

Research Digest

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State DOT Research

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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.

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

<http://idmweb.ksdot.org/PublicLib/publicDoc.asp?ID=003837650>

Item 2

Estimation of Subgrade Resilient Modulus Using the Unconfined Compression Test

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

FHWA/VCTIR 15-R12 • 2014

To facilitate pavement design, the new proposed mechanistic-empirical pavement design guide recommends the resilient modulus to characterize subgrade soil and its use for calculating pavement responses attributable to traffic and environmental loading. Although resilient modulus values could be determined through laboratory testing of actual subgrade soil samples, such testing would require significant resources including a high level of technical capability to conduct the test and interpret results. For smaller or less critical projects, where costly and complex resilient modulus testing is not justified, correlation with the results of other simpler tests could be used. The Virginia Department of Transportation (VDOT) uses a simple correlation with the California bearing ratio (CBR) to estimate the resilient modulus in their current pavement design procedure in accordance with the 1993 AASHTO design guide. As this correlation with CBR is considered to be poor, a simpler unconfined compression (UC) test was explored for better estimation of the resilient modulus of fine-grained soils. Several models were developed in this study to estimate the resilient modulus of fine-grained soil from the results of UC tests. The simplest model considers only the UC strength to predict the resilient modulus with a fair correlation. The more detailed models with stronger correlations also consider the plasticity index, percentage of materials passing the No. 200 sieve, and modulus of the stress-strain curve from the UC test. These models are recommended for implementation by VDOT.

This report is available for free download (422 KB):

http://www.virginiadot.org/vtrc/main/online_reports/pdf/15-r12.pdf

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Item 3

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.

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

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

Item 4

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.

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

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

Item 5

Guardrail and bridge rail recommendations for very low-volume local roads in Kansas

KANSAS DEPARTMENT OF TRANSPORTATION (KDOT)

KS-14-16 • 2014

The determination of warrants for bridge railing and approach guardrails is a fundamental roadside safety issue. These are specialized roadside safety barriers that are intended to capture and smoothly redirect errant vehicles that leave the roadway either on the bridge itself or on the approach to the bridge. The Federal Highway Administration (FHWA) requires tested bridge rails and approach guardrails on all National Highway System (NHS) Roadways. However, states are given the discretion to develop their own policies for non-NHS roads. Currently in Kansas, all bridges constructed with federal funds are required to have one of the Kansas Department of Transportation's (KDOT) standard bridge rails (either corral rail or barrier curb) and approach guardrail (including transition and end treatment). These systems are expensive in terms of the initial cost of a bridge and they have additional safety and maintenance considerations that may outweigh the expected safety benefits on many low-volume applications. In an effort to maximize the safety benefits of the limited funding, KDOT undertook the effort outlined in this report to establish practical risk-based guidelines and policies for bridge rails and guardrails on low-volume local roads.

This report is available for free download (2.4 MB):

<http://idmweb.ksdot.org/PublicLib/publicDoc.asp?ID=003836545>

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Item 6

Improvement of Research Report Distribution and Access and Promotion of More Effective Use of Technical Report Documentation Page, USDOT Form 1700.7

TRANSANALYTICS, LLC

crm 15-003 • 2014

This report covers two studies: (Part A) Improvement of research report distribution and access process improvement of State Planning and Research (SPR) funded reports; and (Part B) Promotion of more effective use of the Technical Report Documentation page (TRDP) (USDOT Form 1700.7).

Results for Part A concluded that all State DOT libraries surveyed (n=21) distribute SPR reports to TRID and NTL. Most distribute to NTIS; but only half distribute to the remaining recipients on the FHWA directive letter. The majority of the State DOT Libraries surveyed have an alert system; catalog SPR-funded reports from their DOT; use group email distribution lists; and store SPR-funded reports on an internal server. About half of the libraries assign a permanent URL. Results for Part B identified that the 1972 TRDP and 1975 instructions are the current information available for completing the TRDP. The most populated fields on the TRDP are: title, author, abstract, keyword, report date and number, performing and sponsoring organization. There is inconsistency regarding the completion of all other fields.

Recommendations for Part A: State DOT libraries should continue to distribute SPR-funded reports to TRID, NTL, and NTIS to maintain discovery and preservation of transportation research. State DOT libraries should maintain their current distribution and preservation practices, and make reports available to researchers and practitioners within three months of report completion and approval.

Recommendations for Part B: A universal TRDP with an instruction sheet should be made available at a central and easily accessible location. This will improve consistency in completion of page. Updating the current 1975 instructions is recommended to clarify ambiguity in certain fields. Inclusion of URLs and use of Transportation Research Thesaurus are recommended with reservations.

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 - 2. Research Methods
 - 3. Results
 - 4. Recommendations for More Effective Use of the Technical Documentation Page

This report is available for free download (4.2 MB):

http://libraryconnectivity.org/files/Improvement-Distribution-and-TRDP_Final-Report.pdf

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Item 7

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.

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

http://www.virginia.gov/vtrc/main/online_reports/pdf/15-r15.pdf

Item 8

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).

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

http://www.virginia.gov/vtrc/main/online_reports/pdf/15-r8.pdf

Item 9

Monitoring Highway Assets with Remote Technology

MICHIGAN DEPARTMENT OF TRANSPORTATION (MI DOT)
RC-1607 • 2014

The purpose of this research was to evaluate the benefits and costs of various remote sensing technology options and compare them to the currently used manual data collection alternative. The DMG's evaluation was used to determine how useful and feasible it would be to perform inventory collection of the Michigan Department of Transportation's (MDOT's) twenty-seven high/medium priority assets. DMG performed a pilot project; using several selected routes in MDOT's Southwest Region, to evaluate different remote technologies and to provide recommendations for how best to implement the most viable of these technologies as data collection tools and data centralization methods.

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

http://www.michigan.gov/documents/mdot/RC-1607_466453_7.pdf?20140826130444

Item 10

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.

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

<http://idmweb.ksdot.org/PublicLib/publicDoc.asp?ID=003837023>

Item 11

A Peer-to-Peer Traffic Safety Campaign

MONTANA DEPARTMENT OF TRANSPORTATION (MDT)

FHWA/MT-14-003/8218 • 2014

The purpose of this project was to implement a peer-to-peer driver's safety program designed for high school students. This project builds upon an effective peer-to-peer outreach effort in Texas entitled Teens in the Driver Seat (TDS), the nation's first peer-to-peer driving safety program run by teens for teens. This program is based on the idea that teens will pay more attention to ideas that are presented by their peers than to those that come from adults. The peer-to-peer traffic safety campaign program empowers high school students to create methods of outreach to their peers. The implementation of this project followed that of the TDS high school program developed by the Texas Transportation Institute, and was assessed using a case-control experimental design across two urban and two rural Montana high schools that included approximately 2,700 students. Results did show some early success in improving teens' awareness of the most dangerous risk factors for teen drivers. Moreover, the program was found to be effective in reaching even those teens in the schools that were not affiliated with the program. These results were more prominent in the rural group than the urban group. However, self-reported driving behaviors did not reflect this change (except for an increase in seatbelt usage). Urban teens reported being influenced most by their peers, closely followed by a parent, whereas rural teens reported being nearly equally influenced by their peers and a parent. Another key finding was that the effectiveness of certain types of peer-to-peer media, such as posters, differed by school size.

This report is available for free download (10.9 MB):

http://www.mdt.mt.gov/other/research/external/docs/research_proj/peer-to-peer/FINAL_REPORT_14.pdf

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Item 12

Performance evaluation and placement analysis of W-beam guardrails behind curbs

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION (NCDOT)

FHWA/NC/2013-10 • 2014

This report summarizes the research efforts of using finite element modeling and simulations to evaluate the performance of NCDOT W-beam guardrails behind curbs under MASH TL-2 impact conditions. A literature review is included on performance evaluation of W-beam guardrails as well as applications of finite element modeling and simulations in roadside safety research.

This report is available for free download (6.8 MB):

<http://cdm16062.contentdm.oclc.org/cdm/ref/collection/p16062coll9/id/161487>

Item 13

Relative Operational Performance of Geosynthetics Used As Subgrade Stabilization

MONTANA DEPARTMENT OF TRANSPORTATION (MDT)

FHWA/MT-14-002/7712-251 • 2014

Full-scale test sections were constructed, trafficked and monitored to compare the relative operational performance of geosynthetics used as subgrade stabilization as well as determine which material properties are most related to performance. Seventeen, 50-ft. long test sections were constructed – fourteen containing geosynthetic reinforcement and three without. A subgrade material was prepared and constructed to an average strength of 1.79 CBR with the exception of two reinforced test sections which were constructed to greater and lesser strengths in order to determine the effect subgrade strength had on the performance of the test sections. The test sections were constructed with an average base course thickness of 10.9 in. with the exception of two controls where the base thickness was intentionally increased to evaluate the effect of base thickness on test section performance. Information from the test sections that were purposely constructed with different subgrade strength and base course thickness were used to correct any variability in the remaining reinforced test sections. Test sections were trafficked using a 45-kip, 3-axle dump truck. Rut, displacement, strain, and pore-water pressure were monitored during trafficking. Post-trafficking excavations were conducted to evaluate damage to the geosynthetic, base contamination from the subgrade, and strength and deformation of the layers. Longitudinal rut was the primary indicator of performance. Geosynthetic material properties were used in a linear regression analysis to determine which properties best related to performance of the test sections in this study as well as test sections from Phase I. It was determined that the strength and stiffness of the junctions and tensile strength properties in the cross-machine direction correlated well with performance. The woven and non-woven geotextiles also performed well, but further research is needed to determine which material properties correspond to performance. Additional work is needed to more confidently specify minimum values for geosynthetic material properties associated with good performance in subgrade stabilization applications.

This report is available for free download (63.5 MB):

http://www.mdt.mt.gov/other/research/external/docs/research_proj/subgrade/final_report-2.pdf

Research Digest

Item 14

Rumble Strip Gaps for High Speed Bicycles on Downgrades

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION (NCDOT)

FHWA/NC/2014-16 • 2014

Shoulder rumble strips (SRS) are a proven safety countermeasure that reduce motor vehicle lane departures; however, they may be seen as an impediment to bicycle travel as they decrease comfort for bicyclists and can impact one's control while bicycling. Existing literature provides recommendations for the placement of regular gaps in SRS, but the testing was limited to low and moderate bicycle speeds. Roads with SRS along long, steep grades present a unique set of risks for cyclists due to the capacity for higher bicycle speeds. This study evaluates how variations in SRS gap lengths and shoulder widths affect a bicyclist's ability to maneuver through these gaps when riding at higher than average bicycling speeds. The findings suggest that as gap length increases, bicyclist comfort is maintained while downhill speed also increases, with subjects reporting fewer instances of discomfort as the gap size increased. The likelihood of a bicyclist hitting a rumble strip while crossing a gap decreased modestly as the gap size increased. Shoulder width did not appear to significantly influence a bicyclist's capability of maneuvering across different gap lengths and had only a minor effect on bicyclist speeds.

This report is available for free download (PDF):

<http://www.ncdot.gov/doh/preconstruct/tpb/research/download/2014-16finalreport.pdf>

Item 15

Standardized Test Method to Quantify Environmental Impacts of Stormwater Pipe Rehabilitation Materials

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

FHWA/VCTIR 15-R11 • 2014

The purpose of this study was to develop a standardized test method that the Virginia Department of Transportation (VDOT) can apply to evaluate the environmental impact of stormwater infrastructure materials. Three laboratory stormwater infrastructure material leaching protocols named static, stirbar, and modified Toxicity Characteristic Leaching Procedure (mTCLP) were developed. These protocols were evaluated for their ability to predict field stormwater quality and aquatic toxicity caused by a pipe rehabilitation material. Cured-in-place pipe (CIPP) was used in this study as a model rehabilitation material because there was prior evidence this technology could cause environmental damage. The study objective was achieved, and during this project it was discovered that the material installation process itself was the main cause of environmental pollution, more than the material. Additional materials and installation processes should be examined in future work.

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

http://www.virginiadot.org/vtrc/main/online_reports/pdf/15-r11.pdf

Item 16

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.

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

<http://idmweb.ksdot.org/PublicLib/publicDoc.asp?ID=003837652>

Item 17

Warm Mix Asphalt Final Report

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT)

WA-RD 723.2 • 2014

The performance of pavements constructed using warm mix asphalt (WMA) technology were compared to the performance of conventional hot mix asphalt (HMA) pavements placed on the same project. Measurements of friction resistance, rutting/wear, ride and pavement condition (alligator, longitudinal and transverse cracking) did not show that the WMA either improved or worsened performance. WMA is an allowable substitute for conventional HMA on all projects using less than 20 percent recycled asphalt pavement (RAP). WMA is not allowed when the RAP content exceeds 20 percent or when any percentage of recycled asphalt shingles (RAS) is incorporated.

This report is available for free download:

<http://www.wsdot.wa.gov/Research/Reports/700/723.2.htm>