

Research Digest

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Item 1

Accelerated pavement testing of low-volume paved roads with geocell reinforcement

KANSAS DEPARTMENT OF TRANSPORTATION (KDOT)

FHWA-KS-14-14 • 2015

The Midwest States Accelerated Pavement Testing Pooled-Fund Program, financed by the highway departments of Kansas, Iowa, Missouri, and New York, has supported an accelerated pavement testing (APT) project to study the rehabilitation of low-volume paved roads with geocells and different infill materials under real-world traffic on a marginal subgrade, and to simulate this type of rehabilitation numerically so that a design method can be developed. To achieve this study objective, four pavement test sections were constructed at the Civil Infrastructure System Laboratory of Kansas State University. Three out of these four lanes had geocell-reinforced bases with three different infill materials: crushed limestone, quarry by-products, and Recycled Asphalt Pavement. The fourth test lane was the control section consisting of crushed stone base. All sections were heavily instrumented. Repeated loads (80-kN single axle) were applied using an accelerated pavement testing machine. The sections with 50-mm hot-mix asphalt (HMA) layer reached the failure criteria of 12.5-mm rut depth after 10,000 passes due to excessive stress in the subgrade. The redesigned sections with 100-mm HMA layer carried 1.2 million passes without reaching 12.5-mm failure rut depth. The geocells with marginal materials as infills appear to be viable in low-volume paved road applications. (100 pages)

This report is available for free download (4.8 MB):

http://ntl.bts.gov/lib/54000/54800/54808/FHWA-KS-14-14_FinalReport.pdf

Research Digest

Item 2

Assessment of Nondestructive Testing Technologies for Quality Control/Quality Assurance of Asphalt Mixtures

IOWA STATE UNIVERSITY. INSTITUTE FOR TRANSPORTATION

IHRB Project TR-653 • 2015

Asphalt pavements suffer various failures due to insufficient quality within their design lives. The American Association of State Highway and Transportation Officials (AASHTO) Mechanistic-Empirical Pavement Design Guide (MEPDG) has been proposed to improve pavement quality through quantitative performance prediction. Evaluation of the actual performance (quality) of pavements requires in situ nondestructive testing (NDT) techniques that can accurately measure the most critical, objective, and sensitive properties of pavement systems. The purpose of this study is to assess existing as well as promising new NDT technologies for quality control/quality assurance (QC/QA) of asphalt mixtures. Specifically, this study examined field measurements of density via the PaveTracker electromagnetic gage, shear-wave velocity via surface-wave testing methods, and dynamic stiffness via the Humboldt GeoGauge for five representative paving projects covering a range of mixes and traffic loads. The in situ tests were compared against laboratory measurements of core density and dynamic modulus. The in situ PaveTracker density had a low correlation with laboratory density and was not sensitive to variations in temperature or asphalt mix type. The in situ shear-wave velocity measured by surface-wave methods was most sensitive to variations in temperature and asphalt mix type. The in situ density and in situ shear-wave velocity were combined to calculate an in situ dynamic modulus, which is a performance-based quality measurement. The in situ GeoGauge stiffness measured on hot asphalt mixtures several hours after paving had a high correlation with the in situ dynamic modulus and the laboratory density, whereas the stiffness measurement of asphalt mixtures cooled with dry ice or at ambient temperature one or more days after paving had a very low correlation with the other measurements. To transform the in situ moduli from surface-wave testing into quantitative quality measurements, a QC/QA procedure was developed to first correct the in situ moduli measured at different field temperatures to the moduli at a common reference temperature based on master curves from laboratory dynamic modulus tests. The corrected in situ moduli can then be compared against the design moduli for an assessment of the actual pavement performance. A preliminary study of microelectromechanical systems- (MEMS)-based sensors for QC/QA and health monitoring of asphalt pavements was also performed. (183 pages)

This report is available for free download (20.4 MB):

http://publications.iowa.gov/19152/1/IADOT_InTrans_UI_TR-653_Lin_Assess_NDT_Techs_QC_QA_Asphalt_Mixtures_2015.pdf

Research Digest

Item 3

Balancing the costs of mobility investments in work zones, phase 1 final report

WAYNE STATE UNIVERSITY. TRANSPORTATION RESEARCH GROUP

RC-1630 • 2015

Work zone safety and mobility continue to be critical transportation concerns in Michigan and elsewhere. Previous research has led to the development of a variety of tools, performance measures and decision-making frameworks to analyze work zone safety and mobility. This Phase 1 research sought to provide additional guidance towards assessment of safety and mobility strategies for work zones. The Phase 1 project objectives were as follows: 1.) determine the accuracy of existing methods for estimating delay and diversion; 2.) determine the cost-effectiveness of select strategies that have been implemented; and 3.) provide guidance towards development of work zone decision support tools. The specific tasks included an assessment of the national state-of-the-art and state-of-the-practice, a survey of travelers to gain insight into public perceptions of work zone operations and delay, and collection and analysis of work zone operational, safety, and cost data. The results showed that the median acceptable work zone travel delay reported by Michigan travelers was 10 minutes. Using data collected from several Michigan freeways, work zone travel speeds were found to remain relatively stable up to a flow rate of approximately 1,700 vehicles per hour per lane. Beyond this point, speeds declined (and subsequent delays increased) dramatically. The work zone crash analysis found incremental crash increases when comparing single-lane closures to shoulder closures, double-lane closures to single-lane closures, and lane shifts to double-lane closures. When comparing Michigan safety results to Highway Safety Manual data from California and Missouri, it was found that the effects of work zone length and duration were very similar between Michigan and Missouri, although the California effects were slightly different. Assessment of the costs associated with nighttime versus daytime asphalt resurfacing projects on freeways found some differences in the actual paving costs per lane-mile, but no differences between other related costs. The report also provides guidance for development of a Phase 2 research plan. (114 pages)

This report is available for free download (2.6 MB):

http://www.michigan.gov/documents/mdot/RC1630_491364_7.pdf

Item 4

Chip seal performance measures: best practices

APPLIED PAVEMENT TECHNOLOGY, INC.

WA-RD 841.1 • 2015

The Washington State Department of Transportation (WSDOT) has a long history of designing, constructing, and maintaining chip seal or bituminous surface treatment pavements. However, to date WSDOT has not developed pavement performance indicators or models to predict chip seal service life, but rather assumes an average life of 6 to 8 years. Due to funding constraints and good pavement management practices, WSDOT has increased the number of pavement segments that are candidates for receiving chip seal applications. In order to improve predictions of chip seal performance and improve their demonstrated cost effectiveness, chip seal performance indicators are needed. The objectives of this research project are to evaluate different performance indicators for chip seal treatments and to develop trigger values for these indicators that will indicate the end of service life and the appropriate index values for resurfacing. Under Phase I of this study, a formal literature review and detailed survey of transportation agency practices were conducted to identify which pavement distress or combination of distresses best characterize the optimal timing for chip seal application. This report summarizes the findings of the literature review, agency survey, WSDOT pavement management and performance modeling practices, and a recommendation of potential performance models for further evaluation as additional data become available (82 pages)

This report is available for free download (2.5 MB):

<http://www.wsdot.wa.gov/research/reports/fullreports/841.1.pdf>

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Item 5

Concrete Pavement Mixture Design and Analysis (MDA): An Innovative Approach To Proportioning Concrete Mixtures

IOWA STATE UNIVERSITY. INSTITUTE FOR TRANSPORTATION. NATIONAL CONCRETE PAVEMENT TECHNOLOGY CENTER

TPF-5(205) • 2015

Mixture proportioning is routinely a matter of using a recipe based on a previously produced concrete, rather than adjusting the proportions based on the needs of the mixture and the locally available materials. As budgets grow tighter and increasing attention is being paid to sustainability metrics, greater attention is beginning to be focused on making mixtures that are more efficient in their usage of materials yet do not compromise engineering performance. Therefore, a performance-based mixture proportioning method is needed to provide the desired concrete properties for a given project specification. The proposed method should be user friendly, easy to apply in practice, and flexible in terms of allowing a wide range of material selection. The objective of this study is to further develop an innovative performance-based mixture proportioning method by analyzing the relationships between the selected mix characteristics and their corresponding effects on tested properties. The proposed method will provide step-by-step instructions to guide the selection of required aggregate and paste systems based on the performance requirements. Although the provided guidance in this report is primarily for concrete pavements, the same approach can be applied to other concrete applications as well. (ix, 40 pages)

This report is available for free download (1.4 MB):

http://publications.iowa.gov/19126/1/FHWA_TPF_5_205_InTrans_Taylor_Concrete_Pavement_MDA_Proportioning_Mixtures_2015.pdf

Item 6

Developing a System for Computing and Reporting MAP-21 and Other Freight Performance Measures

UNIVERSITY OF WASHINGTON. WASHINGTON STATE TRANSPORTATION CENTER (TRAC)

WA-RD 844.1 • 2015

"This report documents the use of the National Performance Monitoring Research Data Set (NPMRDS) for the computation of freight performance measures on Interstate highways in Washington state. The report documents the data availability and specific data quality issues identified with NPMRDS. It then describes a recommended initial set of quality assurance tests that are needed before WSDOT begins producing freight performance measures. The report also documents the initial set of performance measures that can be produced with the NPMRDS and the specific steps required to do so. A subset of those metrics was tested using NPMRDS data, including delay and frequency of congestion, to illustrate how WSDOT could use the freight performance measures. Finally, recommendations and the next steps that WSDOT needs to take are discussed." (100 pages)

This report is available for free download (2 MB):

<http://www.wsdot.wa.gov/research/reports/fullreports/844.1.pdf>

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Item 7

Development, field testing, and implementation of improved bridge parapet designs

OHIO DEPARTMENT OF TRANSPORTATION (ODOT)

FHWA/OH-2015/5 • 2015

A total of 22 test parapets was constructed as part of this project to evaluate different approaches to address premature cracking. The experiments included the use of deeper saw cuts through glass fiber reinforced polymer (GFRP) reinforcement or field cut steel reinforcement, with the saw cut depth increased from 1 1/2 inches (38 mm) to 3 1/2 inches (89 mm). Another experimental modification was the use of polypropylene fibers in the mixture at two different dosage rates, 1 lb/yd³ (0.59 kg/m³) and 2 lb/yd³ (1.19 kg/m³). The research team monitored bridge parapets during and immediately after construction. This included instrumentation with embedded maturity sensors to capture temperature history of the parapets, using Command Center technology. Researchers also observed and documented parapet construction. It was important to note any constructability issues that may arise that may be related to the proposed solutions, since they would potentially impact the cost of implementation. Crack surveys were performed once formwork was removed and sawcutting had been completed. The stiffness gain of parapets and joint cracking were monitored using ultrasonic pulse velocity (UPV) technology. While all of the eight control bridges showed mid-panel cracking, only four of the twelve experimental bridges had mid-panel cracking. Both parapets with Vandal Protection Fence (VPF) posts showed cracks near the posts. The main purpose of using GFRP or field cut steel reinforcement with the 3.5 inch (89 mm) deep saw cut is to create a weakened plane at the control joint through the gap provided in the reinforcement, in order initiate cracking at the joints and reduce the risk of cracking elsewhere on the parapet. From the data gathered, this modification allowed more joints to crack at early stages, and prevented uncontrolled cracking. The parapets with fibers showed no measurable improvement over the parapets without fibers in regards to preventing shrinkage and temperature cracking. Reducing the joint spacing over negative tension areas was found to reduce uncontrolled bridge parapet cracking. However, since the experimental parapets with the reduced joint spacing were coupled with another modification of either the polypropylene fibers or the deeper saw cut, it was hard to determine if this alone would solve uncontrolled bridge parapet cracking. (126 pages)

This report is available for free download (3.3 MB):

<http://worldcat.org/webharvest/h1428070962525/viewonline>

Item 8

The development of crashworthy rails for fiber reinforced polymer honeycomb bridge deck system

KANSAS DEPARTMENT OF TRANSPORTATION (KDOT)

FHWA-KS-15-03 • 2015

Fiber reinforced polymer (FRP) honeycomb panels offer an efficient and rapid replacement to concrete decks. The system consists of FRP honeycomb sandwich panels with adequate guardrails. Although FRP bridge deck panels have already been designed and used over the past several years on a number of through truss bridges, they could not be used on steel girder bridges until approved crashworthy bridge railing attachments could be validated. Two systems have been successfully crash tested, one with steel thrie beams/guardrails on steel posts and the other with concrete barriers. Both systems are now ready for use on temporary/detour bridges, or as permanent deck replacement allowing higher live load while keeping the existing steel girders and substructure. The light weight of FRP honeycomb panels (about 75% lighter than concrete) allows heavier truck loads, while keeping the existing girders and substructure without compromising the safety of the public. The roadway can be made wider by increasing the overhangs, thus allowing for wider farm equipment on narrow bridges in rural areas. The replacement of the concrete deck using this system may be completed in a matter of a few days, or even hours, as opposed to several months when using the conventional methods. (21 pages)

This report is available for free download (requires Safari or Internet Explorer):

<http://dmsweb.ksdot.org/AppNetProd/docpop/docpop.aspx?clienttype=html&docid=9326995>

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Item 9

Evaluating Michigan commercial vehicle enforcement strategies and facilities

WESTERN MICHIGAN UNIVERSITY. TRANSPORTATION RESEARCH CENTER FOR LIVABLE COMMUNITIES
RC-1622 • 2015

This report documents evaluation results and recommendations for Michigan commercial vehicle enforcement strategies and facilities. Through literature review, online survey and site visits, enforcement strategies and facilities in other states and countries were studied. Site visits of existing Michigan commercial vehicle enforcement sites and review of current and past reports by the Michigan Department of Transportation (MDOT) and the Michigan State Police (MSP) revealed the existing conditions of facilities and potential needs for improvements. Benefit-cost analyses for the existing fixed weigh stations and other enforcement sites were conducted. The results indicated that addition of low-speed Weigh-In-Motion (WIM) with bypass lane is most likely to improve efficiency of a number of existing fixed weigh stations. Also, adding a pre-clearance system was found to improve efficiency of specific fixed weigh stations. The results, however, showed that fixed weigh stations are not economically beneficial when located along low volume roads. Recommendations for removing such stations are also provided. Furthermore, the report recommends implementation of systems that integrate enforcement technologies and consolidate data to assist enforcement officers in screening and verifying compliance of commercial vehicles. (xix, 196 pages)

This report is available for free download (5.9 MB):

http://www.michigan.gov/documents/mdot/RC1622_485728_7.pdf

Item 10

Evaluating outcomes of raising speed limits on high speed non-freeways

WAYNE STATE UNIVERSITY
RC-1609B • 2015

The purpose of this research was to assist in determining the potential impacts of implementing a proposed 65 mph speed limit on non-freeways in Michigan. Consideration was given to a broad range of performance measures, including operating speeds, traffic crashes and crash severity, infrastructure costs, fuel consumption, and travel times. Specifically, a prioritization strategy was developed to identify candidate MDOT non-freeway road segments possessing lower safety risks and potential infrastructure costs associated with raising the speed limit from 55 to 65 mph. Ultimately, approximately 747 miles of undivided and 26 miles of divided 55 mph non-freeways were identified as lower risk candidates, representing approximately one-eighth of the MDOT system-wide mileage posted at 55 mph. An economic analysis of the anticipated costs and benefits associated with the proposed speed limit increase was performed for these lower risk candidate segments, in addition to a system-wide estimate. As the travel time savings were expected to outweigh the fuel consumption costs, it was necessary to determine if these net operational benefits outweighed the expected infrastructure upgrade costs and increased crash costs. For roadways possessing horizontal and/or vertical alignments that are not compliant with a 65 mph speed limit, an unfavorable benefit/cost ratio would likely result due to the excessive infrastructure costs incurred during 3R (resurfacing, restoration, rehabilitation) or 4R (reconstruction) projects. Crashes were expected to increase for all implementation scenarios, with a particular increase in the risk of fatal and incapacitating injuries. Due to the substantially large infrastructure costs, application of the 65 mph speed limit is specifically not recommended for non-freeway segments requiring horizontal or vertical realignment to achieve design speed compliance. Even for segments where compliance with the increased design speed is maintained, careful consideration must be given to the potential safety impacts particularly to fatal and injury crashes - that may result after increasing the speed limit. (xiii, 123 pages)

This report is available for free download (1.3 MB):

http://www.michigan.gov/documents/mdot/RC1609B_487484_7.pdf

Research Digest

Item 11

Evaluating the use of unmanned aerial vehicles for transportation purposes

MICHIGAN TECHNOLOGICAL UNIVERSITY

RC-1616 • 2015

Advances in unmanned aerial vehicle (UAV) technology have enabled these tools to become easier to use and afford. In a budget-limited environment, these flexible remote sensing technologies can help address transportation agency needs in operations, maintenance, and asset management while increasing safety and decreasing cost. This project tested and evaluated five main UAV platforms with a combination of optical, thermal, and LiDAR sensors to assess critical transportation infrastructure and issues such as bridges, confined spaces, traffic flow, and roadway assets. A State of the Practice report was completed, and a series of lab testing were accomplished to ensure practicality and safe operations. Field demonstrations were completed at bridges, pump stations, and conferences. The project team gave a series of technical demonstrations at the Intelligent Transportation Systems World Congress in Detroit in September, 2014, enabling outreach to a wide domestic and international audience who gained understanding of the advanced research that MDOT is funding. These demonstrations showed that UAV technologies provide many advantages to helping MDOT cost-effectively assess, manage, and maintain its resources, providing benefit to staff and the traveling public. (143, A-47 pages)

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- 9.2 State of the Practice for Remote Sensing of Transportation Infrastructure Using Unmanned Aerial Vehicles (UAV) / Colin Brooks, et al., October 2013
- 9.3 Comparison of uncalibrated Digital Number output from Tau 2 with calibrated temperature data from the SC640 cameras

This report is available for free download (4 parts):

http://www.michigan.gov/mdot/0,4616,7-151-9622_11045_24249_52176-353767--,00.html

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Item 12

Evaluation of Performance Based Concrete for Bridge Decks

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT)

WA-RD 845.1 • 2015

The Washington State Department of Transportation (WSDOT) revised the concrete specification for bridge decks in 2011 to be more performance based with the desired effect of having less early-age shrinkage cracking. This report evaluates a sample of the bridges constructed with the revised performance based specification against a sample of bridges constructed with the traditional WSDOT specification. The evaluation consists of visual inspections, noting cracks and developing crack intensity diagrams for each bridge. These diagrams are then used to rank and compare the bridge decks. The outcome of this study is that the bridge decks constructed with the performance based specification have much less early-age shrinkage cracking than those constructed using the traditional WSDOT specification. (295 pages)

This report is available for free download (22 MB):

<http://www.wsdot.wa.gov/research/reports/fullreports/845.1.pdf>

Item 13

Feasibility of Reclaimed Asphalt Pavement (RAP) Use As Road Base and Subbase Material

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

VCTIR 15-R6 • 2015

The purpose of this study was to investigate the current state of the practice with regard to the use of reclaimed asphalt pavement (RAP) material for road base and subbase applications and the potential for such use by the Virginia Department of Transportation (VDOT). To achieve the objectives of the study, a comprehensive review of the literature was conducted and the current state of the practice by other state departments of transportation was analyzed. (42 pages)

This report is available for free download (438 KB):

http://www.virginiadot.org/vtrc/main/online_reports/pdf/15-r6.pdf

Item 14

Ground penetrating radar evaluation of new pavement density: Paving Project - SR 539 in Lynden, WA

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT)

WA-RD 839.1 • 2015

The objective of this project was to map pavement surface density variations using dielectric measurements from ground penetrating radar (GPR). The work was carried out as part of an Asphalt Intelligent Compaction demonstration project on SR 539 in Lynden, WA. This demonstration was part of a larger WSDOT project entitled, "Lynden-Aldergrove Port of Entry Improvements." The research found that comparing the GPR dielectrics and core air void data showed no significant correlation. It was speculated this lack of correlation could be due to a density gradient within the 4-inch asphalt depth, and the fact that the GPR equipment only captures the properties of the top 1-1.5 inches. By focusing on the thinnest asphalt sections, the correlation was significantly improved, with an R2 of 0.77. (20 pages)

This report is available for free download (2.2 MB):

<http://www.wsdot.wa.gov/research/reports/fullreports/839.1.pdf>

Research Digest

Item 15

Installation and Laboratory Evaluation of Alternatives to Conventional Polymer Modifications for Asphalt

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

VCTIR 15-R15 • 2015

The Virginia Department of Transportation (VDOT) specifies polymer-modified asphalt binders for certain asphalt mixtures used on high-volume, high-priority routes. These binders must meet performance grade (PG) requirements for a PG 76-22 binder in addition to elastic recovery requirements. This typically results in the use of binders containing styrenebutadiene- styrene (SBS) modifiers. However, other polymer modifiers may also be used to achieve the PG 76-22 classification. One of these modifiers is a copolymer of SBS and polyethylene (PE) (SBS-PE); another modifier is ground tire rubber (GTR). This study was undertaken to investigate the suitability of SBS-PE-modified PG 76-22 binder and GTR-modified PG 76-22 binder for use in Virginia. (27 pages)

This report is available for free download (454 KB):

http://www.viriniadot.org/vtrc/main/online_reports/pdf/15-r15.pdf

Item 16

Investigation of Panel-to-Panel Connections and Block-outs for Full-Depth Precast Concrete Bridge Decks

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

VCTIR 15-R5 • 2015

Experimental tests were performed at Virginia Tech to investigate transverse panel-to-panel connections and horizontal shear connector block-outs for full-depth precast concrete bridge deck panels. The connections were designed for a deck replacement project for a rural three-span continuous steel beam bridge in Virginia. Two reinforced and four post-tensioned connections were designed and tested in cyclical loading. Each connection was tested on a full-scale, two-beam setup in negative bending with a simulated HS-20 vehicle. The block-outs for the horizontal shear connections were also scrutinized during construction and testing. Several surface treatments were investigated to determine the best strategy to limit cracking and leakage at the grout-concrete interface. The strain profile, cracking patterns, and ponding results are presented for all specimens. The reinforced connections and two post-tensioned connections with 167 psi initial stress experienced cracking and leaked water by the end of the cyclic loading regime. In two connections post-tensioned with an initial compressive stress of 340 psi, the tensile stress in the deck under full live load remained below approximately $3v(f'c)$. These transverse connections did not leak water, did not have full-depth cracking, and maintained a nearly linear strain distribution throughout the design life. Full-depth deck panels may be effectively used on continuous bridges if post-tensioning force is applied to the transverse connections to keep the total tensile stress (remaining prestress minus live load stress) below $3v(f'c)$. The block-outs with a sand-blasted surface or an epoxy primer combined with a grout that met the requirements recommended by Scholz et al. (2007) had only slight water leakage, and had smaller cracks at the grout-concrete interface than the control samples. These surface treatments are recommended for best long-term performance. (73 pages)

This report is available for free download (1.7 MB):

http://www.viriniadot.org/vtrc/main/online_reports/pdf/15-r5.pdf

Item 17

Laboratory Evaluation of Asphalt Concrete Mixtures Containing High Contents of Reclaimed Asphalt Pavement (RAP) and Binder

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

FHWA/VCTIR 15-R8 • 2015

This study investigated the effect of added asphalt binder content on the performance and volumetric properties of asphalt concrete mixtures containing reclaimed asphalt pavement (RAP) in the amounts of 0%, 20%, and 40%. A laboratory-produced mixture containing 100% RAP was also evaluated. Performance of the mixtures was evaluated based on three criteria: stiffness (dynamic modulus), fatigue resistance, and rutting resistance (flow number and asphalt pavement analyzer). (43 pages)

This report is available for free download (995 KB):

http://www.viriniadot.org/vtrc/main/online_reports/pdf/15-r8.pdf

Item 18

Low-Cost Rural Surface Alternatives: Demonstration Project

IOWA STATE UNIVERSITY. INSTITUTE FOR TRANSPORTATION

IHRB Project TR-664 / InTrans Project 13-479 • 2015

The goals of this project were to implement several stabilization methods for preventing or mitigating freeze-thaw damage to granular surfaced roads and identify the most effective and economical methods for the soil and climate conditions of Iowa. Several methods and technologies identified as potentially suitable for Iowa were selected from an extensive analysis of existing literature provided with Iowa Highway Research Board (IHRB) Project TR-632. Using the selected methods, demonstration sections were constructed in Hamilton County on a heavily traveled two-mile section of granular surfaced road that required frequent maintenance during previous thawing periods. Construction procedures and costs of the demonstration sections were documented, and subsequent maintenance requirements were tabulated through two seasonal freeze-thaw periods. Extensive laboratory and field tests were performed prior to construction, as well as before and after the two seasonal freeze-thaw periods, to monitor the performance of the demonstration sections. A weather station was installed at the project site and temperature sensors were embedded in the subgrade to monitor ground temperatures up to a depth of 5 ft and determine the duration and depths of ground freezing and thawing. An economic analysis was performed using the documented construction and maintenance costs, and the estimated cumulative costs per square yard were projected over a 20-year timeframe to determine break-even periods relative to the cost of continuing current maintenance practices. Overall, the sections with biaxial geogrid or macadam base courses had the best observed freeze-thaw performance in this study. These two stabilization methods have larger initial costs and longer break-even periods than aggregate columns, but counties should also weigh the benefits of improved ride quality and savings that these solutions can provide as excellent foundations for future paving or surface upgrades. (242 pages)

This report is available for free download:

<http://publications.iowa.gov/20128/>

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Item 19

Overhead guide sign retroreflectivity and illumination

KANSAS DEPARTMENT OF TRANSPORTATION (KDOT)

K-TRAN: KSU-11-6 • 2015

Roadway guide sign visibility during darkness is fundamental to driver safety, especially elderly drivers. Guide sign visibility can be improved by external sign illumination or the use of retroreflective sheeting on signs. Because energy conservation is essential in the midst of a worldwide energy crisis, various Departments of Transportation have investigated usage of energy-efficient lighting technology with overhead guide signs. This report presents results of a survey related to overhead sign lighting usability by states, a laboratory experiment to compare the light distribution of five light sources used to illuminate overhead guide sign by several states, a cost analysis for the tested light sources, a field experiment to compare the visibility of three retroreflective sheeting used by states, a cost analysis for the tested retroreflective guide signs, and an analysis by determining the most cost-effective method of increasing overhead guide sign visibility to drivers during nighttime. A laboratory experiment was conducted to compare the light distribution of three conventional light sources: Metal Halide, Mercury Vapor, and High Pressure Sodium, and two new generation light sources: Induction lighting, and Light Emitting Diode. Combining two decision criteria, the light distribution and the cost, resulted in finding the Induction lighting to be the recommended light source for those states that want to continue illuminating their overhead guide signs. A field experiment was conducted to compare three types of sign sheeting, Engineering Grade (type I), Diamond Grade (type XI), and High Intensity (type IV), in order to determine the sign sheeting material that best improves sign visibility. Combining the decision criteria to compare these three retroreflective sheeting, the visibility and the cost, High Intensity (type IV) is the recommended sign to be used by DOTs, followed by Diamond Grade (type XI). In comparing the best options used to increase sign visibility, sign illumination and sign retroreflectivity, it is found that using retroreflective sheeting is more cost effective than sign illuminating. (144 pages)

This report is available for free download (1.9 MB):

http://ntl.bts.gov/lib/54000/54600/54652/KSU-11-6_FinalReport.pdf

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Item 20

Project Inspection Using Mobile Technology. Phase II, Assessing the impacts of mobile technology on project inspection

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT)

WA-RD 840.2 • 2015

As mobile technology becomes widely available and affordable, transportation agencies can use this technology to streamline operations involved within project inspection. This research, conducted in two phases, identified opportunities for process improvement using mobile technologies and measured the outcomes from incorporating mobile tools as a part of project inspection work. The research also identified additional factors to characterize the use of mobile tools for project inspection. The research approach focused on measuring three main projected outcomes, which include productivity, data quality, and data availability. Additional characteristics were observed to evaluate other aspects of using mobile tools for project inspection, in particular as it relates to recommendations toward how an agency may approach deployment of mobile technology. A pilot program was established where a mobile technology solution was used via field trials to measure these outcomes.... "Phase II of this research developed and implemented a mobile technology solution using the findings from Phase I. In the development stage, the research team worked with the DOTs to define measurable elements to be evaluated as part of the testing, which allowed points of comparison with the corresponding current project inspection practices. Live field use of the mobile technology solution was then deployed and evaluated during a pilot program in WSDOT, TxDOT, and Minnesota DOT (MnDOT). Measures and findings from the pilot program were used to evaluate the effectiveness of the mobile technology solution and provide considerations and recommendations for deployment of mobile tools for the inspection workforce." --p.4 (117 pages)

This report is available for free download (3.3 MB):

<http://www.wsdot.wa.gov/research/reports/fullreports/840.2.pdf>

Research Digest

Item 21

Remote monitoring of fatigue-sensitive details on bridges

WESTERN MICHIGAN UNIVERSITY

MDOT RC-1629 • 2015

Fatigue is one of the most critical problems for steel bridges as well as for any steel structures that needs to be considered during design and operation. The objectives of this study are to explore monitoring technologies, and to develop effective structural and data analysis strategies as well as implementation recommendations for evaluating performance of fatigue-sensitive details and retrofits in steel bridges. Acoustic emission (AE) was selected as a candidate inspection technology, and a monitoring system was installed on a bridge. In general, the performance of the monitoring system and associated software is satisfactory. The majority of AE monitoring challenges are associated with AE data analysis and interpretation of results. In this study, cluster analysis and non-linear mapping signal analysis techniques are used to group AE data with similar waveform characteristics. The presence of the signals that resemble the characteristics of crack opening signals, noise, and structural resonance is identified through waveform analysis. Once the presence of crack opening signals is confirmed, the source location plots are utilized to assess the concentration and the level of activity at the locations of interest. A significant difference is observed in the fatigue life calculated using measured stress, and the stresses calculated using finite element models loaded with a fatigue truck. Hence, a two-tier implementation process is recommended. Tier I process includes the assessment of bridges with repaired details. Tier II process recommends evaluating the entire bridge population with fatigue-sensitive details. Additional recommendations include implementing AE data interpretation capability in an on-line system to provide reliable input with minimal interpretation requirements for inspection-based maintenance management. (131, 49, 44 pages)

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This report is available for free download (3 PDFs):

http://www.michigan.gov/mdot/0,4616,7-151-9622_11045_24249_24251-352370--,00.html

Research Digest

Item 22

STC Synthesis of Transportation Funding Sources and Alternatives in the Southeastern States Now and in the Future

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT (LA DOTD)

FHWA/LA.14/544 • 2015

Most states collect the majority of transportation revenues from sources such as fuel taxes and vehicle registration fees, while relying on the federal government via the Federal Highway Trust Fund (HTF) for additional monies. More often than not, fuel taxes have proven the most resilient source of revenue, yet concerns over increasing fuel efficiency eroding this traditional source of revenue have magnified funding concerns. When examining total revenues adjusted for inflation, most states saw little or no growth in total revenues from 1995 through 2012. Additionally, the HTF has run a deficit in recent years and legislators have utilized general funds to replenish it, leaving future federal funding levels uncertain. Revenue alternatives examined in the literature included vehicle miles travelled fees (VMT fees), tolls, and public private partnerships. The feasibility of implementing an alternative revenue source is likely to depend upon public acceptance. Various surveys that were conducted are summarized on a number of alternative revenue options. Public opinion was often driven by a perception of benefits received, and many options, including tolling, received majority support. Current legislative initiatives are briefly discussed including fees for electric and hybrid vehicles, tolls, and an increased emphasis on local government involvement in transportation. Based on the public opinion surveys reviewed and the alternative revenue options, there are several steps that states may consider. Conducting public outreach to gauge various revenue options will assist in implementation and public understanding of new revenue regimes, should they be deemed necessary. Pilot projects to test various administrative methods for a chosen revenue alternative will also assist in determining an alternative's viability and potential administrative costs. At the very least, it would be prudent for states to consider potential revenue alternatives to fund the transportation infrastructure of the future. (81 pages)

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- Executive Summary
- Introduction
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- Future Revenue Trends
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- Public Opinion and Current Legislative Efforts
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This report is available for free download (1.2 MB):

https://www.ltrc.lsu.edu/pdf/2015/FR_544.pdf

Research Digest

Item 23

Surface resistivity as an alternative for rapid chloride permeability test of hardened concrete

KANSAS DEPARTMENT OF TRANSPORTATION (KDOT)

FHWA-KS-14-15 • 2015

Kansas experiences harsh winters that require frequent use of de-icing salts, making it critical to the long-term durability of concrete structures that the permeability is kept under control. Under current KDOT specification, the Rapid Chloride Permeability (RCP) test, as described in ASTM Standard C1202 (2012), or the Volume of Permeable Voids method, described in ASTM Standard C642 (2013), more commonly known as the boil test, must be performed to evaluate concrete permeability. Surface resistivity testing was investigated as an alternative to these tests. Testing for surface resistivity was set up to evaluate the correlation of surface resistivity with RCP and boil tests, the effect of loss of saturation on the sample, and the repeatability of surface resistivity testing. Results indicate a strong relationship (R-squared value of 0.84) between 28-day surface resistivity and 56-day C1202 RCP testing. Results also correlate well to a mathematical relationship derived through Ohm's Law. Surface resistivity did not have a strong relationship (R-squared value of 0.37) with C642 boil testing. Cylinders were cast to evaluate the effect of saturation levels and differential sample drying. Cylinders were allowed to dry for varying lengths of time at different ages. Results indicated that allowing the samples to dry, regardless of the length of drying time and the age at which the samples were drying, increased the surface resistivity results by an average of 15%. Through the course of this study, including all samples tested, the standard deviation and coefficient of variation on any given set of cylinders is 1.4 and 4.9%, respectively. If only samples used for the correlation of 28-day surface resistivity to 56-day RCP are used, the coefficient of variation is 4.2%. A cost-benefit analysis was performed to evaluate the monetary savings resulting from this research. A triennial analysis indicates a total cost savings by KDOT and contractors of approximately \$980,000 and a cost-benefit ratio of 9.2. As a result of this research, recommended specification limits have been developed for surface resistivity testing. As of January 2014, surface resistivity testing has been added to KDOT Standard Specifications as an alternate test method for concrete permeability. (39 pages)

This report is available for free download (775 KB):

http://ntl.bts.gov/lib/54000/54800/54810/FHWA-KS-14-15_FinalReport.pdf