



# Research Digest

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## *Item 1*

### **Mechanistic-Empirical Pavement Design Guide Flexible Pavement Performance Prediction Models For Montana: Volume I Executive Research Summary**

*MONTANA DEPARTMENT OF TRANSPORTATION*

*FHWA/MT-07-008/8158-1 • 2007*

The objective of this research study was to develop performance characteristics or variables (e.g., ride quality, rutting, fatigue cracking, transverse cracking) of flexible pavements in Montana, and to use these characteristics in the implementation of the distress prediction models or transfer functions included in the Mechanistic-Empirical Pavement Design Guide (MEPDG) software that was developed under NCHRP Project 1-37A. Reliable distress prediction models will enable the Montana Department of Transportation (MDT) to use Mechanistic-Empirical (ME) based principles for flexible pavement design and in managing their highway network. The work conducted within this study included using the MEPDG software to develop local calibration factors in the use of that software for Montana climate, structures, and materials for flexible pavements. The report is comprised of three volumes: Volume I – Executive Research Summary; Volume II – Reference Manual (which includes Selection of Distress Prediction Models, Traffic Characterization and Analyses, and Database for Calibration of ME Distress Prediction Models); and Volume III – Field Guide – Calibration and User’s Guide for the Mechanistic-Empirical Pavement Design Guide.

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## *Item 2*

### **Mechanistic-Empirical Pavement Design Guide Flexible Pavement Performance Prediction Models For Montana: Volume II Reference Manual**

*MONTANA DEPARTMENT OF TRANSPORTATION*

*FHWA/MT-07-008/8158-2 • 2007*

The objective of this research study was to develop performance characteristics or variables (e.g., ride quality, rutting, fatigue cracking, transverse cracking) of flexible pavements in Montana, and to use these characteristics in the implementation of the distress prediction models or transfer functions included in the Mechanistic-Empirical Pavement Design Guide (MEPDG) software that was developed under NCHRP Project 1-37A. Reliable distress prediction models will enable the Montana Department of Transportation (MDT) to use Mechanistic-Empirical (ME) based principles for flexible pavement design and in managing their highway network. The work conducted within this study included using the MEPDG software to develop local calibration factors in the use of that software for Montana climate, structures, and materials for flexible pavements. The report is comprised of three volumes: Volume I – Executive Research Summary; Volume II – Reference Manual (which includes Selection of Distress Prediction Models, Traffic Characterization and Analyses, and Database for Calibration of ME Distress Prediction Models); and Volume III – Field Guide – Calibration and User’s Guide for the Mechanistic-Empirical Pavement Design Guide.

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## *Item 3*

### **Mechanistic-Empirical Pavement Design Guide Flexible Pavement Performance Prediction Models for Montana: Volume III Field Guide Calibration and User's Guide for the Mechanistic-Empirical Pavement Design Guide**

*MONTANA DEPARTMENT OF TRANSPORTATION*

*FHWA/MT-07-008/8158-3 • 2007*

The objective of this research study was to develop performance characteristics or variables (e.g., ride quality, rutting, fatigue cracking, transverse cracking) of flexible pavements in Montana, and to use these characteristics in the implementation of the distress prediction models or transfer functions included in the Mechanistic-Empirical Pavement Design Guide (MEPDG) software that was developed under NCHRP Project 1-37A. Reliable distress prediction models will enable the Montana Department of Transportation (MDT) to use Mechanistic-Empirical (ME) based principles for flexible pavement design and in managing their highway network. The work conducted within this study included using the MEPDG software to develop local calibration factors in the use of that software for Montana climate, structures, and materials for flexible pavements. The report is comprised of three volumes: Volume I – Executive Research Summary; Volume II – Reference Manual (which includes Selection of Distress Prediction Models, Traffic Characterization and Analyses, and Database for Calibration of ME Distress Prediction Models); and Volume III – Field Guide – Calibration and User's Guide for the Mechanistic-Empirical Pavement Design Guide

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## *Item 4*

### **Experimental Assessment of Aggregate Surfacing Materials**

*MONTANA DEPARTMENT OF TRANSPORTATION*

*FHWA/MT-07-011/8117-30 • 2007*

An extensive suite of geotechnical laboratory tests were conducted to quantify differences in engineering properties of three crushed aggregates commonly used on Montana highway projects. The material types are identified in the Montana Supplemental Specifications as CBC-6A, CBC-5A, and CTS-2A. Results from R-value tests and direct shear tests performed on large samples (12 in by 12 in) indicates the CBC-6A aggregates generally exhibited the highest strength and stiffness of the three material types. In terms of strength parameters, there was no statistically significant difference between CBC-5A and CTS-2A materials. The CBC-6A and 5A materials exhibited similar average Rvalues, which were both slightly greater than the CTS-2A materials. Overall, the CTS-2A materials generally exhibited the lowest average strength and stiffness. Although this material was the poorest performer when compared to the two CBC materials, it still exhibited relatively high strength and stiffness. Drainage capacity was quantified by conducting multiple saturated constant head permeability tests on 10-inch-diameter samples of each material type. The CBC-6A and CTS-2A materials had the highest average permeability values, while the CBC-5A materials had the lowest. Permeability was shown to depend more on the fine fraction void ratio ( $e_f$ ) than on aggregate type or maximum particle size. An analytical method of predicting permeability based on  $e_f$  was developed, which will allow MDT designers to estimate permeability based on gradation and state of compaction.

Overall, the CBC-6A materials were generally the best performers in this study. In general, the CBC-5A aggregates exhibited the second highest strength and stiffness, but also had the lowest drainage capacity. The CTS-2A aggregates exhibited the lowest strength and stiffness, but had relatively good drainage capacity. The ability to substitute CTS-2A material for CBC aggregates depends on the relative importance that is assigned to strength, stiffness, and drainage in the pavement design model.

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## *Item 5*

### **Best Practices Handbook on Asphalt Pavement Maintenance**

*MINNESOTA DEPARTMENT OF TRANSPORTATION*

*MNDOT 2000-04 • 2000*

The purpose of this handbook is to provide background information about the importance of pavement preservation and preventive maintenance, as well as present maintenance techniques for a variety of distresses and conditions. The major focus of this handbook is on preventive maintenance activities, which are performed while the roadway is still in good condition with only minimal distress, before the pavement falls into a condition where structural overlays, major milling or reclaiming, or replacement is necessary.

The most common flexible pavement distresses are cracking, roughness, weathering, raveling, rutting and bleeding. If the distresses identified in a pavement are related to structural deficiencies the pavement section is most likely not a candidate for preventive maintenance treatment, and should be scheduled for rehabilitation or reconstruction. Maintenance treatments covered in this handbook include: Crack repair w/sealing, including clean and seal, saw and seal, and rout and seal; crack filling, full depth crack repair, fog seal, seal coat, double chip seal, slurry seal, microsurfacing, thin hot mix overlays, and potholes and pavement patching.

Tables are outlined giving the most common flexible pavement distresses, along with the best practices for rehabilitation for each. Also given are recommended applications for crack sealers and fillers, surface treatments, and pothole patching. Specifications, technical memoranda and special provisions are included for all treatment methods recommended in the handbook.

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## *Item 6*

### **Recommendations for the Connection Between Full-Depth Precast Bridge Deck Panel Systems and Precast I-Beams**

*VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)  
VTRC 07-CR17 • 2007*

Precast bridge deck panels can be used in place of a cast-in-place concrete deck to reduce bridge closure times for deck replacements or new bridge construction. The panels are prefabricated at a precasting plant providing optimal casting and curing conditions, which should result in highly durable decks. Precast panels can be either full-depth or partial-depth. Partial-depth panels act as a stay-in-place form for a cast-in-place concrete topping. This study investigated only the behavior of full-depth precast panels.

The research described in this report had two primary objectives. The first was to develop a performance specification for the grout that fills the haunch between the top of the beam and the bottom of the deck panel, as well as the horizontal shear connector pockets and the panel-to-panel joints. Tests were performed using standard or modified ASTM tests to determine basic material properties on eight types of grout. The grouts were also used in tests that approximated the conditions in a deck panel system. Based on these tests, requirements for shrinkage, compressive strength, and flow were established for the grouts. It was more difficult to establish a test method and an acceptable performance level for adhesion, an important property for the strength and durability of the deck panel system.

The second objective was to quantify the horizontal shear strength of the connection between the deck panel and the beam prestressed concrete beams. This portion of the research also investigated innovative methods of creating the connection. Push-off tests were conducted using several types of grout and a variety of connections. These tests were used to develop equations for the horizontal shear strength of the details. Two promising alternate connections, the hidden pocket detail and the shear stud detail, were tested for constructability and strength.

The final outcome of this study a set of recommendations for the design, detailing, and construction of the connection between full-depth precast deck panels and prestressed concrete I-beams. If designed and constructed properly, the deck panel system is an excellent option when rapid bridge deck construction or replacement is required.

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## *Item 7*

### **A Cost-Comparison Methodology for Selecting Appropriate Hot-Mix Asphalt Materials**

*VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)*

*VTRC 07-R31 • 2007*

The Virginia Department of Transportation's (VDOT) Road and Bridge Specifications lists 9 dense-graded hot-mix asphalt (HMA) surface mixes (three aggregate gradations x three binder types) that could be used on Virginia's highways. VDOT's Special Provision for Stone Matrix Asphalt (SMA) provides 4 additional surface mix options (two gradations x two binder types), for a total of 13 mixes. Although the specifications offer recommendations regarding the types of facilities to program for each mix type, local conditions and experiences heavily influence the predominantly selected mix. Over the past 4 years or so, district pavement managers have routinely used only about 4 dense-graded mixes and 3 of the SMA surface mixes. As material prices continue to climb without budgets doing the same, local circumstances are more often going to contribute to the selection of the less expensive mixes, especially as long as these managers lack a defensible rationale for specifying a more expensive option.

This study offers an economic analysis procedure to help field (i.e., district) pavement engineers select the most cost effective mix for a given application. The procedure is based on the expected performance of each mix. The performance predictions were developed using the 2006 "windshield" condition rating for Virginia's interstate and state primary roads, which reflects the performance for at least 6 years of Virginia's contemporary dense-graded HMA mixes and for up to 11 years of SMA surface mixes. Through examples using typical project families, the study demonstrated that premium prices for SMA can generally be justified by better performance. In one illustration using actual condition and awarded price data, a life cycle cost analysis revealed that the use of SMA in lieu of dense-graded mixtures on interstates might save VDOT in excess of \$7,500 per lane-mile in net present value costs. Extrapolated to the entire Virginia interstate system, the net present value costs associated with an SMA-only resurfacing program would be approximately \$25 million less than the next best hot-mix alternative. A final step in this illustration suggests that VDOT can afford (within the FY 2008 spending plan) to pursue an interstate resurfacing program that makes extensive (if not exclusive) use of SMA. Full-text PDF of this report is available for free download from

[http://www.virginiadot.org/vtrc/main/online\\_reports/pdf/07-r31.pdf](http://www.virginiadot.org/vtrc/main/online_reports/pdf/07-r31.pdf)



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## *Item 8*

### **Evaluation of Best Practices in Traffic Operations and Safety: Phase I: Flashing LED Stop Sign and Optical Speed Bars**

*VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)*

*VTRC 07-R34 • 2007*

In a previous extensive review of overseas literature, researchers identified 42 traffic operations and safety technologies and practices that were not currently deployed in Virginia. These were evaluated for their potential application in Virginia, and 12 measures were determined to be good candidates for piloting. Two of the measures, a flashing light emitting diode (LED) stop sign and optical speed bars (two patterns) were installed at three locations in Virginia for before and after evaluations.

The flashing LED stop sign was installed at a T-intersection in western Albemarle County, Virginia, where the number of crashes was higher than expected. The measures of effectiveness for the sign were average speed of drivers approaching the sign and compliance with the sign. Average speeds decreased significantly (statistically) after the sign was installed, but only by 1 to 3 mph. Speeds decreased more during the night than during the day. The results of the compliance study were inconclusive. Optical speed bars were installed on the centerline and edge line on both approaches to a short section of two-lane roadway in Fairfax County, Virginia. The section of roadway is hazardous, as it has inadequate vertical and horizontal alignment, narrow lanes, and reduced shoulders. A number of crashes had occurred on the section over the years, including a recent fatality. Average speeds both decreased and increased after installation, and the decreases were statistically significant right before and in the middle of the section. The decreases ranged from 1 to 3 mph.

Optical speed bars were also installed across lanes on a major, four-lane undivided highway, at two approaches to a reduced speed limit zone in the town of Zuni, Virginia. Average speeds both decreased and increased after installation. The decreases were statistically significant at the beginning of the 45 mph speed zone on each end of town. The decreases ranged from 3 to 10 mph.

Given the general positive results of the installations, the report recommends that flashing LED stop signs and optical speed bars be considered as safety countermeasures at appropriate locations where the numbers of crashes or crash rates are higher than expected or where excessive speeding occurs.

A costs and benefits assessment indicated that, generally, the benefits in terms of reduced crashes exceeded the costs of the installed measures if only one crash was prevented.

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## *Item 9*

### **Survey of Cathodic Protection Systems on Virginia Bridges**

*VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)*

*VTRC 07-R35 • 2007*

The Virginia Department of Transportation uses cathodic protection (CP) systems on steel-reinforced concrete structures to extend the life of these structures. The purpose of this study was to identify, categorize, and evaluate the performance of the CP systems that have been used on these structures. These systems included galvanic anode CP (GACP) systems and impressed current CP (ICCP) systems. Some of these systems are exposed to chloride ions because of their location in a marine environment; others are on structures located inland that are exposed to chloride ions through the use of deicing salts.

The study showed that greater care needs to be taken to transfer the maintenance and monitoring responsibilities of CP systems that are installed as part of a research study once the study is concluded. Further, some of these CP systems have not been associated with favorable research findings. Moreover, evaluation of inspection reports indicates that procedures are not in place to qualify VDOT bridge inspectors to monitor or evaluate CP systems and to record important data to ensure sufficient CP protection is being achieved with each CP system. Finally, the CP system cannot be treated as a stand-alone appendage during the design and construction of a structure; it must be considered in conjunction with the other electrical systems on a structure.

The initial cost of an ICCP system is not substantially different from the direct cost of a rehabilitative overlay that would be required should such a system not be installed. If properly maintained, a retrofitted ICCP system would be expected to extend the life of a rehabilitated deck an additional 35 years. However, even with the cost of routine monitoring, an ICCP system can provide substantial savings in maintenance and user costs. Similarly, if a GACP system can prevent the need for repairs on approximately 16% of a substructure surface over the life of the structure, the costs of the GACP system would be approximately equal to that of a single rehabilitative intervention.

Based on the results of this study, by preserving the structure and extending the life of the initial structure with a CP system, a future rehabilitation can be deferred or prevented and fewer intermediate repairs will be necessary. This can have significant implications for users of a structure, particularly on congested urban or arterial routes. Further, some CP systems do not require a significant investment in monitoring or maintenance, thereby reducing long-term costs that have sometimes been associated with CP.

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## *Item 10*

### **ITS Evaluation Framework - Phase 2**

*WASHINGTON STATE DEPARTMENT OF TRANSPORTATION*

*WA-RD 672.1 • 2007*

This report documents the results of applying a previously developed, standardized approach for evaluating advanced traveler information systems (ATIS) projects to a much more diverse group of 16 intelligent transportation systems (ITS) projects. The evaluation approach used structured interviews to investigate technical, management and organizational lessons learned. The approach appeared to work well with this diverse group of projects.

This report also includes the individual evaluation reports for the 16 ITS projects that were evaluated. Each report includes a discussion on background information, project description, ITS architecture and standards, system usage and benefits and institutional and technical issues.

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