Research Digest

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Select Research from State Departments of Transportation

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Item 1

Alleviating Concrete Placement Issues Due to Congestion of Reinforcement in Post-Tensioned Haunch-Slab Bridges: Final Report

KANSAS STATE UNIVERSITY TRANSPORTATION CENTER

K-TRAN: KSU-08-7 • 2012

A flowable hybrid concrete mix with a spread of 17 to 20 inches was created with a superplasticizer to be used in post-tension haunch-slab (PTHS) bridges where rebar congestion is heaviest. The mix would allow for proper concrete consolidation. A conventional concrete mix with a slump of three to four inches was also created to be placed on top of the hybrid mix. The conventional mix would be used to create a sloping surface on the top of the concrete. The two mixes could be combined in the PTHS bridge deck and act as one monolithic specimen. Standard concrete tests such as compressive strength, tensile strength, modulus of elasticity, permeability, freeze/thaw resistance, and coefficient of thermal expansion were determined for the mixes and compared. Core blocks were cast using both mixes and composite cores were drilled. The cores were tested and their composite split-tensile strengths were compared to the split-tensile strengths of cylinders made from the respective mixes. A third concrete mix was made by increasing the superplasticizer dosage in the hybrid concrete mix to create a self-consolidating concrete (SCC) mix with a 24-inch spread. The SCC mix was created as a worst-case scenario and used in the determination of shear friction. Eighty-four push-off shear friction specimens were cast using the SCC mix. Joint conditions for the specimens included uncracked, pre-cracked, and cold-joints. Uncracked and pre-cracked specimens used both epoxy- and non-epoxy-coated shear stirrups. Cold-joint specimens used both the SCC mix and the conventional concrete mix. Joint-conditions of the cold-joint specimens included a one-hour cast time, a seven-day joint with a clean shear interface, and a seven-day joint with an oiled shear interface. The shear friction specimens were tested using a pure shear method and their results were compared to the current American Concrete Institute code equation.

This report is available for free download (4.9 MB):
http://idmweb.ksdot.org/PublicLib/publicDoc.asp?ID=003820959

Item 2

Application of Roller Compacted Concrete in Colorado's Roadways

COLORADO DEPARTMENT OF TRANSPORTATION (CDOT)

CDOT-2012-11 • 2012

Roller Compacted Concrete (RCC) is a no-slump concrete mixture that is transported, placed, and compacted with the same construction equipment as asphalt pavement. RCCs were used to construct three sections of pavement in Weld County Road 28 (WCR 28), eastbound of State Highway (EB 66), and westbound of State Highway (WB 66). Three sets of field inspections were conducted: 1) during construction; 2) nine months after construction; and 3) two years after construction. Strength and durability behaviors of the RCCs were tested right after construction, and some of the material properties of the RCCs were further tested nine months after construction.

This report is available for free download (3.2 MB):
http://www.coloradodot.info/programs/research/pdfs/2012/rcc.pdf

Item 3

Assessment of Concrete Pavement Texturing Methodologies in Colorado

COLORADO DEPARTMENT OF TRANSPORTATION. DTD APPLIED RESEARCH AND INNOVATION BRANCH

CDOT-2012-10 • 2012

This report presents information and data produced by the Colorado Department of Transportation's (CDOT's) long-term study of Portland cement concrete pavement (PCCP) textures used within the state. The information includes vehicle accident, friction, and texture data. This information was used as the basis for a review of proposed revisions to the CDOT texture measurement method, CP-77, and a specification for PCCP texturing found in Sections 106 and 412 of the Standard Specifications. The report presents specific recommendations for PCCP texture specifications including a recommended average texture depth greater than 0.05 inches. It further concludes that artificial turf drag is an adequate PCCP surface texture.

This report is available for free download (632 KB):
http://www.coloradodot.info/programs/research/pdfs/2012/texturing.pdf

Item 4

Assessment of the Durability of Wet Night Visible Pavement Markings: Wet Visibility Project Phase IV

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

VCTIR 12-R13 • 2012

This project encompassed a research effort to establish the durability of pavement markings in an on-road installation. Six marking technologies were installed on a portion of Route 460 in Blacksburg, Virginia. A human factors experiment in natural rain conditions was performed to establish the visibility needs of the driver. The retroreflectivity of the markings was measured at intervals of 2 to 5 months, with six measurements over the course of 23 months. The numbers of snow plow crossings and chemical treatments were also measured. Although all markings lost a considerable amount of retroreflectivity after the first winter, the markings installed in grooves or in rumble strips were shown to retain more retroreflectivity and receive less damage than markings installed on the surface of the roadway. Twenty-three months after installation, the retroreflectivity for all markings in active rain conditions had dropped below the 150 mcd/m2/lx minimum recommended from previous research. The reflective tape was the closest to maintaining the minimum with a mean retroreflectivity of 137mcd/m2/lx in 1 in/hr rain. Several other markings maintained a retroreflectivity above 84 mcd/m2/lx; this may still provide a benefit over standard paint. The study recommends that VDOT's Traffic Engineering Division install pavement markings in grooves or in rumble strips. VDOT will determine where the use of grooves or rumble strips is appropriate. Because pavement marking visibility is more critical for high-speed roadways such as interstate roadways and major arterials, these roads should be the highest priority. Grooved markings may also be desired for high-volume roadways where markings may be exposed to higher levels of wear from traffic. The study markings on Route 460 in Blacksburg should be monitored for two more years. The study team should make the measurements after each winter through 2013 and report the findings to VDOT in a brief report. VDOT staff should perform additional cost-benefit analyses to address standard VDOT policy, procedures, and practices and possible supplier warranties.

This report is available for free download (831 KB):
http://www.virginiadot.org/vtrc/main/online_reports/pdf/12-R13.pdf

Item 5

Benefit Cost Models to Support Pavement Management Decisions

UNIVERSITY OF TOLEDO

FHWA/OH-2012/102 • 2012

A critical role of pavement management is to provide decision makers with estimates of the required budget level to achieve specific steady-state network conditions, and to recommend the best allocation of available budget among competing needs for maintenance, rehabilitation, and repair (MR&R) projects or among different networks such as among Districts. This research study developed a model/procedure that uses the current state of the network and a specified future target state, condition deterioration trends (based on the MR&R treatments received) expressed as Markov condition transition matrices, and the unit cost of treatments, to determine the minimum total cost required and the corresponding treatment policy to achieve the desired target state of the network. The model can also determine the best network condition state achievable (and the corresponding treatment policy) with a given budget. The corresponding optimization problems with the objective of either minimizing total cost or maximizing overall network condition are formulated as linear programming problems, so that they can be solved very efficiently. The network level optimization model provides a valuable tool to ODOT decision makers to determine the required network budget and optimal budget allocations.

This report is available for free download (3.4 MB):
http://www.dot.state.oh.us/Divisions/Planning/SPR/Research/reportsandplans/Reports/2012/Pavements/134363_FR.pdf

Item 6

Best Design Practices for Walking and Bicycling in Michigan

MICHIGAN DEPARTMENT OF TRANSPORTATION (MI DOT)

• 2012

The Michigan Department of Transportation (MDOT) has undertaken a research initiative to determine how to optimize pedestrian and bicycle safety while minimizing impacts to vehicular mobility. The best practices in this document provide guidance in the design of nonmotorized improvements that have been shown to reduce crashes involving pedestrians and bicyclists. This best practices report is one of several reports prepared under this research initiative... This report is organized as a toolbox for planners and designers. A summary matrix is provided that provides a general comparison of the potential crash reduction, potential mobility impacts, and cost of each best practice." --Introduction

CONTENTS

- Introduction
- Signalized Intersection Improvements
- Unsignalized Pedestrian Crossing Improvements
- Corridor Improvements

This report is available for free download (4.6 MB):
http://www.michigan.gov/documents/mdot/MDOT_Research_Report_RC1572_Part6_387521_7.pdf

Item 7

Best Practices for Emergency Rerouting : Research Findings and Manual

MICHIGAN DEPARTMENT OF TRANSPORTATION (MI DOT)

• *2012*

MOOT has identified the need for a single statewide approach to documentation for emergency rerouting practices. This research effort documents some of the best practices in incident management and emergency rerouting that have been implemented across the country. The research documents components of programs that are applicable and can easily be adopted by the State of Michigan to increase safety and mobility. This guidance includes recommendations for establishing and maintaining effective inter-agency relationships that foster resource sharing and improved traffic management strategies. It also provides recommendations for permanent signing of emergency reroutes.

This report is available for free download (Website for final Report and appendixes A-D):
http://www.michigan.gov/mdot/0,4616,7-151-9622_11045_24249-288495--,00.html

Item 8

Climate Change Adaptation and Mitigation: State Transportation, Regional, and International Strategies: Synthesis

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT)

• *2012*

"This synthesis and literature review requested by Seth Start, Sustainable Transportation Manager, Washington State Department of Transportation, provides information on strategies other state DOT's countries, and local agencies are using to prepare for climate change adaptation and mitigation of the impacts. This Synthesis gathered published information on how other state DOT's and countries are addressing adaptation of highway infrastructure to the future impacts of climate change. Where available, international policies and practices that support the development and implementation of climate change adaptation strategies, are included to assist State DOT's and local agencies in their planning and procedures, design for pavement and bridges, asset management approaches, and other transportation system management activities. The main focus is on transportation infrastructure; related information that may transferable to transportation facilities was included as available." --p.1

CONTENTS

- State and Regional Adaptation and Mitigation Strategies
- Transportation Adaptation and Mitigation Strategies
- Transportation Functional Area Adaptation and Mitigation
- General Climate Change Adaptation and Mitigation
- Stormwater Adaptation and Mitigation
- Research Currently Underway
- International Adaptation and Mitigation to Climate Change
- Local Agency Approaches to Adaptation and Mitigation

This report is available for free download (356 KB):
http://www.wsdot.wa.gov/NR/rdonlyres/565C56AA-27C6-484C-AAB4-C4DBECA2FBA6/0/AdaptationandMitigationStrategiesSynthesisJuly2012FINALSethS.pdf

Item 9

Concrete Performance Using Low-Degradation Aggregates

WASHINGTON STATE TRANSPORTATION CENTER (TRAC)

WA-RD 790.1 • 2012

The durability of Portland cement concrete (PCC) has long been identified as a concern by transportation communities around the United States. In this study, the long-term performance of two batches of concrete incorporating either low-degradation (LD) or normal (NM) aggregates subjected to freezing and thawing conditions was experimentally studied. The freezing and thawing test method (ASTM C666) was followed to condition all the test samples. Dynamic modulus and fracture energy for both groups of concrete samples after different numbers of freeze-thaw cycles were measured through nondestructive modal and cohesive fracture tests, respectively. Due to the higher air content in LD concrete, surface scaling was less severe under frost action. Test results showed that different aggregate degradation has an important effect on the freeze-thaw resistance of the concrete and the rate of decrease in fracture energy with number of freeze-thaw cycles for the LD concrete is higher than for the NM concrete. Compared to the dynamic modulus of elasticity, the fracture energy is a more sensitive parameter for evaluating concrete degradation caused by the frost action. Thus, the degradation of aggregate in concrete can be better evaluated by the cohesive fracture test. Additional research is needed to identify an appropriate threshold for when aggregate degradation properties become a concern. Until that time, it is recommended that WSDOT maintain their current restrictions on using low-degradation aggregates in concrete.

This report is available for free download (1.8 MB):
http://www.wsdot.wa.gov/research/reports/fullreports/790.1.pdf

Item 10

Deterioration and Cost Information for Bridge Management

COLORADO DEPARTMENT OF TRANSPORTATION. DTD APPLIED RESEARCH AND INNOVATION BRANCH

CDOT 2012-4 • 2012

This study applies contract bid tabulations and element-level condition records to develop element-level actions, costs for actions, transition probabilities for models of deterioration of bridge elements, and transition probabilities for improvements to elements due to actions. The information on actions, costs, and transition probabilities is input to a Pontis BMS bridge database. The study uses transition probabilities for element deterioration to compute the number of years to possible loss of safety in bridges, and to compute the number of years for inspection intervals. It examines variations in costs of actions and deterioration of elements among CDOT regions. A set of software applications was developed to handle bid tabulations, compute costs of actions, compute transition probabilities, and mediate the steps needed for movement of data into and out of Pontis BMS.

This report is available for free download (9.2 MB):
http://www.coloradodot.info/programs/research/pdfs/2012/pontis.pdf

Item 11

Developing an Active Traffic Management System for I-70 in Colorado

COLORADO DEPARTMENT OF TRANSPORTATION (CDOT)

CDOT-2012-9 • 2012

The Colorado DOT is at the forefront of developing an Active Traffic Management (ATM) system that not only considers operation aspects, but also integrates safety measures. In this research, data collected from Automatic Vehicle Identification (AVI), Remote Traffic Microwave Sensors (RTMS) and Real-Time weather data were utilized to incorporate safety within the ATM system. Preliminary investigation of crashes along 20-miles of I- 70 revealed that the mountainous terrain and adverse weather during the winter season may increase crash likelihood. A traditional automatic incident detection system is a reactive approach to mitigating the effects of crashes without attempting to avoid primary incidents. To reduce the risk of primary incidents, a more proactive approach that identifies locations where a crash is more likely to happen in real-time can be implemented.

This report is available for free download (1.9 MB):
http://www.coloradodot.info/programs/research/pdfs/2012/atm.pdf

Item 12

Developing Standards and Specifications for Full Depth Pavement Reclamation

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION (PENNDOT)

FHWA-PA-2012-004-090107 • 2012

The report summarizes the work conducted during the development of procedures for conducting full depth reclamation of existing asphalt surfaced and unsurfaced roads. The report describes full depth reclamation, and includes a summary of available literature, a Best Practices document, construction of two field projects, development of design and construction guidance documents, and training materials for full depth reclamation.

This report is available for free download (7.5 MB):
ftp://ftp.dot.state.pa.us/public/pdf/BPR_PDF_FILES/Documents/Research/Complete%20Projects/Extending%20Pavement%20Life/FDR%20Final%20Report.pdf

Item 13

Establishment of Local Trip Generation Rates or Equations for Mixed-Use Developments in Kansas

KANSAS DEPARTMENT OF TRANSPORTATION (KDOT)

K-TRAN: KU-11-7 • 2012

Currently, the trip generation rates and equations contained in the Institute of Transportation Engineers (ITE) Trip Generation Manual, 8th Edition are based on the information collected at single-use, free-standing sites and cannot be directly applied to multi-use developments. Application of this data for multi-use development sites requires use of an adjustment factor called "internal capture rate", which is expressed as a percent reduction to the trips generated by individual land uses. These reductions are applied externally to the site at the entrances, adjacent intersections and roadways. They are distinct and separate from "pass-by" and "diverted-link" trips and are applied before "pass-by" and "diverted-link" trip reductions are applied. While the trip generation rates for individual uses on a multi-use development site may be the same or similar to what they are for free-standing sites, there is potential for interaction between among those uses within the site, particularly where the trip can be made by walking. As a result, the total generation of vehicle trips entering and exiting the multi-use site may be reduced from simply a sum of the individual, discrete trips generated by each land use. Because the development of mixed-use or multi-use sites is increasingly popular, ITE wishes to increase the database on multi-use developments in order to provide internal capture data for a broader range of land uses. ITE would appreciate additional data from analyses of such developments. The goal of this research project is to establish a local trip generation rate model for multi-use developments in state of Kansas, which can potentially be submitted to the ITE headquarter for inclusion in the national database as well. The primary objectives were to identify several appropriate multi-use development sites in the state and document vehicular trip data generated by each site in order to develop a trip generation model that can be used to better estimate trip numbers generated by such sites. A total of three sites were selected and studied for this project including "Mission Farms" and "Park Place" developments, both in Leawood, Kansas; and "Metcalf95 Complex" in Overland Park, Kansas

This report is available for free download (5.3 MB):
http://idmweb.ksdot.org/PublicLib/publicDoc.asp?ID=003823096

Item 14

Evaluation of Long-Term Performance and Noise Characteristics of Open-Graded Friction Courses

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION. MATERIALS LABORATORY

WA-RD 691.2 • 2012

This report describes the second of three experimental installations of open-graded friction course (OGFC) “quieter pavements” designed to reduce the noise generated at the tire/pavement interface. Experimental sections of OGFC were built using asphalt rubber (AR) and styrene-butadiene-styrene (SBS) modified asphalt binders. A section of conventional hot mix asphalt (HMA) served as the control section for the two experimental sections. The noise level of the OGFC-AR test section was audibly quieter than the HMA control section for only a period of five months after construction. The OGFC-SBS section was not initially audibly quieter than the HMA and never attained that level of noise reduction for the entire monitoring period of four years. The OGFC-AR test section was prone to excessive raveling and rutting and in places wore through to the underlying pavement. The OGFC-AR was removed by grinding in January of 2012 because of safety concerns with the rutting and in preparation for a project that reconstructs the entire corridor. Open graded friction course quieter pavements are not recommended for use in Washington State due to the short duration of their noise mitigation properties and unacceptable life cycle cost.

This report is available for free download (1.8 MB):
http://www.wsdot.wa.gov/research/reports/fullreports/691.2.pdf

Item 15

Feasibility of Digital Imaging to Characterize Earth Materials

UNIVERSITY OF MICHIGAN

RC-1557 • 2012

This study demonstrated the feasibility of digital imaging to characterize earth materials. Two rapid, relatively low cost image-based methods were developed for determining the grain size distribution of soils and aggregates. The first method, called "sedimaging," provides the grain size distribution for particles between 2.0 mm (U.S. Standard Sieve Number 10) and 0.075 mm (Sieve Number 200) in size. The test utilizes a 7 ft. sedimentation column to rapidly segregate the particles by size. An image processing program based on mathematical wavelet decomposition determines the dominant particle size at approximately 5000 points in an image of the sedimented soil and computes the percentages by size as traditional sieving would. The sedimaging test also reports the percentage of particles smaller than the #200 sieve, the equivalent of "percentage loss by wash" in sieving. The second test utilizes a 3 ft. x 3 ft. tilting backlit Translucent Segregation Table (TST) for obtaining the size distribution of particles in the 40 mm (or larger) to 2.0 mm range. In this test the particles are only somewhat segregated to insure that smaller particles are not hidden from camera view behind larger particles. The dimensions of every particle in the specimen are determined to compute the percentages by size. Results of the Sedimaging and TST tests may be combined to produce a single traditional particle size distribution.

This report is available for free download (Website includes links to 6 PDFs):
http://www.michigan.gov/mdot/0,4616,7-151-9622_11045_24249-280828--,00.html

Item 16

Hydraulic Efficiency of Grate and Curb-Opening Inlets Under Clogging Effect

COLORADO DEPARTMENT OF TRANSPORTATION. DTD APPLIED RESEARCH AND INNOVATION BRANCH

CDOT-2012-3 • 2012

The goal of this project is to investigate the hydraulic efficiencies of Type 13 (bar inlets), Type 16 (vane inlets), and Type R (curb-opening inlets) for street and roadway drainage. Although these inlets have been widely used in many metropolitan areas, the design empirical formulas and coefficients have not been verified. In this study, a flume was constructed in the laboratory to simulate street gutter flows ranging from 6 to 18 inch of flow depths. Type 13, 16, and curb-opening inlet models were built using a 1/3 scale to investigate the depth-flow relations under both on-grade and in-sump conditions. It was found that the flow interception capacity for a sump inlet is determined by either weir or orifice hydraulics, whichever is less for the given flow depth. Two new splash-velocity curves were developed to model the street gutter flow around a Type 13 or 16 inlet on a grade. In this study, a decay-based clogging factor was developed and recommended for the design of a series of inlets. The clogging effect shall be applied to the effective wetted length for an inlet that operates like a weir, or to the effective opening area for an inlet that operates like an orifice in a sump.

This report is available for free download (1.4 MB):
http://www.coloradodot.info/programs/research/pdfs/2012/inlets.pdf/at_download/file

Item 17

Identification of Causes and Solution Strategies for Deck Cracking in Jointless Bridges

MICHIGAN STATE UNIVERSITY. DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

CEE-RR- 2012/04 / SPR No. 108522 • 2012

Bridges have traditionally relied on a system of expansion joints and flexible bearings to accommodate movements due to temperature, creep, and shrinkage loading. Joints and elements in their vicinity experience a high amount of degradation; thus modern design approaches are advocating their removal, with movement accommodated through flexible piles and abutment walls. While jointless bridges have been performing well, many of them suffer from widespread early-age transverse deck cracking. Restrained concrete shrinkage was identified as the most dominant source for the noted damage based on a literature review and a field investigation. Deck cracking is caused by the build-up of tensile forces resulting from the increased rigidity in jointless bridges. Experimentally calibrated finite-element models were used to predict deck cracking in two bridge systems under shrinkage-induced loading and a parametric study was conducted to investigate the influence of design parameters on restrained shrinkage cracking.

This report is available for free download (Website):
http://www.michigan.gov/mdot/0,4616,7-151-9622_11045_24249-288491--,00.html

Item 18

Impact of Non-Freeway Rumble Strips, Phase 1

MICHIGAN DEPARTMENT OF TRANSPORTATION (MI DOT)

RC-1575 Final • 2012

In an effort to reduce lane-departure crashes, in 2008 the Michigan Department of Transportation (MDOT) began a three-year statewide non-freeway rumble strip installation initiative. This initiative called for the installation of milled centerline rumble strips on all rural non-freeway highways with a posted speed limit of 55 mph and a paved roadway width greater than 20 ft and shoulder rumble strips on roadways with paved shoulders that were at least 6 ft wide. Approximately 5,400 miles of non-freeway roadways were ultimately included in this rumble strip installation initiative. As this initiative was believed to be the largest of its kind in the United States at the time, it was important for MDOT to evaluate the impacts associated with the rumble strip installations to provide guidance for future implementation both within Michigan and other states. The objectives of this study included: Identification and analysis of “Before” traffic crashes. Assessment of impact of rumble strips on driver behavior, bicyclist safety, roadside noise, and short-term pavement performance.

This report is available for free download (Website):
http://www.michigan.gov/mdot/0,4616,7-151-9622_11045_24249-283852--,00.html

Item 19

A Model to Forecast Peak Spreading

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

FHWA/VCTIR 12-R11 • 2012

"As traffic congestion increases, the K-factor, defined as the proportion of the 24-hour traffic volume that occurs during the peak hour, may decrease. This behavioral response is known as peak spreading: as congestion grows during the peak travel times, motorists may shift their departure time to a non-peak hour. Knowing whether K-factors will remain constant or will change will affect the estimation of travel demand, and the resultant transportation performance, since the traffic volume during a given hour may affect travel speed and vehicle emissions. The purpose of this study was to develop a model for forecasting peak spreading whereby peak spreading is measured as change in the K-factor. Data were collected from 32 continuous count stations in the six Northern Virginia counties of Arlington, Fairfax, Fauquier, Loudoun, Prince William, and Stafford for the period 1997-2010. Because some stations gave two-directional counts and some gave only one-directional counts, there were 52 station-direction combinations, or sites, for analysis purposes. The data collected showed that the average annual K-factor adjusted for months for which data were not available decreased by an average of 0.006 ($p < 0.01$), from 0.103 to 0.097, during the period. The 24-hour volume-to-capacity ratio, which is a surrogate for travel congestion, increased by an average of 0.7 ($p < 0.01$), from 7.3 to 8.0. Both changes were statistically significant. Two models to forecast K-factors were developed in this study. Model 1, for use with an established roadway with an existing K-factor, explained 88% of the variation in K-factors and is based on the previous K-factor, the percentage increase in the jurisdiction's employment, and the roadway functional class. Model 2, for use with a new roadway without an existing K-factor, explained 66% of the variation in K-factors and is based on the percentage change in the jurisdiction's employment; circuity, i.e., whether the route is radial or circumferential; and for freeways, the 24-hour volume-to-capacity ratio. Use of these variables is advantageous as they are typically available when a 10-year forecast is made. The two models have three implications for forecasting peak spreading. First, site characteristics (e.g., functional class, 24-hour volume-to-capacity ratio) and regional socioeconomic characteristics (e.g., jurisdictional employment growth) affect the K-factor. Second, the 24-hour volume-to-capacity ratio affects the forecasts, even though the effect is evident only after controlling for other variables. Third, the K-factor varies more across sites with the time period held constant than across time periods with the site held constant. The study recommends that the Virginia Department of Transportation (VDOT) consider the use of the two models when more detailed data are not available; their use would provide an empirically based alternative to assuming the K-factor will remain constant. A potential study limitation is that congestion during the "before" period in Northern Virginia was already so great that any congestion-based effects on peak spreading had already occurred. However, as the large variability in K-factors across sites dampened the overall effect of congestion, it may be the case repeating this study in other locations would yield similar results."

This report is available for free download (895 KB):
http://www.virginiadot.org/vtrc/main/online_reports/pdf/12-r11.pdf

Item 20

Optimizing the Analysis of Routing Oversize/Overweight Loads to Provide Efficient Freight Corridors: Final Report

KANSAS DEPARTMENT OF TRANSPORTATION (KDOT)

KTRAN: KSU-11-4 • 2012

The subject of this report is limited specifically to Kansas' highways. Current features of the State Highway System were looked at to determine corridors that do not limit Oversize/Overweight (OS/OW) vehicles, or that limit loads to varying degrees. Now that roundabouts are becoming more common throughout the state and the nation, many individuals, both in the public and private sectors, believe that the main concern for efficient movement of oversized loads are roundabouts that were being constructed. However, information that has been collected indicates that vertical clearance, diamond interchanges, curbs, non-removable signs, enhancements at pedestrian crosswalks all limit the ability for over-length loads to make turns to varying degrees. While it is not usually feasible to remove structures with limited vertical clearance, it is feasible to develop policies to better control OS/OW movements.

This report is available for free download (4.4 MB):
http://idmweb.ksdot.org/PublicLib/publicDoc.asp?ID=003820460

Item 21

Pilot Car Wait Time Notification System for Work Zones: Phase 1 Final Report

KANSAS DEPARTMENT OF TRANSPORTATION (KDOT)

KS-08-12 • 2012

The primary objective of this research is to determine a cost-effective method of informing drivers about delay time they will encounter when approaching a pilot car operation at two-lane highway work zones. Based on literature review and discussions with KDOT personnel, six notification systems were identified during the preliminary research to relay information to drivers: * Highway advisory radio (HAR) with static sign notification * Static sign displaying maximum wait time * Countdown timer displayed on flagger's stop sign * Portable variable-message sign * Countdown timer displayed on approach sign * Portable message sign with countdown timer. A feasibility study was conducted for each of the notification systems. The research group decided to pursue the concept of a countdown timer displayed on an approach sign to the work zone. The reasons used for selection of this notification system are given in chapter three of this report.

This report is available for free download (4.8 MB):
http://idmweb.ksdot.org/PublicLib/publicDoc.asp?ID=003823425

Item 22

Pilot Car Wait Time Notification System for Work Zones: Phase 2 Final Report

KANSAS DEPARTMENT OF TRANSPORTATION (KDOT)

KS-08-13 • 2012

The Kansas Department of Transportation (KDOT) does routine roadwork (rehabilitation) on two-lane rural highways where traffic must be narrowed to one lane through the construction work zone. This operation involves the use of traffic control signs and flaggers to stop the motorists and a pilot car to lead the drivers through the one lane work zone. A preliminary study the fall of 2002 was two-fold: first, to determine the driving public's desire to know the anticipated wait time when approaching a work zone with a pilot car operation; and second, to determine a practical notification method. Surveys of drivers waiting in line (the queue) at four different pilot car work zones showed the driving public had a desire to be notified of the anticipated wait time when approaching a pilot car operation. Six possible notification systems were identified as being capable of relaying information to drivers. The concept of a "portable message sign with countdown timer" was chosen after feasibility studies were conducted during Phase 1. The development effort included items such as determining the wording to use on the sign, purchasing and assembling the sign parts and developing the algorithm for real time monitoring of the pilot car location. Field testing of the initial prototype 48" x 48" sign with stand and countdown timer took place during September and October of 2004. A survey to access the effectiveness of the sign to the driving public was conducted using questionnaires distributed to a randomly selected group of drivers waiting in the queue during one of the field tests. The replies to the public survey were overwhelmingly positive for the wait time notification. Phase 2 developed a workable and deployable prototype based on the concepts of the system demonstrated in Phase 1. Communication issues related to gaps in coverage were solved by using an algorithm to estimate wait time rather than using real time communications. The sign evolved to a "mini-trailer" design to make the unit easily portable and to meet the Category IV definition of "trailer mounted devices" which aren't required to be crash tested. The production prototype was tested at an operating pilot car construction zone in October 2008. The system worked as designed and the algorithm generally kept the displayed wait time within one (1) minute of the arrival of the pilot car. KDOT continues to evaluate the existing production prototype system for the possibility of implementing the use of the Driver Notification Sign system on pilot car operation construction zones where appropriate.

This report is available for free download (3.9 MB):
http://idmweb.ksdot.org/PublicLib/publicDoc.asp?ID=003823229

Item 23

Pilot Implementation of a Resource Guide to Enhance the Incorporation of Safety into the Regional Planning Process: Final Report

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

FHWA/VCTIR 12-R8 • 2011

To incorporate safety into the regional planning process, a Virginia-specific resource guide was recently developed for use by districts of the Virginia Department of Transportation (VDOT) and planning district commissions (PDCs). In order to determine how to enhance the implementation of the guide throughout Virginia, a pilot implementation of the guide was conducted in one Virginia PDC -- the Roanoke Valley - Alleghany Regional Commission -- where representatives helped identify tasks the guide should help them accomplish. Deliverables included (1) acquiring crash locations for incorporated cities (for which VDOT has not historically maintained roads); (2) identifying high-crash locations; (3) determining potential crash countermeasures; and (4) using safety-related performance measures that do not rely exclusively on crash data. These four deliverables corresponded to three modules in the resource guide: data needs (Deliverable 1), data analysis (Deliverables 2 and 3), and performance measures (Deliverable 4). The pilot implementation showed that most (87% of county crashes and 93% of city crashes) crashes could be successfully located in a geographic information system environment; that potential crash countermeasures could be identified based on a study of the characteristics of these crashes; and that for instances where crash data are likely to be sparse, non-crashbased performance measures are feasible. However, the pilot implementation showed that four additional types of guidance, not fully specified in the resource guide, may make accomplishing these tasks easier: the steps for querying crashes from VDOT's Crash Records Database and then importing those crashes into a geographic information system for an entire jurisdiction approaches for determining what constitutes a crash cluster and whether a given cluster represents a relatively high concentration of crashes; ways to identify crash countermeasures based on examining crash characteristics; geometric characteristics; and, if necessary, the crash diagram and narrative - ways to use performance measures to support a program of interest to the region. These four types of guidance are provided in Appendix B and in the examples provided in the body of this report. The pilot implementation also showed that it may be productive to focus on using the guide for short-term safety and planning initiatives first rather than focusing only on long-range planning issues.

This report is available for free download (1.2 MB):
http://www.virginiadot.org/vtrc/main/online_reports/pdf/12-r8.pdf

Item 24

Portable Concrete Barrier Condition and Transition Plan Synthesis: Final Report

MONTANA STATE UNIVERSITY. WESTERN TRANSPORTATION INSTITUTE

FHWA/MT-12-002/8117-41 • 2012

Precast (or portable) Concrete Barrier (PCB) is a guardrail system that is intended to contain and redirect a vehicle that has left the travel lane. Barrier connections are typically formed using steel wire or bar to form loops which are joined by a steel pin. While the materials used in connection systems are quite strong, exposure to the elements and winter maintenance chemicals can, over time, lead to corrosion and loss of effectiveness. The identification of such corrosion was a concern to the Montana Department of Transportation (MDT), which decided that additional research should be done on this issue to determine what, if any, past research has been done regarding PCB in general, PCB connection corrosion, the maintenance of barrier connection systems, and approaches to address corrosion on existing and future installations. The research would also identify approaches that may be taken in developing and implementing a transition plan for replacing PCB if needed. This report presents a synthesis of information from past published research and reports, as well as information from a survey of transportation agencies conducted as part of this project, regarding precast concrete barriers, the corrosion of their connection systems, approaches to rating/ranking this corrosion, and current state DOT practices for their maintenance and replacement. Potential strategies for prioritizing barrier replacement are identified and discussed.

This report is available for free download (3.6 MB):
http://www.mdt.mt.gov/other/research/external/docs/research_proj/cmb/final_report.pdf

Item 25

Preparation and Testing of Drilled Shafts with Self-Consolidating Concrete

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

FHWA/VCTIR 12-R15 • 2012

In this study, self-consolidating concrete (SCC) was evaluated in drilled shafts and the integrity of drilled shafts was determined using cross-hole sonic logging (CSL), a low-strain nondestructive integrity testing technique. SCC has very high flowability. It was placed in the drilled shafts of the bridge on Route 28 over Broad Run in Bristow in Prince William County, Virginia. There were two bridges at the site; the one carrying the northbound traffic had drilled shafts using conventional concrete with high consistency (i.e., flowability). Half of the shafts of the bridge carrying the southbound traffic were cast with SCC. During placement, properties of the fresh concrete were tested and specimens were prepared to determine the hardened properties. The integrity of the shafts within the reinforcing cage was determined using CSL, with sonic echo/impulse response also used to evaluate several test shafts. The use of acousto-ultrasonic (AU) measurements to determine the cover depth outside the reinforcing cage was also evaluated during laboratory testing. In addition to the Route 28 shafts, three test shafts with conventional and SCC concretes were cast in an area headquarters. These shafts had intentional voids created through the use of sand bags and Styrofoam to investigate further the ability of the nondestructive test equipment. The results indicated that SCC is highly desirable for drilled shafts; it flows easily, filling the hole, and the removal of the temporary casing is facilitated by this highly workable material. CSL is a satisfactory nondestructive method to determine the integrity of shafts. Sonic echo/impulse response also showed promise as a method that complements CSL for determining the integrity of a shaft.

This report is available for free download (1.2 MB):
http://www.virginiadot.org/vtrc/main/online_reports/pdf/12-r15.pdf

Item 26

Retroreflectivity of Existing Signs in Pennsylvania: Final Report

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION (PENNDOT)

FHWA-PA-2012-003-E01041-WO9 • 2012

The Pennsylvania Department of Transportation (PennDOT) Bureau of Highway Safety and Traffic Engineering initiated this research effort in response to the release of the new 2009 Manual on Uniform Traffic Control Devices (MUTCD) which mandates that all states shall have a sign maintenance method designed to maintain traffic sign retroreflectivity at or above the established minimum levels in place by January 2012. The goal of this research effort was to collect and analyze sign retroreflectivity measurements on a subset of PennDOT owned and maintained signs throughout the Commonwealth of Pennsylvania in order to better understand the potential service life of signs with regard to nighttime visibility in Pennsylvania. As PennDOT implements its sign management system, with respect to compliance with the minimum retroreflectivity levels, the findings of this research will assist PennDOT in better determining when signs may need replaced. Retroreflectivity levels were measured on a sample of 1,000 traffic signs using a DELTA Light and Optics RetroSign 4500 retroreflectometer. In order to obtain regional variety, an equal portion of signs (one third in each county) were measured in Lackawanna, Lehigh and Lancaster counties to represent the northern, central and southern tiers of the state. The number of yellow warning signs, white regulatory signs, green directional signs and red Stop, Yield, Do Not Enter and Wrong Way signs to be measured was determined using the proportion of each sign color's overall population in the state. PennDOT's current standard specifications for reflective sheeting require the use of Type III or Type IV sheeting for post-mounted sign installations and the sign sheeting manufacturer warranties are typically 10 years; therefore the data collection efforts were limited to Type III signs aged 10 years or older. The study recommends an expected sign life of 15 years for yellow, white, red and green signs in Pennsylvania.

This report is available for free download (1.5 MB):
ftp://ftp.dot.state.pa.us/public/pdf/BPR_PDF_FILES/Documents/Research/Complete%20Projects/Smart%20Transportation%20Solutions/Retroreflectivity%20of%20Existing%20Signs.pdf

Item 27

Review of the Virginia Department of Transportation's Truck Weight Data Plan for the Mechanistic-Empirical Pavement Design Guide: Final Report

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

VCTIR 12-R4 • 2011

In 2003, staff of the Virginia Transportation Research Council (now the Virginia Center for Transportation Innovation and Research) and the Virginia Department of Transportation (VDOT) developed a plan to collect traffic and truck-axle weight data to support the Guide for Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures, known as the Mechanistic-Empirical Pavement Design Guide (MEPDG). The purpose of this study was to review VDOT's traffic data plan for the MEPDG and revise it as needed. The review included an assessment of the data obtained from the VDOT and Virginia Department of Motor Vehicles weigh-in-motion (WIM) sites and the appropriateness of the truck weight groups in VDOT's traffic data plan. Information on truck travel patterns and characteristics was compiled.

This report is available for free download (809 KB):
http://www.virginiadot.org/vtrc/main/online_reports/pdf/12-r4.pdf

Item 28

Sharing the Road: Optimizing Pedestrian and Bicycle Safety and Vehicle Mobility

MICHIGAN DEPARTMENT OF TRANSPORTATION (MI DOT)

RC-1572 • 2012

Reducing crashes involving pedestrians and bicyclists continues to be a major concern in the design of Michigan roads. In seeking to improve the safety of pedestrians, bicyclists, and motorists on Michigan roads, it is important to balance the needs of improved safety and mobility. This report provides a comprehensive review of safety improvements through a series of reports: A pedestrian and bicycle crash analysis in Michigan; a review of national design guidelines with respect to pedestrian and bicycle improvements; a case study analysis of recently completed improvements in Michigan; an analysis of existing guides and manuals that influence the design of roadways in Michigan; finally, and a set of recommended best design practices for walking and bicycling in Michigan.

This report is available for free download (Website with links for PDF downloads):
http://www.michigan.gov/mdot/0,4616,7-151-9622_11045_24249-279311--,00.html

Item 29

Study of KDOT Policy on Lane and Shoulder Minimum Width for Application of Centerline Rumble Strips: Final Report

KANSAS STATE UNIVERSITY TRANSPORTATION CENTER

KSU-10-7 • 2012

The objectives of this research were: a) to obtain updated information on DOTs' policies and guidelines for installation of centerline rumble strips (CLRS) in the United States in order to identify current practices; b) to verify the before-and-after safety effectiveness of CLRS currently installed in Kansas; c) to determine if CLRS cause levels of exterior noise that can disturb nearby residents and propose a minimum distance from houses for installation of CLRS in Kansas; d) to estimate the effects of CLRS on vehicles' operational speed and lateral position and to verify if it is safe to install CLRS on sections of highways with narrow shoulders; and e) provide recommendations of when it is beneficial to install rumble strips, given known values of traffic volume, shoulder width, and the presence of other types of rumble strips. The methodologies that were applied in this research include: a) an email survey that was sent to all state DOTs to verify their current guidelines for installation of CLRS; b) application of Bayesian before-and-after methods to investigate the safety effectiveness of CLRS in Kansas; c) field data collection according to standard procedures to verify if CLRS produce exterior noise levels that can disturb residents that live nearby to treated highways, d) standard field data collection methods to investigate how CLRS impact vehicular lateral position and operational speed; and e) modeling and interpretation of regression equations to predict number of crashes.

This report is available for free download (3.5 MB):
http://idmweb.ksdot.org/PublicLib/publicDoc.asp?ID=003821547

Item 30

Thermal response of a highly skewed integral bridge

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)
FHWA/VCTIR 12-R10 • 2012

The purpose of this study was to conduct a field evaluation of a highly skewed semi-integral bridge in order to provide feedback regarding some of the assumptions behind the design guidelines developed by the Virginia Department of Transportation. The project was focused on the long-term monitoring of a bridge on Route 18 over the Blue Spring Run in Alleghany County, Virginia. The 110-ft-long, one-span bridge was constructed at a 45° skew and with no approach slabs. It incorporated an elasticized expanded polystyrene material at the back of the integral backwall. Bridge data reflecting thermally induced displacements, loads, earth pressures, and pile strains were acquired at hourly intervals over a period of approximately 5 years. Approach elevations were also monitored. Analysis of data was used to formulate design recommendations for integral bridges in Virginia. Field results indicated that semi-integral bridges can perform satisfactorily at a 45° skew provided some design details are modified. The relatively high skew angle resulted in a pronounced tendency of the semi-integral superstructure to rotate in the horizontal plane. This rotation can generate higher than anticipated horizontal earth pressure acting on the abutment wingwall. Study recommendations include modifying the structural detail of the backwall-wingwall interface to mitigate crack formation and placing the load buttress close to the acute corner of a highly skewed abutment to reduce the abutment horizontal rotation. The use of elastic inclusion at the back of the semi-integral backwall resulted in the reduction of earth pressures and negligible approach settlements. The study recommendations include proposed horizontal earth pressure coefficients for design and a revised approach to calculating the required thickness of the elastic inclusion. While recommending that the existing VDOT guidelines allow an increase in the allowable skew angle from 30° to 45° for semi-integral bridges, the study also proposes a field investigation of the maximum skew angle for fully integral bridges because of the inherently low stiffness associated with a single row of foundation piles. The study indicates that current VDOT guidelines can be relaxed to allow design of a wider range of jointless bridges. The implementation of integral design has been shown to reduce bridge lifetime costs because of the elimination of deck joints, which often create numerous maintenance problems.

This report is available for free download (2.7 MB):
http://www.virginiadot.org/vtrc/main/online_reports/pdf/12-r10.pdf

Item 31

Tire/Pavement and Environmental Traffic Noise Research Study: Final Report

COLORADO DEPARTMENT OF TRANSPORTATION. DTD APPLIED RESEARCH AND INNOVATION BRANCH
CDOT-2012-5 • 2012

In response to an interest in traffic noise, particularly tire–pavement noise, CDOT elected to conduct tire-pavement noise research. Following a rigid set of testing protocols, data was collected on highway traffic noise characteristics along with safety and durability aspects of the associated pavements. This report completes a comprehensive, long-term study to determine if particular pavement surface types and/or textures can be used as quieter pavements, and possibly be used to help satisfy FHWA noise mitigation requirements. The study addressed: The noise generation/reduction characteristics of pavements as functions of pavement type, pavement texture, age, time, traffic loading, and distance away from the pavement; correlations between source measurements using on-board sound intensity (OBSI) and wayside measurements including both statistical pass-by (SPB) and time-averaged measurements; and The collection of data that can be used for validation and verification of the accuracy of the FHWA Traffic Noise Model (TNM) to use on future Colorado highway projects.

This report is available for free download (4.2 MB):
http://www.coloradodot.info/programs/research/pdfs/2011/qpr3.pdf

Item 32

Trackless tack coat materials : a laboratory evaluation for performance acceptance

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

VCTIR 12-R14 • 2012

The purpose of this study was to develop, demonstrate, and document laboratory procedures that could be used by the Virginia Department of Transportation (VDOT) to evaluate non-tracking tack coat materials. The procedures would be used to qualify candidate material formulations for field validation. The procedures were developed and were demonstrated through an evaluation of five "trackless" tacking materials and two conventional tacking materials. The evaluation demonstrated that the trackless materials outperformed the conventional materials in the laboratory tracking test and in the bond performance tests for tensile and shear strength. The study recommends that VDOT formalize the described laboratory procedures to produce a Virginia Test Method to qualify candidate non-tracking tack coat materials for field verification. It further recommends that VDOT formalize the field verification system and includes general direction on the elements to include in that process. This work is part of a program of research designed to support a move to performance-oriented specifications for the interlayer bond for pavement construction. The non-tracking tack coat materials investigated in this study are expected to facilitate the improved performance of this bond and, as a consequence, the pavement system as a whole. This work supports an anticipated incremental improvement to an annual asphalt concrete program that is worth between $200 million and $400 million per year (not including new construction). When applied to investments on this scale, even nominal improvements easily translate into considerable savings.

This report is available for free download (391 KB):
http://www.virginiadot.org/vtrc/main/online_reports/pdf/12-r14.pdf

Item 33

Use of precast slabs for pavement rehabilitation on I-66

VIRGINIA CENTER FOR TRANSPORTATION INNOVATION AND RESEARCH (VCTIR)

FHWA/VCTIR 12-R9 • 2012

Highway agencies continuously strive to expedite pavement construction and repairs and to evaluate materials and methods to provide long-lasting pavements. As part of this effort, agencies have used precast concrete slabs for more than 10 years with successive improvements in processes and systems. The Virginia Department of Transportation recently used two precast systems along with conventional cast-in-place repairs on a section of jointed reinforced concrete pavement on I-66 near Washington, D.C. One precast system, precast concrete pavement (PCP), used doweled joints. The other precast system, prestressed precast concrete pavement (PPCP), used transversely prestressed slabs post-tensioned in the longitudinal direction. Both precast systems are performing satisfactorily after 1.5 years of traffic, and the contractor was satisfied with the constructability. In multiple locations, transverse expansion joints in PPCP were observed to be wider than the 1/2-in width specified; excessively wide joints often compromise joint sealant performance, and erosion from water flowing through such joints may result in eventual loss of support over time. There were a few cracks in the PPCP section, originating mainly from grouting holes, cracks in the block-out patches, cracks and loss of epoxy at lifting hook holes, and corner breaks. There were some mid-slab cracks in the PCP slabs immediately after opening to traffic, but they are still tight and stable after 1.5 years of traffic. Even though the precast slabs initially cost more than the cast-in-place repairs to construct, the ability to construct the pavement within a short period of lane closure per day and the probability of improved quality control of plant-cast concrete warrant their use. Since this was the first application in Virginia, certain issues occurred and most were overcome, such as matching of slabs and grout leakage. The project was successfully completed and further implementation is recommended.

This report is available for free download (7.7 MB):
http://www.virginiadot.org/vtrc/main/online_reports/pdf/12-r9.pdf