycle cost analysis required by law.

Additionally, MCL 257.710 of the Michigan Vehicle code allows use of studded tires in combination with the 1979 rule promulgated in R247.717. This law should be repealed to ensure that expected service life is obtained for long-life pavements.

Longer Term Time Frames

Striving for longer lasting pavements has been a part of MDOT's culture for years. MDOT will continue to support development and implementation of innovations in designing, constructing, and maintaining Michigan roadways utilizing established methods and processes as outlined in the "Evaluation of Materials and Processes" section.

There are many examples of MDOT innovation in the past and present. The cost benefit of a particular innovation, product, or material in pavements is ultimately analyzed using the network analysis tools presented in the "Upfront Investment to Reduce Life Cycle Costs" Section. Real time performance data should be used to analyze performance and ensure that any innovation, product, or material truly adds value for taxpayers. However, given the fact that an innovative concept, by definition, does not embody a history of performance, any analysis of benefits would require an estimate of improvement to baseline performance. For that reason, the true test of any innovation's performance can only be realized after sufficient data are accumulated over time.

Suggested Legislative Language

The following boilerplate language is suggested in order that the Department execute the plan to reduce the overall Equivalent Uniform Annualized Cost (EUAC) of its pavements' life cycle:

The Department shall continually strive to lower the Equivalent Uniform Annualized Cost (EUAC) of hot mix asphalt and Portland cement concrete pavements. Beginning in 2018, the Department will issue a biennial report that provides specific measures the Department is taking to achieve this goal. The report will list demonstration projects that incorporate a specific enhancement that is intended to decrease the EUAC of a particular pavement type. Additionally, any material enhancements, increased acceptance limits, or construction requirements made to specifications that have the potential to enhance pavement performance will be reported along with their intended benefits. Furthermore, any new materials submitted to the Department will be reported with the status of each. When sufficient performance data have been obtained for an individual enhancement, the Department will provide a performance curve and EUAC that will be compared to the baseline performance curve and EUAC as published in the 2012 "Pavement Design and Selection Manual," and an inflation-adjusted reduction in annual spending will be provided as compared to costs in 2015.

Furthermore, it is suggested that modifications be made to the life cycle cost analysis, pavement demonstration program, and studded tire laws as follows:

- **Life Cycle Cost Analysis**
  Modify State Law MCL 247.651h to increase the threshold for performing an LCCA from $1,000,000 to $2,000,000 and to allow for engineering analysis techniques to determine the appropriate maintenance, repair, and resurfacing schedule for the subject project when no historical data are obtainable from the Department or other sources.

- **Pavement Demonstration Program**
  MCL 247.651 - 247.675, Sec 1i. sets forth the requirements for demonstration projects to evaluate new constructions methods, materials, or designs. This section should be modified to remove the requirement to have a balance between hot mix asphalt and concrete, thus allowing the Department to demonstrate innovations as they become available. If the balancing requirement is left in place, there should be an allowance for the Department to let and

construct four demonstration projects: two in 2017 and two in 2018, which would include long life pavement enhancements that are not to be part of the pavement demonstration program balancing requirement. These four projects would consist of a 30-year and 50-year design for both hot mix asphalt and concrete. Demonstration projects should only include methods, materials, or designs that have a sound research base behind them, since the Department should not be developing methods, materials, or designs that have not been previously vetted at some level within the transportation realm.

If the cap on the number of demonstration projects allowed in a year is increased, it is recommended that a separate appropriation for these projects be established from a source other than currently existing transportation funding. This will allow the Department to deliver additional innovative projects while still delivering the standard road program.

SB 879 amendments to address Life Cycle Cost Analysis and Pavement Demonstration Program:

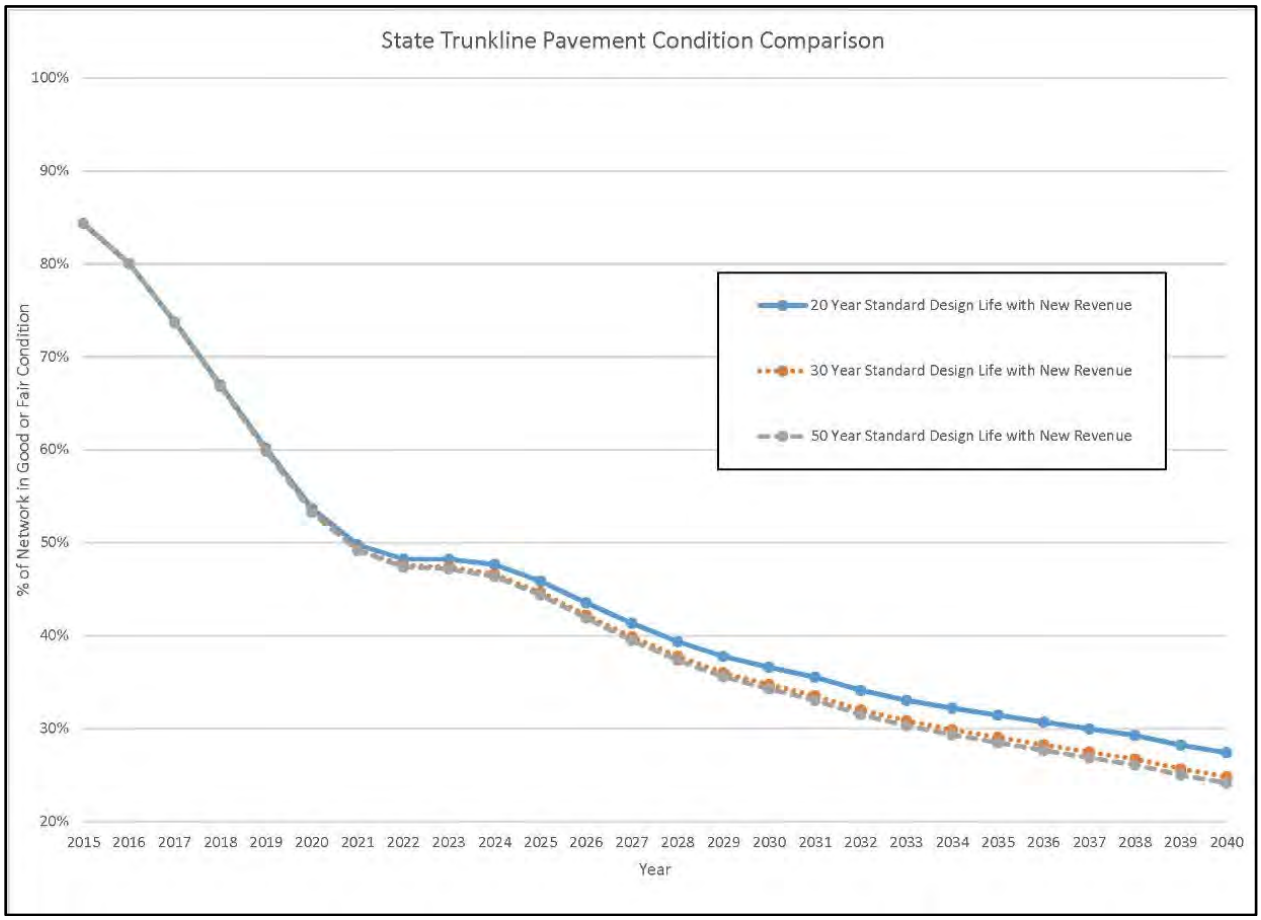
- Page 2 line 3 – Strike "$1,000,000.00" and replace with "$2,000,000.00"
- Page 3 line 18: After (B), strike all of the subsection and replace with "If historical data is not obtainable from the Department or other sources, appropriate maintenance, repair, and resurfacing schedules for a particular project may be determined by appropriate engineering analysis techniques upon approval by the chief engineer of the Department."
- Page 4 line 24: Add new (d): "Demonstration projects should only include methods, materials, or designs that have a sound research base behind them."
- Page 4 line 26: Delete after (3) and replace with "Nothing in the subsection requires that any individual demonstration project be duplicated with both asphalt and concrete."
- Page 5 line 15: Add new (6): "For demonstration projects contemplated under this section, the Department shall strive to reduce the equivalent uniform annual cost by 5 percent over the next 10 years."
- Page 5 line 15: Add new (7): "$10,000,000 is appropriated from the General Fund to fund a portion of the demonstration projects in this section."

- **Studded Tires**
  State Administrative Rule 710 of Act No. 300 of the Public Acts of 1949, as amended, being MCL 257.710 of the Michigan Compiled Laws allows the use of studded tires. This law would need to be repealed to minimize pavement wear and ensure the expected service life is obtained for long life pavements.

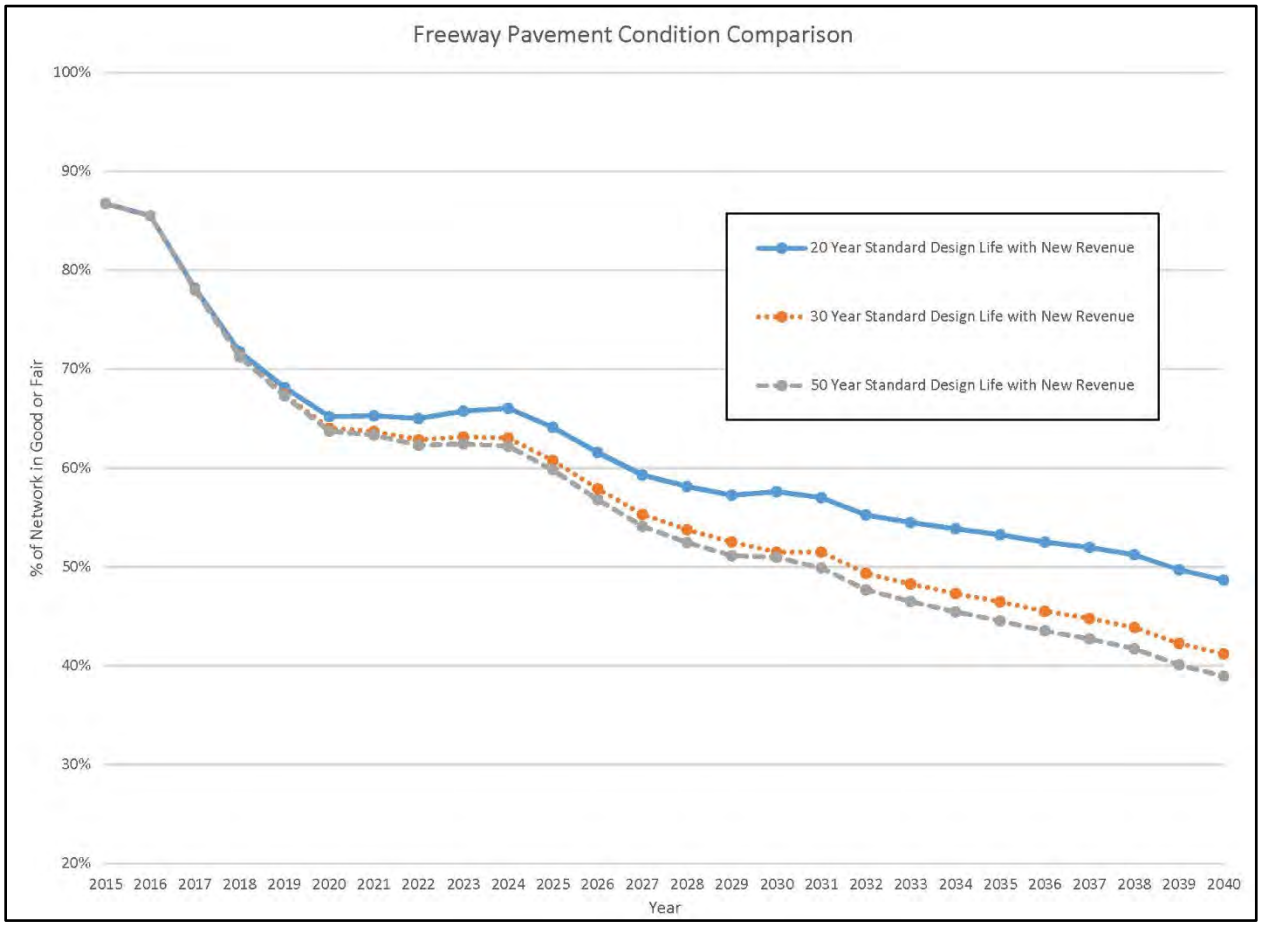
Conclusion

Based on current funding levels, including the new revenues provided by the Legislature beginning in 2017, MDOT would not be able to construct these long life pavements and sustain 2015 level pavement condition. The following graph depicts the impact to the state trunkline condition level based on current practices (standard 20-year design life) and proposed 30- and 50-year design life.

Trunkline pavement condition will decline in each scenario but will decline more under the proposed 30- and 50-year design life scenarios.



The negative pavement conditions outcomes are more significant when the proposed 30- and 50-year designs are examined at the freeways level, as depicted in the graph below. Freeways carry 60 percent of all trunkline traffic and 76 percent of trunkline commercial traffic. An additional 8 to 10 percent drop in freeway pavement condition, which would occur with the proposed 30- and 50-year designs, would have additional negative impacts for drivers and for the state's economy.



MDOT will continue to seek new materials, technologies, and construction methods that have potential to improve pavement performance. MDOT will use its New Materials Evaluation Procedure, Pavement Demonstration Program, and Research Findings and Results in evaluating these innovations. MDOT's technical staff continues to work closely with Michigan universities and other national experts to investigate a wide variety of issues that impact pavement performance. MDOT will continue to provide leadership and remain technically engaged to national research by ad hoc consortium and through national pooled resource opportunities. The primary focus of these programs and initiatives may not be specific to developing a 50-year pavement, but it can further the development of long life pavements by establishing the methodology needed to reduce overall life cycle cost through improved performance.

For the 30- and 50-year pavement designs described in the report, no actual cost or performance data exists. Without these actual costs, the actual net present value of these proposals cannot be determined. This reduction may be achieved by improving overall pavement performance through innovations, improved material quality, enhanced specification requirements, and utilization of asset management principles. While the true costs and performance remain unknown, projections of performance and costs are the best available way to estimate the net present value of a particular 30- or 50-year designed pavement.

MDOT is proposing to construct four demonstration/pilot projects in 2017 that will utilize the 30-year design life and applicable enhancements and two in 2018 that will utilize a 50-year design and applicable enhancements. Additionally, MDOT is proposing to incorporate four of the enhancements noted on page 26 for both concrete and hot mix asphalt into its standard practices. It is anticipated that these enhancements will be included in applicable projects starting in the October 2016 letting. The four enhancements for hot mix asphalt projects will be:

1) Increased mat density to 93 percent for acceptance
2) Verification of aggregate specific gravities
3) Tightening of percent within limits acceptance parameters
4) Increased use of material transfer device with remixing capabilities.

The enhancements for the concrete projects will be:

1) Increased aggregate properties for resistance to material related distress and increased freeze thaw durability
2) Corrosion resistant coating of dowel and lane tie bars
3) Tightening of percent within limits acceptance parameters
4) Enhanced acceptance of air and air system; use of hardened air as acceptance.

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REPORT BACKGROUND

Public Act 175 of 2015 as approved by Governor Rick Snyder on November 10, 2015, amends Public Act 51 of 1951 and sets forth the following requirements for the Michigan Department of Transportation (MDOT) regarding the *Roads Innovation Task Force Report*.

Sec. 1j.
(1) No later than December 1, 2015, the department shall form a special internal task force specifically named the Roads Innovation Task Force. The purpose of the task force shall be to create a comprehensive public report that does all of the following:

d) Evaluates road materials and construction methods that, when implemented, could allow the department to build high-quality roads in this state that last longer than those typically constructed by the department, with a goal of roads lasting at least 50 years, higher quality roads, and reduced maintenance costs

e) Focuses on materials and processes that may cost more in initial up-front spending but that still produce life-cycle construction and maintenance savings. The department shall strive to achieve a reduction of at least 50% in its net present value 50-year life cycle costs as compared to the commensurate net present value 50-year life cycle costs for road construction and maintenance costs from 2015, in a manner that results in no state roads being rated in poor condition and has no net degradation from overall 2015 level pavement surface evaluation and rating (PASER) scores within the plan's first 10 years.

f) Focuses on longer-term time frames that seek to maximize value to the taxpayers of this state on a total cost basis, regardless of funding or financing considerations. The report shall not incorporate or reference plans or suggestions regarding bonding, refinancing, or financing innovations.

(2) Not later than March 1, 2016, the department shall finalize and make public the report described in subsection (1). The task force shall present that report at a public hearing before a joint committee hearing of the standing committees of the Senate and House of Representatives with primary responsibility for transportation issues called by the Chairs.

(3) Not later than June 1, 2016, the task force shall update the finalized report described in subsection (2) to provide suggested boilerplate language which coincides with how the department would execute the plan and attempt to achieve the targets described in subsection (1). The plan shall include sufficient detail to allow the legislature to monitor and track progress, estimate how long it is expected to take to achieve targets, and project what the inflation adjusted reduction in annual spending will be once fully implemented as compared to the costs associated with 2015.

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INTRODUCTION

This report is being issued to meet the initial requirements of Sec. 1j. (1) and (2) above. The report is divided into three major sections:

- "Evaluation of Materials and Processes" (addressing (1) a) above) – This section discusses how MDOT evaluates new materials and processes and provides typical examples.
- "Upfront Investment to Reduce Life Cycle Costs" (addressing (1) b) above) – This section provides an assessment of 50-year pavements, comparing current MDOT standards against proposed higher standards to achieve longer lasting pavements with potential reduced life cycle costs and assess the cost of those pavements.
- "Longer Term Time Frames" (addressing (1) c) above) – This section discusses methods that MDOT currently uses to evaluate longer term time frames as applied to materials and construction methods.

PAVEMENT BASICS

Contemporary pavement design is based on procedures recommended by the American Association of State Highway and Transportation Officials (AASHTO) and included in the AASHTO Design Guide. Pavements typically are designed for a 20-year period of performance, although some states use 30- to 40-year periods; 20 years was adopted early in the interstate program as the standard design life for federal-aid projects. It was considered a reasonable length of service in view of the system's extent, proposed budget, and available information about pavement design and future traffic growth. It has been demonstrated that a pavement's overall life can be extended beyond its design life by use of preventive maintenance fixes applied at optimal times. The original construction plus preventive maintenance results in the pavement's overall service life.

Highway pavements are mixtures of aggregate and Portland cement or hot mix asphalt. The pavement supports vehicle loads and transfers them to the soil below through layers of surface, base course, and subgrade. Pavement design involves determining the most economical combination of pavement layers (taking into account both thickness and type of materials) appropriate for the soil foundation and the traffic to be carried, while addressing such variables as environmental conditions, soil drainage, and pavement aging and weathering. The pavement performance period (service life) is the actual length of time that the pavement is in service before major rehabilitation is needed. Pavement performance depends on many factors, including:

- Thickness of the various pavement layers.
- Design details, such as transverse contraction joint spacing for Portland cement concrete (PCC) pavements and asphalt binder selection for hot mix asphalt.
- Quality of construction materials and practices.
- Maintenance practices, including the type and timing of maintenance actions.
- Properties of roadbed soil (subgrade).
- Environmental considerations (primarily precipitation and temperature).
- Number and weight of axle loads to which the pavement is subjected.

Design life is the basis for the combination of design features chosen by the pavement engineer. In designing new and reconstructed pavements, for example, designers can provide thicker pavements for increased traffic loadings because a given percentage of increase in the expected loads can be accommodated by a much smaller percent increase in the pavement thickness and cost.

Other high-performance design features can yield additional benefits. Such features include shorter slabs (for concrete pavements), full-depth paved shoulders, positive subsurface drainage, and improved materials specifications. But because thicker pavement and high-performance design features cost more than conventional pavement, a highway agency is faced with difficult choices. Building long-lasting, lower maintenance pavement involves tradeoffs between higher initial costs and lower life cycle costs, with a result of degrading the overall network condition.

Over the years, many paving innovations have been tried and implemented in an attempt to extend pavement life, while reducing life cycle costs. In theory, quality-based innovations should reap rewards in terms of overall reduced life cycle cost. On the other hand, the risk of potential failure also exists when exploring innovative ideas, which could equate to an actual loss in performance. Potential risk and reward are important factors in the decision to pursue an innovative idea. Wholesale implementation of an innovation that has not been proven by long-term pavement performance can have long lasting impacts on overall network condition if it does not perform well.

Life cycle costs include the full range of construction and maintenance costs during the life of the pavement, as well as costs associated with the maintenance of traffic in work zones for project level life cycles. Other costs include delay costs incurred by passenger and freight transportation on the section being reconstructed. Delay costs may be due to construction activities, lane blockages, lower speeds, or the higher incidence of accidents involving road users and highway construction personnel in work zones. Although life cycle costs are a strong argument for using long-lasting, lower maintenance pavement, it is not always possible to fund higher initial costs because of budget constraints.

EVALUATION OF MATERIALS AND PROCESSES

PA 175 requires MDOT to evaluate ". . . road materials and construction methods that, when implemented, could allow the department to build high-quality roads in this state that last longer than those typically constructed by the department, with a goal of roads lasting at least 50 years, higher quality roads, and reduced maintenance costs." The act also recommends MDOT pursue this effort ". . . in a manner that results in no state roads being rated in poor condition and has no net degradation from overall 2015 level pavement surface evaluation and rating (PASER) scores within the plan's first 10 years."

MDOT continually seeks out new materials, technologies, and construction methods that have potential to improve pavement performance. MDOT's method to assess these innovations include its New Materials Evaluation Procedure, Pavement Demonstration Program, and Research

Findings and Results. MDOT's technical staff continue to work closely with Michigan universities and other national experts to investigate a wide variety of issues that factor into pavement performance such as design, materials selection, and construction methods. MDOT is also involved in ongoing national research initiatives related to pavement performance. Studies of national interest often pool technical and monetary resources from several states to leverage capital, maximize the quality of the end product, and avoid redundant research. In addition, the Federal Highway Administration oversees several research programs with emphasis on pavement performance, including the Strategic Highway Research Program, and National Cooperative Highway Research Program, among others. The primary focus for these programs is not specific to developing the protocol for 50-year pavements, but the research does rely on strategies to reduce overall life cycle cost through improved performance.

There is inherent risk whenever demonstrating any new material, technology, or construction method. MDOT routinely solicits expertise from within, as well as that of others nationally, in efforts to help determine whether an innovation may show likelihood for success prior to considering it for field demonstration. Over the years many innovations have proven to be successful, such as the implementation of the hot mix asphalt Superpave system, hot mix asphalt longitudinal joint density, high performance concrete paving mixtures, stringless paving technology, and others. On the other hand, there have also been innovations that have proven to be unsuccessful in increasing long-term performance, for example: Core 10 (ASTM A-588) weathering steel bridge beams and guardrail, very open-graded "super drainable" bases beneath concrete pavements, recycled tire rubber for embankment fill, as well as others.

New Materials

MDOT has long maintained active interest in seeking out and evaluating new materials and products that may potentially improve the performance and longevity of Michigan's transportation infrastructure. To ensure that new and innovative products add value, they are evaluated from concept to statewide implementation and standard practice through a formal process. Further, in an effort to ensure thorough and unbiased evaluations, an integral part of MDOT's technical culture demands that the experts explore beyond the Michigan experience and look at national and international perspectives.

A new material or product is defined as one that has not previously been approved for use by MDOT. In other words, there is no direct link between the material or product and a current MDOT specification or approved products list, which means there is no way for the material or product to be specified for use on an MDOT project. Initiation of new material or product evaluations are not only prompted from within MDOT, but are also brought forth by vendors from the private sector. MDOT provides a Web site to assist vendors when submitting their wares for MDOT consideration. Once a product is submitted, it is logged into a New Materials Informational System (NeMIS) database. It is then forwarded to the appropriate subject-matter expert at MDOT for review. From this point forward, the assigned MDOT reviewer is responsible for direct and transparent dialogue with the vendor relative to the ongoing status of their evaluation. Further, the MDOT reviewer is responsible for all documentation, including any specifications, which may be required for implementation in the event the product is determined to be acceptable for use on

MDOT projects. Finally, the disposition of the evaluation is updated in the NeMIS database for future reference. Figure 1 shows the flow of a new material or product from initial submittal through evaluation close out.

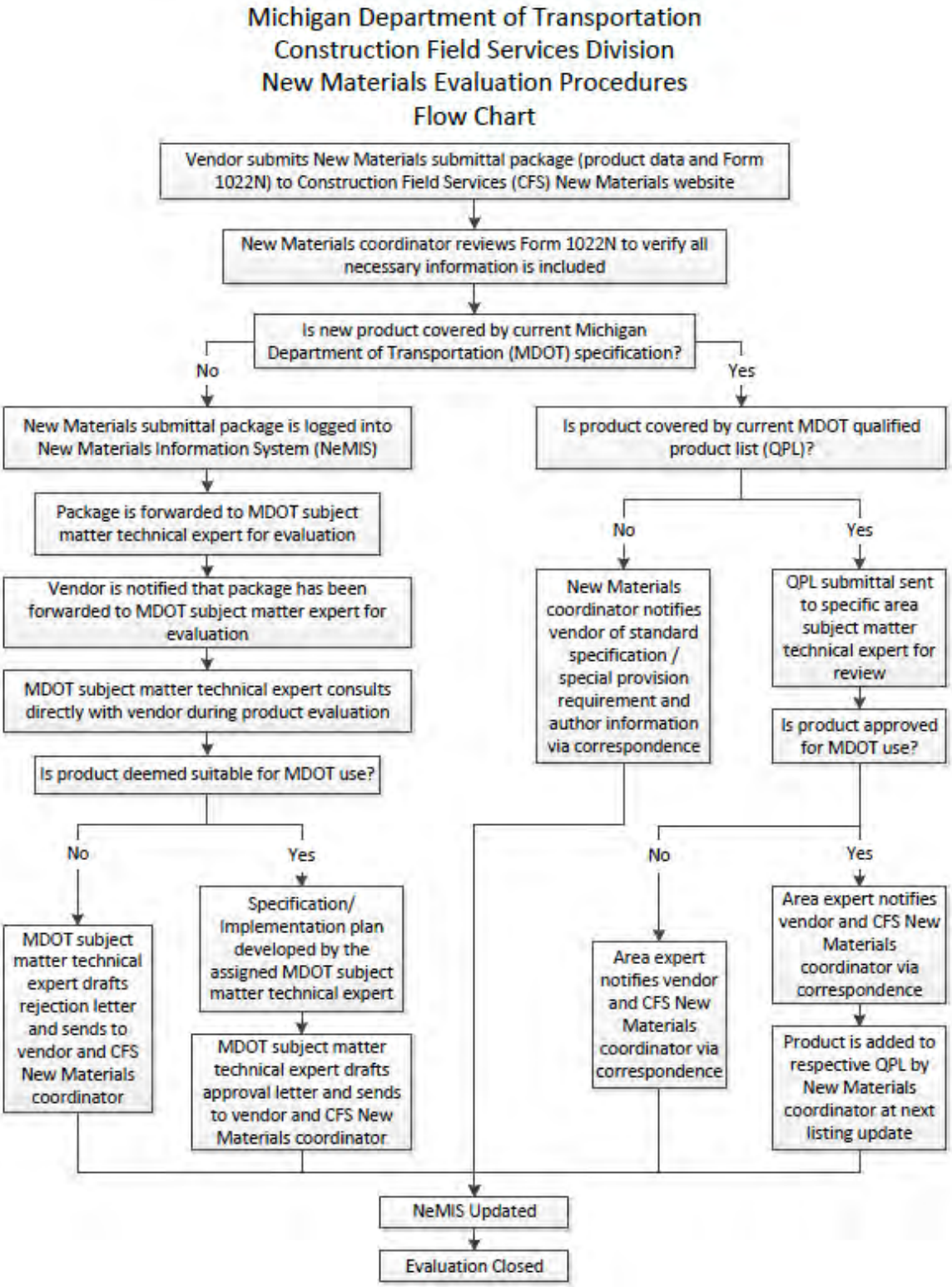

Michigan Department of Transportation
Construction Field Services Division
New Materials Evaluation Procedures
Flow Chart
Vendor submits New Materials submittal package (product data and Form 1022N) to Construction Field Services (CFS) New Materials website
New Materials coordinator reviews Form 1022N to verify all necessary information is included
Is new product covered by current Michigan Department of Transportation (MDOT) specification?
No
Yes
New Materials submittal package is logged into New Materials Information System (NeMIS)
Package is forwarded to MDOT subject matter technical expert for evaluation
Vendor is notified that package has been forwarded to MDOT subject matter expert for evaluation
MDOT subject matter technical expert consults directly with vendor during product evaluation
Is product deemed suitable for MDOT use?
No
Yes
MDOT subject matter technical expert drafts rejection letter and sends to vendor and CFS New Materials coordinator
Specification/ Implementation plan developed by the assigned MDOT subject matter technical expert
MDOT subject matter technical expert drafts approval letter and sends to vendor and CFS New Materials coordinator
Is product covered by current MDOT qualified product list (QPL)?
No
Yes
New Materials coordinator notifies vendor of standard specification / special provision requirement and author information via correspondence
QPL submittal sent to specific area subject matter technical expert for review
Is product approved for MDOT use?
No
Yes
Area expert notifies vendor and CFS New Materials coordinator via correspondence
Area expert notifies vendor and CFS New Materials coordinator via correspondence
Product is added to respective QPL by New Materials coordinator at next listing update
NeMIS Updated
Evaluation Closed

Figure 1

If the material or product is deemed suitable for MDOT use, the MDOT subject matter expert would then engage all stakeholders toward developing a plan for implementation. The implementation plan may result in a pavement demonstration or pilot project. If applicable, the evaluation of a new material or product would also entail a cost-benefit analysis once in-service performance data are available for the specific innovation/product/material. In addition to the economic analysis, an assessment of product availability and long-term supply are considered. Once an evaluation has been completed, the item may require approval by MDOT's Engineering Operations Committee for inclusion as a standard practices or specification.

Pavement Demonstration Program

Public Act 259 of 2001 (Pavement Demonstration Program) provides an avenue for MDOT to construct up to four pavement demonstration projects each year with intent to evaluate new construction methods, materials, or designs. MDOT may conduct a pavement demonstration project that may be all or a portion of that project. The Department shall make a final report for each demonstration project following the demonstration life of the project (which may be shorter than the actual pavement life of the material used for the project) that assesses the cost-effectiveness and performance of the pavement materials and design used in the project and compares the results to the pavement material identified under MDOT's standard pavement selection process. This law was devised and passed to address state law that requires an LCCA to be performed on all projects with pavement costs in excess of $1,000,000. The LCCA process is a tool to select the lowest cost pavement design over the expected service life of the pavement. The LCCA process must include, by law, historical information for initial construction and maintenance costs, and performance (service life). This information, however, may not yet be available when considering a new or innovative pavement system or feature for demonstration, thus precluding consideration of the innovative system or feature in project design. In addition, new pavement designs and new technologies are generally more expensive than the standard methodologies, which may reduce their chance of being selected as the lowest cost alternative even if they were included into the selection process as an LCCA-based alternative. The Pavement Demonstration Program provides an avenue for trying new and innovative ideas outside the jurisdiction of the normal process. Without the pavement demonstration law, MDOT's ability to innovate would be severely restricted.

To date, MDOT has constructed several demonstration projects. Each demonstration project must include a work plan that defines measurable goals and objectives for determining the potential success of the project. Theoretical performance versus actual performance is always one of the considerations in the plan. Once completed, a construction report for each demonstration project is written to document the initial phases of construction. Interim field performance evaluations are then conducted throughout the project's service-life. These evaluations are used to assess the ultimate cost-effectiveness and performance of the pavement feature being demonstrated. Ultimately, the final performance report provides the synopsis and disposition for the demonstration project reported to MDOT's Engineering Operations Committee for their policy-based action. Furthermore, each year in accordance with Act 51, Public Acts of 1951, Section 247.651i(1) and 247.651i(4), the Department is required to report to the Senate and House of Representatives Transportation Standing Committees and the Senate and House of

Representatives Appropriations Subcommittees on Transportation on the status of the Pavement Demonstration Program (see Attachment F for the latest copy of this report).

Prior to the Pavement Demonstration Program, MDOT engaged in active pavement demonstration through the Federal Highway Administration's (FHWA) Strategic Highway Research Program. MDOT is still an active participant in this program. Examples of Michigan participation in these national demonstration programs include the European pavement constructed in Detroit (completed in 1993), the multi-faceted PCC demonstration project on northbound US-23 in Monroe County (completed in 1992), and the asphalt demonstration test section located on US-127 north of Lansing and east of St. Johns (completed in 1994).

Perhaps the most noteworthy and highest profile demonstration project that gained a significant amount of national spotlight was the European pavement demonstration project. This project was a collaborated effort between FHWA and MDOT to learn whether unique features of European concrete pavements could be cost-effectively incorporated into the domestic highway infrastructure in efforts to enhance its performance and longevity. As part of this demonstration project, an MDOT standard section was constructed immediately adjacent as a control to compare relative performance over time. To date, there is no clear indication whether the European pavement section will eventually achieve a more cost-effective service life compared to what was constructed (at that time) as the MDOT standard pavement section. However, considering the European pavement's significant relative initial cost, it is expected that the future preservation cost of the European pavement section will need to be substantially lower than the MDOT pavement section for the European pavement to be considered cost effective. However, periodic performance monitoring of the European pavement and its accompanying Michigan control section over the past 20 years has brought to light several key features of the European pavement section that have shown promising results and, therefore, were implemented by MDOT into current standard practice. Examples include moving to shorter joint spacing (from 27 feet to 16 feet), requiring higher quality aggregates in the concrete on certain high traffic volume routes, modifying the gradation of the aggregate base layer to provide a more stable paving platform, and adopting a 14-foot widened truck lane on high commercial truck corridors to provide improved edge support for truck loadings. Likewise, there were aspects of the European pavement that did not merit implementation, either as a result of substandard performance or not from a cost-benefit perspective. MDOT and FHWA will continue to monitor the performance of this demonstration project throughout its continuing service life.

Research

MDOT's research program is another avenue used to evaluate innovations, products, and materials. In addition, Michigan is recognized nationally as a leader in highway research. A significant volume of quality research has had its inception through MDOT's longstanding highway research program, with much of it implemented as nationally recognized standard practice. The Department's research program not only embraces homegrown efforts, but also taps into those efforts by other state departments of transportation and the private sector.

Historically, MDOT is a pioneer in the area of pavement smoothness and other pavement surface characteristics. The first generation of advanced laser-based equipment for measuring the smoothness of pavements was developed in Michigan. Through advancements in computer-based data acquisition and processing, over time, the technology has grown well beyond Michigan to the point where several generations of innovation later the laser-based smoothness technology has acquired a reputation as the gold standard for precision smoothness measurement throughout the nation.

Michigan was also in the national spotlight relative to developing standard methods and techniques for maintaining and preserving the quality of its pavements. Throughout the 1960s and 1970s, while most state departments of transportation were focusing the resources toward building their new interstate highway network, Michigan had the vision to recognize that, as the new road system starts to age and deteriorate, advanced techniques geared toward maximizing longevity through preventive maintenance would be required. What further complicated the issue was that these strategies not only had to be durable and long lasting, but they also had to be applied while in the midst of ever-increasing live vehicular traffic. Recognizing that there are often consequences in terms of reduced longevity of the repair (not to mention worker safety) associated with maintaining a roadway under live traffic, research was directed toward developing innovative methods and materials intended to promote rapid, yet durable, repair techniques that would minimize interruption to the motoring public while reducing danger to workers as a result of prolonged exposure in a construction zone.

A recent MDOT sponsored research project that will assist the Department in potentially implementing the use of new materials is "A Method to Assess the Use of New and Recycled Materials in Pavement." This research resulted in an analysis framework and software (called NewPave) that will help MDOT identify the impacts of new and recycled materials on pavement performance and the environment. The methodology includes a "Sustainability and Life Cycle Analysis" procedure.

In order to take advantage of national research relating to pavements, in 1987, Michigan committed to participate in the federally-sponsored five year-long Strategic Highway Research Program, which evolved into the current and ongoing FHWA sponsored Long Term Pavement Performance (LTPP) program. At its peak, Michigan's participation in the LTPP program included an inventory of test sections in the program at 17 locations throughout the state. These sections have been retired as pavements were reconstructed. As of January 2016, there are 11 active test sections at three locations (US-127 St. Johns, I-96 Sunfield, and I-69 Emmett).

The LTPP program created the largest set of pavement performance data ever collected, by far. This data resides at: https://infopave.fhwa.dot.gov/. The LTPP archives include construction and material data, climatic data, traffic data, and performance data for over 2,500 sections in the United States and Canada, including those in Michigan.

In addition to data, the LTPP program maintains a large materials reference library with physically over 1,000 tons of subgrade, subbase, base, hot mix asphalt, and concrete samples from LTPP sites

that have been tested. Much of this information was used in the development of the new AASHTO standards for Mechanistic Empirical Pavement Design (MEPDG), which MDOT is currently implementing.

In summary, MDOT will continue to evaluate alternative pavement designs, materials, and construction practices through our New Materials Evaluation Procedure, Pavement Demonstration Program, and Research Findings and Result. Furthermore, the appetite for new innovations, products, or materials for pavement applications is never-ending, as MDOT works to optimize overall network pavement performance with available funding. This is accomplished by developing a true understanding of how pavements perform over time relative to the factors that may have the greatest overall impact on their performance. Understanding the causes and effects of pavement performance allows MDOT to design pavements that are both reliable and have a low life cycle cost. The rewards for innovation, when implemented, should allow the Department to build high-quality roads that last longer with reduced maintenance costs.

UPFRONT INVESTMENT TO REDUCE LIFE CYCLE COSTS

PA 175 requires that MDOT (1) report on materials and processes that may cost more in initial upfront spending but that still produce life cycle construction and maintenance savings and (2) strive to achieve a reduction of at least 50 percent in its net present value 50-year life cycle costs as compared to the commensurate net present value 50-year life cycle costs for road construction and maintenance costs from 2015. This is to be done in a manner that results in no state roads being rated in poor condition and has no net degradation from overall 2015 level pavement surface evaluation and rating (PASER) scores within the plan's first 10 years.

A proven pavement section that would require less Capital Preventative Maintenance (CPM) treatments (or no CPM treatments) to meet the noted requirements for a 50-year period has not yet been determined in Michigan, nationally, or globally. MDOT solicited input from national and statewide experts including FHWA, national research centers, universities, industry associations, and transportation providers. MDOT has been unable to precisely specify and predict the initial and future costs associated with a pavement to achieve a 50 percent reduction in its 50-year life cycle costs. However, proposed strategies that may lead to a reliable increase of pavement service life to 50 or 75 years with the potential to significantly reduce CPM operations are listed for each pavement type detailed in Table 2. In order to design and construct these pavements, additional funding levels (included in Table 2 and based on the Network Analysis section below) would be required to see no net degradation as compared to the overall 2015 network condition level and result in no state roads being rated in poor condition. In addition to the Network Analysis, a Roads Innovation Funding Analysis was performed and is also included.

Table 1 provides the estimated costs associated with constructing long life pavements using MDOT's traditional 20-year pavement design as compared to a 30- and 50-year design life. These costs are analogous with the cross sections presented in Attachment A.

Table 1

	20-Year Pavement Design Life (Current Standard)	30-Year Pavement Design Life	50-Year Pavement Design Life
Estimated Reconstruction Cost per Lane Mile	$2,000,000	$3,700,000	$4,700,000

Following is the breakdown used in arriving at the costs in Table 1. The specific enhancements that were considered for the assumptions in the increased costs are summarized in Table 2.

30-Year Pavement Design Additional Costs:

<u>$0.1 million/mile – Increased overall additional cross section thickness costs.</u> These costs account for the additional costs of providing a thicker subbase and base. The additional thickness is to provide greater protection against the impacts of frost heave on pavements and to provide a better foundation for the hard surface pavement.

<u>$0.4 million/mile – Increased material requirements.</u> These costs are for the increased material requirements (higher quality material) that would be required to provide a more durable, thicker pavement. Additionally, acceptance requirements within the pavement specifications would be increased. This results in the contractor having a higher risk for penalties and remove and replace requirements that result in an increase in their unit costs for either hot mix asphalt or concrete. An estimated increase of approximately 50 percent was added onto the unit cost of standard material and acceptance methods as compared to those proposed in the report.

<u>$0.5 million/mile – Increased drainage requirements and potential utility relocation costs.</u> These costs are for the additional embankment needed to ensure that underdrain drainage outlets would be 2 feet above the flowline (2 feet free board) of the ditch. Additionally, in most instances, ditching would be required to provide positive drainage to the nearest water course. In lieu of these items in urban sections, pump-houses may need to be constructed as a result of the deeper ditches with no accessible positive drainage outlet. Furthermore, to avoid utility cuts in the pavement, it is proposed that utilities be moved outside the roadbed with limited transverse crossings. These costs are highly variable on a project-by-project basis depending on available drainage and existing utilities.

<u>$0.7 million/lane mile – Additional right-of-way (ROW) costs.</u> These costs are for the increased footprint of the roadbed to accommodate thicker cross sections and to provide the 2 feet free board noted above. Additionally, the ditching required to provide positive drainage would result in the need for additional ROW or for construction of pump-houses. These costs are highly variable on a project-by-project basis depending on the location and local cost of property. For purposes of this report, a strip of 25 feet of ROW acquisition was assumed.

The costs noted above result in an increased cost of $1.7 million/lane-mile, which was added to the baseline cost of $2 million/lane-mile that MDOT currently uses for programming projects**. The result is $3.7 million/lane-mile for constructing a 30-year pavement design with an estimated 50-year service life.**

50-Year Pavement Design Additional Costs:

<u>$0.25 million/lane mile – Increased overall additional cross section thickness costs.</u> These costs account for the additional costs of providing a thicker subbase and base. This additional thickness is to provide greater protection against the impacts of frost heave on pavements and to provide a better foundation for the hard surface pavement.

<u>$0.75 million/lane mile – increased material requirements.</u> These costs are for the increased material requirements (higher quality material) that would be required to provide a more durable, thicker pavement. Additionally, acceptance requirements within the pavement specifications would be increased. This results in the contractor having a higher risk for penalties and remove and replace requirements, which results in an increase in their unit costs for either hot mix asphalt or concrete. An estimated increase of approximately 100 percent was added onto the unit cost of standard material and acceptance methods as compared to those proposed in the report.

<u>$1.0 million/lane mile – Increased drainage requirements and potential utility relocation costs.</u> These costs are for the additional embankment needed to ensure that underdrain drainage outlets would be 3 feet above the flowline (3 feet board) of the ditch. Additionally, in most instances, ditching would be required to provide positive drainage to the nearest water course. In lieu of these items in urban sections, pump-houses may need to be constructed as a result of the deeper ditches with no accessible positive drainage outlet. Furthermore, to avoid utility cuts in the pavement, it is proposed that utilities be moved outside the roadbed with limited transverse crossings. These costs are highly variable on a project-by-project basis depending on available drainage and existing utilities.

<u>$0.7 million/lane mile – Additional rights-of-way (ROW) costs.</u> These costs are for the increased footprint of the roadbed to accommodate thicker cross sections and to provide the 3 feet free board noted above. Additionally, the ditching required to provide positive drainage would result in the need for additional ROW or for construction of pump-houses. These costs are highly variable on a project-by-project basis depending on the location and local cost of property. For purposes of this report, a strip of 25 feet of ROW acquisition was assumed.

The costs noted above result in an increased cost of $2.7 million/lane-mile, which was added to the baseline cost of $2 million/lane-mile that MDOT currently uses for programming projects. **The result is $4.7 million/lane-mile for constructing a 30-year pavement design with an estimated 50-year service life.**

Roads Innovation Task Force Report
June 1, 2016
Revised September 8, 2016

SUMMARY

Baseline cost for reconstructing a roadway utilizing 20-year pavement design:	**$2 million/lane mile**
30-year pavement design additional costs:	
Increased overall additional cross section thickness	$0.1 million/lane mile
Increased material requirements	$0.4 million/lane mile
Increased drainage requirements and potential utility relocation costs	$0.5 million/lane mile
Additional ROW costs for increased foot print to accommodate thicker cross section and drainage needs	$0.7 million/lane mile
Total Estimated Cost 30-Year Design	**$3.7 million/lane mile**
50-year pavement design additional costs:	
Increased overall additional cross section thickness	$0.25 million/lane mile
Increased material requirements	$0.75 million/lane mile
Increased drainage requirements and potential utility relocation costs	$1.0 million/lane mile
Additional ROW costs for increased foot print to accommodate thicker cross section and drainage needs	$0.7 million/lane mile
Total Estimated Cost 50-Year Design	**$4.7 million/lane mile**

Table 2 is a summary of potential pavement design and specification enhancements and estimated funding levels required to meet the net present value cost reductions as required by the statue.

Table 2
Potential Pavement Enhancements

	20-Year Design Life (Current Standard)	30-Year Design Life	50-Year Design Life
Hot Mix Asphalt Design	-**Standard Hot Mix Asphalt** -6″ Aggregate Base -18 ″ Sand subbase -Underdrains as required	-**Perpetual Pavement Design** -10″Aggregate Base -26 ″ Sand subbase -Underdrains as required	-**Perpetual Pavement Design** -12 ″ Aggregate Base -24 ″ Sand subbase -Underdrains as required
Additional Considerations	Standard specifications for materials, acceptance and construction	Enhanced specifications for materials, acceptance, and construction: - Enhanced materials including Gap graded Superpave, Polymerized binder, limitations on use of recycled asphalt and shingles - Enhanced acceptance including 93.0% mat density, longitudinal joint density of 92.0%, 9.0 microns minimum film thickness, fines to effective binder limit of 1.20 during production, production belt sample verification for aggregated consensus properties, G_{se} and G_{sb}, tightening of percent within limits (PWL) acceptance parameters, PWL factor less than 75 requires removal and replacement - Enhanced construction methods including use of material transfer device and use of echelon paving for mainline, maximum mean roughness index of 65 inches per mile	Enhanced specifications for materials, acceptance, and construction: - Enhanced materials including Gap graded Superpave, Polymerized binder, limitations on use of recycled asphalt and shingles, require Class 2 sand subbase - Enhanced acceptance including 94.0% mat density, longitudinal joint density of 92.5%, 9.0 microns minimum film thickness, fines to effective binder limit of 1.20 during production, production belt sample verification for aggregated consensus properties, G_{se} and G_{sb}, tightening of percent within limits (PWL) acceptance parameters, PWL factor less than 90 requires removal and replacement - Enhanced construction methods including use of material transfer device and use of echelon paving for mainline, maximum

	20-Year Design Life (Current Standard)	30-Year Design Life	50-Year Design Life
		- Enhanced drainage requirements, bottom of sand subbase 2' above any ditch flow line - No utilities within the roadbed - Limitations or prohibitions of recycled materials that may be detrimental to long term performance	mean roughness index of 55 inches per mile, intelligent compaction with uniformity requirements - Enhanced drainage requirements, bottom of sand subbase 3' above any ditch flow line - No utilities within the roadbed - Limitations or prohibitions of recycled materials that may be detrimental to long term performance
Concrete Design	- **Jointed Plain Concrete Pavement** - 6" Open graded drainage course base - Geotextile Separator - 10" Sand subbase - Open graded underdrains	- **Jointed Plain Concrete Pavement** - 6" Cement treated permeable base - Geotextile Separator - 24" Sand subbase - Open graded underdrains	- **Continuously Reinforced Concrete Pavement** - 4" Hot mix asphalt base - 6" Aggregate Base - 18" Sand subbase - Underdrains as required
Additional Considerations	Standard specifications for materials, acceptance, and construction	Enhanced specifications for materials, acceptance, and construction: - Enhanced materials including pre-stress aggregate, use of cementitious materials at 20 to 40%, corrosion resistant coating of dowel and lane tie bars, total alkali of 3lbs/yd3, natural aggregate for cement treated permeable base, optimized aggregate gradation - Enhanced acceptance including hardened air-void system requirements, rapid chloride permeability	Enhanced specifications for materials, acceptance, and construction: - Enhanced materials including pre-stress aggregate, use of cementitious materials at 20 to 40%, corrosion resistant coating of dowel and lane tie bars, total alkali of 3lbs/yd3, natural aggregate for cement treated permeable base, optimized aggregate gradation, embedded steel would be corrosion resistant - Enhanced acceptance including hardened air-

	20-Year Design Life (Current Standard)	30-Year Design Life	50-Year Design Life
		requirements, tightening of PWL acceptance requirements, PWL factor less than 75 requires removal and replacement - Enhanced construction including not allowing construction traffic onto the new slab until minimum wet cure time of 7 days, construction traffic loads limited to standard legal loads, curing requirements such as water or specialized curing compounds, maximum mean roughness index of 65 inches per mile - Enhanced drainage requirements, bottom of sand subbase 2' above any ditch flow line - No utilities within the roadbed - Limitations or prohibitions of recycled materials that may be detrimental to long term performance	void system requirements, rapid chloride permeability requirements, tightening of PWL acceptance requirements, PWL factor less than 90 requires removal and replacement - Enhanced construction including 28 day wet cure with not allowing construction traffic onto the new slab until minimum cure time of 7 days, construction traffic loads limited to standard legal loads, curing requirements such as water or specialized curing compounds, maximum mean roughness index of 55 inches per mile - Enhanced drainage requirements, bottom of sand subbase 3' above any ditch flow line - No utilities within the roadbed - Limitations or prohibitions of recycled materials that may be detrimental to long term performance
Estimated Reconstruction Cost per Lane Mile	$2,000,000	$3,700,000	$4,700,000
Estimated Initial Investment (First 10 Years)	$15 billion	$111 billion	$140 billion
Estimated 50 Year Costs	$170 billion	$129 billion	$163 billion
Estimated Net Present Value	$55 billion	$95 billion	$119 billion

It should be noted that many assumptions were used to arrive at these pavement design costs and the associated construction costs. Although many of the costs of material enhancement can be determined, the costs associated with enhanced specification requirements are unknown because there is no historical information regarding any impacts these specifications may have on the construction or the associated risks to the contractor. Furthermore, the cost to obtain additional rights-of-way (property acquisition needed for an increased road footprint), to improve or reconstruct bridges along the corridor, to upgrade safety features to meet standards, and to relocate any utilities within the road footprint can only be estimated. The design life for most bridge major components exceeds 30 years; however, the bridge may need a deep concrete overlay to match up with a 30-year design life or a deck replacement using epoxy coated reinforcement to match up with a 50-year pavement. Each roadway location will have different needs. Estimating the costs for an entire network is a challenge requiring many assumptions. In some cases, these unknown specific costs may far exceed the actual cost of the long life pavement design.

The following table provides items that MDOT believes will have increased service life benefits that will exceed the additional costs to incorporate the items into standard practices.

Enhancement Item	**Anticipated Cost ($)**	**Anticipated Life Extension (years)**
Hot Mix Asphalt		
Increased mat density to 93 percent for acceptance	5/ton	1–5
Mix design requirement of 9.0 micron minimum film thickness	1/ton	1–2
Limitation of fines to effective binder of 1.20 during production	1/ton	1–2
Verification of aggregate specific gravities	1/ton	1–2
Tightening of percent within limits acceptance parameters	10/ton	1–5
Increased use of material transfer device with remixing capabilities	2/ton	1–5
Increased ride quality acceptance requirements	1/ton	1–2
Limitations on recycled material allowances	8/ton	1–5
Portland Cement Concrete		
Increased aggregate properties for resistance to material related distress and increased freeze thaw durability	3/syd	1–5
Use of supplemental cementitious materials at 20 to 40 percent	1/syd	1–5
Corrosion resistant coating of dowel and lane tie bars	1/syd	1–3
Enhanced acceptance of air and air system; use of hardened air as acceptance	3/syd	1–2
Tightening of percent within limits acceptance parameters	10/syd	1–5

Enhancement Item	Anticipated Cost ($)	Anticipated Life Extension (years)
Increased time frames for concrete curing before allowing construction traffic	2/syd	1–5
Increased ride quality acceptance requirements	1/syd	1–2
Wet curing of concrete	3/syd	1–3
Stricter limitations on recycled material allowances	1/syd	1–5

Pavement cross sections are provided in Attachment A. Although a two lane freeway is shown, these same cross sections would represent a two lane non-freeway section except that the shoulders would be of different widths. For forecasting purposes, costs are based on a per lane mile cost. The costs given for the "Estimated Reconstruction Cost per Lane Mile" in Table 1 account for both freeway and non-freeway costs. The historical cost for a non-freeway reconstruction is $1.9 million and a freeway is $2.1 million. The primary difference between the two cross sections is the shoulder width and the overall thickness of the pavement structure.

To gain additional perspective on proposed design strategies and potential innovations, MDOT requested input from a variety of sources, as detailed in the attachments to this report, including:

- University centers of excellence – Michigan Technological Institute, University of Michigan; Attachment B
- National pavement experts – Dr. David Timm, Dr. Tom Van Dam, Dr. Robert Rasmussen; Attachment C
- Departments of transportation and other transportation partners: New York State Department of Transportation, Iowa Department of Transportation, County Road Association, American Council of Engineering Companies of Michigan, Michigan Municipal League; Attachment D
- Industry associations: Kentucky Association of Highway Contractors, Illinois Road and Transportation Builders, Construction Industries of Massachusetts, AGC of New York, AGC of Texas, Michigan Concrete Association, Asphalt Pavement Association of Michigan, Michigan Aggregate Association, Michigan Infrastructure & Transportation Association, Michigan Road Preservation Association; Attachment E.
- Additionally, MDOT received public input on methods to improve the overall quality of Michigan roads; Attachment G.

Innovations ranged from new products to specification enhancements and included some individual products. Many of the organizations also noted recent and past performance improvements that have been made to MDOT's standards and acceptance specifications such as adaptation of the hot mix asphalt Superpave system, use of jointed plain concrete pavement, and implementation of MEPDG. Additionally, it was noted that while our industry partners support the need and desire to increase roadway life, there is concern that certain innovations could lead to long-term material supply shortages as they pertain to premium materials. MDOT is encouraged to work with its industry partners to ensure long term sustainability for any innovative

idea that would deviate from current specifications and/or greatly increase certain material usages. MDOT will continue to engage its many partners on the subject of longer lasting pavements.

MDOT's Current 20-Year Design Life Pavements

MDOT currently designs pavements for a 20-year design life consistent with the national practice. Design life is the anticipated life of the pavement section at the time of initial construction. Design life does not include any additional life estimates provided by future preventive maintenance. A pavement's design life may be extended by applying CPM treatments at various times throughout its life; this is referred to as the pavement's "service life." When CPM treatments can no longer cost effectively maintain the serviceability of the pavement, a major rehabilitation or reconstruction project is performed, defining the end of the service life for the pavement. Based on historical performance data, MDOT's service lives for newly constructed hot mix asphalt and concrete pavements are currently 33 and 34 years, respectively. These service lives include three and four cycles of CPM treatments for hot mix asphalt and concrete, respectively.

MDOT has designed and constructed very few pavement sections with design lives exceeding 20 years. One of the primary considerations for a long life pavement is that the surface must endure the impacts of the elements, including Michigan's extreme climate (hot summers and cold winters), normal oxidation, freeze thaw cycles, diverse soil conditions, and snow removal operations including the application of chemical deicing solutions. CPM treatments refurbish the surface and restore the roadway's functional qualities such as skid resistance, ride quality, and noise reduction, while protecting the pavement structure from water infiltration. The consideration of these CPM treatments are an integral part of the design of long life pavements.

MDOT uses a pavement management approach that relies on having a sufficient initial Design Life and an application of cost-effective CPM treatments throughout the life of the pavement to correct minor pavement deterioration. This proactive approach to pavement management extends pavement service life by efficiently and cost-effectively delaying further deterioration. In the early 2000s, the Transportation Asset Management Council was created to advise the State Transportation Commission and promote pavement preservation on all of Michigan's roadways. MDOT is committed to using a comprehensive preventive maintenance approach to obtain long lasting roads.

Designing and constructing long life pavements would significantly increase initial costs and may impede MDOT's ability to maintain/sustain the remaining trunkline roadways in an acceptable condition. A network analysis was performed (see Network Analysis below) to determine the level of funding required to maintain the entire road system at an acceptable condition level while these projected 50- and 75-year service life pavements are being constructed. Previous pavements designed and constructed by MDOT having longer design/service lives were implemented within the constraints of the Pavement Demonstration Program (see Attachment F).

30-Year Design, 50-Year Service Life Pavements
To achieve a 50-year service life pavement, MDOT is proposing to increase the design life to 30 years utilizing the state of the art design methodology MEPDG, in addition to modifying material requirements, acceptance specifications, and construction methods. MDOT could also establish required maintenance schedules to extend the service life to 50 years.

The following modifications are proposed to achieve a 50-year service life:

Hot Mix Asphalt (50-Year Service Life)
The proposed hot mix asphalt (HMA) approach to achieve a long life HMA pavement would be based on the principles of Perpetual Pavement and 30-year traffic projections. The perpetual pavement design methodology begins with a strong, yet flexible, HMA bottom layer that resists tensile strain caused by traffic loading. This stops cracks from forming in the bottom of the pavement. A strong, rut resistant intermediate HMA layer completes the permanent structural portion of the pavement. The surface layer is relatively thin, rut resistant, and often possesses properties that enhance surface functionality such as improved surface drainage and/or skid resistance.

Due to the robust nature of the underlying layers, it is anticipated that any distresses that develop would be isolated in this surface mixture. Thus, although this surface is expected to last many years, it would need to be periodically milled off and replaced in kind.

The HMA layers would be placed on an aggregate base and sand subbase with the individual layer thicknesses determined by the design. The total HMA thickness is normally 8 to 12 inches or more. The overall combined aggregate base and sand subbase would be a minimum thickness of 36 inches to resist frost. MDOT's standard use of subbase underdrains would be utilized with subgrade underdrains where necessary. Modifications to the drains would be required to ensure appropriate drainage and cleaning capabilities. Ditches would be required to be deeper to provide positive drainage; outlets would be 2 feet above the ditch bottom.

The following enhancements could be made to the acceptance specifications to potentially achieve the 50-year service life for the HMA long-life pavements:

- Gap-graded Superpave (GGSP) mixture would be required as the HMA surface course.
- A polymerized binder would be required for all courses with additional testing requirements (MSCR (test method AASHTO M 332/T350) and other state of the art testing) to ensure no use of recycled engine-oil bottoms.
- Density requirements would be set at 93.0% minimum for all HMA layers.
- Longitudinal joint density would be set at 92.0% minimum for all layers.
- A minimum film thickness requirement of 9.0 microns would be required for all mixes.
- The fines-to-effective binder ratio would be limited to a maximum of 1.20 during production.
- Belt sample verification would be conducted on mix design aggregate consensus properties during production with limiting tolerances.
- Belt sample verification would be conducted on aggregate bulk specific gravity (G_{sb}) and effective specific gravity (G_{se}) during production with limiting tolerances.

- Increase the Percent Within Limits (PWL) acceptance requirements; to be determined.
- PWL factor for any individual acceptance parameter of less than 75 would require removal and replacement.
- All utilities would be removed from the roadbed. This effort will improve ride quality, roadbed density (uniform support), and performance.

The following material requirements could be required in addition to standard requirements:
- No Recycled Asphalt Pavement (RAP) or Recycled Asphalt Shingles (RAS) allowed in GGSP and surface courses.
- RAP/RAS use would be limited to Tier 2 (18-27%) for levelling and Tier 1 (0-17%) for base course mixtures
- Limitations or prohibitions of recycled materials that may be detrimental to long term performance.

The following items could be required for construction in addition to standard requirements:
- Use of a material transfer device for all mainline HMA courses.
- Require echelon (use of 2 pavers to eliminate cold joints) paving for mainline paving.
- Bond coat specifications and application rates.

Concrete (50-Year Service Life)
The proposed approach to achieve long life concrete pavement is based on jointed plain concrete pavement constructed on a cement treated permeable base. The traffic for this design would be based on 30-year projections. This design would ensure that minimal transverse cracking would occur. The cement treated permeable base would ensure that the pavement structure would remain stable, provide drainage, and minimize faulting. The cement treated permeable base would be constructed on a 24-inch thick sand subbase. A geotextile separator fabric would be installed between the cement treated permeable base and sand subbase layers to prevent co-mingling and contamination of one layer into the other. MDOT's standard use of open-graded underdrains would be utilized with subgrade underdrains where necessary. Modifications to the drains would be required to ensure appropriate inspection and cleaning capabilities. Ditches would be required to be deeper to provide positive drainage; outlets would be 2 feet above the ditch bottom.

The following enhancements could be made to the acceptance specifications to potentially achieve the 50-year service life:
- Hardened air-void system requirement as follows as determined by test method ASTM C 457:
  1. Spacing factor not exceeding 0.008 inches
  2. Specific surface not less than 630 in^2/in^3
  3. Total air content not less than 5.50%
- Alkali Silica Reactivity – concrete shall be proportioned such that the maximum total alkali content contributed by Portland cement (as determined in accordance with test method AASHTO T 105) shall not exceed $3 lbs/yd^3$.
- Rapid Chloride Permeability requirements (test method ASTM C1202) of 1200 Coulombs or less.
- Tightening of PWL acceptance requirements; to be determined.

- PWL factor for any individual acceptance parameter less than 75 would require removal and replacement.
- All utilities would be removed from the roadbed. This effort will improve ride quality, roadbed density (uniform support), and performance.

The following material requirements could be required in addition to standard requirements:
- Physical properties of the coarse aggregate would be defined as geologically natural meeting MDOT freeze-thaw requirements for pre-stressed concrete quality.
- Optimized aggregate gradation would be required in the concrete paving mixture.
- Aggregate for cement treated permeable base would be geologically natural material.
- Require supplemental cementitious materials at 25 to 40% minimum replacement of the Portland cement.
- Corrosion resistant coating of dowel and lane tie bars meeting requirements of test method ASTM A1078 (Type 2 coating) or use of new materials such as carbon fiber.
- Limitations or prohibitions of recycled materials that may be detrimental to long term performance.

The following items could be required for construction in addition to standard requirements:
- Construction traffic would not be allowed onto the slab until the new concrete pavement has attained a minimum wet cure time of 7 days.
- Construction traffic loads would be limited to standard legal load limits.
- Curing requirements such as water curing or using specialized curing compounds would be required.

Hot Mix Asphalt (HMA) and Concrete (50-Year Service Life)
In addition to the above noted requirements for the construction of each new pavement type, the following parameters could be used for both pavement designs:

- Underdrain outlets will be 2 feet above the flow line of the ditch.
- The bottom of sand subbase would be 2 feet above the flow-line of any ditch.
- Outside lanes would be designed at 14 feet (striped at 12 feet).
- For freeways with 3 or more lanes, the inside lane (median lane) would be designed structurally for 75% of the design traffic resulting in a thinner pavement thickness than the truck lanes.
- The maximum acceptable as-constructed Mean Roughness Index (MRI–a number calculated by averaging the International Roughness Index values from the two wheel path profiles) would be 65 inches/mile.
- Ride quality specifications would be revised to impose penalties for excessive diamond grinding of the hardened concrete surface in lieu of proper surface profile (grade) control during initial paving.

The above noted modifications to both HMA and concrete should allow for a reduction in the overall net present value (NPV) 50-year life cycle cost. Based on the designs presented, it is expected that the following Pavement Preservation Strategies would be applicable:

Hot Mix Asphalt – Perpetual Pavement (50-Year Service Life)

- Initial Construction – Year 0
- Mill GGSP and Replace with GGSP – Year 15
- Mill GGSP and Replace with GGSP – Year 30
- Crack Seal – Year 40
- Minor Rehabilitation – Year 50

Concrete – Jointed Plain concrete Pavement (50-Year Service Life)
- Initial Construction – Year 0
- Diamond Grinding and Reseal Joints – Year 15
- Concrete Patching, Diamond Grinding and Joint Resealing – Year 30
- Reseal Joints – Year 40
- Major Rehabilitation or Reconstruction – Year 50

Both of these preservation strategies also rely on scheduled routine maintenance with an emphasis on ensuring that drainage outlets are periodically cleaned and properly maintained.

NOTE: The proposed 30-Year Design/50-Year Service Life Pavement Strategies are based on engineering judgement as actual pavement performance data does not exist.

50-Year Design, 75-Year Service Life Pavements
In addition to analyzing a pavement that could provide a 50-year service life, MDOT has been asked to consider a 50-year pavement design having a 75-year service life. Although it is theoretically possible to design a pavement for 50 years that would not need significant intermediate repair work, it may not be realistic in terms of technology and cost-effectiveness considerations. It is important to note that current design procedures are based on structural models that evaluate the pavement response to traffic loading, but do not take into account the effects of 50 years of Michigan environmental impacts, material degradation, or the impact of snow removal operations. For example, hot mix asphalt oxidizes as it ages, which makes it brittle and prone to cracking. As another example, joint seals in concrete pavements have a limited life and need periodic replacement to minimize the amount of water entering the pavement structure. The effects of moisture, temperature, and sun over time impact pavement materials. This results in the need to periodically resurface or treat the surface by performing maintenance (CPM treatments).

Projecting traffic for 20 years into the future has a degree of uncertainty, but accurately projecting 50 years of traffic has a much higher uncertainty. The growth rate used for projecting future traffic is based on recent years' data on truck traffic and economic conditions. Economic conditions change in unpredictable ways over a pavement's service life, as do other factors affecting traffic, resulting in inaccurate projections. This effect is amplified when estimating traffic for 50 years. Furthermore, geometric and safety standards change, meaning that a 50-year pavement design with an expected service life of 75 years may become obsolete before the end of its life.

Additional factors must be taken into consideration for these 50-year design/75-year service life pavements. To account for the additional construction effort that would be needed, there would be impacts on mobility because the length of project construction time would increase. Certain

projects would also require additional temporary traffic schemes for mobility, which would be costly. Additional right-of-way may also be required to allow for the increased roadway footprint as a result of temporary traffic schemes and the requirements for proper drainage of the roadway base. This additional roadway footprint would result in the need for environmental studies and clearances. The increase in material quality would result in the need to seek materials outside of Michigan, which would drive up material costs. MDOT has not been able to estimate these additional costs.

In conclusion, designing and constructing 50-year design life/75-year service life pavements may be possible. The cost of the longer lasting pavement and the high degree of uncertainty of the pavement performance adds risk. With limited funding available, adopting 50-year pavement designs would result in a degradation of the network as compared to the overall 2015 level pavement condition. MDOT's asset management approach of using a mix of fixes would no longer be possible.

With the above noted concerns and limitations, the following are considerations for a 50-year pavement design, having an approximate 75-year service life, for both hot mix asphalt and concrete pavements.

HMA (50-Year Design/75-Year Service Life)
The proposed hot mix asphalt (HMA) section would be based on the principles of Perpetual Pavement and would use 50-year traffic projections. This design methodology is the same as described previously, but the individual layers would be determined. Additionally, the design reliability would be increased to 99 percent and the design procedure would make use of the AASHTOWare MEPDG Design software. MDOT's standard use underdrains would be utilized with subgrade underdrains where necessary. Modifications to the drains would be required to ensure appropriate inspection and cleaning capabilities.

The following enhancements could be made to the acceptance specifications to potentially achieve a 50-year design life and 75-year service life:

- Gap-graded Superpave would be required as the surface course.
- A polymerized binder would be required.
- Density requirements would be set at 94.0% minimum for all HMA layers.
- Longitudinal joint density would be set at 92.5% minimum for all layers when not using echelon paving.
- A minimum film thickness requirement of 9.0 microns would be required for all mixes.
- The fines to effective asphalt binder ratio would be limited to a maximum of 1.2 during production.
- Belt sample verification would be conducted of mix design aggregate consensus properties during production with limiting tolerances.
- Belt sample verification would be conducted of aggregate G_{sb} and G_{se} during production with limiting tolerances.
- Tightening of PWL acceptance requirements; to be determined.

- PWL factor for any individual acceptance parameter less than 90 would require removal and replacement.
- All utilities would be removed from the roadbed. This effort will improve ride quality, roadbed density (uniform support), and performance.

The following material requirements could be required in addition to standard requirements:

- No RAP/RAS allowed in GGSP and surface mixtures.
- RAP/RAS would be limited to Tier 1 (0-17%) for levelling and not allowed in base course mixtures.
- Require Class 2 sand subbase with a permeability specification requirement.
- Limitations or prohibitions of recycled materials that may be detrimental to long term performance.

The following items could be required for construction in addition to standard requirements:
- Use of a material transfer device for all HMA courses.
- Require echelon paving for mainline paving.
- Requirements for and checking of bond coat application rates.
- Intelligent compaction specification for base supported by falling weight deflectometer testing.
- Latitude and longitude location for underdrain outlet identification.
- No partial width construction.

Concrete (50-Year Design/75-Year Service Life)
The proposed concrete section could be continuously reinforced concrete pavement constructed on 4 inches of hot mix asphalt base. The asphalt base would be placed on 6 inches of aggregate base and 18 inches of sand subbase. MDOT's standard use of underdrains would be utilized where necessary. The traffic for this design would be based on a 50-year projection. Additionally, the design reliability would be increased to 99 percent and the design procedure would make use of the AASHTOWare MEPDG Design software. MDOT's standard use of open-graded underdrains would be utilized with subgrade underdrains where necessary. Modifications to the drains would be required to ensure appropriate inspection and cleaning capabilities.

The following enhancements could be made to the acceptance specifications to potentially achieve the 50-year design life and 75-year service life:
- Hardened air-void system requirement as follows as determined by test method ASTM C 457:
  1. Spacing factor not exceeding 0.008 inches
  2. Specific surface not less than 630 in^2/in^3
  3. Total air content not less than 5.50%
- Alkali Silica Reaction – concrete shall be proportioned such that the maximum total alkali content contributed by Portland cement (as determined in accordance with test method AASHTO T 105) shall not exceed 3 lbs/yd^3.
- Rapid Chloride Permeability requirements (test method ASTM C1202) of 1200 Coulombs or less.

- Tightening of PWL acceptance requirements; to be determined.
- PWL factor for any individual acceptance parameter less than 90 would require removal and replacement.
- All utilities would be removed from the roadbed. This effort will improve ride quality, roadbed density (uniform support), and performance.

The following material requirements could be required in addition to standard requirements:
- Physical properties of the coarse aggregate would be defined as geologically natural meeting MDOT freeze-thaw requirements for pre-stressed concrete quality.
- Optimized aggregate gradation would be required in the concrete paving mixture.
- Require supplemental cementitious materials at 25 to 40% minimum replacement of the Portland cement.
- All embedded steel would be highly corrosion-resistant steel.
- Limitations or prohibitions of recycled materials that may be detrimental to long term performance.

The following items could be required for construction in addition to standard requirements:
- 28-day continuous wet cure.
- Construction traffic would not be allowed onto the slab until the new concrete pavement has attained a minimum wet cure time of 7 days.
- Construction traffic loads would be limited to standard legal load limits.
- Curing requirements such as water curing or specialized curing compounds.
- Intelligent compaction specification for base supported by falling weight deflectometer testing.
- Latitude and longitude location, for underdrain outlet identification.
- No partial width construction.

Hot Mix Asphalt and Concrete (50-Year Design/75-Year Service Life)
In addition to the above noted requirements for each pavement type, the following parameters could be used for both pavement designs:
- The bottom of sand subbase would be 3 feet above the flow-line of any ditch.
- Outside lanes would be designed at 14 feet.
- For freeways with 3 or more lanes, the inside lane (median lane) would be designed structurally for 50% of the design traffic resulting in a thinner pavement thickness than the truck lanes.
- The maximum acceptable as-constructed Mean Roughness Index (MRI – a number calculated by averaging the IRI values from the two wheel path profiles) would be 55 inches/mile.
- Ride quality specifications would be revised to impose penalties for excessive diamond grinding of the hardened concrete surface in lieu of proper surface profile (grade) control during initial paving.
- Outlet underdrains would be 3 feet above the flow line of the ditch.

The above noted modifications to both hot mix asphalt and concrete should allow for a reduction in the overall NPV 50-year life cycle cost. Based on the designs presented, it is expected that the following Pavement Preservation Strategies would be applicable:

Hot Mix Asphalt – Perpetual Pavement (75-Year Service Life)

- Initial Construction – Year 0
- Mill GGSP and replace with GGSP – Year 20
- Mill GGSP and replace with GGSP – Year 40
- Mill GGSP and replace with GGSP – Year 55
- Crack Seal – Year 65
- Major Rehabilitation – Year 75

Concrete - Continuously Reinforced Concrete (75-Year Service Life)
- Initial construction – Year 0
- Pavement patching and spall repair – Year 20
- Pavement patching, spall repair and diamond grinding – Year 40
- 2 Course hot mix asphalt overlay – Year 55
- Pavement patching and crack sealing – Year 65
- Major Rehabilitation or Reconstruction – Year 75

Both of these preservation strategies also rely on routine maintenance with an emphasis on ensuring that drainage outlets are periodically cleaned and properly maintained.

NOTE: The proposed Pavement Strategies are based on engineering judgement as actual pavement performance data is not available.

Network Analysis

Performance Measure and Strategy Tool Use

MDOT uses several performance measures and forecasting tools to evaluate current pavement condition and to project future pavement condition. MDOT measures pavement condition primarily using either the PASER or Remaining Service Life (RSL) performance measures. Each measure has its own modeling software to project future pavement condition. PASER estimates are forecasted using the Pavement Condition Forecasting System (PCFS), while RSL estimates are forecasted using the Road Quality Forecasting System (RQFS).

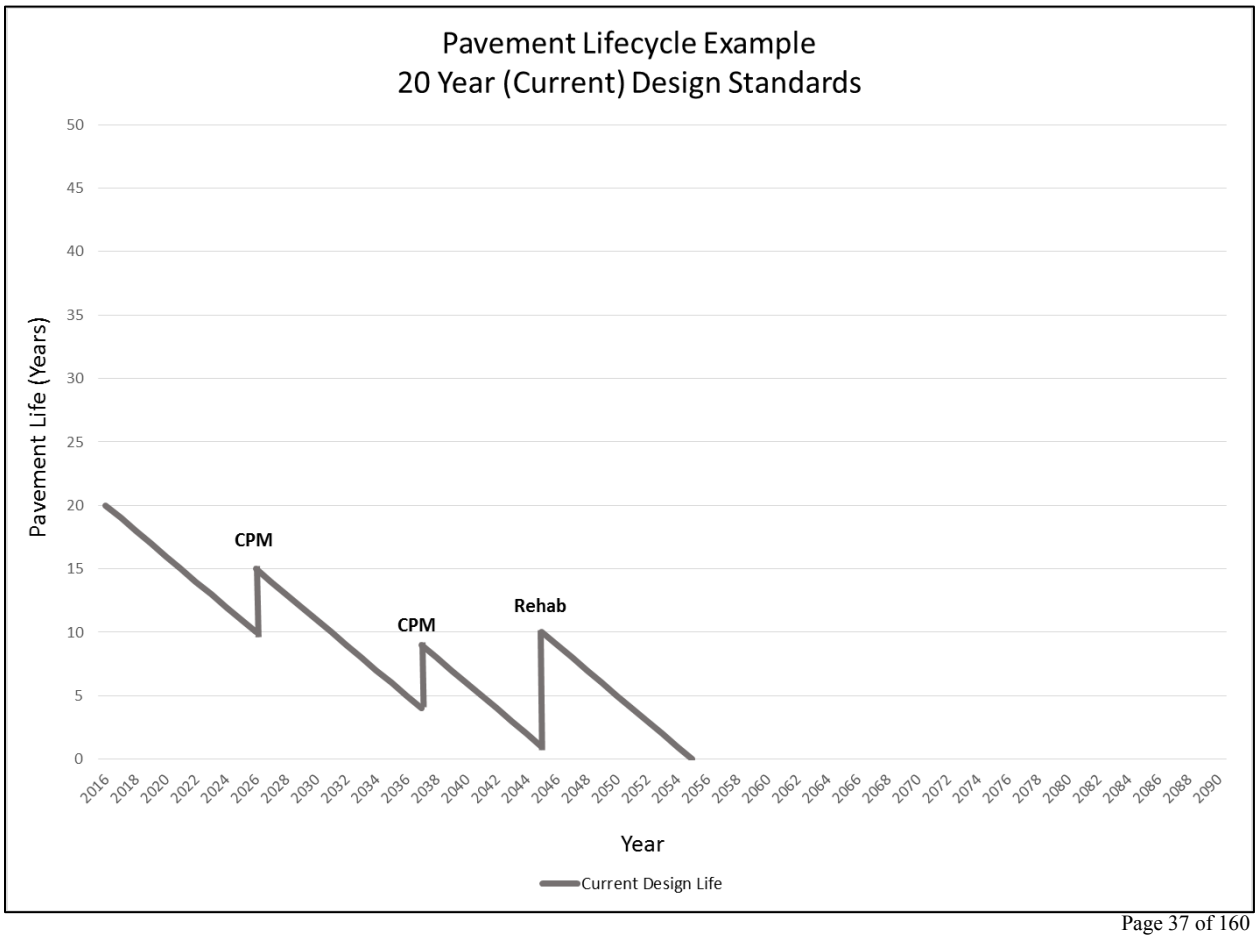
For both forecasting tools, this analysis posed a significant challenge, given that neither tool was designed to forecast to 50 or 75 years. PCFS only forecasts 10 years, while RQFS can forecast 35 years. Given that the length of forecasting is less of an issue for RQFS and that both RSL and PASER currently measure the trunkline network at 15 percent “poor” based on 2014 data, RQFS was utilized to help project future costs.

It should also be noted that RQFS is designed to incorporate projected future inflation into the analysis it provides. All dollar values in the following scenarios are inflation adjusted dollars, not current dollars. For the first six years, inflation was estimated to be between 4 and 4.5 percent, and for 2021 and beyond, 4 percent was used, which are standard inflation estimates for the industry.

Years	Annual Inflation Rate
2015-2020	4-4.5%
2021+	4%

Current 20-Year Design Standards "Meet and Sustain" Strategy
MDOT's current scenario has a 90 percent good/fair pavement condition goal, as approved by the State Transportation Commission. Consequently, MDOT has a strategy based on current standards and practices that is designed to meet this goal and maintain pavement condition at that goal into the future. This strategy is based on implementing a comprehensive mix of fixes (reconstruction, rehabilitation, and capital preventive maintenance improvements) on the right pavements at the right time. This approach has been nationally accepted as the most effective way to maintain the pavement network. In addition, this scenario reflects current practices and design standards where a reconstruction project would have an average design life of 20 years.

To achieve the 90 percent good/fair pavement goal, an investment of $15 billion over the next 10 years would be required. This equates to an average annual investment of $1.5 billion. In order to maintain pavement condition at goal level for an additional 40 years, another $155 billion ($3.9B per year) would be required. The next 50 years would therefore require investments totaling $170 billion ($3.4B per year). In addition, the Net Present Value of this scenario is $55 billion.

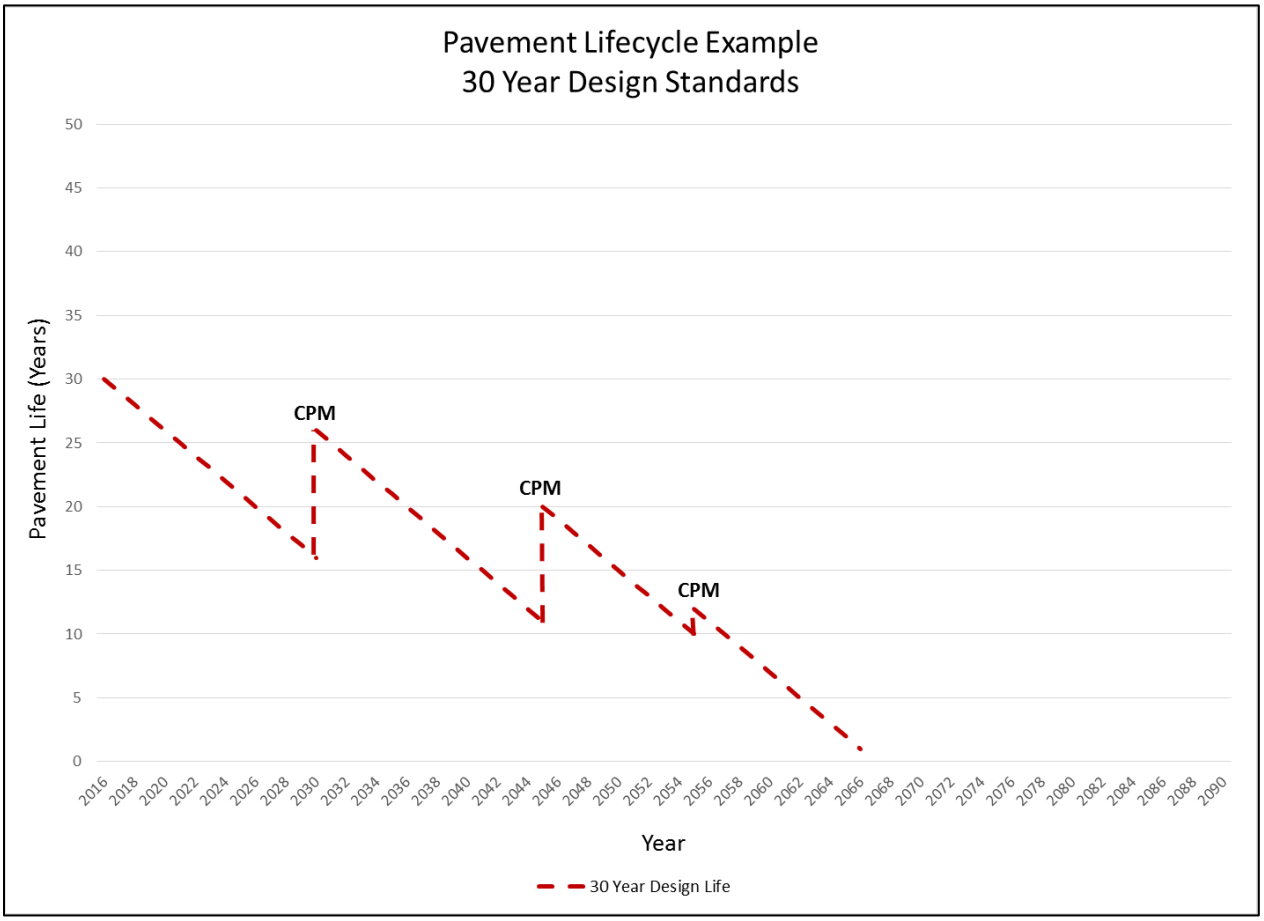


30-Year Design Life/50-Year Service Life Strategy Analysis

This scenario would utilize enhanced design and material standards, to reconstruct pavements that would last 30 years without additional work, but could last up to 50 years before a new reconstruction project is required, if proper preventive maintenance work is done. At an estimated cost of $3.7 million per lane mile, it would require an initial investment of roughly $111 billion ($11 billion per year) over the first 10 years to reconstruct the entire 30,000 lane-mile trunkline system, resulting in a 30-year design life and zero "poor" pavements. These costs may not include all costs related to the project such as utility relocations, right-of-way acquisition, etc.

However, additional investment in preventive maintenance would be needed to achieve the 50-year service life. The initial preventive maintenance investment would begin roughly 15 years after the first reconstruction projects were completed with additional preventive maintenance work starting around year 30. As illustrated in the graph below, it is anticipated that three rounds of preventive maintenance work would be required to achieve the 50-year service life. This additional investment would total approximately $18 billion ($450M per year).

This scenario would require a total 50-year investment of about $129 billion (an average of $2.6 billion per year) to implement. The Net Present Value of this scenario is $95 billion.

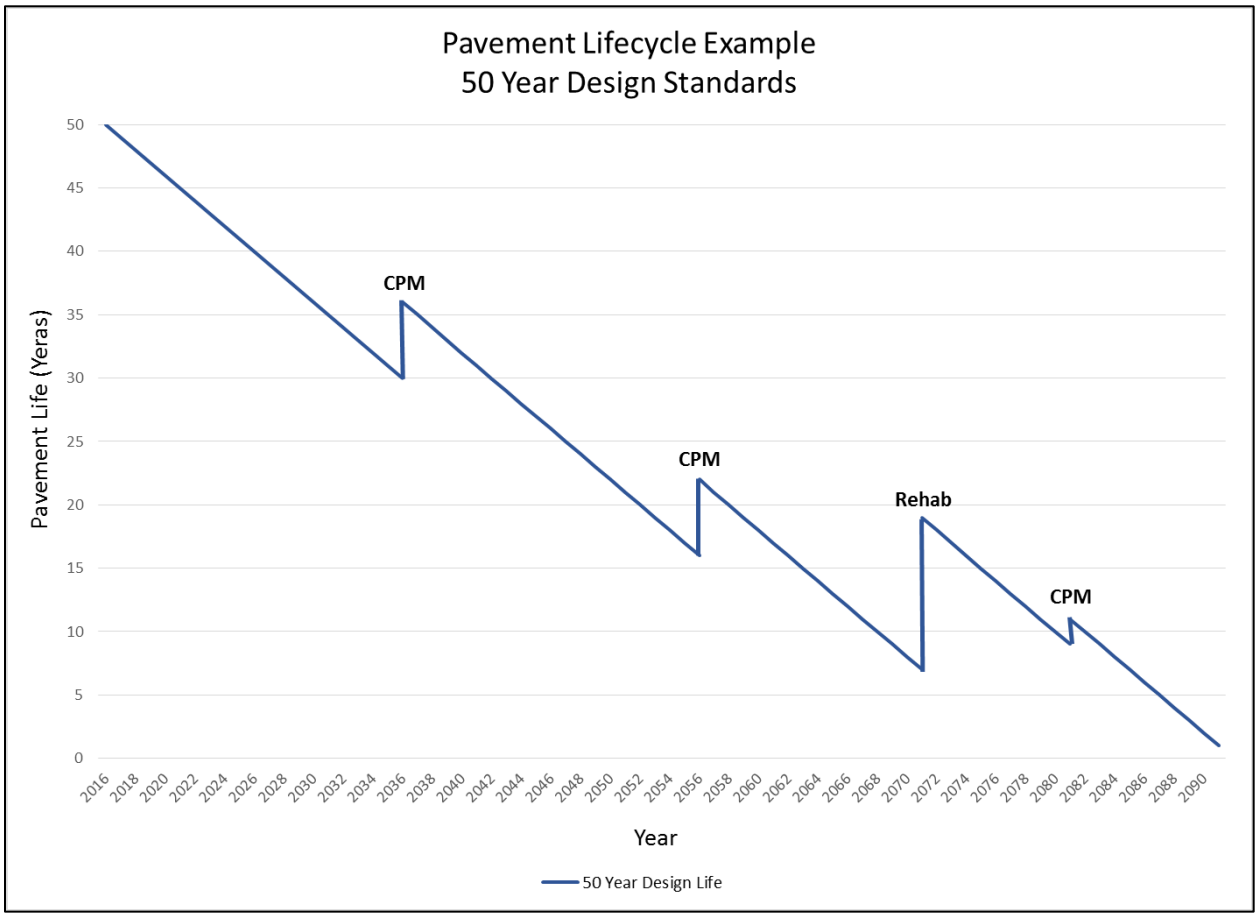


50-Year Design Life/75-Year Service Life Strategy Analysis

This scenario has the most expensive upfront costs but the greatest long-term savings. At an estimated cost of $4.7 million per lane mile, it would require an initial investment of roughly $140 billion ($14 billion per year) over the first 10 years to reconstruct the entire 30,000 lane-mile trunkline system, resulting in a 50-year design life and zero "poor" pavements. If left alone, with no life-extending preventive maintenance or rehabilitation work, these pavements may last 50 years before requiring additional reconstruction efforts. These costs may not include all costs related to the project such as utility relocations, right-of-way acquisition, etc.

However, the service life of these pavements can be extended to as far as 75 years when preventive maintenance and rehabilitations are applied. The initial preventive maintenance investments would begin roughly 20 years after the first new reconstructs happen with a second round of preventive maintenance beginning in year 40, adding an additional $23 billion ($560 million per year) of investments. By year 50, with additional preventive maintenance and rehabilitation investments, pavement service life could be extended to 75 years.

This scenario would require a total investment for the first 50 years of approximately $163 billion (an average of $3.3 billion per year) to implement. The Net Present Value of this scenario is $119 billion.



Roads Innovation Task Force Report
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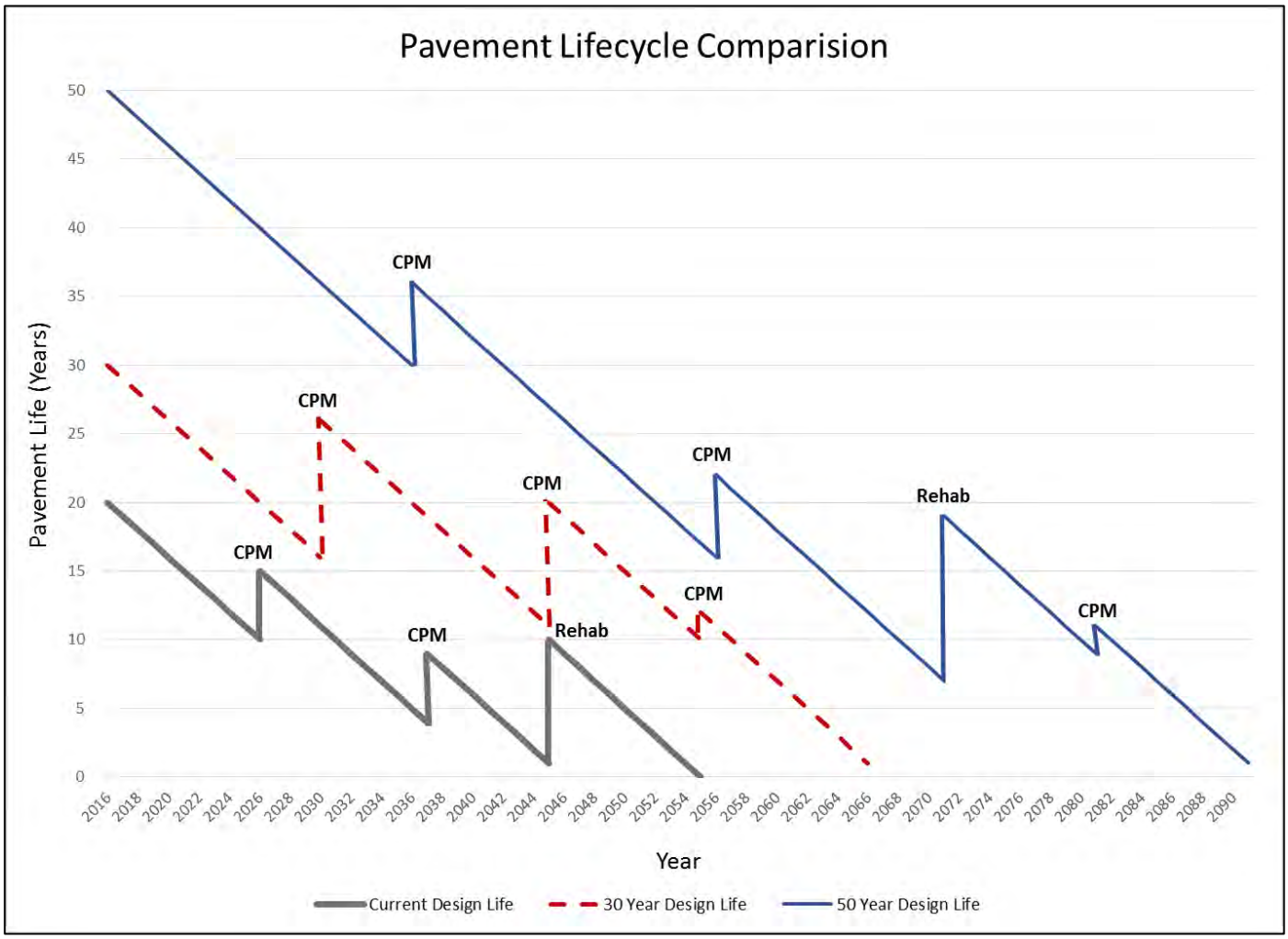
Summary

Achieving the existing goal by implementing current design standards and practices has the lowest initial costs. However, it would require a great deal of additional long-term investment to maintain because higher-cost reconstruction and rehabilitation work is needed in the later years after inflation has increased those costs dramatically. Using the 30- or 50-year design standards would offer significant long-term cost savings, compared to current practices because of the delayed need for those expensive fixes; however, those scenarios require far greater initial investments.

Regarding Net Present Value (NPV), both the 30/50-year design standard and the 50/75-year design standard have a significantly higher NPV than MDOT's current design standards and practices. Thus both new design standards fail to achieve the desired 50 percent reduction in NPV from current practices based on this analysis. This is due largely to the previously mentioned substantial initial investments required to implement the 30/50 and 50/75 design standards within 10 years.

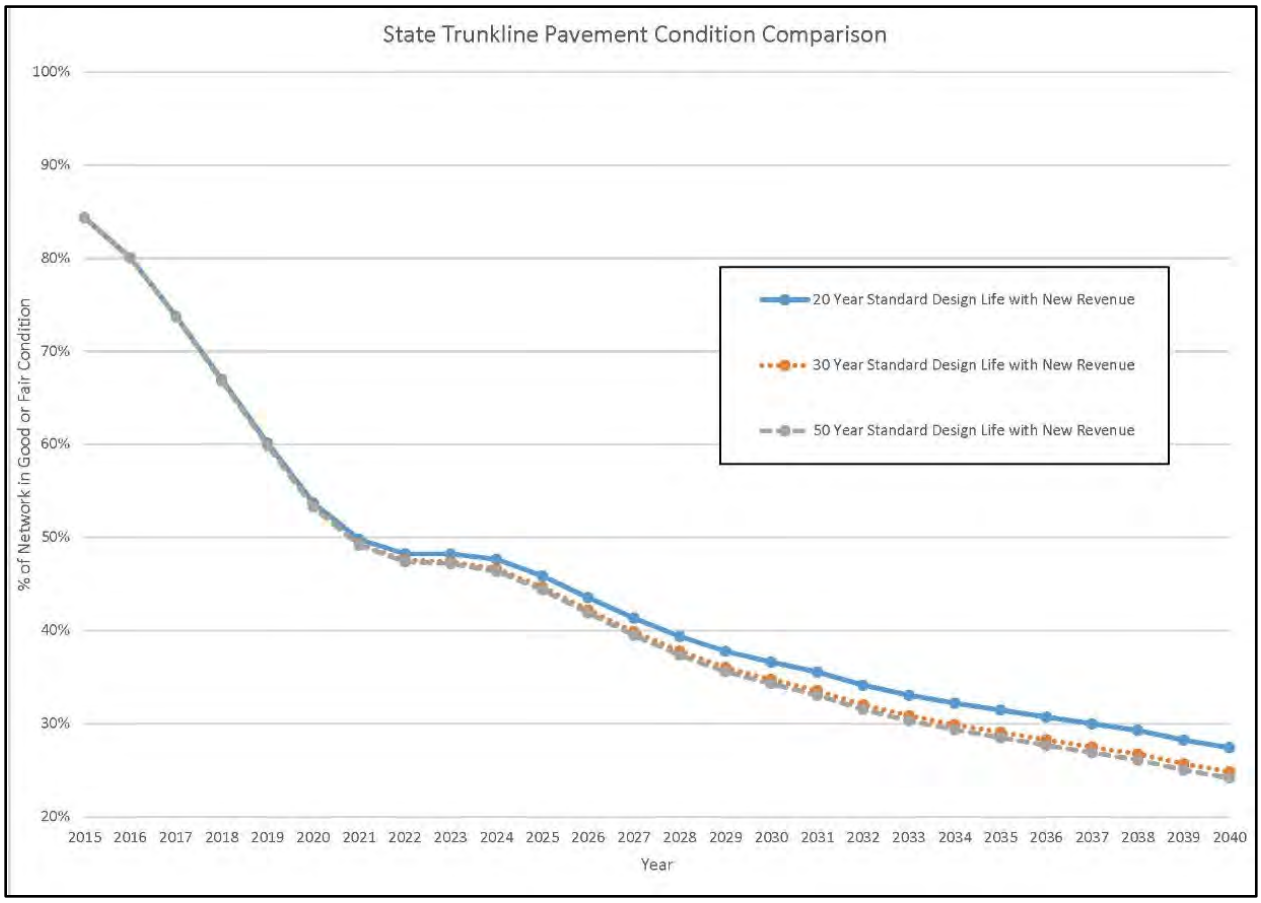


10 Year Pavement Condition Forecast

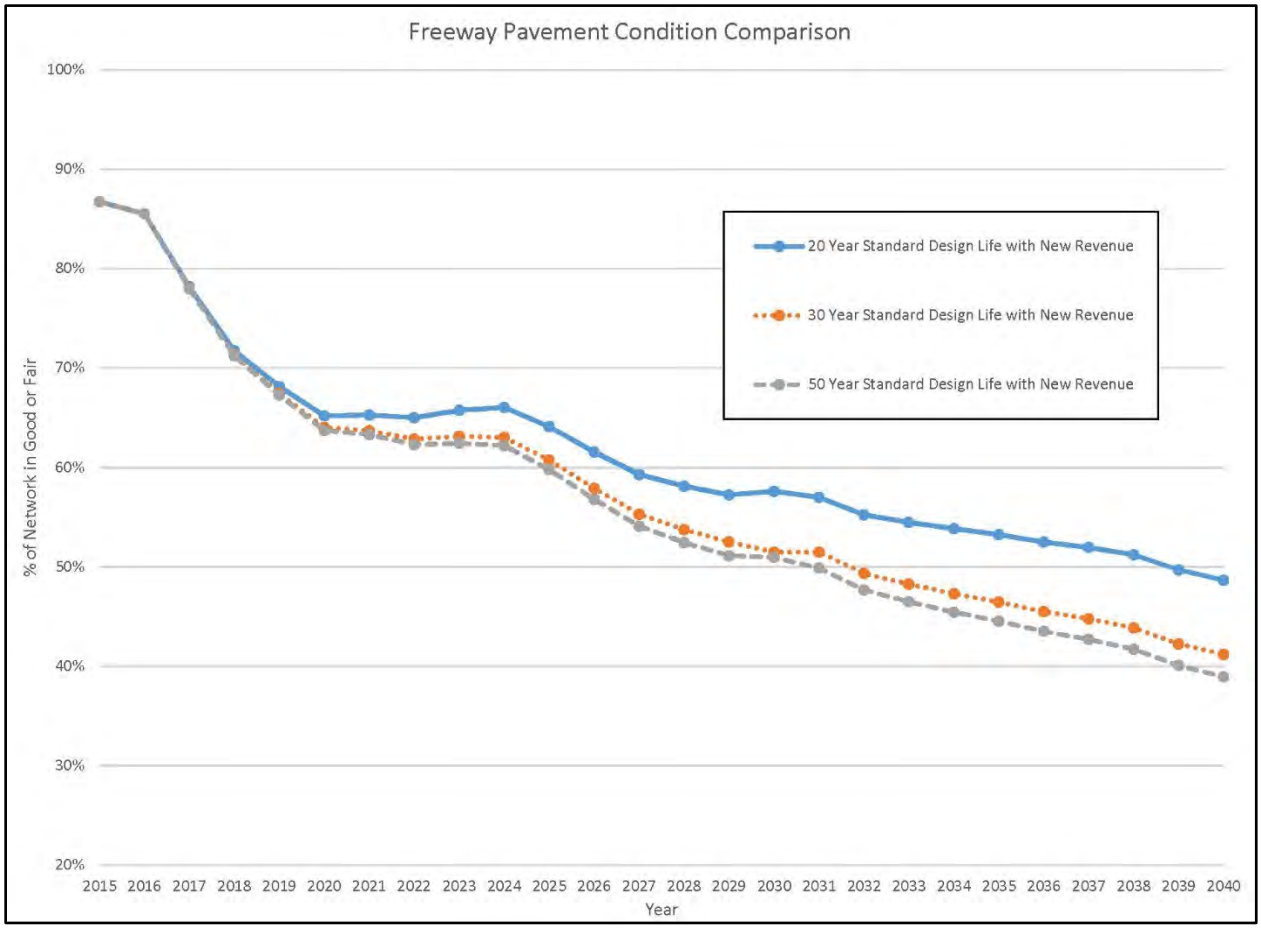
MDOT has used its pavement condition forecasting tool to analyze the impacts of new funding enacted in 2015. The analysis performed encompassed a 10-year timeframe, from 2016 to 2025. The pavement condition forecast of MDOT's current pavement preservation investment levels, which implement a "mix of fixes" that includes reconstruction work at the current 20-year design standards, was compared to proposed 30- and 50-year design life. The results of this analysis are depicted in the graph below.

Beginning in 2017, new revenue from legislation enacted in 2015 would be used for enhanced reconstruction work. This analysis assumes this funding would be held exclusively for higher volume roads; therefore, all monies were invested on the freeway network, at an assumed cost of $3 million per lane mile for the 30-year design life/50-year service life roads and $4 million per lane mile for the 50-year design life/75-year service life roads.

In addition to the investment inputs, the forecasting tool also assumes a 4 percent per year inflation factor to construction costs beginning in year 6 of the forecast.



The negative pavement conditions outcomes are more significant when the proposed 30- and 50-year designs are examined at the freeways level, as depicted in the graph below. Freeways carry 60 percent of all trunkline traffic and 76 percent of trunkline commercial traffic. An additional 8 to 10 percent drop in freeway pavement condition, which would occur with the proposed 30- and 50-year designs, would have additional negative impacts for drivers and for the state's economy.



As illustrated above, based on current funding levels, MDOT would not be able to construct these long life pavements without impacting the overall 2015 level pavement surface evaluation and rating scores.

Following is a summary of estimated funding projections that would be required to meet and sustain the 90 percent good/fair pavement goal (currently approved by the State Transportation Commission) using today's design standards alongside what would be expected to achieve similarly sustained levels of service for 30- and 50-year design standards. Funding levels less than these would result in a degradation of the condition level as compared to the 2015 condition level.

Estimated Funding Projections

Funding Impacts	Investment Needed First 10 Years	Average Investment Needed Next 40 Years
Current Standards 20-Year Design Life with Mix of Fixes	$15 billion	$3.9 billion/year
20-Year Design Standards Reconstruct	$60 billion	$9 billion/year
30-Year Design Standards Reconstruct	$111 billion	$450 million/year
50-Year Design Standards Reconstruct	$140 billion	$560 million/year

Potential Life Cycle Cost Savings from Enhanced Design Standards

MDOT's current pavement condition forecasting tools do not have the capacity to project pavement condition 50 years into the future. The following table and corresponding text describe the life cycle savings from one year of enhanced reconstruction methods.

Based on the parameters that were listed in the 50-Year Pavements document, a 50-year outlook was created for each design strategy: 20-year design/40-year service life (MDOT's current design standard), 30-year design/50-year service life, and 50-year design/75-year service life. This 50-year outlook summarizes how many additional lane miles of rehabilitation work is possible, within those 50 years, from the life cycle savings that are available from the enhanced design pavement.

For each design, a life cycle cost per one lane mile was calculated for 50 years of capital work (refer to *50-Year Life Cycle Cost/Lane Mile* row in the table below). The 50-year outlook for each design standard was developed using the work types and cost of each work type that would be completed by the fiftieth year. The 20-year design/40-year service life was extended, adding a rehabilitation project to reach the 50-year outlook. The 50-year design/75-year service life does not include the last two improvement projects that occur outside the 50-year window, which are needed to reach the 75-year service life.

The 50-year life cycle lane mile cost was used to calculate a savings with the 30-year design/50-year service life and 50-year design/75-year service life standards. Savings were determined by finding the difference between their 50-year cost and the current 20-year design/40-year service life standard 50 year cost. The lane mile savings is shown in the *50-Year Life Cycle Cost Savings/Lane Mile* row in the table below. This savings is not additional revenue, but revenue savings that would go back into the construction program.

To calculate the additional lane miles of rehabilitation work, the 50-year life cycle lane mile cost savings was divided by the average inflated freeway rehabilitation project cost per lane

($2.3 million). The result is the lane miles of work that can be done per one lane mile of road that is constructed using one of the new design standards. For every lane mile of pavement construction that uses the enhanced design (30-year design and 50-year design standards), the savings result in the ability to construct an additional 1.7 miles and 1.2 miles of rehabilitation work over the 50-year timeframe, respectively.

An analysis was performed based on additional annual investment in keeping with the revenue package enacted in 2015 to construct enhanced pavement design sections utilizing the 30- and 50-year designs. Estimated savings begin with full implementation in 2022 of the enacted revenue package, which gradually increases funding over the next six years.

50-Year Outlook: Potential Per Lane Mile Life Cycle Cost Savings From Enhanced Reconstruction Design Standards			
	20-Year Design/ 40-Year Service Life (Current Standard)	30-Year Design/ 50-Year Service Life	50-Year Design/ 75-Year Service Life
2016 Reconstruction Cost/Lane Mile	$2,000,000	$3,700,000	$4,700,000
50-Year Life Cycle Cost/Lane Mile	$8,164,750	$4,231,500	$5,410,000
50-Year Life Cycle Cost Savings/Lane Mile		$3,933,250	$2,754,750
Additional Lane Miles of Rehabilitation Work from 50-Year Life Cycle Cost Savings/Lane Mile of Initial Reconstruction		1.7*	1.2*
Lane Miles Reconstructed from Road Innovation Funding, beginning in 2022	144	78	61
Total Additional Lane Miles of Rehabilitation Work from 50-Year Life Cycle Cost Savings	N/A	133	73

* Additional rehabilitation work from cost savings was calculated using a 50-year, inflation adjusted average cost of $2.3 million per lane mile.

Enhanced reconstruct design savings table assumptions:

- Life cycles reflect type of fix and year of fix identified in the 50-Year Roads Task Force document
- Cost of fixes based on average costs for particular fix plus 4% annual inflation beginning in 2021

LONGER TERM TIME FRAMES

Public Act 175 of 2015 requires that (1) MDOT focus on longer-term time frames that seek to maximize value to the taxpayers of this state on a total cost basis, regardless of funding or financing considerations and (2) shall not incorporate or reference plans or suggestions regarding bonding, refinancing, or financing innovations.

Striving to achieve longer lasting pavements has been a part of MDOT's culture for years. MDOT will continue to support development and implementation of innovations in designing, constructing, and maintaining its roadways to maximize value to the taxpayers. Current methods and processes as outlined in the "Evaluation of Materials and Processes" section will be utilized to evaluate these innovations as applicable.

There are many examples of MDOT innovation in the past and present. Following are examples for concrete and hot mix asphalt pavements.

Recent changes to MDOT's concrete specifications that will potentially improve performance include the following:

- Well graded aggregate mixes
- Reduced cementitious content requirements
- Use of supplemental cements
- Use of supplemental cements in year round construction
- Air content quality testing
- Use of wear resistant epoxy coating on load transfer dowels

Additional changes being evaluated to help effectively control and monitor critical performance properties are as follows:

- Initial field curing of strength samples–reduced testing variability
- Concrete permeability testing–resistivity, a new property measure that more directly relates to long term durability than conventional testing
- Air system checks–Super Air Meter, measuring the quality of the air system in addition to the historic total volume measurement

Recent changes to MDOT's hot mix asphalt specifications that will potentially improve performance include the following:

- Regress air voids to 3% on all mixes, E3 mixes require a 43 angularity on top courses. Air voids RQL set at 1.5%. Goal is to get more asphalt cement in mixes.
- Only allow fine graded mixes on top and leveling courses. Goal is to increase durability of mixes.
- Implementation of Longitudinal Joint Specification. Improve overall performance of longitudinal joints.

- Changed to a softer design grade (-22 to -28) of asphalt cement for the Capital Preventive Maintenance Program (1 ½″ overlays with or without milling). The goal is to improve the resistance to cracking.

Additional changes that are being evaluated are a result of MDOT and the Asphalt Pavement Association of Michigan (APAM) embarking on a new quality initiative to ensure that Michigan asphalt procedures and asphalt pavements are of the highest quality in the nation. A Peer Review Team of national experts was assembled to review MDOT specifications, production practices, and field procedures.

The objective of the initiative is to evaluate Michigan's current practices and benchmark them against regional and national best practices. The Peer Review Team was asked to offer suggestions for changes aimed at improving asphalt pavement performance. Ten focus areas were identified for the detailed review:

1. RAP and RAS Usage
2. Mix Design Practices
3. Construction Practices
4. Acceptance Specifications
5. Mixture Specifications
6. Input from the Field
7. Ride Quality
8. Warm Mix Asphalt
9. Liquid Binder Testing and Certification
10. 50-Year Pavement

Additionally, MDOT is working with its industry partners to train contractor and inspection personnel to ensure quality. Following are some of the areas being addressed through the Construction Quality Partnership training initiative:

- Loader stockpile operations
- Plant certification
- Quality control and quality assurance testing
- Best practice pavement operations
- Quality control/quality assurance workshops–clearly defined responsibilities and processes to produce quality pavements
- Quality control planning–how to develop, accept and then communicate the plan to everyone involved in the process
- Preventive maintenance and repair seminars–agency and industry personnel are trained on best practices

Furthermore, MDOT's participation in programs and research such as the Federal *Strategic Highway Research Program*, MDOT's *Clare Test Road*, and *Michigan Aggregate Test Road* are

examples of a willingness to constantly improve the performance of our pavements. MDOT has adopted nationally recommended pavement design standards such as Jointed Plain Concrete Pavement, Hot Mix Asphalt Superpave System, and is implementing the use of Mechanistic Empirical Pavement Design, all in line with the goal of achieving the least cost pavement life cycle. Utilizing the results of research and free enterprise allows MDOT to continue identifying innovations such as solar roadways, bendable concrete, and many others for possible evaluation and ultimate inclusion into standard practices.

The cost benefit of a particular innovation, product, or material in pavements is ultimately analyzed utilizing network analysis tools as presented in the section titled "Upfront Investment to Reduce Life Cycle Costs." True "as constructed" performance in Michigan should be used and reflected in any economic analysis to ensure that it is a true representation of a value added innovation, product, or material and indeed a value to the taxpayer. Life extension benefits of innovations and new products or materials in pavements can be estimated initially with the true test from actual pavement performance once it is constructed and performs in place.

MDOT will continue to evaluate new innovations making use of its many resources and will incorporate new innovations that provide value to pavement performance, while considering value and current life cycle laws. This will not ensure that the target of a reduction of at least 50 percent in its net present value 50-year life cycle costs as compared to the commensurate net present value 50-year life cycle costs for road construction and maintenance costs is met, but it will ensure that MDOT is striving to do so. Once a particular enhanced pavement is constructed or innovation is incorporated, one can monitor the actual costs and performance and eventually determine the net present value and evaluate it against the desired target noted above.

SUGGESTED LEGISLATIVE LANGUAGE

Public Act 175 of 2015 requires that MDOT's Roads Innovation Task Force update and finalize the report described in Subsection (2) to provide suggested boilerplate language, which coincides with how the Department would execute the plan and attempt to achieve the targets described in Subsection (1). The plan is to include sufficient detail to allow the legislature to monitor and track progress, estimate how long it is expected to take to achieve targets, and project what the inflation-adjusted reduction in annual spending will be once fully implemented as compared to costs in 2015.

Suggested Boilerplate Language:

> *The Department shall continually strive to lower the Equivalent Uniform Annualized Cost (EUAC) of hot mix asphalt and Portland cement concrete pavements. Beginning in 2018, the Department will issue a biennial report that provides specific measures the Department is taking to achieve this goal. The report will list demonstration projects that incorporate a specific enhancement that is intended to decrease the EUAC of a particular pavement type. Additionally, any material enhancements, increased acceptance limits, or construction requirements made to specifications that have the potential to enhance pavement performance will be reported along with their intended benefits. Furthermore, any new*

materials submitted to the Department will be reported with the status of each. When sufficient performance data have been obtained for an individual enhancement, the Department will provide a performance curve and EUAC that will be compared to the baseline performance curve and EUAC as published in the 2012 "Pavement Design and Selection Manual," and an inflation-adjusted reduction in annual spending will be provided as compared to costs in 2015.

MDOT will continue to seek new materials, technologies, and construction methods that have the potential to improve pavement performance and reduce life cycle costs. MDOT will use its New Materials Evaluation Procedure, Pavement Demonstration Program, research findings, and results in evaluating these innovations. MDOT's technical staff will continue to work closely with Michigan universities and other experts to investigate a variety of issues that impact pavement performance. MDOT will continue to provide leadership and remain technically engaged in national research by ad hoc consortia and through national pooled resource opportunities. Participating in these programs and initiatives will increase MDOT's innovative capacity with the goal of increasing pavement performance and reducing life cycle costs. Furthermore, MDOT will initiate a synthesis of national and international best practices in pavement design, materials, and maintenance in wet freeze climates to identify best practices that MDOT may implement to improve pavement performance.

MDOT currently uses Equivalent Uniform Annual Cost (EUAC) methodology for life cycle cost analysis, as outlined in the Department's *Pavement Design and Selection Manual* (February 9, 2012 Edition). MDOT will monitor its goal of achieving longer life pavements with reduced life cycle costs by using the manual's current pavement performance curves. These performance curves will be used as the 2015 baselines. Improvements made to enhance pavement performance and reduce life cycle costs will be compared to these performance curves to determine their effectiveness. Actual initial costs and maintenance costs, along with actual performance history of the projects incorporating the performance enhancements, will be used for the comparative analysis. It should be understood that collecting actual performance information will take years, in most cases, to account for actual traffic loading and environmental factors. In some cases, it may be possible to utilize accelerated loading facilities (such as the National Center for Asphalt Technology, Minnesota Test Track (MnRoad) as part of the National Road Research Alliance, or the Federal Highway Administration's Accelerated Load Facility at the Turner-Fairbank Highway Research Center) to predict long-term performance. However, there is currently no way to assess environmental impacts on full-scale pavements under accelerated traffic loadings at these facilities or others. Environmental impacts can only be achieved by building an actual test section with live traffic and monitoring the environmental impacts as they occur over time.

Although no targets have been established, MDOT will strive to achieve net reductions in EUAC for hot mix asphalt and Portland cement concrete pavements over the next 20 years. Incremental progress will be tracked and reported. As technology advances, it may be possible at some point to accelerate both traffic and environmental performance predictions on a full-scale model, which may facilitate expedited determinations relative to life cycle cost reductions.

For reporting purposes, MDOT will utilize its existing demonstration program and materials evaluation procedure to report those items that have been evaluated and/or demonstrated in actual pavement projects. Research findings will also be reported for those items that have had documented impacts on pavement performance. Additionally, any specification-related changes to material enhancements, increased acceptance limits, or construction methods that have the potential toward enhanced pavement performance will be reported. Any enhancements made will be included in a biennial report to the legislature for monitoring purposes. Each enhancement will be reported along with its expected contribution to improve pavement performance and reduction in overall life cycle costs.

In addition to the legislation covered by the suggested boilerplate language, MDOT suggests modifications be made to the life cycle cost analysis, pavement demonstration program, and studded tire laws as follows:

Life Cycle Cost Analysis

Michigan law requires the application of Life Cycle Cost Analysis (LCCA) to evaluate equal pavement designs for both concrete and hot mix asphalt based on past performance to determine the most cost effective pavement type for a particular project. Because the needed historical data is not yet available to develop proper performance curves for long life (50-year) pavements, the Department can only evaluate such pavements using LCCA and general estimations. Proposed 30- and 50-year design life pavements would need to be exempt from the LCCA law to be considered a viable option for road construction.

State Law 247.651h, Act 51 requires that ". . . the Department shall develop and implement a life-cycle- cost analysis for each project for which total pavement costs exceed $1,000,000 funded in whole, or in part, with state funds. The Department shall design and award paving projects utilizing material having the lowest life-cycle costs." This law also requires that ". . . life cycle cost shall compare equivalent designs and shall be based upon Michigan's actual historic project maintenance, repair, and resurfacing schedules and costs as recorded by the pavement management system, and shall include estimates of user costs throughout the entire pavement life." Furthermore, the law states that, "For pavement projects for which there are no Michigan actual historic project maintenance, repair, and resurfacing schedules and costs as recorded by the pavement management system, the department may use actual historical and comparable data for equivalent designs from states with similar climates, soil structures, or vehicle traffic." MDOT has considered and continually seeks out performance data from other states that could be used in the LCCA process. The Department is aware of states that have constructed long life pavements and are monitoring their progress. Once these pavements have been in place long enough and actual performance data can be obtained, MDOT may be able to translate the data for use in long life pavement LCCA in Michigan.

MDOT has no historic performance or maintenance data on these proposed long-life pavements, and therefore, a life cycle cost analysis (based on actual costs) cannot be performed. Any long life pavements undertaken through use of the Roads Innovation Fund would not conform to the

above requirements and, thus, would need to be exempt from the current life cycle cost analysis required by law.

MDOT proposes the following in order to allow the Department to innovate at the project level and not violate statue.

Modify State Law MCL 247.651h to increase the threshold for performing an LCCA from $1,000,000 to $2,000,000 and to allow for engineering analysis techniques to determine the appropriate maintenance, repair, and resurfacing schedule for the subject project when no historical data are obtainable from the Department or other sources.

Demonstration Projects

MCL 247.651 - 247.675, Sec 1i. sets forth the requirements for demonstration projects to evaluate new constructions methods, materials, or designs. This section should be modified to remove the requirement to have a balance between asphalt and concrete, thus allowing the Department to demonstrate innovations as they become available. Demonstration projects should only include methods, materials, or designs that have a sound research base behind them, since the Department should not be developing outside methods, materials, or designs for the private sector.

If the cap on the number of demonstration projects allowed in a year is increased, it is recommended that a separate appropriation for these projects be established from a source other than currently existing transportation funding. This will allow the Department to deliver its standard road program in addition to the innovative projects.

SB 879 amendments to address Life Cycle Cost Analysis and Pavement Demonstration Program:

- Page 2 line 3 – Strike "$1,000,000.00" and replace with "$2,000,000.00"
- Page 3 line 18: After (B), strike all of the subsection and replace with "If historical data is not obtainable from the Department or other sources, appropriate maintenance, repair, and resurfacing schedules for a particular project may be determined by appropriate engineering analysis techniques upon approval by the chief engineer of the Department."
- Page 4 line 24: Add new (d): "Demonstration projects should only include methods, materials, or designs that have a sound research base behind them."
- Page 4 line 26: Delete after (3) and replace with "Nothing in the subsection requires that any individual demonstration project be duplicated with both asphalt and concrete."
- Page 5 line 15: Add new (6): "For demonstration projects contemplated under this section, the Department shall strive to reduce the equivalent uniform annual cost by 5 percent over the next 10 years."
- Page 5 line 15: Add new (7): "$10,000,000 is appropriated from the General Fund to fund a portion of the demonstration projects in this section."

Studded Tires
State Administrative Rule 710 of Act No. 300 of the Public Acts of 1949, as amended, being MCL 257.710 of the Michigan Compiled Laws allows the use of studded tires. This law would need to be repealed to minimize pavement wear and ensure the expected service life is obtained for long life pavements.

State and federal statutory requirements and restriction pay a role in how MDOT maximizes its limited transportation dollars. MDOT consistently works to maximize the use of these limited funds, operating within the requirements of state and federal law.

A wide variety of state and federal laws have been enacted that impact road construction, addressing aspects related to safety, labor, the environment, planning, and other areas of concern. Although these laws may have incrementally increased the time and cost of implementing transportation projects, most are intended to help address issues that cost society in other ways, such as pollution or loss of life. As these laws have been enacted, their requirements have been incorporated into the MDOT's business processes. Many of these federal and state requirements are now an integral part of the way the Department does business.

FEDERAL REQUIREMENTS
The vast majority of regulations for the Department's operation derive from federal law. For any project that contains even one dollar of federal funding, all federal requirements apply. However, many of the federal laws apply regardless of the source of funding. For example, Title VI of the Civil Rights Act, the Occupational Safety and Health Act, the Endangered Species Act, the Clean Air Act, the Clean Water Act, and hazardous waste laws apply regardless of the funding source or approval path.

Some of the major federal laws impacting transportation are as follows:
- Americans with Disabilities Act, 42 USC Chapter 126
- Buy America, 23 USC 313 (requirement for domestic iron and steel)
- Davis-Bacon Act, 40 USC 3141 et seq., 23 USC 113
- Disadvantage Business Enterprise Program, 23 USC 140, 23 CFR part 230
- Federal Contracting Laws and Regulations, 23 USC 112 (including the Brooks Act, 40 USC 471 et seq.)
- Native American Graves Protection and Repatriation Act, 1990, 23 USC 3001 et seq.
- National Environmental Protection Act of 1969 (NEPA) – 42 USC 4321
- Occupational Safety Health Act Requirements, 29 USC Chapter 15
- Planning Laws and Regulations, 23 USC 134, 135
- Public Hearings/Public Involvement, 42 USC 6901 et seq.
- Title VI of the Civil Rights Act, 1964, 42 USC 2000d et seq.

The following table lists the major environmental laws as cited in the 2013 stewardship agreement signed by the Department and the Federal Highway Administration.

Applicable Federal Laws, Regulations, Orders, and Procedures

Environmental Topic	Law	Implementing Regulations
Antiquities Act, 1906	16 USC 431-433	36 CFR 251.50-64 42 CFR 3
American Indian Religious Freedom Act, 1978	42 USC 1996	N/A
American with Disabilities Act, 1990	42 USC 126	23 CFR 652
Archeological and Historic Preservation Act, 1974	16 USC 469	36 CFR 66
Archeological Resources Protection Act, 1980	16 USC 470	43 CFR 7 18 CFR 1312 32 CFR 79 36 CFR 229 36 CFR 296
Bald and Golden Eagle Protection Act, 1940	16 USC 668	N/A
Title VI of the Civil Rights Act, 1964	42 USC 2000d et seq.	49 CFR 21 and 23 CFR 200
Civil Rights Restoration Act, 1987	20 USC 1681 et seq.	N/A
Clean Air Act, 1970	42 USC 7401 et seq. 42 USC 7509, 75219(a) 23 USC 109(J)	23 CFR 771 40 CFR 51 & 93
Clean Water Act, 1972	33 USC 1251 et seq.	33 CFR 26 40 CFR 122-124
Coastal Zone Management Act, 1972	16 USC 1451	15 CFR 923-930
Comprehensive Environmental Response, Compensation, and Liability Act, Superfund Amendments and Reauthorization Act,	42 USC 9601 et seq.	40 CFR 300 43 CFR 11
Department of Transportation Act, Section 4 (f), 1966	49 USC 303 23 USC 138	23 CFR 774
Endangered Species Act, 1973	16 USC 1531 et seq.	7 CFR 335; 50 CFR 17, 23, 81, 222, 225-227, 402, 424, 450, 453
Executive Order 11991, Protection and Enhancement of Environmental Quality, 1970	N/A	N/A
Executive Order 11988, Floodplain Management;	N/A	23 CFR 650, 771; 44 CFR 59-62, 64-68, 70-71, 75-77
Executive Order 11990, Protection of Wetlands	N/A	DOT Order 5660.1A 23 CFR 777

Environmental Topic	**Law**	**Implementing Regulations**
Executive Order 12898, Environmental Justice, 1994	N/A	Federal Register Vol. 60, No. 125, pp. 33896-33903 FR Vol. 59, No. 32
Executive Order 13166, Limited English Proficiency,2000	N/A	Federal Register Vol. 70, No. 239, pp. 74087-74100
Executive Order 11990, Protection of Wetlands, 1977	N/A	23 CFR 777
Farmlands Protection Policy Act, 1981	7 USC 4201-4209	7 CFR 658
Federal Aid Highway Act, 1956	23 USC 101	23 CFR
Fish and Wildlife Coordination Act, 1934	16 USC 661-666(C)	N/A
General Bridge Act, 1945	2 USC 525	2 CFR Parts 114-115
Highway Beautification Act, 1965	23 USC 131, 136, 319	23 CFR 750 23 CFR, 751, 752
Intermodal Surface Transportation Efficiency Act, 1991	40 CFR 93 (CEQ)	23 CFR 771 (FHWA)
Land & Water Conservation Act, Section 6(f), 1965	16 USC 4601-8(f);	N/A
Migratory Bird Treaty Act, 1918	16 USC 703 et seq.	N/A
National Environmental Policy Act, 1969	42 USC 4321 et seq.	23 CFR 771, 772, and 777
National Flood Insurance Act, 1968 and Flood Disaster Protection Act, 1973	42 USC 4001 et seq.	N/A
National Forest Management Act, 1976	16 USC 1604(g) (3) (B)	N/A
National Historic Preservation Act, Section 106, 1966	16 USC 470f,	23 CFR 771; 36 CFR 60; 36 CFR 63; 36 CFR 800
National Trails System Act, 1968	16 USC 1241-1249	251; 43 CFR 8350
Native American Graves Protection and Repatriation Act, 1990	25 USC 3001 et seq.	43 CFR 10
Noise Control Act, 1972	42 USC 4901 et seq. 23 USC 109i	3423 CFR 772
Public Hearings/Public Involvement	42USC6901et seq.	43 CFR 10256-300 40 CFR 61, 23 CFR 751
Rivers and Harbor Act, 1899	Section 9, Section 10	33 CFR Parts 114-115; 23 CFR 650

Environmental Topic	Law	Implementing Regulations
Resource Conservation and Recovery Act, 1976 and Hazardous and Solid Waste Amendments, 1984	42 USC 6901 et seq.	40 CFR 280, 281, 260-265 40 CFR 61
Rivers and Harbor Act, Section 9, Section 10	33 USC 403	33 CFR Parts 114-115
Safe, Accountable, Flexible, Efficient Transportation	23 USC 6002-6011	23 CFR 771
Safe Drinking Water Act, 1974	42 USC 300f et seq.	N/A
Surface Transportation & Uniform Relocation Assistance Act, 1987	23 USC 144(O)	23 CFR 752 (Wildflowers)
Wild and Scenic Rivers Act, 1968	16 USC 1271-1287	36 CFR 251, 297; 43 CFR 8350

STATE REQUIREMENTS

Much like the federal government, the state has a framework that governs aspects of the Department's operations. The following is background on state regulations that have an impact on how MDOT functions, as well as suggestions for legislative changes that could better allow the Department to operate.

- **Environmental Laws**
  Most Michigan environmental laws mirror federal laws so that the state may obtain federal aid for its environmental programs or, in the case of wetland permits, control the permitting process. Public Act 451 of 1994 includes all state environmental laws pertaining to transportation. Only one aspect of this state law exceeds the requirements of federal law: Part 31 of the Natural Resources and Environmental Protection Act (Act 451 of 1994), which pertains to floodplains. In addition, Public Act 169 of 1970 allows communities to establish local historic district ordinances; the Department is required to consult with the local historic district commission on projects located in such a local historic district.

- **Vehicle Registration Fee Diversion**
  The Michigan Vehicle Code was amended by Public Act 152 of 2003 to create the Transportation Administration Collection Fund (TACF) and the Traffic Safety and Law Enforcement Fund (TS&LEF). The creation of these two funds, along with increases in vehicle registration fees to support them, enable the annual diversion of $50 million in vehicle registration fees to the Secretary of State's office and $17 million in vehicle registration fees to the Michigan State Police. Public Act 141 of 2005 transferred another $10 million per year in various license fees from the Michigan Transportation Fund to the TACF. While these diversions do not directly impact project cost, they do erode available transportation revenue for highway construction projects.

MDOT will continue to work with the paving industries to identify changes in the Michigan law that will allow for innovation with the goal of constructing long life pavements.

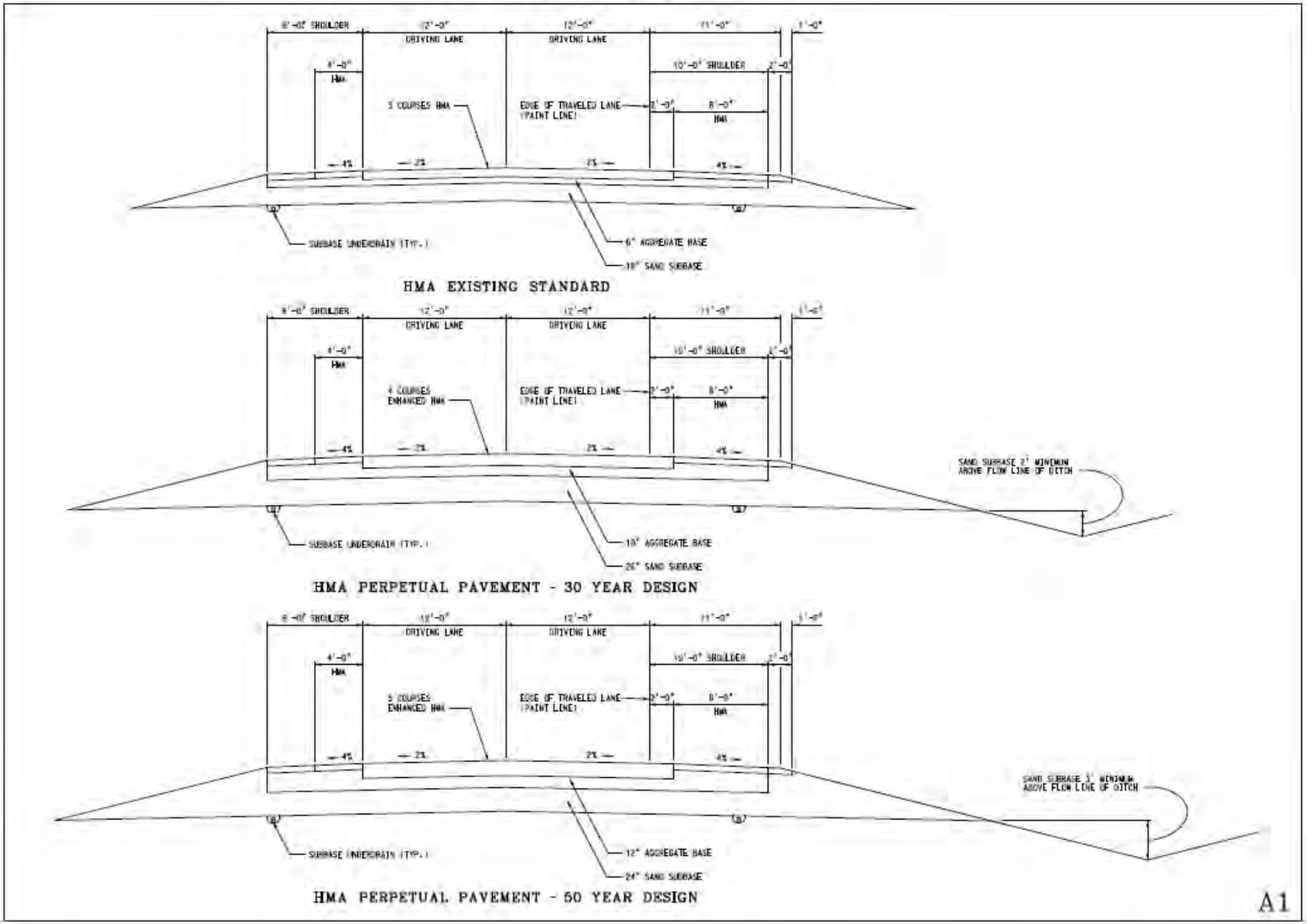
MDOT is proposing to construct four demonstration/pilot projects in 2017 that will utilize the 30-year design life and applicable enhancements and two in 2018 that will utilize a 50-year design and applicable enhancements. Additionally, MDOT is proposing to incorporate four of the enhancements noted on page 26 for both concrete and hot mix asphalt into its standard practices. It is anticipated that these enhancements will be included in applicable projects starting in the October 2016 letting. The four enhancements for hot mix asphalt projects will be:

1) Increased mat density to 93 percent for acceptance
2) Verification of aggregate specific gravities
3) Tightening of percent within limits acceptance parameters
4) Increased use of material transfer device with remixing capabilities.

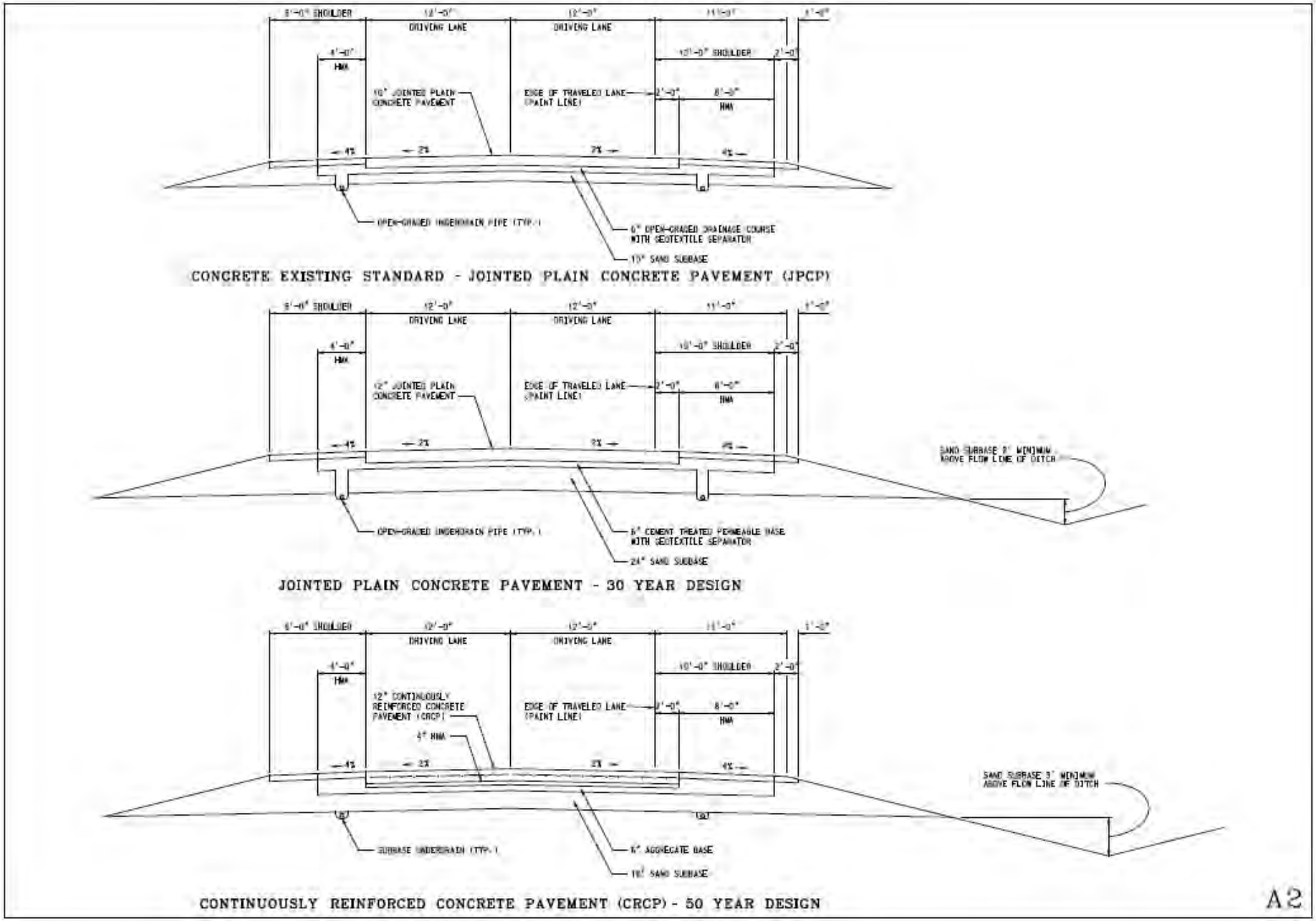
The enhancements for the concrete projects will be:

1) Increased aggregate properties for resistance to material related distress and increased freeze thaw durability
2) Corrosion resistant coating of dowel and lane tie bars
3) Tightening of percent within limits acceptance parameters
4) Enhanced acceptance of air and air system; use of hardened air as acceptance.

ATTACHMENT A
Typical Cross Sections for HMA and Concrete (Designs: Standard, 30-Year, and 50-Year)



ATTACHMENT A
Typical Cross Sections for HMA and Concrete (Designs: Standard, 30-Year, and 50-Year)



ATTACHMENT B

University Centers of Excellence
August 2015

Michigan Technological University's Transportation Material Research Center (TMRC)

Introduction

At the request of the Michigan DOT, the Transportation Materials Research Center (TMRC) at Michigan Tech was asked to assemble a summary of state DOT sponsored research projects, in the area of transportation materials, that have led to technology or technical solutions that have been implemented by a DOT or the transportation construction industry in general. This request pertained to research conducted across the U.S, not in Michigan only. The time frame to assemble this report was short (i.e., one week) making a comprehensive in-depth review impossible. However, included in this report is a brief summary of key projects meeting the afore mentioned criteria.

Approach

Given the short time frame, researchers at the TMRC made use of their extensive network of contacts in the transportation construction industry and contacted over thirty researchers, nationally, and asked each to identify any state DOT sponsored research projects that have developed innovations (nationally) relative to pavements and pavement materials that have been implemented. From the responses, key projects were identified, additional information was obtained by reviewing the NCHRP web site and the TRIS database, and the final list provided was developed.

It should be noted the list provided is clearly not a complete and exhaustive list of all materials-related projects that have led to implementation. Rather, it should be viewed as the tip of the iceberg. To develop a more complete list, it would be necessary to study in-depth the research program of each state, in addition to spending more time examining information at the federal level. Also within major research consortiums such as the National Center for Asphalt Technology (NCAT) or the National Concrete Pavement Technology Center (CP Tech), there is a trove of information regarding implementation that simply could not be fully examined for this report. With regards to the CP Tech Center, it should be noted that one activity they support is the National Concrete Consortium (NCC). The NCC has as members 30 state DOTs and the Illinois Tollway and through their semi-annual meeting, the most current research is delivered through presentations and publications, providing the states with an extraordinary means of staying abreast of the current research.

With respect to implementation, almost all projects listed have been implemented as a business practice within some group of states. Where possible those states are identified but in many cases the list is too long to be presented without more in-depth analysis. There are a couple notable exceptions. The Integrated Manual of Concrete Practice (IMCP) is a reference for the industry and provides a concise summary of best practices. It is not a specification per se but has resulted in a significant improvement in pavement construction quality by providing this information to DOT

engineers and contractors. Likewise, the research on deicers and joint deterioration cited has led to some changes in specifications but the larger benefit was, again, providing this information to DOT engineers and contractors so they could approach their respective duties with more complete knowledge of the issues.

For the sake of presentation, the technologies are grouped in terms of material (i.e., asphalt and concrete) and no inference of priority is implied by the order of presentation in the list.

Asphalt

Warm Mix Asphalt
Web Link: (https://www.fhwa.dot.gov/everydaycounts/technology/asphalt/intro.cfm) -
Institution: Numerous
Related Studies – NCHRP Report 691
Web Link (Related Study): http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_691.pdf
Institution (Related Study): Advanced Asphalt Technologies, LLC
Implemented By: Many DOTs

Foamed Warm Mix Asphalt
Web Link: (http://www.fhwa.dot.gov/pavement/asphalt/wma.cfm)
Institution: Numerous

Crumb Rubber Modified Asphalt
Web Link: https://www.fhwa.dot.gov/pavement/asphalt/crmbrubr.cfm
Institution: Oregon State University (many others)
Related Studies: NCHRP Report 459
Web Link (Related Study): http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_459-a.pdf
Institution (Related Study): University of Wisconsin & Auburn University
Implemented By: Illinois Tollway, Other DOTs

Recycled Asphalt Shingles
Web Link: http://www.illinoistollway.com/documents/10157/90097/RP_ARA_WRV_RAS-HMAFieldTrials_20101020.pdf
Institution: University of Illinois
Implemented By: Illinois Tollway, Other DOTs

The Illinois Tollway's Use of Recycled Asphalt and Greener Concrete for Improved Sustainability in Composite Concrete Pavements
Web Link: http://pavement.engineering.asu.edu/wordpress/wp-content/uploads/2013/12/Illinois-Tollway-Steven-Gillen.pdf
Institution: University of Illinois
Implemented By: Illinois Tollway

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Use or Recycled Shingles and Recycled Asphalt in Pavement
Web Link
http://ibtta.org/sites/default/files/documents/2014/14JerseyCity/Beckemeyer_Gillen.pdf
Institution: University of Illinois
Implemented By: Illinois Tollway, Many DOTs

Improved Mix Design, Evaluation, and Materials Management Practices for Hot Mix Asphalt with High Reclaimed Asphalt Pavement Content
Web Link: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_752.pdf
Institution: Auburn University & University of Minnesota
Implemented By: NCHRP

Investigation of Low Temperature Cracking in Asphalt Pavements National Pooled Fund Study 776
Web Link: http://www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=1522
Institution: University of Minnesota & University of Illinois

Related Studies: Designing, Producing, and Constructing Fine-Graded Hot Mix Asphalt on Illinois Roadways
Web Link (Related Study): https://apps.ict.illinois.edu/projects/getfile.asp?id=3444
Institution (Related Study): University of Illinois
Implemented By: Minnesota, Wisconsin, Illinois, Iowa, and the City of Chicago Departments of Transportation. Also, from this research, the Disk-Shaped Compact Tension test (DCT) was developed and adopted by ASTM as ASTM D7313 Standard Test Method for Determining Fracture Energy of Asphalt-Aggregate Mixtures Using the Disk-Shaped Compact Tension Geometry

Concrete

Development of Performance Properties of Ternary Mixtures
Web Link:
http://ntl.bts.gov/lib/54000/54100/54193/FHWA_IADOT_NCPTC_TPF_5_117_Taylor_Use_Ternary_Mixtures_in_Concrete_2014.pdf
Related Studies: Pooled Fund Study TPF-5(117)
Web Link (Related Study): http://trid.trb.org/view/2011/M/1101041
Institution: Iowa State, University of Utah
Implemented By: Many DOTs

Integrated Materials and Construction Practices for Concrete Pavement: A State-of-the-Practice Manual
Web: Link: http://www.cptechcenter.org/technical library/documents/imcp/imcp_manual_october2007.pdf

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Institution: Iowa State (numerous others)
Implemented By: Many DOTs

Bonded Concrete Overlay of Asphalt Mechanistic-Empirical Design Procedure (BCOA-ME)
Web Link: http://www.engineering.pitt.edu/Vandenbossche/BCOA-ME/
Institution: University of Pittsburgh (Also Iowa State and University of Illinois)
Related Studies: FHWA Pooled Fund Study TPF 5-165
Web Link (Related Study): http://trid.trb.org/view/2008/P/1351330
Institution (Related Study): University of Pittsburgh
Implemented By: Many DOTs

FHWA ASR Development & Deployment Program
Web Link: https://www.fhwa.dot.gov/Pavement/concrete/asr.cfm
Institution: University of Texas-Austin & University of New Brunswick
Implemented By: AASHTO – Published PP-65 - Standard Practice for Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction
Implemented By: FHEA

The Deleterious Chemical Effects of Concentrated Deicing Solutions on Portland cement Concrete
Web Link: http://www.sddot.com/business/research/projects/docs/SD2002-01_Final_Report_Final.pdf
Institution: Michigan Technological University
Implemented By: Various states

Deicer Scaling Resistance of Concrete Mixtures Containing Slag Cement (Phase 2)
Web Link: http://www.intrans.iastate.edu/research/documents/research-reports/deicer_scaling_w_cvr.pdf
Institution: University of Toronto & Iowa State

Deicer Scaling Resistance of Concrete Mixtures Containing Slag Cement (Phase 3)
Web Link: http://www.intrans.iastate.edu/research/documents/research-reports/deicer_scaling_resistance_3_w_cvr.pdf
Institution: University of Toronto & Iowa State

Interim Guide for Optimum Joint Performance of Concrete Pavements
Web Link: http://www.cptechcenter.org/technical-library/documents/Joint-Performance-Guide.pdf
Institution: Iowa State, Michigan Technological University & Purdue
Implemented By: Many DOTs

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Improved Specifications and Protocols for Acceptance Tests on Processing Additions in Cement Manufacturing
Web Link: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_607.pdf
Institution: CTL
Implemented By: NCHRP

Guidelines for Early-Opening-to-Traffic Portland Cement Concrete for Pavement Rehabilitation
Web Link: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_540.pdf
Institution: Michigan Technological University
Implemented By: NCHRP

Super Air Meter to Determine Air Void Spacing and Size Distribution in Fresh Concrete
Web Link: http://www.superairmeter.com
Institution: Oklahoma State University

Related Studies: Pooled Fund TPF-5(297) Improving Specifications to Resist Frost Damage in Modern Concrete Mixtures
Web Link (Related Study): http://trid.trb.org/view/2014/P/1358537
Institution (Related Study): Oklahoma State & Purdue
Implemented By: AASHTO – Adopted as a provisional standard

Resistivity Meter for Estimating Concrete Permeability
Web Link: http://www.concreteresistivity.com/Surface%20Resistivity.pdf
Institution: University of Florida

Related Studies: TPF-5(179) Evaluation of Test Methods for Permeability (Transport) and Development of Performance Guidelines for Durability
Web Link (Related Study): http://trid.trb.org/view/2012/P/1351328
Institution (Related Study): Purdue
Implemented By: Many DOTs

Evaluation of Methods for Characterizing Air Void Systems in Wisconsin Paving Concrete
Web Link: http://wisdotresearch.wi.gov/wp-content/uploads/03-16_FINAL.pdf
Institution: Michigan Technological University
Implemented By: ASTM (pending)

Internal Curing on Concrete Properties
Web Link: http://trid.trb.org/view/2015/M/1351069
Institution: Numerous
Implemented By: Many DOTs

ATTACHMENT B

University Centers of Excellence
August 2015

Sustainability

Sustainability Performance Metrics for Roadway Design and Construction
Web Link: http://www.ce.washington.edu/research/construction/greenroads.html
Institution: Washington State University
Implemented By: FHWA

An Integrative Framework to Study Carbon Emissions of Road Construction Projects
Web Link: http://www.construction.mtu.edu/cass_reports/webpage/plca_estimator.php
Institution: Michigan Technological University

Related Studies: Carbon Footprint for HMA and PCC Pavements
Web Link (Related Study):
http://www.michigan.gov/documents/mdot/MDOT_Research__Report_RC-1553_363800_7.pdf
Institution (Related Study): Michigan Technological University
Implemented By: FHWA, National Asphalt Pavements Association (NAPA)

University of Michigan's Center of Excellence for Concrete Pavement Performance (CPP)

Long Life Concrete Pavements-National and Michigan Perspective

Long life concrete pavements (LLCPs) are defined as pavement sections designed and built to last 40+ years without premature construction and materials related distress with minimal pavement repair activities for restoration of ride quality and lower life cycle and user delay costs. In the past, concrete pavements were routinely designed and constructed for a 20- to 25-year service life. Concrete pavements deteriorate over time due to a combination of traffic, environmental loading, and material degradation. Pavement performance is controlled by numerous factors (more than 30), which individually can become the "weakest link" causing premature failure. To achieve such improvement in performance necessitates a much better understanding of the many factors which affect distress development over the pavement's service life.

The major distress types in concrete pavements are: cracking, faulting of cracks and joints (i.e. permanent offset between surfaces), spalling (i.e. dislocation of parts of the concrete) and concrete materials related deterioration, such as frost related damage from deicer salt and freeze-thaw cycles in a wet-freeze climate such as Michigan. The challenge is to keep the individual distresses below established threshold values. Due to these many factors, pavement design for handling truck traffic, drainage, varying subgrade conditions, and environmental conditions (climate) have developed empirically and somewhat differ from state–to-state based on field experience collected from extensive forensic evaluations. The construction practices and environment during construction have a significant effect on long-term pavement performance (e.g. paving during dry, hot condition leading to built-in curling or permanent warping versus paving with extensive curing/shading such as is done in Germany).

ATTACHMENT B

University Centers of Excellence
August 2015

The Federal Highway Administration (FHWA) provided in 2012 a major new pavement design and analysis program to DOT's and industry consultants known as AASHTO-ware Pavement ME Design, which was more than 10 years in development at a cost of over $10 million. The main aim of this effort was to provide a better theory-based design to capture the sophisticated input data on traffic load spectra, climate, materials, etc. that affect pavement performance. This advanced approach intends to quantify the impact of each of the many design parameters on the likelihood of a certain type of distress (e.g. cracking, joint faulting, road roughness, etc.) versus accumulated traffic loading over time. While calibrated for national conditions using the Long-Term Pavement Performance (LTPP) sections, the Pavement ME Design software better serves state needs when calibrated for local factors in order to be able to predict with high confidence pavement performance (i.e. relationship between response and distress) over time and traffic applications. This is currently underway in Michigan and elsewhere. It is a major undertaking and pavement and materials experts at Michigan State University have completed this work.

With the Pavement ME as a major tool for pavement performance prediction, many states are starting to understand how their local climate conditions and materials can be integrated into more reliable pavement designs. As California has a very arid climate that leads to warping, the use of shorter slabs can be accommodated in pavement performance predictions using Pavement ME. Likewise, the use of larger diameter dowels, widened lanes, high-performance concrete, and other factors can and have been used to better understand the likely pavement performance impacts the design may have. The use of Pavement ME can also give pavement engineers a better feel for scenarios where the AASHTO 1993 method may have led to overdesign of the PCC thickness.

It is too early to provide an assessment of the field performance for current LLCP's projects in neighboring states such as Minnesota since their program (year 2000) for high performance concrete pavements with a 60-year design life has not reached sufficient age to make recommendations for adaptation by MDOT. However, their use of best practices in material, design, and construction tolerances to better ensure long-term performance is one that is adoptable.

A joint MDOT-University of Michigan forensic investigation is planned for FY 2016 with the main objective to evaluate the performance to date of the Michigan Aggregate Test Road located on US-23 in Monroe County. Constructed in 1992 with a 20-year design life, the 6 mile project has performed well, only requiring minor preventive maintenance (in year 2013), primarily in one of the 5 different test sections, which developed premature materials related distress (cracking) within years 1 and 2 after construction. This project can provide valuable information on the design, materials and construction factors for LLCP requirements for Michigan's severe traffic loading and environmental conditions.

ATTACHMENT C

National Pavement Experts' Input on 50-Year Pavements
August 2015

Dr. David Timm, P.E., Auburn University
- Concurred with MDOT's initial enhancements to acceptance specifications, material requirements and construction requirements for both a 30 and 50 year pavement design.
- Suggested reduced Recylced Asphalt Pavements (RAP) in the HMA base course if trying to achieve fatigue resistant mixture; **MDOT incorporated suggestion reducing allowance of RAP from Tier 2 (18-27%) to Tier 1 (0-17%) allowance for 30 year design and from Tier 1(0-17%) to no allowance in base course for 50 year design.**
- Suggested not using 100% reliability in mechanistic empirical design methodology; **MDOT reduced the reliability to 99%.**

Dr. Tom Van Dam, P.E., Nichols Consulting Engineers
- Concurred with MDOT's initial enhancements to acceptance specifications, material requirements and construction requirements for both a 30 and 50 year pavement design.
- Suggested using Rapid chloride Permeability testing with a limit between 1000 and 1500 Coulombs rather than resistivity as the resistivity requirements have not been finalized at this point; **MDOT incorporated Rapid Chloride Permeability requirements at 1200 Coulombs.**
- Suggested using 99% reliability instead of 100% reliability in mechanistic empirical design methodology but; **MDOT reduced the reliability to 99%.**
- Suggested using corrosion resistant steel for 50 year pavement design; **MDOT incorporated this requirement.**

Dr. Robert Rasmussen, P.E., The Transtec Group
- Concurred with MDOT's initial enhancements to acceptance specifications, material requirements and construction requirements for both a 30 and 50 year pavement design.
- Suggested additional binder testing requirements such as MSCR and checking for recycled engine oil bottoms; **MDOT incorporated both of these generally as specifics need to be looked into to determine specification requirements.**
- Suggested limiting recycled asphalt shingles in addition to recycled asphalt pavement; **MDOT incorporated same the same restrictions for both recycled products.**
- Suggested better bond coat and testing requirements; **MDOT incorporated general requirements with specifics to be determined**
- Suggested control of total cement and supplementary cementitious materials, **MDOT incorporated and set the value at 3lbs/yd^3**
- Suggested well-graded/optimized concrete mixture; **MDOT current specifications require this.**
- Suggested aggregate requirement for low coefficient of thermal expansion; **MDOT incorporated pre-stressed aggregate quality as a requirement.**

ATTACHMENT D

Departments of Transportation and Other Transportation Partners' Input

NEW YORK STATE DOT

In general, for any long-term pavement design, it is expected that the long life applies to the structural ability of the pavement system, and that some sort of renewal treatment will be necessary for the riding surface. In 50 years, surface distresses and loss of friction will become unacceptable without any treatments.

A1. Our current policy for new and reconstructed pavement designs emphasize depth of granular sub-layers for strength and frost protection, and continuous edge drains for durability. Construction practice focuses on proper compaction of HMA as actually measured on the project, and for PCC pavement great care is taken with joint placement to ensure consistent slab sizes given the constraints placed by utility locations.

MDOT RESPONSE: MDOT has increased its depth requirements for strength and frost protection and requires the use of continuous underdrain systems for ling life pavements. MDOT has increased the compaction requirements for HMA and is increasing dowel bar alignment requirements for concrete pavements. MDOT will be removing all utilities from the road bed for the long life pavements.

A2. Proper maintenance and timely scheduling of topical treatments are the key to good pavement life. Cleaning drainage, sealing cracks, repairing joints, and timely surface treatments should be programmed well in advance to avoid deferring critical work.

MDOT RESPONSE: MDOT will be increasing maintenance of underdrains and will schedule CPM treatments to address crack sealing, joint repair, and surface treatment renewal for the long life pavements.

A3. Our current design life is 50 years, but as mentioned above that is only the structural design life of the pavement. We plan on a number of maintenance and minor rehabilitation treatments within that 50 years.

MDOT RESPONSE: MDOT will be performing either a 30 year or 50 year design life with planned maintenance.

THE IOWA DEPARTMENT OF TRANSPORTATION, Dr. Christopher Williams

The Iowa Department of Transportation has sponsored work associated with the below technologies developed by Iowa State University under Dr. Christopher Williams. These new technologies are at various stages of patent review:

- Bio asphalt derived from fast pyrolysis with one patent issued and a 2nd pending issue. A number of papers have been published on this set of technologies.
- Biopolymers, an alternative to butadiene (soft block) in styrene-butadiene block co-polymers, that is derived through radical polymerization processes of triglycerides. The leading patent is with atom transfer radical polymerization (ATRP) and Iowa State University (ISU) have

recently received notice of splitting this patent application into four separate patents. Their second application on this technology is with reversible addition fragmentation atom transfer and can be split into multiple patents like the ATRP application. These polymers are used in a wide variety of applications ranging from use in infrastructure materials (modifying asphalt as well as PCC), to use as adhesives, in paints/coatings, tires, shoes, etc. A few papers have been published on these technologies.

- A material (polymer) derived from glycerol that is a compatibilizer/stabilizer for use in ground tire rubber modified asphalt. The polymers are water soluble and can be used as viscosity modifiers for use in soil amendment, capping/sealing gas and oil well heads, etc. ISU currently can treat the polymers with a material for 3 cents/pound and convert them to being non-water soluble. They have a provisional patent under review and it will likely get split into multiple patents when it is converted.
- Iowa State University has also developed a series of bio-based materials that are warm mix asphalt technologies and is in the process of updating a provisional patent that will likely get split into two different patents.
- ISU has developed a bio-based flux which can be blended with really hard asphalt like vacuum tower bottoms. This disclosure is about to be submitted as a provisional patent.
- ISU also developed a hard block polymer, an alternative to styrene, for use in block co-polymers analogous to the biopolymer noted above.

<u>Pavement/Pavement Materials Innovations</u>

Sources TRB/NCHRP:

1) Precast Concrete Pavement Systems:
   - Modular panels that are cast and cured elsewhere, then assembled onsite when traffic volume is low, reduce traffic congestion and offer many other advantages over traditional cast-in-place construction in high-density urban areas.
   - Modular panels make the construction process safer and more efficient because roadwork can be completed overnight, on weekends and during off peak hours, reducing the need for roadway closures.
   - Because they are precast, panels can be subject to higher quality control standards during fabrication. This results in greater durability, so roads last longer before needing replacement or costly repairs. Precast panels can also be cast thinner, so they are ideal for roadways underneath overpasses with limited clearance heights.
2) The Aggregate Imaging System (AIMS):
   - NCHRP Report 555 recommended the Pine Instrument's AIMS research prototype. This study was developed in collaboration with NCHRP's IDEA (Innovations Deserving Exploratory Analysis) program and FHWA.
   - Researchers tested an AIMS prototype at the Texas Department of Transportation and FHWA's mobile asphalt materials testing laboratory.
   - Under a Federal Highway Administration grant 32 laboratories, most at state highway agencies are testing AIMS which automates the process of measuring aggregate characteristics that affect pavement durability and safety.
   - The lab tests are part of a Technology Partnerships project to refine the prototype and make it a marketable product. The Technology Partnerships Program, part of the

Highways for LIFE initiative, provides funds to private industry to test promising technologies that enhance highway quality and safety or cut construction congestion.
- The planned outcome is an industry tool capable of accurately and rapidly measuring aggregate shape characteristics. Such a tool would offer an automated method of qualifying aggregate shape properties and surface texture to meet specifications, ensure good pavement performance and enhance roadway safety. The ultimate goal is to develop a commercially available product.

3) Blended Aggregates for Concrete Mixture Optimization:
   - FHWA-HIF-15-019 July 2015 Tech Brief
   - The combined grading of aggregates used in concrete mixtures for paving applications can have a direct impact on workability, and indirectly on mixture performance. The measurement of what comprises a good combined gradation is the topic of this tech brief.
   - A best practice for Jointed Concrete Pavements
4) Thin Asphalt Concrete Overlays:
   - NCHRP Synthesis 464 published in 2014.
   - Authors from NCAT.
   - Thin asphalt overlays are extremely useful as a routine maintenance/pavement preservation tool.
   - The thin layers allow pavement managers to overlay more lane-miles with the same tonnage.
   - Thin overlays are often shown to have lower life-cycle costs than do other types of pavement preservation treatments.
5) Pavement Patching Practices:
   - NCHRP Synthesis 463 published in 2014.
   - Authors from multiple consultants and universities.
   - This synthesis summarizes current practices for patching both concrete and asphalt pavements.
   - Both reactive and planned patching are addressed.
   - This synthesis covers management or administrative issues, materials, methods, equipment, specifications and tests, traffic control, and other aspects of patching operations.
6) AASHTO-Ware Pavement ME Design:
   - FHWA product developed in 2012
   - A new pavement design and analysis program to DOT's and industry consultants.
   - This new pavement design and analysis software provides a better theory-based design to capture the sophisticated input data on traffic load spectra, climate, materials, etc. that affect pavement performance.
   - The Pavement ME Design software better serves state needs when calibrated for local factors in order to be able to predict with high confidence pavement performance (i.e. relationship between response and distress) over time and traffic applications. This work was completed in 2015 for Michigan pavements and was a major undertaking by experts at Michigan State University.
   - MDOT launched its implementation of the Mechanistic-Empirical Pavement Design Guide (ME-PDG) which includes the use of the Pavement ME Design software in 2015.

7) National Center for Asphalt Technology (A NCAT/MnROAD Partnership):
   - This innovation/implementation effort will fund new research at the MnROAD Facility relating to pavement preservation performance and the development of a national Hot Mix Asphalt crack performance test.
   - The research will help develop a better understanding nationally of the life extending benefits of pavement preservation techniques.
   - The research will also develop an asphalt cracking test to help engineers better understand how pavement performance is affected by the use of recycled material (RAP), binder modification options, additives, warm/conven

COUNTY ROAD ASSOCIATON (CRA)

Submitted by Steven M. Puuri, Engineering Specialist

The County Road Association has solicited input from our members on the innovative practices the Counties have successfully incorporated in their construction and preventative maintenances practices which could be considered in your "50 Year Pavement" and innovative practice report. Additionally, the County Road Association (CRA) and our county members have been actively participating in the Michigan Transportation Asset Management Council (TAMC) pavement evaluation and preventative maintenance strategies which has proven to be a tremendous collaborative statewide effort to increase the understanding of pavement preservation.

It is clear from the TAMC analysis that the vast majority of the federal-aid road pavement conditions in Michigan are in fair (45%) to poor (38%) condition; and recent evaluations demonstrate the pavement conditions are deteriorating. When you focus on the local agency road system the pavement conditions are worse than the state trunklines; local agency pavement conditions are in fair (39%) to poor (47%) condition and degrading at a more rapid rate. The question should be "Why are the pavements in such bad condition and what do we need to do to address our abysmal road conditions?"

Instead we are being asked how we can develop a "50 Year Pavement". This is a wonderful goal to strive for as road agencies, we defer to the pavement researchers to offer innovative research studies to consider for Michigan. However, it is CRA's belief that the current condition and degradation trend in Michigan is not due to a lack of innovative ideas, it is due to decades of inadequate funding. If the appropriate funding was maintained over the past 30 years, the appropriate preventative maintenance strategies would have been performed at the appropriate time, such that the pavement life cycle could have been extended to nearly 50 years.

To bolster this assertion, we suggest that MDOT's report review the local agency reconstruction and preventative maintenance projects performed each year. The CRA contends that the vast majority of these projects involve preventative maintenance (not total reconstruction); these projects typically resurface a road that has been in place for over 20 years. Therefore, the local agency has determined that a preventative maintenance project is required to provide 10 to 20 more years of service life (which is approaching 50 years of life). These projects do not often require

road base and drainage system Reconstruction due to degraded condition, therefore the road base and drainage often exceeds 50 years of life.

In summary the CRA supports the quest for "50 Year Pavements" as a great goal, however we suggest that MDOT bring attention to the needs for timely preventative maintenance in order to realize this goal. Additionally, the current pavement conditions on the local road agency network require immediate investment. We support any initiatives to extend the new pavement project life expectancy and we support increased investment to preserve the pavement conditions before we see our roads in fair condition degrade to poor condition which requires four to five times the investment.

The following comments are provided by our County Road Association members:

Comments from Ingham County

There isn't any silver bullet in the road engineer's tool box. Road engineers are half way through our second century evaluating what works and what doesn't. It boils down to depth of the pavement section (clay grade through wearing surface) and quality of said materials! Comments from the asphalt and concrete pavement industries will confirm that hypothesis.

We can continue to get 15 to 25 years of service life working with in situ road materials at $30 per sq. yd. or spend $150 per sq. yd. to totally rebuild our roads for 50 year service life.

Comment from Houghton County Road Commission

We have seen some positive results from using geogrids to stabilize the road base.

Comments from Dickenson County Road Commission

1. Recycle in place (saves time, materials, energy)
2. Ground rubber modified asphalt (proposed improve performance)
3. Polypropylene fiber mix pavements (proposed to control cracking, shoving & rutting)
4. Fabric interlayer between courses (proposed to control reflective cracking, rutting & shoving)
5. Early application of Preventative Maintenance (chip seal or slurry seal at 1-2 years)
6. Open graded drainage course bases.

Comments from Charlevoix County Road Commission:

Submitted by Keith Ogden, Commissioner

This is response is directed toward your recent request to provide information that would enhance roadway longevity, specifically directed toward MDOT's 50 year road concept.

We, here at the Charlevoix County Road Commission have recent and helpful experience that we are happy to share with you. Gravel roads are outside the scope of the analysis, which leaves hard surface roads of either asphalt or concrete. Since most of our roads in the county are asphalt, they will be discussed first.

ATTACHMENT D

Departments of Transportation and Other Transportation Partners' Input

Some 25 years ago, and under a previous Board and manager, our standards for new pavement over gravel were a 6" gravel base and a 2" thick single course of asphalt, 20' wide. Failures developed quickly, beginning in the first 6 or 8 years and included break offs, longitudinal stress cracks in the wheel tracks and longitudinal center joint separation. By increasing our requirements and standards to 8" of gravel base, 3" of two course asphalt, 22' wide (local) and 24' wide (primary) nearly doubled longevity. However, even with the newer requirements, we still experienced edge break offs (not as frequent as before) and some wheel track stress cracking (again, not as frequent as before). Where our current county wide road millage is funding a pavement reconstruction project (always on a well travelled road) our standards are now 4" of asphalt, in most areas, with a 26' or 28' width.

A look at the details may be appropriate at this time. Since our roads are "open ditch" type (no curbs) we rely on gravel shoulders, and herein lies one of our greatest problems. Gravel shoulders erode both from wind and water runoff, leaving an exposed pavement edge (and drop-off) that invites liability. Gravel shoulders also create another problem often overlooked; saturation under the pavement edge. When water (often mixed with diluted chloride) runs off the roadway, it saturates the shoulders as well as a limited distance under the pavement edge. Now comes our plow truck cleaning snow from the shoulder (a necessary operation to ensure visibility, keeping the snow banks form drifting onto the roadway and providing a safety pull off area) and by the very nature of our maintenance, are running on that saturated pavement edge, which being inadequately supported with dry compacted material, breaks off. This happens frequently during spring and fall when snow accumulates, but temperatures are not cold enough to "tighten" the affected edge area. In other words, our own trucks are damaging the very roads we are charged with keeping in good condition.

So, what to do? Dur1ng the fall and early winter, before snow depths are significant, our drivers try to stay on the pavement and avoid the edge. Where affordable, during new construction we are paving the shoulders right out to the grass (which means there is no gravel shoulder). On an experimental basis, we placed Afton stone shoulders on one recent project.

Afton stone is 100% pure limestone (we had It analyzed) crushed to our granular shoulder specification. It seems to form a weak molecular bond with water (imagine real weak concrete) and is much more resistant to abrasion than regular 23A (at least until it gets absolutely saturated). Afton stone is a local product, perhaps unavailable elsewhere in the state, but anywhere pure limestone is found should be a source that would work as well. These previously mentioned shoulder treatments have reduced our return maintenance costs (although our traditional under funding has not allowed us to keep detailed records of savings).

Any discussion of edge failures should also include intersection overruns, of which we are painfully familiar. Many years ago, we were accepting a 25 or 30 foot radius as adequate. Now, we use as much of the right-of-way as we can, which allows a radius of some 50 or 55 feet. When we have the money, we also curb those radii with concrete. Our tapers going into an intersection radius have been increased to as much as 225 feet on our bigger projects. Each of the intersection improvements listed have contributed in their own way to reducing return maintenance costs, as

well as longevity. We no longer experience deep ruts adjacent to the radius, or edge crumbling, both of which create historical liability.

Another small improvement Charlevoix County has generated in roadway surface design is percent of grade (sometimes called "stope"). While most counties require a 2"centerline to pavement edge slope on their asphalt surface, both Oakland County and Charlevoix County requires 2"· The extra slope moves water a little quicker (and the slope design lasts longer into the future) when you consider that a slope gets "beat" down to something less as time goes on, to where water pockets lying on the roadway are commonplace.

The foregoing analysis focused mainly on new construction methods. We have also had very good luck with a rehabilitation procedure that extends life of an existing roadway an additional 8 to 12 years (and maybe longer) depending on the condition and width of the original asphalt surface. Where an old asphalt roadway was constructed 20 feet wide, we wedge each outer edge a foot or more with an inch and a half or two of new asphalt, over lapping the old pavement to the centerline. Final treatment is a uniform 1 ½" full width asphalt overlay. Included is the placement of new 23A gravel shoulders to match the new pavement edge. The simple overlay (at 1 ½") or the wedge and overlay as described have been our most successful programs these past 20 years. Nearly all of those projects were township funded, and have extended the roadway life significantly. On some of our more recent projects, we have increased the wedge to a little more than 2", and we anticipate life expectancy could last more than the 8 to 12 years stated above.

Any discussion about asphalt pavement longevity should include a look at the material itself. In the old days, the 411 mix (subsequently 1100 and finally number 11 - not necessarily in that order) was a good mix, resilient and forgiving - but tended a little toward premature rutting in the wheel tracks. Many agencies turned to 13A as an "improvement• (which It wasn't). 13A was a stiff, brittle mix that tended to crack transversely after about the 5"' year, especially after a few summers of oxidation and a few cold winters or "thermal cracking", those cracks (on some of our roads every 50 feet or so) are unsightly but so far not dangerous. An asphalt overlay is not the answer to covering the cracks (reflectivity is sure to follow). Total reconstruction is the only answer, but that expense does not contribute to a 50 year life cycle.

Our current use of 4E1 modified mix will (hopefully) be the asphalt of long term durability. For rural Northern Michigan roads that suffer through the freeze-thaw cycle, are often located over less than optimum soil conditions, and quite often paid for "by others" (think townships), asphalt is probably the best choice of surface types, from the standpoint of engineering economics. To summarize asphalt, the materials that go into constructing an asphalt roadway - the sand subbase, the gravel base, the mix design - are probably currently fixed at their maximum efficiency; there isn't going to be much room to improve materials. To Increase longevity will require improving design parameters. More of this, and more of that thicker, wider pavement, wider Intersections, thicker base, better drainage, more paved shoulders, curbs as necessary, and some unmentioned improvements in geometrics. If all those requirements are met, will a road last 50 years? Not without some sort of maintenance. An inch and a half overlay a time or two in 50 years might make it to the 50 year mark, assuming the initial construction was a little "overdesigned" for the

anticipated type and volume of traffic, and the weather and soil type were cooperative. There would still be a need for ditch clean out, shoulder grading (where not paved), mowing, and of course snow removal during those 50 years. Not to mention capacity increases to match future development and growth.

A note about roads with concrete surfaces: except for a couple "hand-me-down" concrete roadways (ex-state trunk lines) Charlevoix County's hard surface roads are all asphalt, with average daily traffic counts less than 4,000. However, this writer has extensive experience with concrete roads (a retired fleet manager with years of design, construction and maintenance experience with the Oakland County Road Commission). Concrete roadways do one thing very well, that is to resist rutting in the wheel tracks. Concrete roads typically designed some years ago with their multitude of longitudinal and transverse joints seem to do their job pretty well for the first 10 or 15 years. After that, joint failure (spalling and heaving) become endemic. Slab movement, tilting and cracking, and in some cases exploding (I can remember many of those hot summer days of "blow·-ups") create an immediate need for prompt and expensive repairs. Extremely heavy traffic, something say above 20,000 can a day, may require the surface durability that concrete offers. However, concrete design should consider European models of continuous reinforcement with no joints, with a depth and width (as well as mix designs) that would preclude typical surface failures found on so many Michigan freeways. Here, the 50 year goal could possibly be met, but at great initial expense. Contractors should be pleased with the idea.

When we think about building roads that last 50 years we are somewhat chained to the past. We rely on our past experience ("hindsight"), what we did or maybe what we should have done. But what about future demands? What about future technology as of today yet unknown? Consider that driverless cars have entered the conversation. We don't have a clear map of the road ahead. Technology that is on, or just over, the horizon could affect roadway design. Let's contemplate possible sensors or controllers that could be located within the roadway; sensors that could keep drivers from drifting into the opposite lane, or devices that could charge electric cars as they travel. For years, Oakland County, for example, has relied on roadway sensors to alert the dispatch office when the bridge decks reached a critical temperature before freezing. The possible innovations we can't foresee are limitless and could all affect roadway design. When preparing for a 50 year life expectancy, anticipating the future (as best we can) is a must.

The Board and the Manager here at the Charlevoix County Road Commission are very supportive of methods and programs to extend road longevity. Longevity has been in the forefront of our talks with our townships, of which 11 of the 15 have some sort of road millage. But, in many cases, the townships have been unreceptive to higher standards. Their explanation is simple enough: during these past years of statewide underfunding, the townships have had to pay all the construction costs. Many of the "old time" township board members recall our old specifications and say "If It was good enough then, why isn't it good enough now?" And by building substandard roads at a reduced cost allowed more money to be spent throughout the townships, which had the appearance of doing more for the people. When the roads fell apart, blame could always be shifted to the road commission, and in some cases rightfully so. With the advent of new money coming our way in the future, the road commission will have the opportunity to re-introduce our township

cost sharing policy (discontinued some years ago) whereby the road commission would pay for the extra inch of asphalt, or extra couple feet of pavement. When that old policy was in effect, the townships were happy to see the better roads resultant. I think you could draw a subtle inference from our experience, and that is education. If you Increase design standards to where increased costs are patently obvious, there should be an explanation of the benefits that will accrue. In other words, people throughout the state, regardless of whose jurisdiction, should somehow be informed that the extra expense is justified in the long run. Education should go hand in hand with the reasons for a 50 year road life.

So, in a sense, we are back to where we started. We can best build for the future with what we know today. All In all, if 50 years a ago, road agencies had been building roads for a 50 year life span, our transportation system would be all the better for it today. It is still an honorable and poignant goal worth striving for.

Our experience here tells us that the single most important aspect to reach that 50 year goal will be to improve roadway design. And we can't forget that design will differ throughout the state, depending on area, temperature and soil differences, traffic volumes and functional classification to name a few. One size won't fit alt. All the players will have to "climb aboard" and that includes MDOT working with the counties, the counties working with the townships, and all of us working with the people. It will be quite a ride!

AMERICAN COUNCIL OF ENGINEERING COMPANIES OF MICHIGAN (ACEC)

The American Council of Engineering Companies (ACEC) of Michigan understands the public's desire for having roads that last longer, perform better and are safe and efficient. We understand why this is also important to our political leaders. Building roads that last longer at the lowest cost possible over the life of the road is in everyone's best interest. ACEC works closely with MDOT on a daily basis and our members regularly share new technology and innovations in highway design. The private sector is an excellent environment for the development of tools and techniques to improve the quality and durability of our transportation system.

In Michigan, many new processes and designs are being used and tested - from carbon fiber reinforcement in bridges to warm mix asphalt pavements. ACEC believes Michigan is a leader in utilizing the best tool to improve the overall condition of our transportation system – asset management. This includes identifying the best initial design for the road, to applying preventative maintenance solutions at the correct times over the useful life of the road. This is one of the most important aspects of extending the life of a pavement and ultimately reducing the overall life cycle costs. Unfortunately, for years Michigan has not adequately funded its transportation system, causing a premature decline in pavement conditions. Engineers have often been forced to apply non-optimal fixes that only address short term safety issues, versus applying a fix that would greatly extend the life of a pavement.

ATTACHMENT D

Departments of Transportation and Other Transportation Partners' Input

One area of improvement that should be implemented is the use of a Qualifications Based Selection process for the procurement of engineering services at the local government level. Local government agencies often use a low bid process to hire engineering firms. This method is flawed in (at least) two fundamental ways: 1) It results in a non-optimal design, which leads to a more expensive road and 2) It forces companies to use the least qualified engineers and to provide the lowest effort in order to be selected for a project. Like state and federal agencies, local governments should be required to select their engineers based on qualifications, competence, and past experience. Fees should be negotiated only after the selected engineer has been able to develop a detailed scope of work with the owner which will ensure there is adequate time to develop a quality set of plans and specifications – that lead to the lowest cost roadway for a defined useful life. This process increases the opportunity for fewer project extras and overruns and fosters greater cooperation that can lower the overall life cycle costs for a project.

From and engineering perspective, the greatest opportunity for extending the life of pavements in Michigan is to: 1) improve the base for pavements and 2) make sure that the pavement has proper drainage. Michigan's climate produces multiple freeze-thaw cycles in the spring and fall which can cause damage to roads if large amounts of water are trapped in the materials below the pavement. Removing the water in pavement bases and subbases is critical to reducing damage to the pavement structure. Greater efforts up front in the design process to investigate the pavement sub-structure could result in a more uniform base. The use and thickness of free-draining base material and the use of engineered fabrics should be studied, as well as the design of the underdrain systems, to optimize the removal of water below the pavement.

Like any other structure, roads and bridges must receive regular maintenance and interim repairs in order to maximize their design life, and Michigan must make it a priority to properly fund this effort.

The American Council of Engineering Companies of Michigan is the voice of Michigan's engineering industry. Council members – numbering nearly 100 firms throughout the state employing over 6,000 people – are engaged in a wide range of engineering/architectural/surveying works that propel the state's economy, and enhance and safeguard Michigan's quality of life. These works allow people to drink clean water, enjoy a healthy life, take advantage of new technologies, and travel safely and efficiently. The Council's mission is to contribute to Michigan's prosperity and welfare by advancing the business interests of member firms.

MICHIGAN MUNICIPAL LEAGUE (MML)

Submitted by Daniel P. Gilmartin, Executive Director & CEO

The Michigan Municipal League appreciates the opportunity to contribute comments for the report required by the "Roads and Innovation Task Force". This is the task force that was created by recently passed legislation. We understand that this report will attempt to identify ways the department can build higher quality, longer lasting roads that will last at least 50 years. The report also aims to identify ways to build those roads at a reduced life-cycle cost and maximize the value to the taxpayer.

ATTACHMENT D

Departments of Transportation and Other Transportation Partners' Input

Over the last two years as the Legislature debated ways to increase funding for roads, the Michigan Municipal League has staunchly supported the need to invest new revenue into the transportation system. It was widely acknowledged that our infrastructure was in desperate need of repair and rapidly deteriorating due to the lack of proper investment over the past two decades. We believe that all road agencies need to be both efficient and innovative. We also firmly believe that investing the proper resources is the most important factor in building a road that will have both a long life-cycle and be cost efficient.

Michigan's Transportation Asset Management Council is a leader in asset management practices and we should take full advantage of their expertise. To fully realize the benefits of asset management we need to have the resources available that allow local road agencies to make the proper repair at the proper time. If we under invest there is no technology or innovative product that will protect the integrity of the system.

Study after study has shown that we need to invest significantly more in our transportation system than we do today. Making the proper investment coupled with asset management is a proven, cost efficient way to maintain our infrastructure. Without the proper investment the true benefits of asset management will never be realized.

Thank you for the opportunity to have the thought of the Michigan Municipal League included in this report.

ATTACHMENT E

Industry Associations' Input

KENTUCKY ASSOCIATION OF HIGHWAY CONTRACTORS

A1 & A2 - I'm not sure I could answer your question about # 1 or #2. It seems to be a big deep secret as to what they use.

A3 - Kentucky designs for a 40 year life and uses life cycle cost adjustments when and if they bid paving projects with alternatives between concrete and asphalt. Typically they bid only one or the other. I have been advised the DOT is moving to MEPDG, Mechanistic-Empirical Pavement Design Guide. Also called Pave ME. It replaces the current pavement design standard which is AASHTO 93'. I'm not sure I could answer your question about # 1 or #2. It seems to be a big deep secret as to what they use.

MDOT RESPONSE: MDOT will be increasing its design life to either 30 years or 50 years using MEPDG for the long life pavements.

ILLINOIS ROAD AND TRANSPORTATION BUILDERS

A1. IL uses Life Cycle Cost Assessment to select pavement type. Alternate bidding is used if the LCCA cost of pavement types is within 10%.

MDOT RESPONSE: MDOT uses LCCA as required by law including use on alternate bid projects.

A2. Implement proven technologies that have positive cost//benefit ratios.

MDOT RESPONSE: MDOT will be implementing new technologies and test methods where proven and appropriate.

A3. Pavement selection is based on a 45-year LCCA model.

MDOT RESPONSE: MDOT bases its LCCA analysis period on the service life of the various fix types; currently 25-34 years.

CONSTRUCTION INDUSTRIES OF MASSACHUSETTS

A1. Most of the effort is being made on the side of mix design –

- Reduce Gyratory Compaction Levels – from 100 to 65 – allows more asphalt into the mix which improves crack resistance and stripping. **MDOT did not reduce the gyratory compaction levels, it did field regress air voids to 3.0% in order to increase the asphalt content to improve crack resistance and stripping.**
- Reducing Air Voids from 4.0 to 3.5 also to allow for more asphalt in the mix. **MDOT field regressed air voids from 4.0% to 3.0%**
- Increasing the use of finer gradation mixes (better compaction, smoother ride, less porosity). **MDOT requires the use of fine gradation mixes for HMA top and leveling courses.**
- Checking the PG grade of asphalt cement to be sure it is proper for the area in which the HMA is being placed. **MDOT uses the Long Term Pavement Performance**

asphalt binder computer program to take into account different climatic zones within the state.

- Using Warm Mix Asphalt technology as a compaction aid. **MDOT permissively allows the use of Warm Mix Asphalt on all of it mixes.**
- Controlling the % of RAP used in surface mixes (unknown binder content and type). **MDOT controls the use of RAP in all of its HMA mixtures using a tiered approach to account for unknown binder properties of the RAP.**
- Making <u>all</u> Super Pave Mixes – warm mix asphalt (WMA). **MDOT allows the use of WMA on all of its Superpave mixtures.**
- Utilizing the reduced Ndesign levels for EASL's traffic loading. MDOT did not reduce Ndesign levels based on traffic loading. **MDOT uses the original Superpave Ndesign levels as the follow up research that was conducted by Dr. Prowell supports this decision.**

In the field -

- Improved use of Tack Coat application and grade (RS1-H) reduced tracking tack. **MDOT is in the process of improving its acceptance and testing methods to ensure proper bond coat is being used with additional application rate checks.**
- Special emphasis on longitudinal joint density and construction. **MDOT has a longitudinal joint density specification.**
- In Place density tests on the mat as well as mat temperature monitoring. **MDOT uses field cores for density testing and monitors mat temperature during construction.**
- Equipment (transfer machines) to reduce segregation and improve smoothness of ride. **MDOT will be requiring the use of a material transfer device on these long life pavements.**

Testing –

- Hamburg Wheel Test (rutting) **MDOT has not incorporated the use of the Hamburg Wheel Test for mix design approval.**
- IRI – (road smoothness) – a direct correlation to road longevity is the smoothness of the ride. **MDOT has increased the acceptable limits of IRI for these long life pavements.**
- Some form of Crack Resistance Testing (no one type has been approved – 6 are being utilized and compared) **MDOT has not implemented any of the proposed crack resistance testing. MDOT's warranty specifications have crack thresholds that guard against excessive cracking.**
- Field Core Borings – (density-compaction) **MDOT takes field cores for HMA density testing.**

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Industry Associations' Input

A2. NCHRP is currently ready to publish its research on a yearlong study of Mix Durability and Performance testing that should be published in October. This will provide a summary of what each State is undertaking to improve mix durability.

Design Life for a surface course in 10-12 years before being milled and overlaid. The top course is repaired but the remaining layers are intact.

The base and intermediate layers if properly installed should have service lives of 20 years or more.

To hit a service life of 50 years is certainly achievable and numerous old roads in the US that are still in good form are recognized each year by the Asphalt Pavement Alliance – Perpetual Pavement Awards.

The main issue is in building new roads will the DOT have the money to build a road with the proper thickness of asphalt to give you a 50 year expectation – 2" Binder and 1" Top won't make it.

National Asphalt Pavement Association has a tremendous amount of information on Perpetual Pavement design – Contact Audrey Copeland PhD, PE Audrey@asphaltpavement.org 301.731.4748 x 104

AGC OF NEW YORK STATE

From the NYSDOT Comprehensive Pavement Design Manual: Table 3-2 on Page 7 of the link https://www.dot.ny.gov/divisions/engineering/design/dqab/cpdm/repository/chapter3.pdf

COMPREHESIVE PAVEMENT DESIGN MANUAL, 11/15/2013, 3.2.1

Applicability for Minimum Service Life, Treatment Selection and Life Cycle Cost Analysis Table 3-2 provides the requirements for the minimum service lives, pavement evaluation, treatment selection, and life cycle cost analysis for all projects on the State System and all Federal Aid projects (regardless of jurisdiction).

New/Reconstruction Arterial pavement projects must include the consideration of two or more feasible treatments and a Life Cycle Cost Analysis (LCCA) to determine the best value design. Different pavement type designs will have different construction sequences, traffic control schemes, estimated initial costs, and future maintenance needs. Analysis of these differences and their current and future costs is necessary to arrive at the best value design choice.

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Industry Associations' Input

AGC OF TEXAS

TxDOT has allowed alternatives in a few projects, both design-bid-build and design-build, but mostly selects the pavement type. Currently, when alternate pavement types are allowed, the pavement design life is set for 30 years for both flexible and rigid.

The legislative action may be a reaction to cases where there was a premature pavement failure (PPF). PPFs can be due to design, materials, construction, and impacts outside of the normal parameters of the design such as traffic loads not expected or unpredictable weather or subgrade.

Under most pavement design process, it is cost prohibitive to design a pavement without allowing for some overlay and corrective work in the years before a full rehabilitation term. For longer term designs, the effect of the underlying subgrade and sub-pavements becomes a significant contributor to performance.

The assumptions an agency will include in the design process (potential vertical rise (PVR), subgrade stiffness, traffic and effect of road user delay in the calculations for repair, etc.) is critical to the design.

Long term pavement design is not the same as long term bridge design. There is a more straightforward relationship for the long term bridge design.

A1. The AGC of Texas membership is not supportive of including alternate pavement types in the plans and believes state designers have the tools to determine the pavement type on a case by cases basis.

A2. If you don't have enough funding, you have to do what you can to maintain the pavement. When you don't have the funding to fix the road the way it needs to be fixed, you are going to spend as little as possible to hold it together but you will be out there fixing it a lot more. So while you spend less cash, you have more exposure for workers, increased accidents, and you have more impact to the public's travel time. I am sure Michigan DOT, in conjunction with Michigan State's Pavement Preservation Center can tell you the funding needed to fix what they have and the cost to maintain it.

A3. Typically TxDOT uses 20 year for flexible and 30 year for rigid with allowances for corrective work in the interim (because it shows to be more cost effective in the design process).

MDOT RESPONSE: MDOT will be increasing its design life to either 30 years or 50 years using MEPDG.

MICHIGAN CONCRETE ASSOCIATION (MCA)

We have several sections of Concrete Pavement that were constructed in the late 1950's and early 1960's that are still in service today. There are also many other original Concrete Pavements still

serving as the base support in a composite pavement. Over the last 10 years we have partnered with the department in a concerted effort to improve the performance of newly constructed concrete pavements and to develop a concrete overlay program which extends the life of existing pavements.

The questions at hand are: 1. Can we invest a little more up front to build a more durable pavement and provide a 50% reduction in a 50-year life cycle present value? 2. As we rebuild our infrastructure, can we maintain the remainder of the system in better than poor condition with no loss of PASER scores within the plan's first 10 years. The answer given to the legislature was that this was not possible with the previous investment levels. The existing assets are too far degraded to achieve this goal.

What will it take to construct a concrete pavement that will achieve a 50% reduction in net present value 50-year life cycle cost compared to present practice? We have been partnering with MDOT to make several significant changes to the concrete specifications that research has proven will increase the durability/life of concrete. We are producing a more durable concrete pavement, but we cannot neglect the base structure that our pavements are constructed on. Michigan has benefited greatly from the foundations constructed during the original construction of the interstate system in the late 1950's and 1960's. Base support is a critical element that cannot be ignored or marginalized in the quest for a 50-year pavement.

MDOT and MCA are charter member of the National Concrete Consortium. This group made up of DOT's, Industry, FHWA and Academia was formed in 1996, initially including representatives from 10 Midwest states and now over 30 states participate. New concepts, products and best practices are brought to this expert group and promising ideas are vetted and implemented. It is much more rational and economical to vet products and ideas with partners than in a vacuum. This peer exchange has help Michigan trouble shoot problems and maintain a leading position in innovation.

Recent changes to the MDOT concrete specifications that have proven to improve performance include the following:

- Well graded aggregate mixes
- Reduced cementitious content requirements
- Use of Supplemental cements
- Use of Supplemental cements in year round construction
- Air content quality testing
- Use of wear resistant epoxy coating on load transfer dowels

We are currently working with MDOT in the development and implementation of new test procedures that will help us effectively control and monitor critical performance properties such as:

Initial field curing of strength samples – reduced testing variability

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Industry Associations' Input

- Concrete permeability testing – resistivity, a new property measure that more directly relates to long term durability than conventional testing
- Air system checks – Super Air Meter, measuring the quality of the air system in addition to the historic total volume measurement

We are working with the department to train contractor and inspection personnel such as:

- Construction Quality Partnership (CQP) - Agency and Industry training and certification
  - Loader stockpile operations
  - Plant certification
  - Testing
  - Concrete finishing
  - Curing practice and control
  - Best practice operations
- Quality Control/ Quality Assurance workshops – clearly defined responsibilities and processes to produce quality pavements
- Quality Control Planning – How to develop, accept and then communicate the plan to everyone involved in the process
- Concrete maintenance and repair seminars – Agency and Industry personnel are trained on best practices

Design elements that need to be considered in long term pavement construction:

- Drainage of the pavement subgrade – a critical first step in both design and construction practice
- Uniformity of the subgrade – actions must be built into each project to achieve this
- Non-structural chemical stabilization of the subgrade – a permanent cap or water barrier that protects and minimizes changes in support conditions over time
- Pavement sand subbase – a key reason highways built in the 50's and 60's are still in service today – this granular sand layer has proven to provide good value, but it is not accounted for nor credited to the design of the concrete pavement structure. We should continue to use sand subbase, but we need to include its value in the structure calculation
- Aggregate base drainage layer construction
  - Maximum and minimum thickness – 4 and 6 inch limits, recommended, respectively, for construction and performance considerations
  - Graded for stability and drainability – critical to maximize both conditions
  - Cement stabilization – should supplement a stable base and should not be relied on to stabilize an unstable base

New material showing some potential to enhance durability, these must be performance tested and compared to other products delivering similar enhancements for cost effectiveness:

- Type 1L limestone cements
- Densifying admixtures
- Fiber reinforcement
- Curing materials

We believe that by applying our newly adopted concrete specifications along with a renewed attention to the pavement base support, a 50-year concrete pavement is an attainable goal. This can be accomplished without a significant increase in current pavement costs.

Thank you for the opportunity to contribute to this discussion.

ASPHALT PAVEMENT ASSOCIATION OF MICHIGAN (APAM)

Submitted by A. John Becesy, P.E., Executive Director

On December 22, 2015, MDOT met with industry representatives to discuss the Roads Innovation Task Force created by Enrolled HB 4737. The main purpose of the meeting was to discuss the Report required by the legislation and to seek industry input for that report. Specifically, MDOT asked the industry to provide "industry innovative items or product details that can increase roadway performance". As requested, the Asphalt Pavement Association of Michigan (APAM) is pleased to offer the following information and suggestions.

First, it is important that the public and the Legislature are made aware of the many performance improvements that MDOT, in partnership with the asphalt industry, has already implemented. Some of the improvements are recent, others were done in the past. All of them illustrate MDOT and industry's commitment to continuous quality improvement with the goal of providing high quality pavements for Michigan's taxpayers. The first sections of this document discusses these performance improvements. Several suggestions for additional pavement performance enhancements are offered at the end.

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Industry Associations' Input

Recent Performance Improvements
The asphalt pavement industry has a long history of innovation. The Superpave system has been implemented, more sophisticated quality control methods have been developed, and improved construction techniques are being employed.

Over the last decade, increasing traffic combined with a severe environment and chronic underfunding has placed tremendous demands on Michigan's highway system. To help meet these challenges, the asphalt pavement industry continues to improve our products and processes through the use of new technology and specification improvements.

The Asphalt Pavement Association of Michigan works in partnership with MDOT to improve the performance of asphalt pavements through information sharing and specification reviews.

The following is a list of relatively recent changes made in asphalt mixture specifications /construction specifications / test methods to improve pavement performance:

Jan. 2015: Regress air voids to 3% on all mixes, E3 mixes require a 43 angularity on top courses. Air voids RQL set at 1.5%. Goal is to get more asphalt cement (AC) in mixes.

Jan. 2015: Only allow fine graded mixes on top and leveling courses. Goal is to increase durability of mixes.

10-11-13: Revisions to Longitudinal Joint Specification (FUSP 501(Y), dated 10-11-13). Added full lane removal, adjusted pay equations and other spec refinements.

2013: Changed to a softer design grade (-22 to -28) of asphalt cement for the Capital Preventive Maintenance Program (1 ½" overlays with or without milling). The goal is to improve the resistance to cracking.

12-18-12: Changed the polymer modified asphalt specification to be allowed to go into Tier II (reclaimed asphalt usage category). (12SP904 (A), 12-18-12)

11-05-12: Changed the allowable amount of reclaimed asphalt pavement (RAP) in surface and leveling course so there is a greater chance to be in Tier II. (12SP501 (G), 11-05-12)

2012: Revised MDOT's mix design practice by eliminating back calculating air voids from Nmax to Ndesign. Mixtures are now compacted to Ndesign to determine the actual air void level. This also resulted in an increase of about 0.10 % asphalt content. (spec book change)

2012: Eliminated back-calculated asphalt content for determining specification compliance. We are now using actual measured AC content. (Effective beginning of the 2012 paving season)

2012: Longitudinal Joint Specification. Full implementation in 2012. This has resulted in measurable improvements in joint density.

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09-27-11: Regressed air voids from 4.0 to 3.5%. The first projects were done in 2012. This has resulted in about 0.2% additional asphalt cement in these mixes. Regression has also resulted in an increase of in-place density of almost 1%. (PWL spec 12SP501 (U), 09-27-11)

09-27-11: Modified the allowable fines to effective asphalt cement ratio and implemented Quality Control /Quality Assurance monitoring and shutdown criteria. The goal is to prevent mixes from being brittle and crack susceptible. (PWL spec 12SP501 (U), 09-27-11)

6-01-11: Changed how the asphalt cement is selected for RAP mixtures in Tier II (18 % - 27 % RAP binder). We are now adjusting the cold temperature properties of the binder (bumping down) in Tier II. This has resulted in using "softer" binders. The goal is to improve durability by providing protection against low temperature cracking in the asphalt mix. (12SP501 (G), 6-01-11)

2009: Implementation of the Hot Mix Asphalt (HMA) laboratory quality systems program. All testing labs must meet program requirements including passing the annual HMA Round Robin Testing Program. This has improved the accuracy and consistency of both Quality Control and Quality Assurance testing and has significantly reduced the number of dispute resolution tests. Accurate tests are critical for determining specification compliance.

The asphalt industry is also using the following quality improvement tools in our paving and/or manufacturing processes:

- Screed Attachment/Extension for Joint Construction–Improves joint construction
- Intelligent Compaction Systems – Helps achieve uniform compaction
- Material Transfer Devices – Helps reduce segregation and increase smoothness
- Oscillatory Rollers – Helps achieve mat density
- Echelon Paving – Helps achieve joint density
- Warm Mix Asphalt – Compaction aid and emissions reduction

2015 HMA Peer Review Process – National Benchmarking for Best Practices

In August of 2015, MDOT and APAM embarked on a new quality initiative to ensure that Michigan asphalt procedures and asphalt pavements are of the highest quality in the nation. With this in mind, a Peer Review Team (PRT) of national experts was assembled to review MDOT Specifications, Production Practices and Field Procedures.

The objective of the initiative is to evaluate Michigan's current practices and benchmark them against regional and national best practices. The Peer Review Team was asked to offer suggestions for changes aimed at improving asphalt pavement performance. Ten focus areas were identified for the detailed review:

1. RAP and RAS Usage
2. Mix Design Practices

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3. Construction practices
4. Acceptance Specifications
5. Mixture Specifications
6. Input from the Field
7. Ride Quality
8. Warm mix Asphalt
9. Liquid Binder Testing and Certification
10. Fifty-Year Pavement

On January 8, 2016, the Peer Review Team (PRT) submitted their recommendations for quality improvement to the Department. The PRT recommendations are being reviewed by a joint MDOT /APAM committee. Those recommendations that are determined to be value- added changes leading to increase pavement performance and /or reduced future maintenance costs will be prioritized for further development and implementation.

It is anticipated that the implementation of Peer Review recommendations will lead to improved pavement performance.

Strengths of Michigan Hot Mix Asphalt (HMA) Program

Recently, APAM was made aware of a recent comparison of the MDOT Asphalt Pavement specifications/ procedures versus those of a neighboring state.

The following is a summary of the comparison:

Strengths of Michigan Specifications and Methods:

1. Dust to Effective asphalt binder content QC in production (with a suspension requirement)
2. Limited blend changes (10% total change; helps maintain a stable composite aggregate Gsb and aggregate consensus properties)
3. Round Robin lab qualification testing program (contractor and DOT/Agency Representative required to participate and meet certain requirements; both on the same page with each other)
4. Initial Production Lots (IPL's: validate that a mix can be produced to meet the specification requirements prior to allowing full production and address contractor and DOT/Agency Representative lab testing variances)
5. QC requirements for Gmm

6. Regression from 4% AV to 3% AV with asphalt binder (minimum 43 FAA for stability on low volume mixes)
7. Binder content QC and QA
8. Appropriate pay factor weighting for VMA and binder (VMA & Binder Content = 30%).
9. Joint density specification
10. Hard VMA floor at the design minimum in production
11. M/W Warranties
12. The process for obtaining Express Mix Design status
13. HMA Mix Designer certification

APAM believes that this confirms that MDOT specifications are already technically sound and provide very good performance when applied to properly selected pavement "fixes".

MDOT and Industry – A long history of partnering to improve pavement performance
Over the last 15 + years, the asphalt paving industry has worked in close partnership with MDOT to implement the following new technologies and programs that are focused on improving the performance of asphalt pavements:

Superpave-The Superpave (Superior Performing Asphalt Pavements) system was developed as part of the federal Strategic Highway Research Program. Superpave is a comprehensive system for the design of paving mixes that is tailored to the unique performance requirements dictated by the traffic, environment (climate), and structural section at a pavement site. Implementation began in 1998. MDOT is now specifying Superpave mixes for all of their roadways.

PWL specification (Percent within Limits) – is a statistical based system used to control mixture production and placement, and assure that the asphalt mixes produced have the uniform properties that are needed to provide excellent pavement performance. MDOT began using the PWL specification in 2005. The most recent specification update was completed by a joint MDOT / APAM committee in December 2014 and will be used on MDOT projects in 2015 and beyond.

Perpetual pavements are designed to eliminate "bottom up" fatigue cracking. Therefore, any pavement distress that occurs will be confined to the top surface layer where it can be easily managed with periodic milling and resurfacing. Since 2002, MDOT has constructed four perpetual pavement demonstration projects and is continuing to monitor their performance (all are meeting structural performance expectations). Many asphalt pavements around the county had been recognized as being perpetual pavements (even though they were not specifically designed as such when originally constructed). MDOT has received two Perpetual Pavement Awards. Both pavements were over 50 years old at the time and are still in service today.

ASCRL – Asphalt stabilized crack relief layers are designed to reduce the occurrence of reflective cracking and provide MDOT with a cost-effective alternative when overlaying existing concrete

pavements. MDOT began using ASCRL layers in 1999. Many rehabilitation projects have been built using this mixture. Performance experience has been very good.

Materials and Workmanship warranties – most MDOT asphalt paving projects contain either a 3 year or 5-year M& W warranty. These provide an additional level of assurance that the pavements meet the project specifications.

APAM Suggestions for Improving Pavement Performance

Fix Selection

MDOT is considered a national leader in the use of asset management and employs asset management principles for selecting cost effective 'fixes" for preserving and repairing pavements. However, due to budget constraints, the optimal repair may not always be feasible. This presents a dilemma because sometimes severely deteriorated roads must be "held together" until adequate funds are available to do a major rehabilitation or reconstruction. However, we think the department should strive to minimize the use of short term fixes on roads that are severely deteriorated and have reached the end of their service life. If that must be done, consider communicating the anticipated short service life to the public so they can have realistic expectations for how long the fix will last.

Project Scoping and Fix Selection

Place more emphasis / resources on preliminary engineering include FWD testing, pavement core analysis, underlying pavement condition analysis, etc. to allow a "more tailored" project -specific solution.

Composite pavements:

Adequately repair the existing deteriorated concrete prior to overlaying with HMA.
Consider using 2 courses of GGSP (SMA). This has been successfully done in other states (Virginia).

Consider the Saw and Seal technique used for managing the occurrence of reflective cracking and minimization of associated distress caused by reflective cracks. This was successfully done (mid 90's) on I-96, Lansing, near the Creyts Road bridge.

APAM Proposal to further improve the performance of Longitudinal Joints

Conduct field research project(s) to evaluate alternate methods to improve the performance of Longitudinal Joints.

Evaluate the performance of the following (vs. a "standard" control section):

1. Double tacking all joints.
2. Use a PG graded AC to seal the centerline after paving.
3. The use of a joint mastic on all surface course applications to ensure a tight, secure joint.
4. While milling the centerline rumble strip on M roads, apply a fog seal as well.

Identify several projects with different traffic volumes for field evaluation.

Other Suggestions:
Completely close roadways for rehabilitation/reconstruction where feasible. This would encourage the use of echelon paving and material transfer devices.

MICHIGAN AGGREGATE ASSOCIATION (MAA)

Submitted by Douglas E. Needham, P.E., President
The following comments are provided on behalf of the Michigan Aggregate Association, a statewide association that represents over 80 companies that are engaged in the production of crushed stone, sand, gravel, recycled aggregate and slag.

While we have not been able to find a new crushing process or a state of the art aggregate processing change, we do want to offer a few general comments that were received during the discussion with our membership.

1. Increase the roadway base layer to increase strength and improve drainability.
2. Make sure that all roadway drains are clear and free of obstructions.
3. Require that only concrete/HMA reclaimed from an MDOT spec'd roadway be allowed to be used on MDOT projects.
4. Make sure that proposed value engineering changes do not negatively impact the base material.
5. Place an increased level of importance on ensuring projects have adequate inspection.
6. Ensure that material that is used for roadway base meets current specifications.

While MAA certainly supports the need and desire to increase roadway life, we are concerned that certain innovations could lead to long-term material supply shortfalls. MAA encourages MDOT to work with the aggregate industry to ensure long term sustainability for any innovative idea that would deviate from current specifications and/or greatly increase certain aggregate usage. Thanks for the opportunity to provide comments.

Submitted by John Perry, EDW C. Levy Company
The Levy Group of Companies is an industry leader in marketing, processing, and distribution for a wide variety of high quality construction aggregates in eastern Michigan.
Our wide network of production and distribution locations allow us to competitively serve the market with blast furnace and steel furnace slag aggregates, natural occurring glacial sand and gravel, quarried calcium carbonate and dolomitic limestones, and quarried trap rock. Furthermore,

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Levy is also vertically integrated and engaged in the production of ready-mix concrete, asphalt and asphalt paving.

One of our key business values is to provide "Solutions for Your Environment". This value drives our companies to strive to become market leaders in the supply of quality construction aggregates, asphalt, concrete, and related construction services. To achieve this goal, we understand the importance to have technical expertise in each of our business units, and to be involved with our customers, including State and Local Agencies, in the search for a value creating solution.

This approach grants Levy a unique perspective on how to bring value to stakeholders by extending pavement life. Below, you will find a brief summary of our experts' views on how to achieve a 50-year pavement life.

Our collective view suggests there are five key elements to achieving a 50-year pavement life.

1. Stabilized Frost Resistant Subbase
2. Strong Drainable Base Course
3. Denser Concrete Pavements and Structures
4. Improved Pavement Design and Construction Practices
    - Concrete Pavements and Structures
    - Longer Lasting Asphalt Pavements
5. Strict Maintenance and Repair Practices

Stabilized Frost Resistant Subbase

a. A subbase precluding significant volume change upon freeze and thaw conditions is likely to lead to a more durable foundation and thus an improved lifespan. Stabilization of the subbase with lime or slag cement is utilized in other markets to achieve this desired result and should be considered in Michigan depending on the individual projects' soil conditions.

Strong Drainable Base Course

a. Increase the drainable base thickness to a total of 36 inches to further ensure a more stable foundation.

    i. Consider specifying for both concrete and asphalt pavement designs.

Denser Concrete Pavements & Structures

a. Utilization of slag cement in pavement and structure design to densify the concrete and mitigate the potential for ASR.
b. Utilization of Optimum Aggregate Gradation is an important factor to achieving quality concrete.
    i. Guard against onerous aggregate testing requirements at the concrete plant that defeat this objective including but not limited to LBW requirements.

c. Consider specifying concrete with an RCP (rapid chloride ion permeability) value of 1500 coulombs compared to today's view of 3000 coulombs.
   i. Specify a w/c ratio < .40– use slag cement and/or micro silica with a high range water reducer to achieve result.
d. Consider a specification for drying shrinkage values from today's view of .045% to .02%.
   i. Utilize shrinkage reducing admixtures.

Improved Pavement Design and Construction Practices

b. Improved Pavement Design
   i. With industry involvement via association groups, further evaluate premature pavement failures to determine root cause in an effort to develop improved design and repair practices.

   ii. Consider a two-lift pavement design utilizing asphalt and/or concrete
      1. When designing the primary section utilizing concrete, our suggestion is to design a dense concrete pavement with a 3-4" high friction asphalt overlay or two lifts of high friction SMA. Investing in a stronger foundation would increase the lifetime of the base and support system. The high friction asphalt would be replaced on a strict schedule based on condition- (estimated life span of high friction overlay 5-10 years or high friction SMA 10-15 years) - to minimize water infiltration while maintaining a smoother, safer and quieter ride.
      2. When designing the primary section utilizing asphalt, our suggestions are similar to the concrete design concept of utilizing a stable subgrade and strong drainable base.
      3. Also note, this same concept could be accomplished with full depth concrete pavement, utilizing a white topping as the high friction wear surface.

c. Concrete Pavements and Structures
   i. Consider specifying 14 ft. joint spacing for concrete pavements.
   ii. Study further the use of epoxy coated dowels and their contribution to joint failures in concrete pavements. Consider stainless steel dowels as an alternative.
   iii. Confirm with additional testing that the air void content is 5-8% after the concrete paver.
   iv. Control concrete curing rates to minimizing rapid curing and thus improve durability.

d. Longer Lasting Asphalt Pavements
   i. Reduce pavement stresses by using thicker asphalt pavement cross-sections.
   ii. Secure multiple lifts of asphalt mix with uniform applications of bond coat material.
   iii. Expand the usage of high friction renewable surface courses or high friction SMA.

iv. Increase the use of asphalt cement additives like polymers, antistrips, and chemical warm mix additives.
v. Continue improvements on asphalt longitudinal joints. When possible, consider paving in tandem to eliminate the centerline joint.

e. Continue studying the chemical reactions taking place in the concrete and/or asphalt as a result of using admixtures, asphalt cement additives and chloride additions in the winter on the pavements.

Maintenance Practices

a. Adhering to a stricter schedule for maintenance and repair will mitigate subbase and base failure that triggers the high cost and public inconvenience of total replacement.
b. Joint and crack repair as well as joint sealing should be done on an annual basis.
c. Planned rehabilitation of the pavement at set intervals during the pavement life.
   i. Schedule developed based on inspection and historical data on pavement lifecycles.
d. Maintain proper drainage throughout the life of the pavement by routinely cleaning edge drains.
e. Set appropriate expectations for the public in terms of the life cycle for the mill and fill maintenance process.

The Levy technical team responsible for developing this brief summary is available at your convenience to review questions and discuss in further detail.

Thank you for the opportunity to offer our five elements on the journey to developing a 50 year pavement.

MICHIGAN INFRASTRUCTURE TRANSPORTATION ASSOCIATION (MITA)

Submitted by Glenn J. Bukoski, P.E., Vice President of Engineering Services

At the request of the Michigan Roads Innovation Task Force, we solicited our full MITA membership asking them to submit their ideas on innovative materials, products, methods and processes that have the construction potential to result in roads and bridges that are high quality with extended service life at reduces maintenance costs.
In response to our solicitation we received four member submittals that we will be forward to you for the Task Force's consideration. Each of our four submittals will be a forwarded email with "MITA Innovative Idea Submittal No. 1 thru 5" in the subject line.
We understand that the Task Force will review and consider each of the submittals and based on their determination, may or may not include the submitted idea in the draft report.
Outside the review and consideration context of the Task Force, we are requesting that all four of our submittals be forwarded to the appropriate MDOT staff who today have responsibility for facilitating the collection, review, acceptance, and implementation of new ideas. All of the

innovative ideas we are submitting have been vetted, accepted, and now being used by other DOTs around the country.

If, as an industry, our goal is to be smarter about how we are spending money so roads and bridges are high quality, have long service lives, and are cheaper to maintain we need to have a process in place for the timely vetting and implementation of new ideas and products. We would very much look forward to working with you in a collaborative effort to define, develop, and implement a dynamic and timely "new material process".

Thank you for the opportunity to submit our member innovative ideas for consideration.

Roads Innovation Task Force Solicits MITA "Innovation Ideas" **1-4-16**

Roads Innovation Task Force Solicits MITA "Innovation Ideas"

As part of their effort to prepare the comprehensive report required by enrolled House Bill No. 4737, MDOT's Roads Innovation Task Force is soliciting industry input on innovative materials, products, methods and processes that have the construction potential to result in Michigan roads and bridges that are high quality with extended service life at reduced maintenance costs.

Ideas submitted shall NOT incorporate or reference plans or suggestions regarding bonding, refinancing or financing innovations.

If you have an innovative idea you would like to submit, please respond to this email bulletin with sufficient information about the idea and any supporting documentation. MITA will compile the innovative ideas submitted and will forward them to the Roads Innovation Task Force for their consideration and potential inclusion in the report.

The submittal deadline for your innovative ideas is Wednesday, January 13, 2016.

If you have any questions about this solicitation, please contact Mike Nystrom (Executive Vice President) at mikenystrom@mi-ita.com, Lance Binoniemi (VP of Government Relations) atlancebinoniemi@mi-ita.com, or Glenn Bukoski (VP of Engineering Services) at glennbukoski@mi-ita.com. They can all be reached at 517-347-8336.

Submitted by James H. Cassel, Technical Sales Engineer, EJ

On behalf of EJ (formerly East Jordan Iron Works), I would like to express my gratitude to the Michigan Infrastructure & Transportation Association (MITA) for reaching out to the industry, to solicit ideas, that will improve the roadways and bridges in this great State of Michigan. This is an incredible initiative to tap one our state's greatest resources, the people that call Michigan home. As a family owned, Michigan based company since 1883, the story of Michigan's roadways and our company could not be written without one another. We at EJ are committed to playing a significant role in the advancement and improvement of our infrastructure. EJ continuously strives to be the leading manufacturer in the industry of American made access solutions and water distribution products. Feeding that success is an unwavering commitment to develop, produce,

and bring to market innovative products. Two of those products are presented for review in this submission.

The EJ SELFLEVEL casting is a highly engineered product that is targeted at extending the life of the roadway and improving ride quality. The SELFLEVEL casting is produced for both asphalt and concrete paving surfaces (See Figures 1and 2).

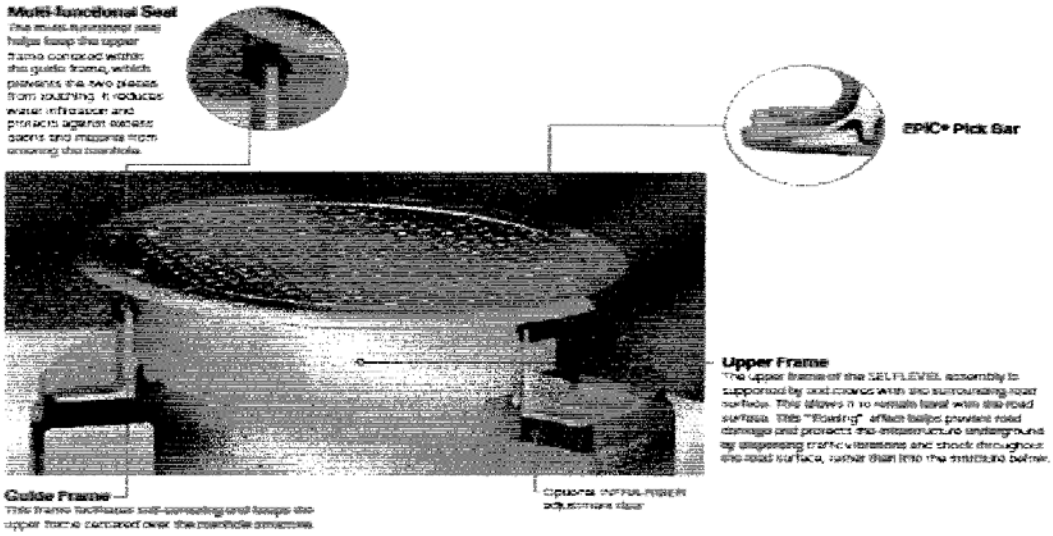


Figure 1

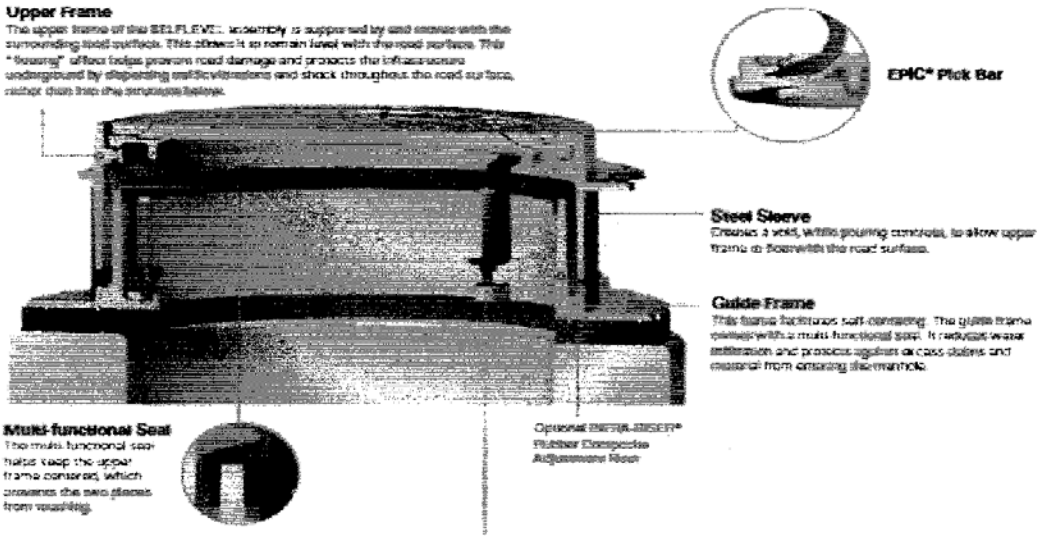


Figure 2

ATTACHMENT E

Industry Associations' Input

The second innovative product being offered with this submission is the EJ Antenna Cover. This cover is intended to provide a solution for wireless communication. Specifically, this cover can be utilized with the Smart Highway and other communication initiatives and will provide a safe and secure location for wireless transmissions. An antenna cover may be used in place of or in conjunction with a pedestal to provide communication to passing vehicles all with no major infrastructure upgrades. Please see Figure 3.

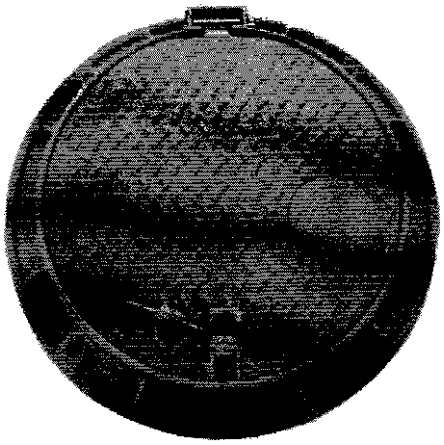


Figure 3

We certainly appreciate the opportunity to partner with MITA and MDOT to pursue innovation in our infrastructure. I do hope the information provided proves useful and can play a significant role in future projects. If you require further information we would be more than happy to meet with you and/or MDOT to answer any questions. Please advise accordingly at your convenience.

Submitted by Chris Owens, P.E. M.ASCE, Manager, Advanced Drainage Systems, Inc.

Good Morning Gentlemen,
Please find the attached submittal regarding innovative pipe materials. Polypopylene pipe, which has already been approved by more than 40 state agencies, is about 3-years into the approval process with MDOT. It's just moving way too slow and other states are reaping the benefits of this innovative material. Ohio DOT, Indiana DOT and Illinois DOT are already ahead of Michigan DOT in approving this product.

As a member of the MDOT Joint Pipe Operations Task Force, I am involved in topics of discussion including better ways to test materials. When MDOT implemented testing plastic pipe materials in their own lab, it was largely a decision based on the fact that there wasn't an established national

testing program. Plastics were new in the 1980s and 1990s and state DOT's were forced to set up testing protocols themselves.

Since then, AASHTO has implemented the National Transportation Product Evaluation Program (NTPEP). NTPEP was established as a Technical Services Program which reports to the AASHTO Standing Committee on Highways. The program combines the professional and physical resources of the AASHTO member departments in order to evaluate materials, products and devices of common interest for use in highway and bridge construction. The primary goals of the program are to provide cost effective evaluations for the state DOTs by eliminating duplication of testing and auditing by the states and duplication of effort by the manufacturers that provide products for evaluation.

Both HDPE and Polypropylene pipe are included in this program. This would be a way to streamline product testing, which will save DOT funds, while ensuring quality products on state projects. MDOT simply does not have the equipment, staff, or resources to keep up with industry testing procedures. All surrounding states including Wisconsin, Illinois, Indiana and Ohio currently participate in this testing program. MDOT is an AASHTO member so why not take advantage of the NTPEP program?

Here is a link to the NTPEP website. www.ntpep.org

Please consider submitting this idea.

Submitted by Chris Owens, P.E. M.ASCE, Manager, Advanced Drainage Systems, Inc.

In response to MITA's solicitation for innovative ideas, please consider the following. The Michigan Department of Transportation has been extremely slow in reviewing and adopting proven innovations in underground construction technology. MDOT's allowable pipe materials under Section 401 and 402 of the Standard Specifications for Construction remain largely unchanged in the last 30 years.

In June of 2013, ADS submitted our polypropylene pipe (HP Storm) to MDOT. ADS has been manufacturing polypropylene pipe for storm and sanitary sewer since late 2008 given its 30+ year history in Europe. Since that time, HP Polypropylene pipe has been approved by over 40 state agencies including neighboring states like Ohio, Indiana and Illinois. Currently, MDOT has approved the joint for HP pipe, which is included on the Qualified Products List, but hasn't done much since.

The 2013 ASCE Report Card on America's Infrastructure assigned a 'D' grade to roads. Continuing to specify the same old technology for our storm sewer will not help improve this grade. Other states have recognized the presence of innovative materials in the storm sewer marketplace and upgraded their specifications to include these materials. Michigan should not be the last to consider upgrading their specifications.

ATTACHMENT E

Industry Associations' Input

HP Storm is the perfect choice when premium joint performance and/or greater pipe stiffness is required. HP Storm couples advanced polypropylene resin technology with a proven, dual- wall (or triple-wall) profile design for superior performance and durability. I have included a summary submittal for reference.

Thank you and we look forward to a favorable response from the "Roads Innovation Task Force.

Advanced Drainage Systems, Inc.

HP Polypropylene Pipe
Stormwater Drainage Pipe Overview

Double Wall Polypropylene HP Pipe 12", 15", 18", 21", 24", 30"

ATTACHMENT E

Industry Associations' Input

Triple Wall Polypropylene HP Pipe 36", 42", 48", 60"

Company and Product Summary

Application: Stormwater Drainage

Size range: 12" ID to 60" ID

Profile: 12" to 30" Dual Wall; smooth interior, corrugated exterior
30" to 60" Triple Wall; smooth interior, smooth exterior, structural corrugated core

Industry Specifications:
ASTM F2736 – Standard Specification for 6 to 30 in. Polypropylene Corrugated Single Wall Pipe and Double Wall Pipe.
ASTM F2764 – Standard Specification for 30 to 60 in. Polypropylene Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications.
ASTM F2881 - Standard Specification for 12 to 60 in. Polypropylene Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications. MODOT Section 1041 – Polypropylene Pipe Culverts
AASHTO Section M330 – Dual Wall and Triple Wall Polypropylene Culvert Pipe
ASTM F477 – Standard Specification for Elastomeric Seals for Joining Plastic Pipe
ASTM D3212 – Standard Specification for Joints and Sewer plastic pipes using flexible elastomeric Seals
ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications.

Manufacturer Information:
Headquarters:
Advanced Drainage Systems, Inc.
4640 Trueman Blvd
Hilliard, OH 43026
Years the company has been in business: 50 years, since 1966

Regional contact:
Chris Owen – Engineered Products Manager
43544 Lancelot Dr.

ATTACHMENT E

Industry Associations' Input

Canton, MI 48188
chris.owen@ads-pipe.com Cell: 248-431-1361

Regional Manufacturing Locations:

- Findlay, OH
- Mendota, IL
- Ennis, TX and Yoakum TX
- Eagle Grove, IA
- Brazil, IN
- Wooster, OH

INNOVATIVE PRODUCT CHARACTERISTICS

- Substantial cost saving over traditional materials.
- High pipe stiffnesses offering installation resilience and long-term sustainability.
- Superior impact resistance in all construction environments.
- High beam strength for installation and grade consistency.
- Joint integrity in excess of industry requirements through the use of two gaskets.
- Gray color provides easy viewing during inspection and resistance to UV degradation.
- Chemically inert.
- Light weight/structurally efficient design.
- Offers two standard lengths depending on site requirements: 20 and 13 feet.
- Exclusive inline bell/spigot eliminates stress risers at joint from inadequate bell holes.
- Same backfill requirements as RCP

ATTACHMENT E

Industry Associations' Input

Submitted by Cindy Malott-Heinz, Jonny Heinz Landscaping LLC

01/05/16
Regarding innovative ideas. Does this include slope restoration areas on bridges and highways? If so I have a product to introduce. I had the opportunity to use it at a large railtrail in Cannonsburg MI.

01/16/16
Good Morning,
Here is the Hydro-cover literature from John Deere.

ATTACHMENT E

Industry Associations' Input

It is not M-Dot approved, but was allowed due to inability to use our normal materials.

ATTACHMENT E

Industry Associations' Input

HYDROCOVER™ FAMILY OF MULCH PRODUCTS

PRODUCT PERFORMANCE

Effective erosion control and soil solutions are our goal. John Deere® Landscapes has an established group of products and technologies that significantly enhance erosion control performance and complement all hydraulic applications. These products include a variety of hydraulic mulches, soil and fiber amendments and straw and fiber mulch binders.

HydroCover™ products are suitable for a wide range of applications including:
Turf Establishment > Golf Courses > Landfills > Highway Work > Recreational Locations > Airports

BFM (Bonded Fiber Matrix) #089798

HydroCover BFM contains a combination of Thermally Refined® wood fiber, a proprietary cross-linked hydro-colloid tackifier and activators. This provides the best protection on steep slopes at the lowest overall cost in a quick, safe and easy hydraulic application. It is less expensive and faster to install than blankets or sod and is more effective than blankets.

Packaging: 50-lb bale; Shipment: 2000-lb pallet – 40 bales per pallet.

PREMIUM-GRADE WOOD #089791

100% Thermally Refined wood fiber holds 12 times its weight in moisture, therefore enhancing seed survival rates. HydroCover Wood fiber, when mixed with seed and fertilizer, forms a homogeneous slurry that ensures evenly distributed strands of grass. HydroCover Wood fiber provides maximum soil coverage with its 100% wood content.

Packaging: 50-lb bale; Shipment: 2000-lb pallet – 40 bales per pallet.

PREMIUM-GRADE WOOD with TACK #089785

Dry organic matter and moisture combine with tackifier to reduce friction in the hose and increase shooting distance. HydroCover Wood with Tack holds 13 times its weight in water, improving turf establishment while controlling erosion immediately after application.

Packaging: 50-lb bale; Shipment: 2000-lb pallet – 40 bales per pallet.

PREMIUM-GRADE WOOD BLEND #089779

Combination of wood fiber with cellulose manufactured from the highest quality materials. HydroCover Wood Blend enhances water holding capacity, reduces soil erosion while improving turf coverage and is easier to pump.

Packaging: 50-lb bale; Shipment: 2000-lb pallet – 40 bales per pallet.

PREMIUM-GRADE WOOD BLEND with TACK #089772

Combination of wood fiber and cellulose, premixed with polymer tackifier. HydroCover Wood Blend with Tack reduces friction in the hose, increasing shooting distance and controls erosion upon application.

Packaging: 50-lb bale; Shipment: 2000-lb pallet – 40 bales per pallet.

PREMIUM CELLULOSE #089766

100% cellulose, ideal for hydroseeding, tacking straw and hay mulch. It shoots very well, allowing machine to run efficiently while providing excellent ground cover.

Packaging: 50-lb bale; Shipment: 2000-lb pallet – 40 bales per pallet.

PREMIUM CELLULOSE with TACK #089760

Cellulose, combined with premixed tackifier and packaged in a 50-lb bale. Designed to break up faster, absorb water rapidly, improve machine performance and hold mulch to the soil surface.

Packaging: 50-lb bale; Shipment: 2000-lb pallet – 40 bales per pallet.

ATTACHMENT E

Industry Associations' Input

For Optimum Results Use ProPlus® Hydro Mulching Solutions

Added Value in Every Tank

- **ProPlus® hydraulic mulch additives** give you more ingredients to make mulch shoot farther, spread more evenly and look better.
- **Helps mulch bond to soil** more securely, seed germinate faster and plants develop deeper roots.
- **Industry's most comprehensive line** of hydraulic mulch additives.

NEW PRODUCTS

- **Aqua-pHix™ Hydro** — Proprietary liquid formula of non-hazardous and non-corrosive, self-buffering, chelated organic and inorganic acids that immediately lower pH of alkaline soils. Dramatically enhances seed germination.
- **JumpStart™** — Proprietary liquid reformulation with long-term penetrating agent added to humic acid and beneficial bacteria solution. Proven to promote faster germination and vegetation establishment.
- **BioPrime™** — Granular formulation containing biostimulant, 18-0-0 slow release nitrogen, humic acid and Endo Mycorrhizae. Designed to sustain long-term plant vitality.
- **FiberBond Ultra™** — Provides both chemical and mechanical bond to hydraulically applied fiber mulch, enabling the fiber matrix to handle higher rates of surface flow energy from rainfall.

(See complete line-up on back page.)

JET SPRAY® with FiberMax™ #000536

- **Pourable fiber mulch** flake that loads 90% faster than any type of baled fiber mulch product.
- **Can be used** in all types of equipment.
- **Delivers 50% more** FiberMax synthetic fiber for a more uniform coverage and reliable erosion control.
- **Flocculating tackifier** increases yield.
- **Every bag goes farther**, providing greater loft within the matrix and outstanding erosion control performance.

Packaging: 40-lb bag

Futerra®

THE FUTERRA® FAMILY: ENVIRONMENTALLY FRIENDLY BLANKETS

An alternative to HydroCover, the Futerra® family of erosion control and revegetation blankets are designed to conform to the soil surface, preventing washouts and seed migration for 99% effectiveness.

- **Better erosion control** by rapidly absorbing water and holding it in place for enhanced germination and growth.
- **Establishes vegetation** faster than traditional stitch-bonded straw, coconut and excelsior blankets.

FUTERRA® F4 NETLESS® #080940, 081075

- **A lightweight, yet lofty matrix** provides high levels of slope protection and vegetative establishment for fine turf and environmentally sensitive applications.
- **There are no nets or threads** to entangle plants and animals or snare maintenance equipment.

FUTERRA® ENVIRONET™ #088606, 088569, 088045, 088627

- **For slopes and environmentally sensitive sites** where windy conditions and/or higher levels of installation stress may be encountered.
- **A thermally fused matrix**, reinforced with a quick degrading, rectangular netting minimizes wildlife entanglement and improves site safety.

ATTACHMENT E

Industry Associations' Input

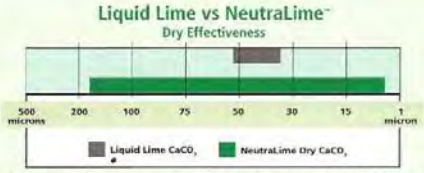
PROPLUS® ACCESSORIES AND ADDITIVES

Look inside for details on 4 new products!

SOIL AMENDMENTS

- **JumpStart™** — NEW *Formulation!*
- NEW **BioPrime™**
- NEW **Aqua-pHix™ Hydro**
- **NeutraLime™ Dry #081220** — Nothing balances soil pH faster, within 6-10 days of application, with the added plus of longer control—up to 18 weeks. Contains 50% more active ingredients than Liquid Lime.

Liquid Lime vs NeutraLime™
Dry Effectiveness



Graduated particle sizing extends minimum effectiveness from 12–18 weeks.

- **NeutraLime™ Liquid #083739** — Balances soil pH and is effective in 7-10 days.
- **AquaGel™ A, B, C, D #084530, 084523, 084775, 084516** — Four ways to hold 400 times the water in a variety of applications, making it an excellent water management tool.

FIBER MULCH AMENDMENTS

- NEW **FiberBond Ultra™**— Provides both chemical and mechanical bonds to mulch matrix.
- **FiberMax™** — Maximize yield and mulch performance with a stronger bond and the added plus of better shooting.
- **FiberLock™** — Patented, crimped fibers are your key to increased yield and sure success on the really long slopes.
- **SlikColor™ #084549** — The only dye marker with the added plus of a slickifier to improve shooting—now in water soluble bags.

TACKIFIERS, SOIL STABILIZERS & DUST CONTROL

- **FlocLoc™ *(PAM)* #084831** — Flocculating soil stabilizer designed to coagulate suspended soil particles, dropping them from runoff to reduce soil erosion and improve water infiltration into the seedbed. FlocLoc can also be used for temporary erosion control and dust control.
- **Tacking Agent 3® #020212**— Requires no cure time to be effective! University tests and field use prove it effectively reduces soil erosion and water runoff immediately after hydroseeding. Also increases the water holding capacity of all types of hydraulic mulches.
- **ConTack® Organic Tackifier** — 100% guar-based organic tackifier reduces the need for re-seeding and minimizes soil erosion by stabilizing mulch and straw. It also helps increase the flow and pumping properties of mulch.
- **ConTack® AT** — A starch-based agricultural tackifier, ConTack AT is an economical choice for tacking straw or hay mulch to enhance germination by holding seed in place and preventing washouts.
- **TackDown™** — The acrylic resin liquid tackifier you need to make sure you've got the job nailed—good in a variety of applications.
- **Vegetative Overspray** — 100% cellulose fiber for added security on general hydroseeding.

Profile
Solutions for your Environment

For technical information, distributor location and customer service call (800) 508-8681.
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750 Lake Cook Road • Suite 440 • Buffalo Grove, IL 60089

www.hydrocovermulch.com

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JOHN DEERE LANDSCAPES

800-347-4272

HC-01 1/09

ATTACHMENT E

Industry Associations' Input

ProGanics Biotic Soil Media is mixed at a rate of 75 or 100 pounds per 100 gallons of water

Application / Loading Procedures

A. Strictly comply with equipment Manufacturer's installation instructions and recommendations. Use approved hydro-spraying machines with the appropriate nozzle whenever possible to achieve best soil coverage. Apply from opposing directions to assure uniform soil surface coverage.

B. To ensure proper application rates, measure and stake area.

C. Fill 1/3 of mechanically agitated hydroseeder with water. Turn pump on for 30-60 seconds to purge and pre-wet lines. Turn pump off.

D. Turn agitator on, open recirculation valve and load low density materials first (i.e. seed and Prescriptive Agronomic Formulations).[1]

E. Continue slowly filling tank with water while loading ProGanics at a rate of 100 pounds per 100 gallons of water (45.4 kg/379 liters) in machines equipped with gear or positive displacement pumps and 75 pounds per 100 gallons of water (45.4 kg/379 liters) in machines with centrifugal pumps.

F. Consult loading chart on the back page to determine the number of bags to be added for desired area and application rate.

G. ProGanics should be completely loaded before water level reaches 75% of the top of tank.

H. Add fertilizer and other high density materials as water level approaches the top of the tank.

I. Top off with water and mix until ProGanics is fully broken apart and hydrated (minimum of 10 minutes — increase mixing time when applying in cold conditions). It is very important to fully hydrate the ProGanics and activate the bonding additives to obtain proper viscosity.

J. Shut off recirculation valve to minimize potential for air entrainment within the slurry.

K. Slow down agitator(s) to minimum speed and start applying with an appropriate nozzle.

L. Spray in opposing directions for maximum soil coverage.

M. Upon completion of application, return immediately to water source to repeat mixing and application sequence or to flush equipment. Be sure to thoroughly purge pump and all lines of residual material from previous load.

N. Apply ProGanics as directed above being sure to include all Prescriptive Agronomic Formulations, fertilizer and seed at their recommended rates. If possible, allow ProGanics to dry slightly[2] prior to application of Hydraulically-applied Erosion Control Products, such as Flexterra® HP-FGM™ or ProMatrix™ EFM™, or Rolled Erosion Control Product (RECP) as directed by manufacturers' product selection guidelines or go to **www.ProfilePS3.com** for assistance. Use caution to insure overspray of hydraulic erosion control product does not cause movement of the ProGanics. When installing rolled erosion control products over ProGanics, take caution to minimize disturbance of the treated surface and avoid excessive foot traffic

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[1] *Do not add additional tackifiers or polymers to this pre-mixed formulation without first consulting Profile Products.*

[2] *Best results and more rapid drying are achieved at temperatures exceeding 60°F (15°C). Drying times may be accelerated in high temperature, low humidity, and windy conditions with product applied on dry soils.*

ATTACHMENT E

Industry Associations' Input

Application Guide for ProGanics™ Biotic Soil Media™ (BSM™)

Loading Chart for ProGanics Biotic Soil Media

Hydroseeder Pump Type	Tank Size (gal)	# of 50-lb bales	(lb)	3,500 lb/ac		4,000 lb/ac		4,500 lb/ac		5,000 lb/ac	
				Sq ft	Acres	Sq ft	Acres	Sq ft	Acres	Sq ft	Acres
Centrifugal	300	4.5	225	2,800	0.06	2,450	0.06	2,178	0.05	1,960	0.05
Gear/Positive Displacement	300	6.0	300	3,734	0.09	3,267	0.08	2,904	0.07	2,614	0.06
Centrifugal	600	9.0	450	5,601	0.13	4,901	0.11	4,356	0.10	3,920	0.09
Gear/Positive Displacement	600	12.0	600	7,467	0.17	6,534	0.15	5,808	0.13	5,227	0.12
Centrifugal	800	12.0	600	7,467	0.17	6,534	0.15	5,808	0.13	5,227	0.12
Gear/Positive Displacement	800	16.0	800	9,957	0.23	8,712	0.20	7,744	0.18	6,970	0.16
Centrifugal	1,100	16.5	825	10,268	0.24	8,984	0.21	7,986	0.18	7,187	0.17
Gear/Positive Displacement	1,100	22.0	1,100	13,690	0.31	11,979	0.28	10,648	0.24	9,583	0.22
Centrifugal	1,500	22.5	1,125	14,001	0.32	12,251	0.28	10,890	0.25	9,801	0.23
Gear/Positive Displacement	1,500	30.0	1,500	18,669	0.43	16,335	0.38	14,520	0.33	13,068	0.30
Centrifugal	3,000	45.0	2,250	28,003	0.64	24,503	0.56	21,780	0.50	19,602	0.45
Gear/Positive Displacement	3,000	60.0	3,000	37,337	0.86	32,670	0.75	29,040	0.67	26,136	0.60
Centrifugal	4,000	60.0	3,000	37,337	0.86	32,670	0.75	29,040	0.67	26,136	0.60
Gear/Positive Displacement	4,000	80.0	4,000	49,783	1.14	43,560	1.00	38,720	0.89	34,848	0.80

Application Rates

% Organic Matter[1]	English (lb/ac)	Metric (kg/ha)
< 0.75	5,000	5,600
≥ 0.75 & < 1.5	4,500	5,040
≥ 1.5 & < 2.0	4,000	4,480
≥ 2.0 & < 3.0	3,500	3,920

For conversions:
1 lb = 0.454 kg
1 ac = 0.41 ha
lb/ac x 1.12 = kg/ha
1 kg = 2.20 lb
1 ha = 2.47 ac

[1] *Based on Soil Test Results. Refer to Profile's Soil Testing and Interpretation Guide for more information.*

Profile
Solutions for your Environment™

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ProGanics™
BIOTIC SOIL MEDIA

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FSC Mixed Sources FPO

BSM-01 05/15

ATTACHMENT E

Industry Associations' Input

MICHIGAN ROAD PRESERVATION ASSOCIATION (MRPA)

Introduction:
The Michigan Road Preservation Association is the voice of the preventive maintenance industry in Michigan. We are dedicated to promoting preventive maintenance concepts and educating users on the quality, safety features and effective uses of preventive maintenance practices.

In 1946, Professor Ben H. Petty of Purdue University observed, "just as soon as a road is built and opened to traffic, we are, from then on, faced with a continuing and increasing problem of maintenance."

Seventy years later, as the Michigan Legislature calls on the Michigan Department of Transportation to build roads that last for 50 years, maintenance, and preventive maintenance in particular, continues to be the key to maintaining a roads serviceability.

Even when a road is constructed with a very costly 50-year design, preventive maintenance is the key to achieving the 50-year lifecycle. Even the Autobahn – the benchmark for road longevity – benefits from pavement preservation techniques. The same micro surfacing process used in Michigan today was tested and perfected on the Autobahn, adding a new wearing course to improve ride quality and extend pavement life on this iconic system.

All roads, from the Autobahn to the interstate and city streets, need preventive maintenance to remain serviceable. The use of the right treatments at the optimum time for a road's condition is the most cost-effective way to achieve a 50-year lifecycle for Michigan roads.

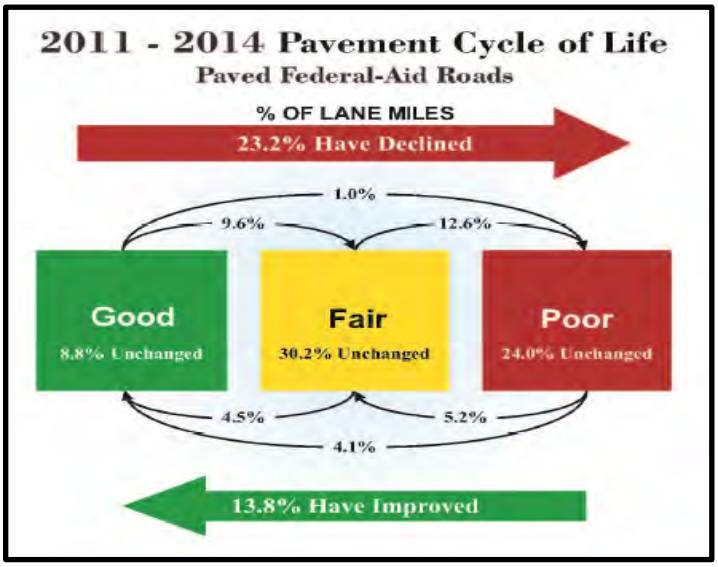
Background – Asset Management and Pavement Condition:
In 2002, the Michigan Legislature made a commitment to preserving and extending the life of transportation assets. The Transportation Asset Management Council (TAMC) was created to advise the State Transportation Commission and promote pavement preservation to state and local governments.

This commitment to using preventive maintenance continues today. Armed with the knowledge that every $1 spent to keep a road in good condition saves $6 to $14 as the road deteriorates to a more costly state of repair, MDOT and local agencies have struggled over the last decade to prioritize pavement preservation in tight budgets.

The *2014 TAMC Annual Report* found that one of every three miles of pavement on the federal-aid eligible road network is in poor condition. The 2014 ratings showed a 5 percent increase in "poor" roads – the largest single-year increase in poor roads in the last seven years and the second largest increase since TAMC began collecting data in 2006.

ATTACHMENT E

Industry Associations' Input



The non-federal aid eligible road system is in an even more abysmal condition. The 2014 TAMC data revealed that 49 percent are in poor condition and just 10 percent are in good condition.

PASER ratings submitted from 2011 to 2014 revealed that 23 percent of lane miles deteriorated while less than 14 percent improved over the 4-year period. TAMC concluded that, "the longer we postpone increased levels of investment, the longer it will take for the public to begin to see any appreciable improvement in the condition of Michigan's roads and bridges."

When residents and business owners demand better roads, they are looking for roads that see them about their daily lives without bone-jarring potholes. They rarely understand if this is a newly constructed road or just a new wearing course. Preventive maintenance treatments allow the public to see visible improvements in serviceability and ride quality throughout the lifecycle of the road. As new revenue for roads becomes available, a continued focus on preventive maintenance to preserve our road assets will allow for visible improvements to the system in the most cost-effective manner.

Innovation – Comprehensive Implementation of Pavement Preservation:

Applying the Right Fix . . . At the Right Time . . . In the Right Place

While many of the treatments used by the pavement preservation industry are not in themselves innovative, the implementation of a comprehensive pavement preservation strategy, system wide, is both an innovation and an efficiency.

Despite everything we know about the importance of pavement preservation, the ability for MDOT or local governments to fully implement preventive maintenance strategies for ALL roads has been as elusive as building roads that last for 50 to 100 years.

Why when we've known how cost-effective asset management can be? The answer is simple. There haven't been enough financial resources at the state or local level for agencies to apply the right fix, at the right time, in the right place, to every mile of road needing attention.

In order to provide the highest quality transportation network for economic benefit and improved quality of life, road agencies are forced to make difficult decisions to balance available resources with the needs of the system.

ATTACHMENT E

Industry Associations' Input

When faced with a decision of rehabilitating or reconstructing a road vital to a business or community; patching potholes to keep roads safe and passable; and sealing the cracks in good roads or resurfacing a fair road, limited funds often go to "worst first" priorities.

In addition, some preventive maintenance treatments have been used in alternative ways in recent years – serving as Band aids – holding a road together until funds are available to make a more appropriate and longer-lasting repair.

If a road is properly built with appropriate drainage, environmental and geological specifications, and pavement preservation is properly implemented on the road from the time it is built, the road can maintain serviceability for 50 years!

The Window of Opportunity:

Asset management in Michigan uses a system known as PASER to rate all roads as good (8-10), fair (5-7) or poor (1-4). Based on the PASER (condition) rating of the road, the average daily traffic volumes and other factors, a mix of fixes is applied along the deterioration curve.
The illustration below, from the *2012 TAMC Annual Report*, demonstrates the window of opportunity when applications work best to keep a road in good, fair or poor condition.specific treatments are recommended at various points along the deterioration curve.

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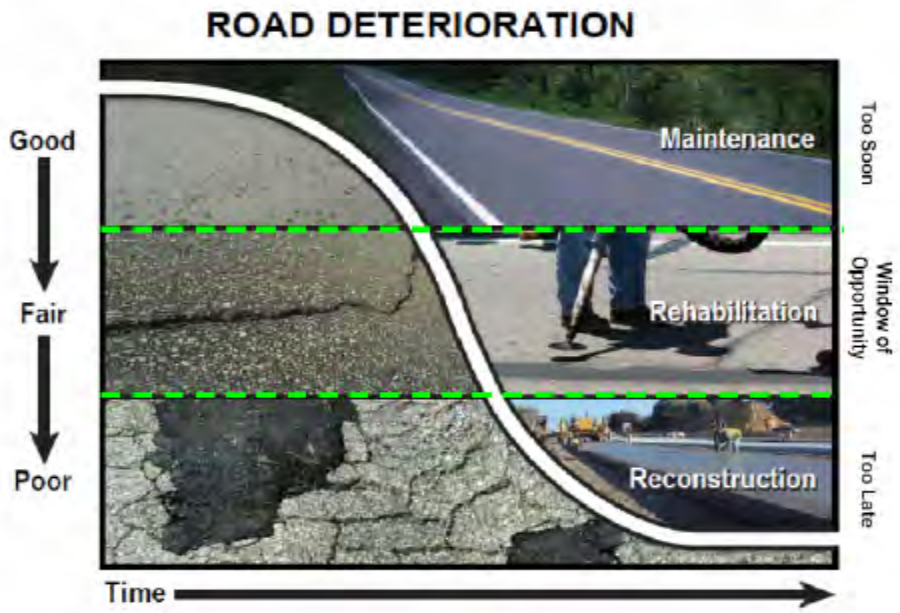
Industry Associations' Input

"Window of Opportunity"

Figure 3 below illustrates the concept in which certain types of treatments are more feasible to use than others. The curved line show how a pavement deteriorates over time. There are certain points along the curve where different types of work activities no longer are feasible. These points define the "window of opportunity."



Keeping Good Roads Good:
A brand new road will receive a rating of 10, but as a road experiences exposure to sunlight, traffic, and routine maintenance such as salt applications and snow plowing, it will eventually start to show signs of cracking and distress.

The first application along the curve, and perhaps the most important to achieving maximum lifecycle, is to prevent water from seeping into the pavement where it can do additional damage.

Crack Sealing is the first treatment along the curve. It prevents water from damaging the base and subbase. Unsealed cracks can allow sand, stones, dirt and other substances to enter the crack in the pavement, weakening the pavement and further enhancing the chance for heaving, creation of additional distress cracking (alligator or crocodile cracks), development of potholes and more. Cracks that are sealed are typically less than ¾ inches wide.

Overband Crack Sealing is the placement of asphalt cement and fibers into and above working cracks and results in a strong yet flexible seal that bonds well to the crack walls, sealing out water and other substances.

Routing with Overband Crack Sealing involves making cuts along the crack to create uniform and smooth edges. This allows the sealant to adhere better to the walls of the crack and allows for

better expansion during the freeze/thaw cycle. This is a definite benefit in Michigan's southern regions which experience several weeks of consistent freeze thaw pattern. A routed crack typically lasts twice as long as a crack that is just cleaned and sealed.

Fog Seals are currently used by MDOT in conjunction with chip seals as an "overcoat" to aid in stone retention. Fog seals are a thin application of a diluted asphalt emulsion. They can be a cost effective stand-alone treatment very early in a pavements life as well.

Many states are using a form of fog seal on newly cut corrugations to help combat their early deterioration which are often times in the longitudinal cold joint. Other states have also found benefit in using fog seals to treat HMA shoulders as a low cost treatment to preserve the less travelled shoulder. When used as stand-alone treatments, they should be used much higher on the deterioration curve to get the most benefit, anywhere from a new construction (10) or good pavements down to a 7.

As a Road Begins to Age – Treatments for Fair Roads:

Micro Surfacing is a "***Polymer-Modified Cold-Mix Paving System.***" When applied on the right road at the right time, micro surfacing is one of the most cost-effective means of preserving long life pavements as well as restoring their surface properties. Used primarily to extend pavement service life, micro surfacing also provides a safe, durable and skid-resistant surface compared to similar overlay methodologies. This product is currently available in MDOT's Capital Preventive Maintenance Program and is routinely contracted as a warranty project. This product was originally developed in Germany to restore the surface properties on the Autobahn. The German road authority needed a very thin, environmentally friendly means of sealing, restoring skid properties and addressing the rutting on their long life pavements. Raschig AG developed the process for the German Autobahns and the product spread around the world from there.

In some cases micro surfacing is being used in Michigan to preserve a good pavement but in other instances it is being used simply to extend the life of a marginal pavement. As Michigan leans towards longer-life pavement designs micro surfacing will be instrumental in preserving these assets. To secure maximum effect, it should be applied to pavements with conditions in the 7 to 8.5 range.

Chip Seals are the most commonly used surface treatment by both state and local agencies on Hot Mix Asphalt (HMA) roads. This product is a part of MDOT's Capital Preventive Maintenance program and is routinely contracted as a warranty project. It is the application of an emulsified asphalt binder followed by the application of a fractured cover aggregate. The asphalt emulsion acts as a sealant to not only repel water but to also preserve the qualities of the original asphalt in the HMA road surface. The aggregate provides a skid resistant wearing course.

ATTACHMENT E

Industry Associations' Input

With part of the intent of the process being to preserve the good qualities of the HMA, it is important to utilize this treatment while the qualities of the HMA are still in good to fair condition. The benefits of the treatment are greatly increased the higher the pavement is on the deterioration curve when placed (6 to 8 on the PASER scale). Though designed to be a preventive measure, limited finances have stretched what chip seal was intended to do to act as "Band-Aid" on questionable pavements where service life has greatly diminished.

Double Chip Seals are effective when there is excess cracking. The process can be used locally, full width, or isolated to wheel paths or shoulders only (**Bar Seals**).

Cape Seal is the practice of following a layer of chip seal with a micro surface. Cape seals maximize the positive aspects of chip seal and micro surface treatments by applying them together. A cape seal is typically applied when the deterioration is greater than what slurry or micro seal is designed to correct, but before the pavement requires an expensive asphalt overlay. Used with crack sealing and surface patching, the chip seal layer prevents water from seeping into the road bed and the micro surface provides a new wearing course. Cape seal is one of the most economical treatments for addressing fair to moderately cracked pavements, while providing a smooth, dense surface, one having good skid resistance and long service life.

Increasing Serviceability of Fair to Poor Roads:

The **Scrub Seal** system is a one-step crack-filling, sealing and rejuvenating application for moderate to severely distressed asphalt surfaces. Scrub seal consists of spraying a designed quantity of emulsion on the roadway in conjunction with a mechanized scrub broom that forces the emulsion in the cracks. It is immediately followed by an aggregate chip spreader which applies an even layer of single size cover aggregate over the emulsion. The aggregate is then rolled into the emulsion to achieve sufficient bonding and embedment, then the surface is swept to remove excess aggregate.

Scrub seal is similar to a chip seal but the thicker, highly polymerized emulsion makes it an ideal treatment on a road that is already showing signs of cracking, raveling, "alligatoring" or more severe surface deterioration. This treatment has resulted in 5-10 year increases in the lifecycle of a road, without having to seal the cracks prior to application and is effective in mitigating reflective cracking. The addition of a fog seal gives the appearance to the motoring public of a new road. It is highly effective as a "Stress-Absorbing Membrane Interlayer (SAMI) for any type of surface treatments such as micro surfacing, slurry or thin-lift overlays.

Additional Innovative Products and Techniques:

Fiberized Bituminous Membrane Interlayer consists of a combination of polymer-modified asphalt emulsion, chopped **fiberglass strands** and quality crushed aggregate. For the same reason fiberglass is specified in today's concrete and asphalt mixes, the realized benefit of the fiberglass is the superior tensile strength which absorbs and bridges pavement distresses, as well as helping to reduce reflective cracking. It is a pavement preservation technique which produces sufficient

tensile strength and flexibility to absorb movements in the pavement structure and can delay the pavement cracking.

This product is in MDOT's Emerging Technology Treatment program and has been applied on at least 13 department projects. Most notably in the Superior Region on I-75. The product is applied over existing pavements prior to asphalt overlays to provide a crack relief layer and to provide a superior bonding layer so the new overlay does not de-bond from the existing pavement. The product was developed by Colas SA for use on French roadways and was brought to the US market in the last 10 years. Ideally the fiberized interlayer would fall somewhere between 5 and 7.5 under asphalt overlays and 6.5 to 7.5 under micro surfacing.

Conclusion:

Since the State of Michigan first made a commitment to adopting asset management and promoting preventive maintenance strategies, the road funding picture has tied the hands of officials to fully implement their pavement preservation plans.

State and local agencies have made the best decisions possible with available revenues to preserve the system. When exploring a perfect world scenario of what it takes to make a road last for 50 years, it's important to realize that many of our roads are already at 50 or more years in their life cycle. Creative use of preventive maintenance techniques have held the system together with Band-Aid approaches.

Depending on the treatment, preventive maintenance improvements typically last 5 to 10 years. A quality built and designed road, with appropriate environmental drainage and geological considerations, along with the proper use of pavement preservation methods will result in long-lasting, safe and reliable roads for Michigan residents.

The use of the right preventive maintenance treatments at the optimum time for a road's condition is THE most cost-effective way to achieve a 50-year lifecycle for Michigan roads!

ATTACHMENT E

Industry Associations' Input

NORTHERN CONCRETE PIPE

Submitted by Thomas R. Washabaugh

Roads Innovation Task Force Suggestions for MDOT 1/13/16

Bridges:

- Precast concrete box culverts with precast headwalls and wing walls allow for one or two day complete removal and replacement of existing bridges. If MDOT would create a standard chart of span, rise and fill heights showing the wall thickness and reinforcing steel for box culverts it would easily save a month or two of review time and an estimated $10,000.00 to $20,000.00 per bridge for engineering design and review fees, and would significantly reduce project lead time.
- Precast box culverts and three-sided bridges are required by MDOT to be designed for HL-93 Modified which in part is a single 72,000 lb. axle load that I don't believe anyone will issue an overload permit for. This adds at least 10% - 15% to the cost, weight, steel reinforcing and deck thickness of the box culvert for a load the bridge will probably never see. We are not aware of any box culvert failures in over 50 years, all of which were designed for much lighter axle loading. I have been told this design load requirement is based on a study of prestressed bridges which has little in common with precast concrete box culverts.

Pipe:

- MDOT could make two trench details, one for rigid pipe and one for flexible pipe because there is a tremendous difference in the actual strength the pipe provides, and the installation process required for each. Outside the influence of roadway this would result in tremendous saving from hauling sand in and dirt out and would result in fewer trucks on the road. Inside the influence of the roadway two trench details for rigid and flexible, along with enforcement of backfill, density, installation techniques and final testing and inspection for all pipe would result in less replacement and repairs in the future.

Note: Most Counties and Cities reference MDOT specifications so these issues affect most projects statewide, not just those bid through MDOT so these savings would be very significant.

ATTACHMENT F

Pavement Demonstration Program Status Report
January 2015

Background
Public Act 259 of 2001 allows the Michigan Department of Transportation (MDOT) to construct up to four demonstration projects per year that are not subject to a Life-Cycle Cost Analysis (LCCA). The LCCA process is a tool to select the lowest cost pavement design over the expected service life of the pavement. The LCCA process must include, by law, historical information for initial construction and maintenance costs, and performance (service life). This information may not be available for new pavement designs, precluding them from being chosen as alternatives. Also, new pavement designs and new technologies are generally more expensive than the standard methodologies, which may reduce their chance of being selected as the lowest cost alternative. The pavement demonstration legislation provides an avenue for trying new and innovative ideas.

Potential advantages of pavement demonstration projects include increased service life, improved customer benefits, and lower maintenance costs. Future LCCAs may utilize cost, performance, and maintenance information from the demonstration projects.

Project Selection
Selection of candidate projects is a collaborative effort between central office pavement personnel, region personnel, and industry groups. Once these partners reach a consensus that a project would make a good candidate, the project goes to MDOT's Engineering Operations Committee for formal approval. Once approved, the project becomes part of the Pavement Demonstration Program.

Additional costs for the demonstration project are funded by the region's rehabilitation and reconstruction budget.

Project List
The following table contains a list of demonstration projects to date.

Table 1. Pavement Demonstration Project List

FY Let	Route	Region	County	Location	Description	Pavement Costs HMA	Pavement Costs Concrete
2003	I-75 NB	North	Ogemaw	Ski Park Road to Roscommon County Line	Low volume unbonded overlay		$1,980,000
2003	M-84 SB	Bay	Bay/Saginaw	Pierce Road to Delta Road	Perpetual pavement	$700,000	
2004	M-3	Metro	Wayne	St. Aubin to McClellan	Thin unbonded overlay		$2,200,000
2005	M-13	Bay	Bay	Mary Drive to North Street	Low volume concrete		$1,200,000

ATTACHMENT F

Pavement Demonstration Program Status Report
January 2015

Table 1. Pavement Demonstration Project List

FY Let	Route	Region	County	Location	Description	Pavement Costs HMA	Pavement Costs Concrete
2005	I-96 WB	Metro	Wayne	M-39 to Schaeffer Road	Perpetual pavement	$4,800,000	
2006	M-99	Univ.	Jackson	Village of Springport	Low volume concrete		$100,000
2008	I-75 NB	North	Cheboygan	Topinabee Mail Road north for 2.37 miles	Perpetual pavement over rubblized concrete	$781,000	
2009	M-1	Metro	Wayne	Tuxedo to Chandler	Thin unbonded overlay		$931,000

NB = northbound; SB = southbound; WB = westbound

Below is a brief description of the status or condition of each project based on recent field visits.

<u>I-75 Northbound (Ogemaw County)</u>: This project, constructed in 2003, is a 6-inch unbonded concrete overlay on the northbound direction only. It includes the following test sections:

- Section 1: 10 foot transverse joint spacing, unsealed joints, no load transfer bars, 0.25 miles
- Section 2: 10 foot transverse joint spacing, sealed joints, no load transfer bars, 0.25 miles
- Section 3: 12 foot transverse joint spacing, unsealed joints, no load transfer bars, 1.5 miles
- Section 4: 12 foot transverse joint spacing, sealed joints, no load transfer bars, 1.5 miles
- Section 5: 12 foot transverse joint spacing, sealed joints, load transfer bars, 0.5 miles

The southbound direction, constructed at the same time, was rubblized (broken into smaller pieces resembling gravel) and overlaid with 6.5 inches of Hot Mix Asphalt (HMA).

Latest Survey: Section 3, which has shown the most distress, had four new panels with cracks this year. Section 4 had two newly cracked panels, while Sections 1, 2, and 5 are in the same condition as last year. Four of the six newly cracked panels are due to a transverse crack, one is a corner crack, and one is a longitudinal crack. The total number of cracked panels represents about 1 percent of the total number in the entire project. These counts do not include the small number of cracked panels that were repaired in 2011.

The rubblize project in the southbound direction has some longitudinal cracking in both lanes and at the centerline joint. It appears there is a significant increase in transverse cracking over last year.

This is most likely due to last winter when there was a long stretch of days with temperatures below freezing.

M-84 Southbound: This project is a 6.5-inch HMA perpetual pavement completed in the fall of 2005. This was a two-lane road that was upgraded to a four-lane boulevard section and was built over a two-year period. The northbound direction contained a standard 6.5-inch HMA cross section and was built in 2004. The southbound contains the perpetual pavement, which is designed for a 40-year life. Polymerization of the HMA and a thicker base are expected to increase the service life over the standard cross section.

Latest Survey: For the third straight year, transverse cracking increased significantly for both directions. This year, there were 2,710 feet of unsealed transverse cracks in the northbound direction (standard cross section), while there were 1,318 feet in the southbound direction (perpetual pavement design). In the previous year, there was a total of 8 feet of unsealed transverse cracking for both directions. The unsealed cracks are discussed because they represent new cracks. The increase in transverse cracking this year is most likely due to last winter when there was a long stretch of days with temperatures below freezing.

M-3: This project is a 4-inch unbonded concrete overlay constructed in the fall of 2005. Normal unbonded overlays are 6 inches or thicker. This project contains four test sections involving a combination of sealed and unsealed joints, with two different HMA bond breaking interlayer mixes. The HMA interlayer mixes are a normal dense-graded HMA and a more open-graded (drainable) HMA. The test sections are as follows:

- Section 1: Open-graded HMA interlayer, unsealed joints
- Section 2: Open-graded HMA interlayer, sealed joints
- Section 3: Dense-graded HMA interlayer, sealed joints
- Section 4: Dense-graded HMA interlayer, unsealed joints

Latest Survey: Overall, 627 of the 6 x 5.5 foot concrete panels have a crack (1.9 percent of the total in the survey area). This is an increase of 162 panels over 2012, which represents a 35 percent increase over last year. Of the 627 total, 287 are on northbound and 340 on southbound. The sealed sections are exhibiting fewer cracks than the unsealed (258 vs. 369), while the dense-graded HMA interlayer is exhibiting fewer cracks than the open-graded HMA (237 vs. 390). The southbound direction experienced the majority of the increase in cracking (106 of the 162 panel increase).

A 2004 mill and resurface on the composite section directly to the north of this project (north of I-94) is being used as a comparison section. A new mill and resurface project was conducted in 2014 ending the life of the 2004 project at 10 years.

M-13: This project is a low-volume concrete design constructed in the summer of 2005. The concrete is 6 inches thick compared to a minimum concrete thickness of 8 inches on non-freeway

routes. Joints are spaced 5.5 feet in both directions and are unsealed. A dense-graded base was used instead of the normal open-graded base material.

Latest Survey: The number of cracked panels noted on this project this year was lower than last year (14 vs. 27). It is not known why the number is lower than last year. The cracked panels represent less than 0.2 percent of the overall surface area of the project. These counts do not include the panels that are cracked at the south side of the bridge over the Pinconning River. They are attributed to heavy equipment (large crane, etc.) that was parked there during a 2009 repair project on the bridge.

I-96 Westbound: This project is a 14-inch HMA perpetual pavement constructed in the fall of 2005. The eastbound direction was reconstructed with concrete. The concrete is a 20-year design, while the perpetual pavement is a 40-year design; this is not a side-by-side comparison.

Latest Survey: The longitudinal joints continue to worsen. The joint between the right lane and the right shoulder, for both the express and local lanes, continuously shows the most distress. The joint between the left and middle express lanes has a few intermittent locations that are very bad. The middle and right lanes were paved at the same time with a technique called echelon paving (two paving trains very close to one another). The longitudinal joint between these two lanes is doing very well. As noted in previous reports, the longitudinal joint problems are typically a construction-related issue and are therefore not considered a problem of the perpetual pavement design.

Two angled transverse joints over a utility trench do not appear to be any worse than last year. However, the area between the two cracks (approximately 6 feet) may have settled a little bit.

M-99: This is the second low-volume concrete design project and is the same as the M-13 project, except the joints are spaced at 6 feet in both directions. It was constructed in summer/fall of 2006 and is approximately 800 feet in length. However, the number of distresses for such a small section of roadway is high. In general, the distresses that are present do appear to be in the same condition as in previous years' surveys. The exception to this would be a couple of transverse cracks that have widened slightly over several years and have a little bit of secondary spalling.

Latest Survey: No new distresses were noted this year. The distress progression on this very short section has been stable for several years.

I-75 Northbound (Cheboygan County): This is another 40-year HMA perpetual pavement design constructed in the fall of 2008. For this project, the existing concrete pavement was rubblized prior to the paving of the HMA. Rubblization is a standard fix; however, the HMA resurfacing is normally a 20-year design.

Latest Survey: This pavement continues to exhibit no distresses other than some raveling in spot locations along the longitudinal joints between lanes and between the right lane and the right

shoulder. This longitudinal joint problem is typically a construction-related problem and not a problem with the perpetual pavement design.

M-1 (Woodward Avenue): This project is a 4-inch unbonded concrete overlay similar to the M-3 project. It was constructed in 2010 and does not contain test sections. All joints were sealed and the same HMA interlayer (drainable open-graded HMA) was used throughout. Transverse joints are spaced at 6 feet, while the longitudinal joints are spaced at 5 feet.

Latest Survey: A total of 123 of the 6 x 5 foot panels are cracked after 4 years of service (an increase of 62 percent over the 76 from last year). This, however, represents only 1.2 percent of the total survey area.

Prepared by: Michael Eacker, P.E.
Pavement Design Engineer
Pavement Management Section
Construction Field Services Division

ATTACHMENT G

Public Input

Real Time Ware, Inc.

Improving and Ensuring the Quality of Our Roads
The Future to 30….40….50 Year Roads
Opening The Lockbox…. Leading The Way

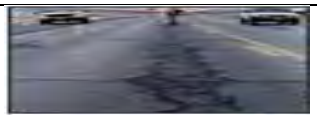
BUILDING HIGH QUALITY ROADS

This presentation consists of four sections:

1. **Evaluation of road materials and construction practices.**
2. **Enforcement of warranties through telemetrics.**
3. **Reduction in maintenance costs through telematics.**
4. **Long term time frames that benefit Michigan and maximizes value to the tax payer.**

Section 1. Evaluation of Road Materials and Construction Practices:

UNTESTED ROAD MATERIALS RESULTS IN CRUMBLING ROADS
MDOT CAN CORRECT THESE PROBLEMS
ROAD DETERIORATION THAT OCCUR WHEN MIX RATIO, SEGREGATION, THICKNESS, COMPACTION ARE OUT OF SPECIFICATION

	POT HOLES CAUSES: OFF MIX RATIO, SEGREGATION, INSUFFICIENT THICKNESS
	BLEEDING CAUSES: OFF MIX RATIO, SEGREGATION, TOO MUCH BINDER
	RUTTING CAUSES: TOO MUCH BINDER, INSUFFICIENT THICKNESS,
	SHOVING CAUSES: TOO MUCH BINDER, OFF MIX RATIO, SEGREGATION
	RAVELING CAUSES: TOO LITTLE ASPHALT BINDER, OFF MIX RATIO, SEGREGATION
	**TRANSVERSE CRACKING** CAUSES: POOR CONSTRUCTION DUE TO IMPROPER OPERATION OF PAVER AND COMPACTOR
	ALLIGATOR CRACKING CAUSES: INSUFFICIENT THICKNESS, OFF MIX RATIO
	AIR VOIDS CAUSES: OFF MIX RATIO, SEGREGATION

ATTACHMENT G

Public Input

❖ SUB-STANDARD MANUFACTURING OF ROAD MATERIALS AND POOR CONSTRUCTION PRACTICES INACCURATE MIX RATIOS, SEGREGATION, ROAD THICKNESS AND COMPACTION ERRORS CAUSE ROADS TO CRUMBLE

MIXING AND SEGREGATION

- Segregation occurs when the stones are not accurately mixed.
- Segregation results when there is a construction delay and the larger stones migrate to the bottom of the asphalt mixture.
- Vibration during shipping causes the larger stones to fall to the bottom.
- Construction equipment used to load and unload the mixed asphalt into the hopper causes the larger stones to roll to the side.

THICKNESS

- Thickness relies on the paving machine's screeds to be properly adjusted. There is no current testing to determine the accuracy of the thickness of the road during installation.

COMPACTION

- Compaction problems are a result of poor construction due to improper operation of the paver and compactor.

If inaccurate asphalt mixtures or segregation goes undetected the resulting roads will prematurely fail. Too low a percentage of asphalt binder results in raveling, segregation and insufficient compaction. Too high of a binder content can result in bleeding, shoving and rutting. Sub-standard roads must be replaced, and potholes must be filled which unnecessarily wastes limited resources. Replacement and repairs are costly and time consuming. Repairs negatively affect motorists and disrupt communities and businesses.

❖ WHAT CAN WE DO TO STOP THE CYCLICAL PROBLEM OF POOR ROADS?

THE SOLUTION IS... Magnetic Flux Tagging of Asphalt and SMARTT™ Sensors

- Magnetic Flux Tagging of Asphalt is a proven innovative technology that can 100% inspect asphalt content during all phases of the manufacturing and application process. The quality of the finished road is directly dependent on the individual components of asphalt as well as how accurately the materials are mixed. Without 100% inspection, segregation and premature failure of the asphalt road is the end result.
- During the past 10 years the automotive industry has successfully used Magnetic Flux Tagging to ensure accurate mix ratios of two-component adhesive.
- Winner of Henry Ford Technology Award. Magnetic flux tagging is required at Ford Motor Company for all two component adhesives (Ford Motor Company has been rated number 1 in quality by J.D. Power & Associates).

ATTACHMENT G

Public Input

❖ ***NEW TECHNOLOGY TO EVALUATE ROAD MATERIALS AND CONSTRUCTION PRACTICES***

THE SOLUTION TO CRUMBLING ROADS

MAGNETIC FLUX TAGGING OF ASPHALT, MFTOA™

MAGNETIC FLUX TAGGING OF CEMENT, MFTOC™

Roads can be manufactured with real time analysis of road materials without interfering with the construction, thereby preventing the delivery and installation of segregated or out of specification asphalt. A new innovation called MFTOA™ tags asphalt at the initial liquid asphalt phase. Sensing MAgnetism Radiated Through Tagging or SMARTT™ sensor inspects the mixture. SMARTT™ sensors telemetrically communicate the information to servers and then the cloud for distribution if the mixture becomes segregated. The data is reported in real time through cell phone, lap top, desk computers etc. to construction site managers, DOT'S, for appropriate action ensuring the finished product is within specification and with documented proof.

All critical processes known to cause segregation, thickness and compaction errors are 100% inspected in real time. Quality is guaranteed ensuring roads last their theoretical lifetime. An array of SMARTT™ sensors also accumulate data for budget forecasting, planning and preventative maintenance

❖ **Overview of Application**

- By tagging asphalt as it is manufactured every mixing phase can be 100% inspected for segregation and out of specification mixtures. Segregation is a primary cause of potholes and premature failures.
- Every asphalt manufacturing process will have an accurate quality inspection. Quality control sensors will be installed at the binder manufacturer, asphalt manufacturer, during transport to the construction site, while compacting, and on the finished road.
- Magnetic Flux Tagging will provide the long term solution for road problems by enabling a comprehensive continuous 100% inspection of the road content, mix ratio, thickness, compaction before, during, and after installation.
- All sensors will be telemetrically interconnected providing real time access to all data. Real time information will be available through cell phones, lap top, PC's. MDOT will be notified of problems immediately. Complete transparency of quality in real time.

ATTACHMENT G

Public Input

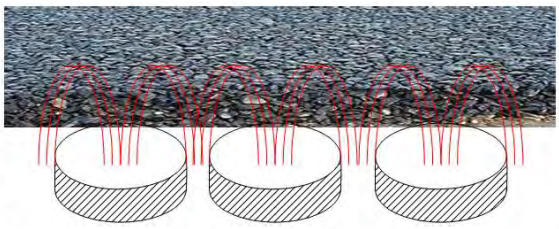
❖ **QUALITY IS THE SUMMATION OF ACCURATE MIXING, SHIPPING, DISPENSING, THICKNESS, COMPACTION, INSTALLATION AND MAINTAINING …….**

EVERY POUND OF ASPHALT AND CEMENT EVERYDAY, YEAR AFTER YEAR!
THE FUTURE TO 30….40….50……YEARS OF ROAD SERVICE!

SMARTT™ SENSORS INSPECT IN REAL TIME THE QUALITY OF THE ROAD MATERIAL NOTIFYING THE MANUFACTURER AND MDOT WHEN THE MATERIAL IS SEGREGATED
MFTOA™ 100% INSPECTION PROCEDURES

ENCIRCLING

TOP-DOWN



BOTTOM-UP

CRACK DETECTION

WHAT ARE SMARTT™ SENSORS?
SENSING MAGNETISM RADIATED THROUGH TAGGING SMARTT™ SENSORS

- TAGGING IS ADDED TO THE BINDER (LIQUID ASPHALT) AND DRY MIXTURE (SAND, STONE ETC. DURING MANUFACTURING. THIS ENABLES SMARTT™ SENSORS TO INSPECT THE MIXING, SHIPPING, INSTALLATION AND COMPACTION OF THE ROAD AS WELL AS POST CONSTRUCTION.

- SMARTT™ SENSORS ARE DESIGNED IN VARIOUS SIZES AND SHAPES.

- SMARTT™ SENSOR INSPECT FOR SEGREGATION DURING ALL MANUFACTURING PHASES, AND IF DETECTED IMMEDIATELY NOTIFIES THE OPERATOR AND MDOT PERSONNEL.

- SMARTT™ SENSOR ACCUMULATE REAL TIME INFORMATION DURING AND AFTER ROAD CONSTRUCTION THEREBY PROVIDING CRUCIAL DATA FOR IMMEDIATE ACTION OR PREVENTATIVE MAINTENANCE

ATTACHMENT G

Public Input

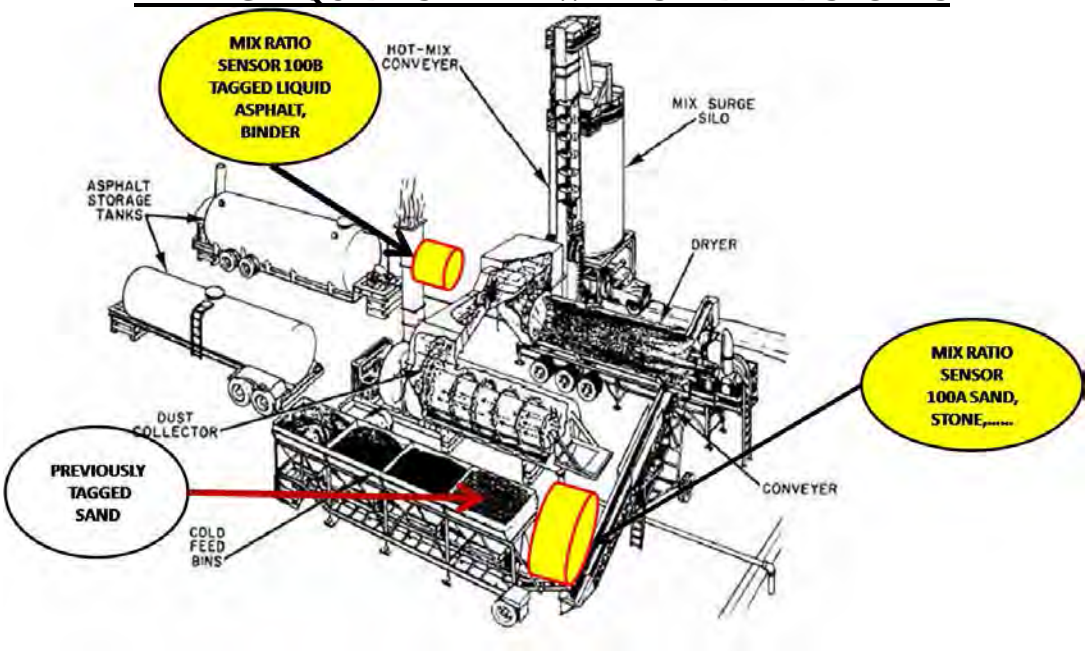
❖ **ALL ROAD MANUFACTURING PHASES ARE 100% INSPECTED FOR QUALITY**

OPERATIONAL STEPS SHOW MAGNETIC FLUX TAGGING AND SMARTT™ SENSORS ENSURE LONG LASTING ROADS.

- THE BINDER IS MANUFACTURED AT A PETROLEUM PLANT. POLYMER OR OTHER ADDITIVES ARE MIXED FOR IMPROVING THE ROADS DURABILITY. 100% INSPECTED FOR QUALITY!

- TRANSPORTING LIQUID ASPHALT TO ASPHALT MANUFACTURING PLANT CAN CAUSE ADDITIVES SUCH AS POLYMERS TO SEGREGATE. VIBRATION AND EXTENDED STORAGE TIME ALSO CONTRIBUTE TO SEGREGATION. 100% INSPECTED DURING SHIPPING FOR QUALITY!

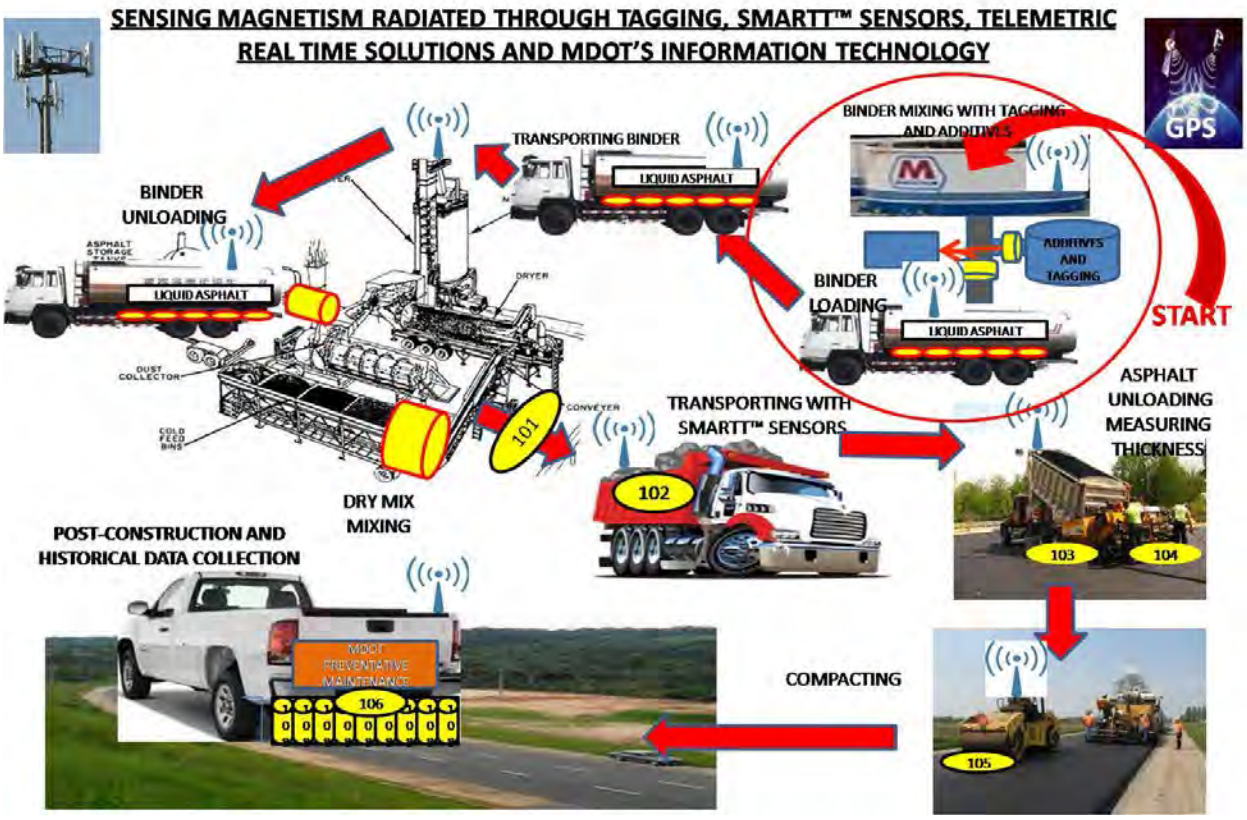
ROAD QUALITY IS GUARANTEED
OPERATIONAL EXPLANATION OF MAGNETIC FLUX TAGGING AND SMARTT™ SENSORS
MIXING LIQUID ASPHALT WITH SAND AND STONES



This figure demonstrates adding Magnetic Flux Tagging when mixing the sand and stone aggregate with liquid asphalt. The permanently mounted sensors measure the mixed ratio in real time. Sensors detect stones or content that are inappropriately added and notify the operator or programmable logic controller prior to mixing with the liquid asphalt. The correction is made avoiding large tonnage of off ratio asphalt, a primary cause of road failure. The first sensor 100A detects if the amount and mixture of proper sized stones are mixed with the sand. An error will

notify the PLC to stop production. The second sensor 100B 100% inspects the mixture ensuring the liquid asphalt binder is accurately mixed prior to being mixed with the cold feed.

❖ **OPERATIONAL OVERVIEW**



SMARTT™ SENSORS UNIVERSALLY POSITIONED PROVIDE A LIFE LINE OF ACCOUNTABILITY, AND ANALYTICAL DATA OF ROAD MATERIALS AND CONSTRUCTION PROCESSES TO ENSURE QUALITY.

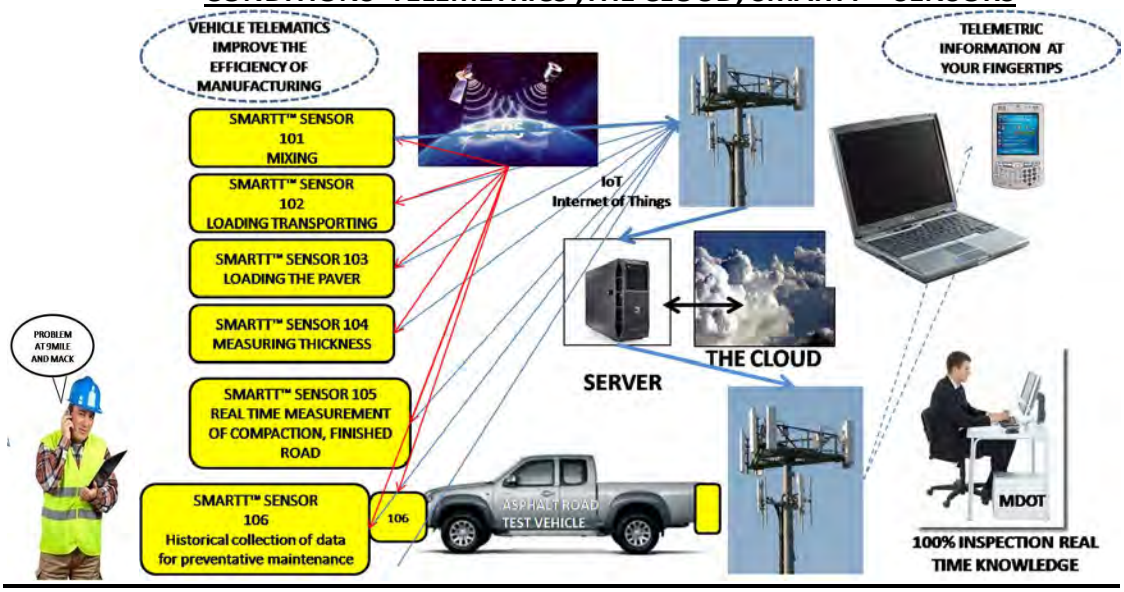
- SENSOR 101: THE ENCIRCLING SENSOR 100% INSPECTS THE ASPHALT AS IT IS LOADED INTO THE TRANSPORT VEHICLE ENSURING IT IS ACCURATELY MIXED
- SENSOR 102: SENSORS DETECT IF SEGREGATION OCCURS DURING LOADING AND WHILE BEING SHIPPED
- SENSOR 103: SENSORS DETECT IF SEGREGATION OCCURS DURING UNLOADING
- SENSOR 104: MULTIPLE SENSORS MEASURES THE THICKNESS OF THE PRE-COMPACTED ASPHALT
- SENSOR 105: MULTIPLE SENSORS PROVIDE REAL TIME INFORMATION OF THE COMPACTION
- SENSOR 106: THE TOP DOWN SENSOR MEASURES IN REAL TIME THICKNESS, COMPACTION AND MIX RATIO, ELIMINATING THE NEED TO REMOVE A CORE AFTER INSTALLATION

ATTACHMENT G

Public Input

SENSOR 107: WHEN A MORE ACCURATE CORE EVALUATION IS REQUIRED, THE ENCIRCLING SENSOR PROVIDES ADDED REAL TIME INFORMATION WITH A TOP TO BOTTOM PROFILE OF THE MIX RATIO AND COMPACTION OF THE ROAD AT THE TEST SITE, WITHOUT RETURNING TO THE LABORATORY FOR DESTRUCTIVE TESTING

❖ **SMARTT™ SENSORS TELEMETRICALLY TRANSMIT CRITICAL DATA OF ROADS CONDITIONS TELEMETRICS ,THE CLOUD, SMARTT™ SENSORS**



Electronic collection and immediate transmission of data during production of road materials during mixing, loading, shipping and unloading. Additionally, at the construction site when dispensing, measuring thickness and during compaction. Similarly, the collection of data continues post manufacturing for reporting road problems, deterioration, and for preventative maintenance planning.

Telemetric data is available in real time through computers, cell phones. Operators are immediately notified of problems in time to correct. The availability and collection of data ensures warranty specifications are adhered to, enabling roads to last their theoretical lifetime.

Section 2. Enforcement Of Warranties Through Telemetrics

All telemetric data is stored in the "cloud" for easy retrieval, enabling enforcement of warranty specifications and guarantees. Each construction process is 100% inspected in real time. Roads are manufactured to warranty specifications and will last their theoretical life.

CLOUD, MDOT'S INTERNET OF THINGS IoT

A central storage of data for sharing and retrieval of crucial road information. It provides road technical information, technical resources, process information, construction schedules,

specifications, warranty information etc. Real time collected data is readily available with on demand access at the construction site as well as throughout MDOT.

ALL DATA WILL BE TELEMTRICALLY COLLECTED, ORGANIZED AND STORED. THE QUALITY OF ROAD MATERIALS AND CONSTRUCTION PRACTICES IS DOCUMENTED TO DETERMINE MANUFACTURER ADHERENCE TO WARRANTY SPECIFCIATIONS AND AGREED UPON GUARANTEES. HISTORICAL DATA IS ORGANIZED AND EASILY ACCESSIBLE.

TELEMETRICS PROVIDE POST-CONSTRUCTION AND HISTORICAL DATA COLLECTION

- MONITORS FOR CHANGES IN THICKNESS, COMPACTION, SEGREGATION, RUTTING…
- MONITOR FOR CRACKING, TOP DOWN AND BOTTOM UP
- EXACT LOCATION OF PROBLEMS OR DETERIORATION ARE TRANSMITTED AND RECORDED FOR IMMEDIATE ACTION OR PREVENTATIVE MAINTENANCE PLANNING

Section 3. Reduction of Maintenance Cost Through Telematics

- Specific sensors designed to record and report manufacturer or MDOT vehicle locations to optimize delivery of road materials and other vehicle activities. Also, telematics enables MDOT to monitor future vehicle inspection of post construction roads and during the performance of routine preventative maintenance checks. This information can be combined with prior telemetric data as well as linked to current traffic congestions, weather conditions and temperature reporting.

1. Optimized delivery of construction materials.
2. Linked to temperature and weather conditions, and traffic reporting.
3. Real Time coordinating of vehicle activity, load, fuel, and maintenance scheduling.
4. Combined with telemetric data ensuring on time delivery of materials without segregation.
5. Ability to monitor vehicle location as well as idle time, and re-assign trucks where needed.
6. Document costly "Fuel Burn" and correct inefficiencies
7. Enable data collection of "run time" of vehicles
   - for timely scheduling of vehicle maintenance
   - To monitor depreciation of the vehicle
   - To assist in manpower scheduling of drivers.

ATTACHMENT G

Public Input

Section 4. Long term Time Frames That Benefit Michigan and Maximize Value To The Taxpayer

❖ LONG TERM BENEFITS FOR OUR STATE ANT ITS TAXPAYERS
NO MORE CRUMBLING ROADS

- 100% inspection ensures quality roads will last their theoretical lives without premature failures. This results in reduction of potholes, budgetary cost savings, less vehicle damage and numerous other benefits for taxpayers, communities, and businesses.

- Adopting Magnetic Flux Tagging to asphalt/cement manufacturing is a long term solution that will provide improved and higher quality roads.

- All critical measurements are detected in real time and MDOT is immediately notified of problems for correction. Deterioration of roads infrastructure are minimized

  This results in direct cost savings for MDOT:

	Annual Costs
– Pothole repair (MI GOV FY2013) …….	$8.8 Million
– Road Manufacturer Contracts……	*$$$
– Costs for truck/vehicle purchases, manpower costs, equipment…….	*$$$
– Infrastructure repair cost (by ignoring basic maintenance and repair) Michigan Asset Management Council 2008" Repair costs Are Exploding" …….	$3.0 Billion

  MDOT budgetary savings can be redirected to new, innovative projects, research, and preventative maintenance. For every dollar spent on maintenance between $4 and $6 are saved on reconstruction (MAMC 2008)

- Real Time telemetric provides accurate data telemetrically sent to the server, ensuring MDOT has up to date material information. If an out of specification event occurs warnings will be sent to cell phone, lap tops etc. for evaluation and appropriate action. Since MDOT is immediately notified of substandard materials or poor construction practices, the problem is corrected <u>before</u> installation. This minimized the need for road tear up and replacement.

	Annual Costs
– Business closures due to re-routing, extensive repair results in less tax revenues, blight, unemployment ……	*$$$
– Traffic crashes in which roadway was a contributing factor (Michigan Transportation by the Numbers TRIP 2014……	$2.3 Billion

ATTACHMENT G

Public Input

- Taxpayer costs for extra car repair/wear accelerated depreciation (VOC) (TRIP 2014) ……. 2.3 Billion

- Taxpayer costs due to congestion Including lost time/wasted fuel…… $3.1 Billion
- Taxpayer costs due to increased tax revenues from higher registration fees, gas taxes, fees etc. ……*$$$

***Costs to be provided by MDOT**

- Vehicle telematics, fuel, temperature, position improves efficiency of road construction operations. Vehicle Telematics provides costs savings by:
  - Optimizing delivery of materials
  - Monitor post construction inspections
  - Monitor and document preventative maintenance checks.
- No longer should the taxpayer be burdened with paying more money to bandage our road.
- The focus should be on asking why are our roads crumbling.
- The key to long lasting roads is <u>ensuring quality during all phases of the manufacturing process</u>
- Magnetic Flux Tagging is the solution, leading the way to 50 year roads.

❖ **<u>BUILDING HIGH QUALITY ROADS THAT LAST 50 YEARS</u>**

- Longer lasting roads is an investment in Michigan.
  - Life cycle costs are <u>NOT</u> an issue because the costs for improving quality is not project specific.
  - Magnetic Flux Tagging ensures quality and as road performance increases the need for pothole repair and replacement decreases.
  - Whether the goal is 20,30,50 year roads, there are no additional costs since quality is controlled from laboratory testing to road compaction.
- Safer, better roads, grow our economy.
- No more crumbling infrastructure.
- 100% inspection of road material manufacturing and construction practices ensure roads that will last 50 years.
- It's time to build high quality roads and move Michigan to the forefront!

Real Time Ware, Inc.
586.725.8850
info@realtimewareinc.com
www.realtimewareinc.com
CONTACT: Thomas Targosz

QUESTIONS AND COMMENTS

RICK SNYDER
GOVERNOR

STATE OF MICHIGAN
DEPARTMENT OF TRANSPORTATION
LANSING

KIRK T. STEUDLE
DIRECTOR

May 26, 2016

The Honorable Earl Poleski
Michigan House of Representatives
P.O. Box 30014
Lansing, Michigan 48909

Dear Representative Poleski:

Thank you for your e-mail dated April 27, 2016, containing questions related to the *Michigan Department of Transportation (MDOT) Roads Innovation Task Force Report (RITF)*. We have provided answers to your questions below:

1. Several commentators noted the short time frame for offering suggestions for the report. Would a longer period allow for better suggestions?

   MDOT continually engages industry and the public regarding specifications, designs and projects. Many of our innovations, efficiencies and practices are a result of collaboration with stakeholders. Conversations regarding long life pavements and the work of the Roads Innovation Task Force are not limited to the time frames of the final due date of the RITF report, and will continue as we and industry are always looking to provide better service and products to our customers.

2. Attachments B and C look the same?

   Yes, a portion of attachment B was duplicated as part of C and this will be corrected.

3. As to Present Value Calculations:
   a. Are maintenance costs included?
   b. What discount rate employed?
   c. How many years out did the PV calculation go?

   a. *Yes, maintenance costs are included in the analysis, along with approximate time frames for performing the maintenance.*

   b. *A discount rate of 4 percent was used in the analysis.*

   c. *Present value calculations were carried out to 50 years.*

4. See page 19
   a. How is it that the Estimated Initial Investment as to a 30-year design life is over 7 times as great as that for a 20-year design life?
   b. As to Estimated 50-year costs, we should see the costs by vintage as to those 50 years
   c. As to Estimated PV amounts, need vintaging of costs and discount rate employed

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a. *The 20-year design scenario follows MDOT's traditional business practices of implementing a mix of fixes and investment levels needed to achieve and maintain its 95 percent good/fair freeway, and 85 percent good/fair non-freeway pavement condition goals. This scenario does not require a massive initial reconstruct investment. Rather, it needs only the additional funding required to implement a consistent, balanced strategy over the entire 50 years. The 30-year scenario was developed under the instructions in the legislation to have roads lasting for 30 years and have zero poor pavements in 10 years. Those scenarios required a massive initial investment to reconstruct 100 percent of the trunkline.*

b. *Regarding the costs that were used, please see Attachment A titled, "Roads Innovation Task Force Costs." The actual costs of the various enhancements that are shown will not be known until an actual project is let with the specific enhancements/innovations. The same can be said for the actual performance impact of the enhancements/innovations and thus, until actual performance has been achieved, we can only assume what benefit may be provided. Without actual project cost and performance information, MDOT will need to work with its industry partners to identify the potential costs and benefits.*

c. *The discount rate used was 4 percent and was calculated over a 50-year time line. The net present value was calculated over a 50-year time line. The annual investments were based on the initial 10-year investments, followed by 40 years of maintenance with the exception of the 20-year design life. That scenario is based on current practices and revenues needed to meet current pavement condition goals. It did not strive to get to 0 percent poor roads in 10 years like the 30- and 50-year designs did. The net present value is lower on the 20-year design because the investment is spread out over the entire 50 years, while the 30- and 50-year design scenarios require large, upfront investments with less maintenance requirements long term. Appropriate discount rate follow-up question: These rates, which are based on historical information and economic projections, affect the outcome of an analysis. The change in rates and prices of items such as Portland cement and asphalt cement result in strategy impacts that are not known in the future, especially in 50 years.*

5. See page 36.

a. How is it that a 30-year design life, which is only 10 more years, is almost double the cost of a 20-year design life?

The 20-year design scenario is structurally different than the 30- and 50-year design scenarios. The 30- and 50-year scenarios were developed under instructions in the legislation to have roads lasting 30 and 50 years and have zero poor pavements in 10 years. Those scenarios required a massive initial investment to reconstruct 100 percent of the trunkline in that 10-year window with subsequent maintenance. The 20-year design scenario follows MDOT's traditional business practices of implementing a mix of fixes and investment levels needed to achieve and maintain its 95 percent good/fair freeway and 85 percent good/fair non-freeway pavement condition goals. This scenario does not require a massive initial reconstruct investment. Rather, it needs only the additional funding required to implement a consistent, balanced strategy over the entire 50 years.

b. How to reconcile this substantially increased costs with the statement by Michigan Concrete Association on page F-3 that, with improved technologies, substantial increases in service life can be "accomplished without a significant increase in current pavement costs"?

MDOT will be meeting with the various industries, as well as others, to discuss the improved technologies and/or enhancements that will be incorporated into specifications used on pilot and demonstration projects. One item to note is that there are proposed changes beyond those strictly related to concrete paving in which the Michigan Concrete Association would be involved.

6. Page F-14.
   a. Note the suggestion by the Michigan Aggregate Association, especially their note 5, that "adequate inspection" occur.

   MDOT adheres to the Federal highway Administration's regulations pertaining to appropriate construction oversight of transportation projects. MDOT will ask the Michigan Aggregate Association for further details on this statement.

7. Attachment F looks only like a sales brochure.

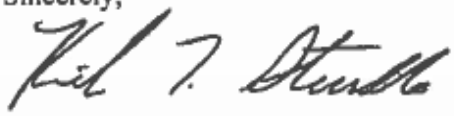
   MDOT solicited comments from many entities and the documents and comments received were put into the report in the format in which they were submitted.

8. Page F-42: Comments from MML look like no more than "More Money Lusting"

   To gain additional perspective on proposed design strategies and potential innovations, MDOT requested input from university centers of excellence (Michigan Technological Institute, University of Michigan (Attachment B), national pavement experts (Dr. David Timm, Dr. Tom Van Dam, Dr. Robert Rasmussen (Attachment C), departments of transportation and other transportation partners (New York State Department of Transportation, Iowa Department of Transportation, County Road Association, American Council of Engineering Companies of Michigan, Michigan Municipal League (Attachment D), and industry associations (Kentucky Association of Highway Contractors, Illinois Road and Transportation Builders, Construction Industries of Massachusetts, AGC of New York, AGC of Texas, Michigan Concrete Association, Asphalt Pavement Association of Michigan, Michigan Aggregate Association, Michigan Infrastructure & Transportation Association, and the Michigan Road Preservation Association (Attachment E).

If you have any questions, please contact either me or Frank Raha, Governmental Affairs Director, at 517-373-5507 or rahaf@michigan.gov.

Sincerely,



Kirk T. Steudle
Director

Maria Ostrander

From: Earl Poleski
Sent: Wednesday, April 27, 2016 4:03 PM
To: Maria Ostrander
Subject: MDOT Roads Innovation Task Force report

My questions, not an all-encompassing list:

1. Several commentators noted the short timeframe for offering suggestions for the report. Would a longer period allow for better suggestions?
2. Attachments B and C look the same?
3. As to Present Value Calculations:
    a. Are maintenance costs included?
    b. What discount rate employed?
    c. How many years out did the PV calc go?
4. See page 19.
    a. How is it that the Estimated Initial Investment as to a 30-year design life is over 7 times as great as that for a 20-year design life?
    b. As to Estimated 50 year costs, we should see the costs by vintage as to those 50 years
    c. As to Estimated PV amounts, need vintaging of costs and discount rate employed.
5. See page 36.
    a. How is it that a 30-year design life, which is only 10 more years, is almost double the cost of a 20-year design life?
    b. How to reconcile this substantially increased costs with the statement by Michigan Concrete Assn on page F-3 that, with improved technologies, substantial increases in service life can be "accomplished without a significant increase in current pavement costs"?
6. Page F-14.
    a. Note the suggestion by Michigan Aggregate Association, especially their note 5, that "adequate inspection" occur.
7. Attachment F looks only like a sales brochure.
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Earl Poleski
64th District State Representative
Office: 517.373.1795

RICK SNYDER
GOVERNOR

STATE OF MICHIGAN
DEPARTMENT OF TRANSPORTATION
LANSING

KIRK T. STEUDLE
DIRECTOR

May 26, 2016

The Honorable Geoff Hansen, Chair
Senate Appropriations Subcommittee
on Transportation
420 Farnum Senate Office Building
Lansing, Michigan 48933

The Honorable Edward Canfield, Chair
House Appropriations Subcommittee
on Transportation
1188 Anderson House Office Building
Lansing, Michigan 48933

Dear Chairmen Hansen and Canfield:

The Michigan Department of Transportation (MDOT) is in receipt of your recent letter. We appreciate your questions and are providing the below responses:

> *Discussions around improving road life from 20 to 30 or even 50 years have been reported. While it appears the conclusion is that despite the desire for building roads with improved lifespan, the cost is out of reach. However, in our discussions, you indicated that the process pointed to some innovative possibilities which could be included in the building of roads now which could extend the life of a 20-year road to 22 or 25 years without additional cost. These are the type of true innovations we need specifically outlined in the report.*

Response:
Table 2 in the report provides pavement enhancements that have the potential to increase pavement performance. It is not known precisely to what extent each one will have on pavement performance, nor the cost. Traditionally, MDOT works with the paving industries to determine the potential extent of enhancements, along with the estimated cost. The actual benefits and costs cannot be determined until a project is designed, let, constructed, and monitored over time. Anything short of this is essentially, an estimate.

The following lists, one for HMA and one for concrete, provide those items MDOT believes will have increased service life benefits that will exceed the additional costs to incorporate the items:

HMA:
- Increased mat density to 93 percent for acceptance
- Mix design requirement of 9.0 micron minimum film thickness
- Limitation of fines to effective binder of 1.20 during production
- Verification of aggregate specific gravities
- Tightening of percent within limits acceptance parameters
- Increased use of material transfer device with remixing capabilities
- Increased ride quality acceptance requirements
- Limitations on recycled material allowances

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Concrete:
- Increased aggregate properties for resistance to material related distress and increased freeze thaw durability
- Use of cementitious materials at 20 to 40 percent
- Corrosion resistant coating of dowel and lane tie bars
- Enhanced acceptance of air and air system; use of hardened air as acceptance
- Tightening of percent within limits acceptance parameters
- Increased time frames for concrete curing before allowing construction traffic
- Increased ride quality acceptance requirements
- Wet curing of concrete
- Stricter limitations on recycled material allowances

Secondly, you mentioned that certain roads in our state are maintained without utilizing federal funds. This provides MDOT and local road commissions a greater amount of flexibility in construction and planning, ultimately making these projects more cost effective. In our discussions, you provided specific examples of where these types of opportunities exist. How does the Department intend to prioritize spending to have the biggest, most direct positive impact on our roadways with the least amount of cost? How many of these opportunities exist and what are those cost savings?

Response:
Please see the enclosed: **MDOT Transportation Program Development Process**

Thirdly, and specifically, what state and federal statutory requirements/restrictions impede MDOT maximizing our limited transportation dollars? This is vital for the legislature to advocate for positive change on behalf of MDOT and Michigan citizens.

Response:
Please see the enclosed: **The Impact of State and Federal Laws on Highway Construction Costs**

Fourthly, my legislative colleagues and I are interested to learn how the department prioritizes road construction projects. We would suggest that the department develop a matrix geared to identify the projects that would have the greatest positive impact on our transportation infrastructure with current funding levels available.

Response:
The Highway Program Development Process outlined in response to #2 identifies the methodology used to prioritize road construction projects. In addition to this practice, MDOT is pursuing development of a prioritization tool as part of an overall movement to an integrated asset management system. An internal team representing pavement, bridge, safety, operations, and planning have developed a plan for potential implementation. The prioritization tool will take existing MDOT pavement condition, history, and traffic data to prioritize projects outside of

the current Five-Year Program structure (projects 5 to 10 years out). This tool will be utilized by the regions as well as statewide planning for project selection. Project prioritization will identify pavement needs based on pavement deterioration by segments. The pavement needs will be prioritized at the project level based on segment data and weighting. Funding and other asset priorities have precluded us from developing it before this time. We anticipate the project starting in the summer of 2017, assuming funding and other IT priorities are addressed.

> *I would also ask the department to refer to the attached questions posed by Representative Earl Poleski, and provide detailed explanations related to design life costs, initial investment and vintaging costs, and present value calculations. Any questions from your team should be directed to Rep. Poleski's office directly.*

Response:
The response to Representative Earl Poleski has been completed and is enclosed.

> *Finally, we believe it is important that the process be monitored over time. Suggested boilerplate language, which may assist the process and help hold all the parties accountable over time, is desired to that end.*

Response:
From the report:

BACKGROUND:
Public Act 175 of 2015 requires that MDOT's Roads Innovation Task Force update and finalize the report described in Subsection (2) to provide suggested boilerplate language, which coincides with how the Department would execute the plan and attempt to achieve the targets described in Subsection (1). The plan is to include sufficient detail to allow the legislature to monitor and track progress, estimate how long it is expected to take to achieve targets, and project what the inflation-adjusted reduction in annual spending will be once fully implemented, as compared to costs in 2015.

MDOT will continue to seek new materials, technologies, and construction methods that have the potential to improve pavement performance and reduce life cycle costs. MDOT will use its New Materials Evaluation Procedure, Pavement Demonstration Program, research findings, and results in evaluating these innovations. MDOT's technical staff will continue to work closely with Michigan universities and other experts to investigate a variety of issues that impact pavement performance. MDOT will continue to provide leadership and remain technically engaged in national research by ad hoc consortia and through national pooled resource opportunities. Participating in these programs and initiatives will increase MDOT's innovative capacity with the goal of increasing pavement performance and reducing life cycle costs.

MDOT currently uses Equivalent Uniform Annual Cost (EUAC) methodology for life cycle cost analysis, as outlined in the Department's *Pavement Design and Selection Manual*

(February 9, 2012 Edition). MDOT will monitor its goal of achieving longer life pavements with reduced life cycle costs by using the manual's current pavement performance curves. These performance curves will be used as the 2015 base lines. Improvements made to enhance pavement performance and reduce life cycle costs will be compared to these performance curves to determine their effectiveness. Actual initial costs and maintenance costs, along with actual performance history of the projects incorporating the performance enhancements, will be used for the comparative analysis. It should be understood that collecting actual performance information will take years, in most cases, to account for actual traffic loading and environmental factors. In some cases, it may be possible to utilize accelerated loading facilities (such as the National Center for Asphalt Technology, Minnesota Test Track (MnRoad) as part of the National Road Research Alliance, or the Federal Highway Administration's Accelerated Load Facility at the Turner-Fairbank Highway Research Center) to predict long-term performance. However, there is currently no way to assess environmental impacts on full-scale pavements under accelerated traffic loadings at these facilities or others. Environmental impacts can only be achieved by building an actual test section with live traffic and monitoring the environmental impacts as they occur over time.

Although no targets have been established, MDOT will strive to achieve net reductions of 25 percent in EUAC for hot mix asphalt and Portland cement concrete pavements over the next 20 years. Incremental progress will be tracked and reported. As technology advances, it may be possible at some point to accelerate both traffic and environmental performance predictions on a full-scale model, which may facilitate expedited determinations relative to life cycle cost reductions.

For reporting purposes, MDOT will utilize its existing demonstration program and materials evaluation procedure to report those items that have been evaluated and/or demonstrated in actual pavement projects. Research findings will also be reported for those items that have had documented impacts on pavement performance. Additionally, any specification-related changes to material enhancements, increased acceptance limits, or construction methods that have the potential toward enhanced pavement performance will be reported. MDOT will strive to make at least one enhancement each year that has been judged worthy as potentially having a direct impact on increasing pavement performance. These enhancements will be included in a biennial report to the legislature for monitoring purposes. Each enhancement will be reported, along with its expected contribution to improve pavement performance and reduction in overall life cycle costs.

SUGGESTED BOILERPLATE LANGUAGE:
MDOT proposes inclusion of the following language in annual budget bills:

> *The Department shall continually strive to lower the Equivalent Uniform Annualized Cost (EUAC) of hot mix asphalt and Portland cement concrete pavements. Beginning in 2018, the Department will issue a biennial report that provides specific measures the Department is taking to achieve this goal. The report will list demonstration projects that incorporate a specific enhancement that is intended to decrease the EUAC of a*

particular pavement type. Additionally, any material enhancements, increased acceptance limits, or construction requirements made to specifications that have the potential to enhance pavement performance will be reported, along with their intended benefits. Furthermore, any new materials submitted to the Department will be reported with the status of each. When sufficient performance data has been obtained for an individual enhancement, the Department will provide a performance curve and EUAC that is compared to the base line performance curve and EUAC as published in the 2012 "Pavement Design and Selection Manual," and an inflation-adjusted reduction in annual spending will be provided as compared to costs in 2015.

If you have any questions, please contact either me or Frank Raha, Office of Governmental Affairs Director, at 517-373-5507 or rahaf@michigan.gov.

Sincerely,

Kirk T. Steudle
Director

Enclosures

MDOT Transportation Program Development Process

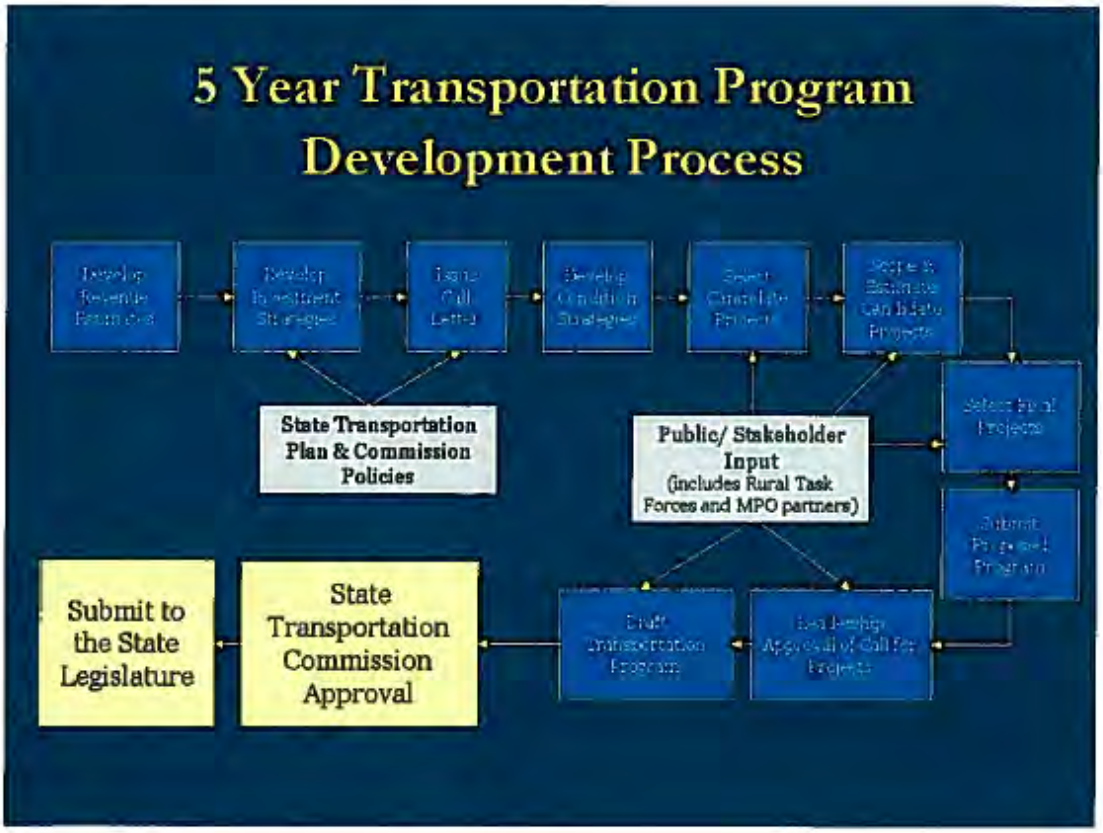
MDOT takes an asset management approach to managing highway investments. Asset management is a strategic approach to linking data, goals, investment strategies, programs, and projects into a systemic process to ensure achievement of a desired result. This process also includes monitoring results and making adjustments, as appropriate. This strategic approach can be described in a circular model as shown below.

These are the steps in the asset management process:

- Goals and objectives are established.
- System inventory and condition data is collected.
- The condition data is analyzed and rates of deterioration are computed.
- Performance measures and standards are set or reaffirmed.
- Investment strategies are developed using forecasting tools.
- Those investment strategies are implemented through the development of programs, selection of projects, and institution of practices (MDOT highway program development process), which fit into the investment strategies.
- The process and system is monitored and adjusted based on the outcome of the projects and programs that were implemented.

MDOT's Highway Program development process is a yearlong, multi-stage process as shown in the following flowchart. MDOT continues to emphasize and strengthen partnering efforts with transportation stakeholders and the general public throughout this process. MDOT also continues to implement processes developed at workshops and stakeholder meetings to incorporate context-

sensitive solutions into transportation projects, and seek public input from a variety of sources on future Five-Year Transportation programs.



MDOT Transportation Program Development Key Steps

Determine Estimated Federal and State Revenue Available

The Five-Year Program identifies strategies that efficiently utilize the state and federal funds we expect to be available over the time frame.

Develop Investment Strategies

The State Transportation Commission (STC) establishes policies, goals, and objectives that provide the basis for funding allocation decisions. Investment levels are developed for each work program category (road, bridge, safety, etc.) that support the direction established by the STC and facilitate the accomplishment of program goals and objectives.

Issue Call for Projects

MDOT issues an internal Call for Preservation Projects annually for the Highway Program. A letter and instructions are issued to all seven MDOT regions, which are responsible for proposing preservation projects. Key emphasis areas and strategic objectives are outlined and detailed technical instructions are issued. Target funding levels for each region are calculated from a

formula based on weightings relating the pavement conditions, usage, costs, and eligible lane miles.

Develop Condition Strategies

Regional improvement strategies for the road and bridge networks are developed by MDOT region staff using the Road Quality Forecasting System (RQFS) and Bridge Condition Forecasting System (BCFS) tools, as well as input from partners and stakeholders. These strategies will guide project selection and ensure that a mix-of-fixes is incorporated into program development. There are a number of repairs or fixes that can be made to existing facilities that have different impacts to the trunkline network. Fixes are categorized into three groups: Long term, medium term, and short term. By applying a mix-of-fixes approach that includes a combination of long, medium, and short term fixes, MDOT is able to systematically address system needs in the most cost-effective means possible. Once a recommended strategy is approved, candidate road and bridge projects are selected that are consistent with the strategy and funds available.

Candidate Project Selection and Submittal

Candidate projects are selected based on a need that meets program criteria. For road and bridge rehabilitation and reconstruction projects, the pavement or bridge must meet criteria for condition, which is based on the distresses that are evident in the road or bridge under consideration. Some of the distresses that are measured are cracking, rutting, roughness, and faulting (i.e. movement of the pavement).

A list of candidate projects is compiled and prioritized. Priority is determined by the severity of the distress, the amount of traffic on the roadway, public input, maintenance costs, the context of the roadway, and other factors. For instance, a roadway that serves commercial or industrial businesses may be given preference over a similar roadway that does not.

From the prioritized list of projects, a list of projects is selected to proceed with scoping and estimating. This list is determined by the funds available for construction. To assure that there is a good cross section of projects to make a final selection, a surplus of candidate projects are selected to proceed to the scoping stage.

Scope and Estimate Candidate Projects

The first step in preparing the scope of a project is to review the project and verify the proposed fix in the field. A group of technical staff is assembled and drives the proposed project from end to end. This van tour identifies work in addition to the pavement or bridge work (i.e. drainage work, sidewalk needs, safety work, access issues, etc.) Also at this time, some project issues such as environmental issues and utility conflicts can be identified. Crash data is also compiled and researched to look for areas of concern during the van tour. Other items of work not originally considered may be added at this point in the process. For example, if a road project is proposed, but no bridge work, the van tour may identify some preventive maintenance work that can be performed on the bridges, so that all the needs in the corridor can be addressed in a single project.

During this time, public input is solicited in several ways. Candidate projects are discussed with local road agencies, local governmental agencies, and MPOs, and input is solicited from the general public either through the public agencies or through project specific input sessions.

Once the need is verified on the van tour and additional issues are identified, a scoping document is prepared. The scoping document is a thorough analysis of all the aspects of the project and may look at several types of fixes so the most cost effective fix can be selected. It also analyzes several methods of maintaining traffic during construction so that customer mobility can be maximized. Other items considered during scoping are upgrades to the operation of the roadway, complete streets/context sensitive solutions, innovative construction methods, environmental impacts and necessary permits, etc. Rough preliminary plans are drafted for the project during the scoping stage and these plans are used as the beginning point for the design stage of the project.

A detailed estimate is performed based on estimated contract pay items and the expected unit prices for these pay items. An inflation rate is applied to the estimate so that an accurate cost for the year of construction can be determined.

Final Project Selection

When the scoping documents are completed and a project scope and estimate are finalized, project selection can be completed. Projects are selected to meet the approved program strategies as closely as possible. During final project selection, consideration is given to providing a balance of work across the regions, so that mobility for our customers can be provided region-wide. Other items considered during final selection are similar to those used in the prioritization of candidate projects.

Final Program Submission

Candidate projects are submitted to the CFP subcommittees for review. Feedback is provided to the regions based on analysis of program consistency with approved strategies and submittal criteria, condition data, appropriate fix life project estimates, and if proposed budget of projects are within established thresholds.

Updates are made to the projects based on subcommittee feedback and final program submittal is made.

Call for Projects Approval

The subcommittees then recommend approval of the projects to the Call for Projects Approval Committee, which reviews the program and recommends approval to the MDOT Chief Administrative Officer and Chief Operations Officer.

The Approval Committee is not only responsible for recommending final approval of the program, but is the centerpiece in the MDOT processes for ensuring statewide consistency and compliance. As such, the Approval Committee is responsible for the following actions throughout the Call for Projects process:

- Approve program approach to transportation system management for consistency throughout the state.
- Approve region and statewide strategies.
- Recommend CFP Program (including project list) for final executive approval.
- Provide strategic direction.

- Approve funding.
- Resolve any projects or conflicts in the CFP submittals that do not comply with the guidelines in the CFP Letter.
- Approve changes to the CFP process, tools, data, etc.
- Approve adding/deleting programs to the CFP.

Five-Year Transportation Program

Assembly of the draft Five-Year Transportation Program begins after the CFP process is completed for the Highway Program. Each year, the Five-Year Transportation Program is finalized when it is approved by the STC. The document is also submitted to the Michigan State Legislature.

Public Involvement and Outreach

Outreach and coordination occurs throughout the Five-Year Transportation Program process, beginning with candidate project selection and continuing through final project selection and review of the draft transportation program. Stakeholders include the public, rural task forces, MPO partners, individual units of government, and the Michigan State Legislature.

Adjustments throughout the Process

Within a strategic, proactive, asset management approach to system preservation, it is essential to monitor progress, obtain feedback, and when necessary, make adjustments or refinements in order to improve the project selection process in future years. Within each cycle of the CFP process, MDOT makes observations about the data, analytical tools, assumptions made in the analysis, forecast condition, and the overall program development process, and makes the necessary modifications. Program and project changes are also made over the course of any given year in response to customer and stakeholder comments and changing system needs and constraints.

Road Quality Forecasting System (RQFS)

As a part of MDOT's efforts to apply a comprehensive asset management approach to its decision making process, MDOT uses a pavement condition forecasting model, the Road Quality Forecasting System (RQFS), to aid in the creation of the department's pavement preservation initiatives. Using RQFS, the department can make educated forecasts to the future condition of MDOT's trunkline network measured by remaining service life (RSL). This can be done using a variety of possible funding levels and pavement improvement strategies.

The Impact of State and Federal Laws on Highway Construction Costs
May 26, 2016

Question: *What state and federal statutory requirements/restrictions impede MDOT maximizing our limited transportation dollars?*

Response: MDOT consistently works to maximize the use of limited transportation dollars, operating within the requirements of state and federal law.

A wide variety of state and federal laws have been enacted that impact road construction, addressing aspects related to safety, labor, the environment, planning, and other areas of concern. Although these laws may have incrementally increased the time and cost of implementing transportation projects, most are intended to help address issues that cost society in other ways, such as pollution or loss of life.

As these laws have been enacted, their requirements have been incorporated into MDOT's business processes. Many of these federal and state requirements are now an integral part of the way MDOT does business. Some of the major federal laws impacting transportation are listed below:

- Americans with Disabilities Act, 42 USC chapter 126
- Buy America, 23 USC 313 (requirement for domestic iron and steel)
- Davis-Bacon Act, 40 USC 3141 et seq., 23 USC 113
- Disadvantage Business Enterprise program, 23 USC 140, 23 CFR part 230
- Federal Contracting laws and regulations, 23 USC 112 (including the Brooks Act, 40 USC 471 et seq.)
- Native American Graves Protection and Repatriation Act, 1990, 23 USC 3001 et seq.
- National Environmental Protection Act of 1969 (NEPA) – 42 USC 4321
- Occupational Safety Health Act requirements, 29 USC chapter 15
- Planning laws and regulations, 23 USC 134, 135
- Public Hearings/Public Involvement, 42 USC 6901 et seq.
- Title VI of the Civil Rights Act, 1964, 42 USC 2000d et seq.

Many of the federal laws apply regardless of the source of funding. For example, Title VI of the Civil Rights Act, the Occupational Safety and Health Act, the Endangered Species Act, the Clean Air Act, the Clean Water Act, and hazardous waste laws apply regardless of the funding source or approval path. The following pages also include a list of major environmental laws as cited in the 2013 stewardship agreement signed by MDOT and FHWA.

Applicable Federal Laws, Regulations, Orders and Procedures

Environmental Topic	Law	Implementing Regulations
Antiquities Act, 1906	16 USC 431-433	36 CFR 251.50-64 42 CFR 3
American Indian Religious Freedom Act, 1978	42 USC 1996	N/A
American with Disabilities Act, 1990	42 USC 126	23 CFR 652
Archeological and Historic Preservation Act, 1974	16 USC 469	36 CFR 66
Archeological Resources Protection Act, 1980	16 USC 470	43 CFR 7 18 CFR 1312 32 CFR 79 36 CFR 229 36 CFR 296
Bald and Golden Eagle Protection Act, 1940	16 USC 668	N/A
Title VI of the Civil Rights Act, 1964	42 USC 2000d et seq.	49 CFR 21 and 23 CFR 200
Civil Rights Restoration Act, 1987	20 USC 1681 et seq.	N/A
Clean Air Act, 1970	42 USC 7401 et seq. 42 USC 7509, 75219(a) 23 USC 109(J)	23 CFR 771 40 CFR 51 & 93
Clean Water Act, 1972	33 USC 1251 et seq.	33 CFR 26 40 CFR 122-124
Coastal Zone Management Act, 1972	16 USC 1451	15 CFR 923-930
Comprehensive Environmental Response, Compensation, and Liability Act, Superfund Amendments and Reauthorization Act,	42 USC 9601 et seq.	40 CFR 300 43 CFR 11
Department of Transportation Act, Section 4 (f),	49 USC 303 23 USC 138	23 CFR 774
Endangered Species Act, 1973	16 USC 1531 et seq.	7 CFR 335; 50 CFR 17, 23, 81, 222, 225-227, 402, 424, 450, 453
Executive Order 11991, Protection and Enhancement of Environmental Quality, 1970	N/A	N/A
Executive Order 11988, Floodplain Management;	N/A	23 CFR 650, 771; 44 CFR 59-62, 64-68, 70-71,
Executive Order 11990, Protection of Wetlands	N/A	DOT Order 5660.1A 23 CFR 777
Executive Order 12898, Environmental Justice, 1994	N/A	Federal Register Vol. 60, No. 125, pp. 33896-33903

Environmental Topic	Law	Implementing Regulations
Executive Order 13166, Limited English Proficiency, 2000	N/A	Federal Register Vol. 70, No. 239, pp. 74087-74100
Executive Order 11990, Protection of Wetlands, 1977	N/A	23 CFR 777
Farmlands Protection Policy Act, 1981	7 USC 4201-4209	7 CFR 658
Federal aid Highway Act, 1956	23 USC 101	23 CFR
Fish and Wildlife Coordination Act, 1934	16 USC 661-666(C)	N/A
General Bridge Act, 1945	2 USC 525	2 CFR Parts 114-115
Highway Beautification Act, 1965	23 USC 131, 136, 319	23 CFR 750 23 CFR, 751, 752
Intermodal Surface Transportation Efficiency Act,	40 CFR 93 (CEQ)	23 CFR 771 (FHWA)
Land & Water Conservation Act, Section 6(f), 1965	16 USC 4601-8(f);	N/A
Migratory Bird Treaty Act, 1918	16 USC 703 et seq.	N/A
National Environmental Policy Act, 1969	42 USC 4321 et seq.	23 CFR 771, 772, and 777
National Flood Insurance Act, 1968 and Flood Disaster Protection Act, 1973	42 USC 4001 et seq.	N/A
National Forest Management Act, 1976	16 USC 1604(g) (3) (B)	N/A
National Historic Preservation Act, Section 106,	16 USC 470f,	23 CFR 771; 36 CFR 60;
National Trails System Act, 1968	16 USC 1241-1249	251; 43 CFR 8350
Native American Graves Protection and Repatriation Act, 1990	25 USC 3001 et seq	43 CFR 10
Noise Control Act, 1972	42 USC 4901 et seq. 23 USC 109i	3423 CFR 772
Public Hearings/Public Involvement	42USC6901et seq.	43 CFR 10256-300 40 CFR 61, 23 CFR 751
Rivers and Harbor Act, 1899	Section 9, Section 10	33 CFR Parts 114-115; 23 CFR 650
Resource Conservation and Recovery Act, 1976 and Hazardous and Solid Waste Amendments, 1984	42 USC 6901 et seq.	40 CFR 280, 281, 260-265 40 CFR 61
Rivers and Harbor Act, Section 9, Section 10	33 USC 403	33 CFR Parts 114-115
Safe, Accountable, Flexible, Efficient Transportation	23 USC 6002-6011	23 CFR 771
Safe Drinking Water Act, 1974	42 USC 300f et seq.	N/A

Environmental Topic	Law	Implementing Regulations
Surface Transportation & Uniform Relocation Assistance Act, 1987	23 USC 144(O)	23 CFR 752
Wild and Scenic Rivers Act, 1968	16 USC 1271-1287	36 CFR 251, 297; 43 CFR 8350

State Laws

Numerous amendments have been made to PA 51 of 1951 and the Michigan Vehicle Code over the past 50 years. Some of the changes to Act 51 include creation of the Transportation Economic Development Fund in 1987, the Transportation Asset Management Council in 2003, the Complete Streets Advisory Council in 2010, and transportation funding study and citizens' advisory committees in 2000 and again in 2007.

The Michigan Vehicle Code was amended by Public Act 152 of 2003 to create the Transportation Administration Collection Fund (TACF) and the Traffic Safety and Law Enforcement Fund (TS&LEF). The creation of these two funds, along with increases in vehicle registration fees to support them, enable the annual diversion of $50 million in vehicle registration fees to the Secretary of State's office and $17 million in vehicle registration fees to the Michigan State Police. Public Act 141 of 2005 transferred another $10 million per year in various license fees from the Michigan Transportation Fund to the TACF. While these diversions do not directly impact project cost, they do erode available transportation revenue for highway construction projects.

Michigan's prevailing wage law, Public Act 166 of 1965, requires that wages and fringe benefits on state-funded projects shall not be less than the wages in union contracts in the locality where the work is to be performed. Michigan's act mirrors the language of the federal prevailing-wage act.

Most Michigan environmental laws mirror federal laws so the state may obtain federal aid for its environmental programs or, in the case of wetland permits, control the permitting process. Public Act 451 of 1994 includes all state environmental laws pertaining to transportation. Only one aspect of this state law exceeds the requirements of federal law: Part 31 of the Natural Resources and Environmental Protection Act (Act 451 of 1994), which pertains to floodplains. In addition, Public Act 169 of 1970 allows communities to establish local historic district ordinances; MDOT is required to consult with the local historic district commission on projects located in such a local historic district.

RICK SNYDER
GOVERNOR

STATE OF MICHIGAN
DEPARTMENT OF TRANSPORTATION
LANSING

KIRK T. STEUDLE
DIRECTOR

May 26, 2016

The Honorable Earl Poleski
Michigan House of Representatives
P.O. Box 30014
Lansing, Michigan 48909

Dear Representative Poleski:

Thank you for your e-mail dated April 27, 2016, containing questions related to the *Michigan Department of Transportation (MDOT) Roads Innovation Task Force Report (RITF)*. We have provided answers to your questions below:

1. Several commentators noted the short time frame for offering suggestions for the report. Would a longer period allow for better suggestions?

   MDOT continually engages industry and the public regarding specifications, designs and projects. Many of our innovations, efficiencies and practices are a result of collaboration with stakeholders. Conversations regarding long life pavements and the work of the Roads Innovation Task Force are not limited to the time frames of the final due date of the RITF report, and will continue as we and industry are always looking to provide better service and products to our customers.

2. Attachments B and C look the same?

   Yes, a portion of attachment B was duplicated as part of C and this will be corrected.

3. As to Present Value Calculations:
   a. Are maintenance costs included?
   b. What discount rate employed?
   c. How many years out did the PV calculation go?

   a. *Yes, maintenance costs are included in the analysis, along with approximate time frames for performing the maintenance.*

   b. *A discount rate of 4 percent was used in the analysis.*

   c. *Present value calculations were carried out to 50 years.*

4. See page 19
   a. How is it that the Estimated Initial Investment as to a 30-year design life is over 7 times as great as that for a 20-year design life?
   b. As to Estimated 50-year costs, we should see the costs by vintage as to those 50 years
   c. As to Estimated PV amounts, need vintaging of costs and discount rate employed

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a. *The 20-year design scenario follows MDOT's traditional business practices of implementing a mix of fixes and investment levels needed to achieve and maintain its 95 percent good/fair freeway, and 85 percent good/fair non-freeway pavement condition goals. This scenario does not require a massive initial reconstruct investment. Rather, it needs only the additional funding required to implement a consistent, balanced strategy over the entire 50 years. The 30-year scenario was developed under the instructions in the legislation to have roads lasting for 30 years and have zero poor pavements in 10 years. Those scenarios required a massive initial investment to reconstruct 100 percent of the trunkline.*

b. *Regarding the costs that were used, please see Attachment A titled, "Roads Innovation Task Force Costs." The actual costs of the various enhancements that are shown will not be known until an actual project is let with the specific enhancements/innovations. The same can be said for the actual performance impact of the enhancements/innovations and thus, until actual performance has been achieved, we can only assume what benefit may be provided. Without actual project cost and performance information, MDOT will need to work with its industry partners to identify the potential costs and benefits.*

c. *The discount rate used was 4 percent and was calculated over a 50-year time line. The net present value was calculated over a 50-year time line. The annual investments were based on the initial 10-year investments, followed by 40 years of maintenance with the exception of the 20-year design life. That scenario is based on current practices and revenues needed to meet current pavement condition goals. It did not strive to get to 0 percent poor roads in 10 years like the 30- and 50-year designs did. The net present value is lower on the 20-year design because the investment is spread out over the entire 50 years, while the 30- and 50-year design scenarios require large, upfront investments with less maintenance requirements long term. Appropriate discount rate follow-up question: These rates, which are based on historical information and economic projections, affect the outcome of an analysis. The change in rates and prices of items such as Portland cement and asphalt cement result in strategy impacts that are not known in the future, especially in 50 years.*

5. See page 36.

a. How is it that a 30-year design life, which is only 10 more years, is almost double the cost of a 20-year design life?

The 20-year design scenario is structurally different than the 30- and 50-year design scenarios. The 30- and 50-year scenarios were developed under instructions in the legislation to have roads lasting 30 and 50 years and have zero poor pavements in 10 years. Those scenarios required a massive initial investment to reconstruct 100 percent of the trunkline in that 10-year window with subsequent maintenance. The 20-year design scenario follows MDOT's traditional business practices of implementing a mix of fixes and investment levels needed to achieve and maintain its 95 percent good/fair freeway and 85 percent good/fair non-freeway pavement condition goals. This scenario does not require a massive initial reconstruct investment. Rather, it needs only the additional funding required to implement a consistent, balanced strategy over the entire 50 years.

b. How to reconcile this substantially increased costs with the statement by Michigan Concrete Association on page F-3 that, with improved technologies, substantial increases in service life can be "accomplished without a significant increase in current pavement costs"?

MDOT will be meeting with the various industries, as well as others, to discuss the improved technologies and/or enhancements that will be incorporated into specifications used on pilot and demonstration projects. One item to note is that there are proposed changes beyond those strictly related to concrete paving in which the Michigan Concrete Association would be involved.

6. Page F-14.
   a. Note the suggestion by the Michigan Aggregate Association, especially their note 5, that "adequate inspection" occur.

   MDOT adheres to the Federal highway Administration's regulations pertaining to appropriate construction oversight of transportation projects. MDOT will ask the Michigan Aggregate Association for further details on this statement.

7. Attachment F looks only like a sales brochure.

   MDOT solicited comments from many entities and the documents and comments received were put into the report in the format in which they were submitted.

8. Page F-42: Comments from MML look like no more than "More Money Lusting"

   To gain additional perspective on proposed design strategies and potential innovations, MDOT requested input from university centers of excellence (Michigan Technological Institute, University of Michigan (Attachment B), national pavement experts (Dr. David Timm, Dr. Tom Van Dam, Dr. Robert Rasmussen (Attachment C), departments of transportation and other transportation partners (New York State Department of Transportation, Iowa Department of Transportation, County Road Association, American Council of Engineering Companies of Michigan, Michigan Municipal League (Attachment D), and industry associations (Kentucky Association of Highway Contractors, Illinois Road and Transportation Builders, Construction Industries of Massachusetts, AGC of New York, AGC of Texas, Michigan Concrete Association, Asphalt Pavement Association of Michigan, Michigan Aggregate Association, Michigan Infrastructure & Transportation Association, and the Michigan Road Preservation Association (Attachment E).

If you have any questions, please contact either me or Frank Raha, Governmental Affairs Director, at 517-373-5507 or rahaf@michigan.gov.

Sincerely,

Kirk T. Steudle
Director

RICK SNYDER
GOVERNOR

STATE OF MICHIGAN
DEPARTMENT OF TRANSPORTATION
LANSING

KIRK T. STEUDLE
DIRECTOR

August 31, 2016

The Honorable Mike Shirkey
Michigan State Senate
P.O. Box 30036
Lansing, Michigan 48909

Dear Senator Shirkey:

Response to Roads Innovation Task Force Report Questions

Public Act 175 of 2015, signed by Governor Rick Snyder on November 10, 2015, amended Public Act 51 of 1951 and set forth requirements for the Michigan Department of Transportation (MDOT) regarding the *Roads Innovation Task Force Report*. The report included recommendations for long life pavements (30- and 50-year designs), along with enhancements that could be made to material and acceptance requirements to improve pavement performance and pavement life.

MDOT's response to your questions are as follows:

1. ***What are the specific test installations that are going to include stretch design standards intended to test "what can be possible"?***
   As a result of the Roads Innovation Task Force (RITF) report and legislative inquiries, MDOT is proposing to construct Hot Mix Asphalt (HMA) and Concrete 30- and 50-year design life pavement demonstration projects.

   The 30-Year HMA Pavement will include the following design standards:
   - Mechanistic Empirical Pavement Design (MEPD) that requires 11.25" of HMA.
   - The overall aggregate base and sand subbase cross section will be increased to a minimum 36" to resist frost. The 20-year design standard is 24."
   - The subbase underdrain outlets will be a minimum of 2' above the ditch line to keep the subbase from becoming saturated. With 20-year design, there is no minimum. The ditches become filled with material which backs up the water into the subbase.
   - Use of Gap Graded Superpave as the HMA top course.
   - Required use of material transfer device.
   - Increase the film thickness for HMA to coat the aggregate.
   - Increased mat density to 93%.
   - Increased ride quality requirements from 75 per 20-year design to 65.
   - Limit fines to effective ratio to 1.2 during production. This will improve the asphalt cement contract to coat the aggregate.
   - Limit recycled material allowance to Recycled Asphalt Pavement only.

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The 50-Year HMA Pavement will include the 30-year design standards, as well as:

- The HMA pavement thickness is 11.0" due to traffic levels.
- Increase the mat density to 94.00%.
- The subbase underdrain outlets will be a minimum of 3' above the ditch line.
- Ride quality increase to 55.

The 30-Year Concrete Pavement design standards will include:

- A cement treated permeable base for uniform support of the concrete pavement.
- A geotextile fabric separator between the cement treated permeable base and the subbase to prevent commingling of the materials.
- The subbase underdrain outlets will be a minimum of 2' above the ditch line.
- An additional pay item for Concrete Curing. This will require the contractor to ensure an improved cure process.
- Dowel bars with a higher quality corrosion resistant coasting than the 20-year design.
- Enhanced acceptance testing of air content.
- Increased ride quality requirements.
- Limit recycled material.
- Allow supplemental cementation materials at 20-40%. This increases the density of the concrete which reduces the permeability.

The 50-Year Concrete Pavement will include the 30-Year design standard. In addition, the following will be required:

- Increased freeze thaw requirements to 0.030 freeze thaw from 0.040 for the 20- and 30-year design. This increases the aggregate durability and reduces the aggregate expansion. There will be less expansion in the concrete slab.

2. ***Where and When?***

Four projects have been identified and are shown in Table 1 below. The two 30-year projects are slated for a 2017 letting and the two 50-year projects are slated for a 2018 letting.

Table 1

Construction Year	Design Life	Pavement Type	Region	Control Section	Job No.	Route	Location	Miles
2017	30	HMA	Grand	41132	119012	US-131	14 Mile to White Creek	3.553
2017	30	Conc	Bay	25085	115799	I-69	Ballenger Hwy to Fenton Rd	1.556
2018	50	HMA	Bay	25132	119085	I-475	Carpenter Rd to Clio Rd	3.061
2018	50	Conc	Grand	41132	117992	US-131	10 Mile to 14 Mile	4.362

3. ***Design elements being tested?***
   The response to Question 1 covers the changes in the design elements.

4. ***Hoped or expected outcome?***
   The design changes for the 30- and 50-year demonstration projects are expected to increase the pavement service life. We expect the demonstration pavements will require less maintenance during the pavement service life. The demo projects will be monitored to collect costs to determine the benefit/cost of the demo designs.

5. ***How are we going to measure the outcomes?***
   Enclosed is the guideline for "Work Plans for Pavement Demonstration Projects." The project specific work plan will follow this guideline. Each project will have the work plan developed by December 1, 2016. MDOT regularly monitors pavement condition as part of its asset management process. MDOT will highlight the four demonstration projects each reporting cycle.

   The demo HMA projects performance will be monitored by the following tests:
   - Indirect Tensile Strength
   - Dynamic Modules
   - Shear Modules of Asphalt Cement
   - Creep Compliance
   - In-Place Air Voids

   The Concrete demonstration projects performance will be monitored by the following tests:
   - Hardened Air
   - Permeability
   - Long-Term Load Transfer Ability
   - Coefficient of Thermal Expansion

These tests will be required in the demonstration project work plan.

In addition to the 30- and 50-Year demonstration projects, MDOT is in the process of requiring the following enhancements on applicable 2017 Projects:

HMA Enhancements:
- Increased mat density to 92.50%
- Increased use of Material Transfer Device
- Begin checking of specific gravity in 2017 with implementation as a quality assurance check in 2018
- Longitudinal Joint enhancement by piloting 4 enhancements per the recommendation of the HMA Construction Sub Committee

Concrete Enhancements:
- Enhanced epoxy coating for load transfer dowels
- Establish pay item for curing of concrete sub
- Enhanced acceptance of air and air systems; begin piloting Super Air Meter (quality control in 2017 with implementation for quality assurance in 2018)

- Enhanced acceptance testing for permeability; begin piloting Resistivity Meter (quality control in 2017 with implementation for quality assurance in 2018)

MDOT is working on development of the application guidelines and acceptance criteria for these enhancements.

Table 2 provides the best estimated demonstration costs per lane mile.

Table 2

Design Life	Pavement Type	Region	Control Section	Job Number	Route	Demo Lane Miles	Control Lane Miles	Additional Cost Per Lane Mile of Demo Section
30	HMA	Grand	41132	119012	US-131	5.11	9.11	$1,762,632
30	Conc	Bay	25085	115799	I-69	5.26	5.26	$2,212,457
50	HMA	Bay	25132	119085	I-475	8.57	8.57	$1,730,644
50	Conc	Grand	41132	117992	US-131	6.72	10.72	$2,453,896

The total increased cost for the 30- and 50-year demonstration projects is estimated to be $52 million.

We hope we have addressed your concerns. If you have further questions, please contact either me or Randy Van Portfliet, Bureau of Field Services Director, at 906-786-1830, or vanportflietr@michigan.gov.

Sincerely,

Kirk T. Steudle
Director

Enclosure

BFS:CFS:CJB:clc

bc: M. Van Port Fleet
R. Van Portfliet
P. Browne
M. Chaput
J. Gutting
Executive File

REGION DEVELOPMENT GUIDELINES
FOR
WORK PLANS FOR PAVEMENT DEMONSTRATION PROJECTS

At their September 2002 meeting, the Engineering Operations Committee (EOC) approved Guidelines for Pavement Demonstration Projects. As the law states, "*Each demonstration project shall include measurable goals and objectives for determining the success of that project. The department shall make a final report for each demonstration project following the demonstration life of the project, which may be shorter than the actual pavement life of the material used for the project, that assesses the cost-effectiveness and performance of the pavement materials and design used in the project and compares the results to the pavement material identified under the department's standard pavement selection process.*" Hence, a work plan must be developed to address this requirement.

The following guidelines further explain how a work plan should be developed for department demonstration projects. The purpose of the work plan is to fully describe the demonstration aspect and its particular use on a project. It answers the following questions: How will the demonstration aspect be used? Does it enhance overall pavement performance? What are its benefits? Is it cost-beneficial? Additionally, a general description of the project and how the work will be performed will be included.

Department Oversight
The regions/TSCs have primary responsibility for the initiation, construction, monitoring, and reporting of projects utilizing pavement demonstration. The Pavement Committee maintains statewide oversight of the process and review/approval responsibility for project acceptance. Final approval is the responsibility of the EOC. The region/TSC will draft a work plan, which is then submitted to the Pavement Committee for review and acceptance.

WORK PLAN COMPONENTS

Summary Page
Provide a brief (snapshot) summary of the project. Include the project location and description, identification (Control Section & Job Number, milepoints of different test sections, if applicable), demonstration aspect, proposed construction date, and whether the project is Rehabilitation & Reconstruction or Capacity Improvement.

Background Statement
Describe the project details and the purpose of the demonstration. Include some background on the demonstration aspect regarding its primary benefits and development/usage to date. Also include information about the existing pavement (lanes, cross section, history, etc.) and traffic levels. Why was this project selected to demonstrate the aspect's effectiveness?

Description of the Demonstration Aspect (Fix)
Provide a detailed description of the project. Include any additional information not included in the background statement regarding how the demonstration is expected to extend the pavement's service life.

Objective
Provide a concise statement regarding the intended accomplishments from this project with emphasis on the technical merits involved.

Study Tasks
Provide a listing of the work tasks involved to accomplish the project objective. These could involve pre-testing of materials, specific construction oversight, collection of samples, field documentation, data collection and analysis, documentation/reporting, assessment of the cost-effectiveness and performance as

compared to the department's standard pavement design/construction. Note whether the vendor or material supplier has a role in the project outcome and/or is their presence required on-site.

Anticipated Results
Describe what benefits are likely to occur and how they apply to current department practices.

Documentation and Reporting
Describe what project documentation is required. How long will project monitoring need to take place? As a minimum, after construction is completed, a series of reports are required. They are:

Construction Report - Documents how the work was performed with emphasis on any deviation from the intended course of action. Include all pertinent information about the demonstration aspect itself, including actual usage, limits, material testing reports, other testing results, IDRs, and deviations from plan details. Provide initial conclusions about the demonstration aspect and recommendations on additional trial projects if desired.

Progress Reports - Depending on the duration of the monitoring cycle, one or more progress reports may be required. Their primary purpose is to report on current field performance, including trends over time, and recommendations on further use. As an example, over a 15-year monitoring period, progress reports could be done at 3, 5, and 10 years.

Final Report - The key elements of the final report will address whether the objective was accomplished, documents project costs and benefits derived, and **assesses the cost-effectiveness as it compares to the department's standard methods.** This will require a life cycle cost analysis of the demonstration as it compares to the department's standard. The minimum performance period used in the analysis will require 3 data points over a period of 6 years. This will require the demonstration to be in service for a minimum of 7 years. Other functional benefits such as safety, ride, etc. should be included.

Additionally: Provide a detailed accounting of the project's findings and a summary of previous information from past reports. Include all data analysis and outcomes from study tasks with conclusions/recommendations regarding the demonstration's use and implementation into department practice.

Project Oversight
Identify a regional contact person(s) who will take the lead on the project. If more than one region is involved, identify a "lead" region. If multiple persons are involved, identify individual roles and responsibilities. Include a description of assistance required from others, including the central office or contracted (non-department) personnel.

Budget
Estimate the cost that will be incurred to monitor the project. These costs typically include personnel costs needed for project oversight (collect data, write reports, etc.). Also include any special materials, testing equipment, consultant services, etc. that may be required as a result of the uniqueness of the project.