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State DOT Reports

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Item 1

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 2

Determining changes in greenhouse gas emissions (1990-2010) due to pavement technology

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT)

WA-RD 838.1 • 2015

This research quantifies the changes in greenhouse gas (GHG) emissions and energy consumption from WSDOT between 1990 and 2010 associated with (1) using warm mix asphalt (WMA), reclaimed asphalt pavement (RAP), fly ash and slag in pavement materials, (2) use of the dowel bar retrofit (DBR) as a portland cement concrete pavement (PCCP) rehabilitation practice, (3) improvements in WSDOT pavement network roughness, and (4) adoption of a long-life asphalt concrete pavement (ACP) strategy. (66 pages)

This report is available for free download (webpage with PDF link):
http://www.wsdot.wa.gov/Research/Reports/800/838.1.htm

Item 3

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

Item 4

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 5

An Evaluation of Roadside Activity and Behavior of Deer and Black Bear to Determine Mitigation Strategies for Animal-Vehicle Collisions

VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)

FHWA/VTRC 16-R4 • 2015

Virginia is consistently among the top 10 states with the highest number of deer-vehicle collisions (DVCs), with more than 56,000 DVCs per year since 2007. The Virginia Department of Transportation has targeted a section of I-64 on and near Afton Mountain for safety and mobility improvements because of a high number of crashes and traffic stoppages. DVCs are a primary driver safety concern in the area, and vehicle collisions with black bears are also relatively frequent. Mitigation strategies are needed to address this issue. The purpose of this study was to evaluate white-tailed deer activity and behavior along (1) an interstate roadside adjacent to unfenced isolated underpasses used by deer and (2) a stream corridor / highway intersection with no viable underpass for deer. Although not a primary focus, black bear and other wildlife activity was also evaluated. Two years of camera data and animal carcass removal data were analyzed to gain a better understanding of deer and black bear activity and behavior relative to the two road and landscape features. (43 pages)

This report is available for free download (1.3 MB):
http://www.virginiadot.org/vtrc/main/online_reports/pdf/16-r4.pdf

Item 6

Evaluation of the Need for Longitudinal Median Joints in Bridge Decks on Dual Structures

IOWA STATE UNIVERSITY. INSTITUTE FOR TRANSPORTATION

IHRB Project TR-661 / InTrans Project 13-470 • 2015

The primary objective of this project was to determine the effect of bridge width on deck cracking in bridges. Other parameters, such as bridge skew, girder spacing and type, abutment type, pier type, and number of bridge spans, were also studied. To achieve the above objectives, one bridge was selected for live-load and long-term testing. The data obtained from both field tests were used to calibrate a three-dimensional (3D) finite element model (FEM). Three different types of loading—live loading, thermal loading, and shrinkage loading—were applied. The predicted crack pattern from the FEM was compared to the crack pattern from bridge inspection results. A parametric study was conducted using the calibrated FEM. The general conclusions/recommendations are as follows: -- Longitudinal and diagonal cracking in the deck near the abutment on an integral abutment bridge is due to the temperature differences between the abutment and the deck. Although not likely to induce cracking, shrinkage of the deck concrete may further exacerbate cracks developed from thermal effects. -- Based upon a limited review of bridges in the Iowa DOT inventory, it appears that, regardless of bridge width, longitudinal and diagonal cracks are prevalent in integral abutment bridges but not in bridges with stub abutments. -- The parametric study results show that bridge width and skew have minimal effect on the strain in the deck bridge resulting from restrained thermal expansion. -- Pier type, girder type, girder spacing, and number of spans also appear to have no influence on the level of restrained thermal expansion strain in the deck near the abutment. (99 pages)

This report is available for free download (Website with links to PDFs):
http://publications.iowa.gov/20466/

Item 7

Improving the Accuracy of Camber Predictions for Precast Pretensioned Concrete Beams

IOWA STATE UNIVERSITY. INSTITUTE FOR TRANSPORTATION

IHRB Project TR-625 / InTrans Project 11-390 • 2015

The discrepancies between the designed and measured camber of precast pretensioned concrete beams (PPCBs) observed by the Iowa DOT have created challenges in the field during bridge construction, causing construction delays and additional costs. This study was undertaken to systematically identify the potential sources of discrepancies between the designed and measured camber from release to time of erection and improve the accuracy of camber estimations in order to minimize the associated problems in the field. To successfully accomplish the project objectives, engineering properties, including creep and shrinkage, of three normal concrete and four high-performance concrete mix designs were characterized. In parallel, another task focused on identifying the instantaneous camber and the variables affecting the instantaneous camber and evaluated the corresponding impact of this factor using more than 100 PPCBs. Using a combination of finite element analyses and the time-step method, the long-term camber was estimated for 66 PPCBs, with due consideration given to creep and shrinkage of concrete, changes in support location and prestress force, and the thermal effects. Utilizing the outcomes of the project, suitable long-term camber multipliers were developed that account for the time-dependent behavior, including the thermal effects. It is shown that by using the recommended practice for the camber measurements together with the proposed multipliers, the accuracy of camber prediction will be greatly improved. Consequently, it is expected that future bridge projects in Iowa can minimize construction challenges resulting from large discrepancies between the designed and actual camber of PPCBs during construction. (267 pages)

This report is available for free download (webpage with links to PDFs):
http://publications.iowa.gov/20447/

Item 8

Investigation of Negative Moment Reinforcing in Bridge Decks

IOWA STATE UNIVERSITY. INSTITUTE FOR TRANSPORTATION

IHRB Project TR-660 / InTrans Project 13-469 • 2015

Multi-span pre-tensioned pre-stressed concrete beam (PPCB) bridges made continuous usually experience a negative live load moment region over the intermediate supports. Conventional thinking dictates that sufficient reinforcement must be provided in this region to satisfy the strength and serviceability requirements associated with the tensile stresses in the deck. The American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications recommend the negative moment reinforcement (b2 reinforcement) be extended beyond the inflection point. Based upon satisfactory previous performance and judgment, the Iowa Department of Transportation (DOT) Office of Bridges and Structures (OBS) currently terminates b2 reinforcement at 1/8 of the span length. Although the Iowa DOT policy results in approximately 50% shorter b2 reinforcement than the AASHTO LRFD specifications, the Iowa DOT has not experienced any significant deck cracking over the intermediate supports. The primary objective of this project was to investigate the Iowa DOT OBS policy regarding the required amount of b2 reinforcement to provide the continuity over bridge decks. Other parameters, such as termination length, termination pattern, and effects of the secondary moments, were also studied. Live load tests were carried out on five bridges. The data were used to calibrate three-dimensional finite element models of two bridges. Parametric studies were conducted on the bridges with an uncracked deck, a cracked deck, and a cracked deck with a cracked pier diaphragm for live load and shrinkage load. The general conclusions were as follows: -- The parametric study results show that an increased area of the b2 reinforcement slightly reduces the strain over the pier, whereas an increased length and staggered reinforcement pattern slightly reduce the strains of the deck at 1/8 of the span length. -- Finite element modeling results suggest that the transverse field cracks over the pier and at 1/8 of the span length are mainly due to deck shrinkage. -- Bridges with larger skew angles have lower strains over the intermediate supports. -- Secondary moments affect the behavior in the negative moment region. The impact may be significant enough such that no tensile stresses in the deck may be experienced (112 pages)

This report is available for free download (website with PDF links):
http://publications.iowa.gov/id/eprint/20465

Item 9

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.virginiadot.org/vtrc/main/online_reports/pdf/15-r5.pdf

Item 10

Investigation of Truck Mounted Attenuator (TMA) Crashes in Work Zones in Virginia

VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)

FHWA/VTRC 16-R7 • 2015

Truck mounted attenuators (TMAs) are deployed on shadow vehicles in work zones to mitigate the effects of errant vehicles that strike the shadow vehicle, either by smoothly decelerating the vehicle to a stop when hit head-on or by redirecting the errant vehicle. The purpose of this study was to investigate crashes involving TMAs in work zones in Virginia. The objectives of the study were (1) to review trends over the last 3 to 5 years in crashes involving TMAs including a measure of traffic exposure such as the frequency of work zones using TMAs; and (2) to identify the causal factors of crashes in work zones where TMAs are involved. A.n email survey of Virginia Department of Transportation (VDOT) and contractor staff was administered to obtain information on the opinions of field forces with regard to the use of TMAs in work zones and their safety in mobile and lane closure operations. Crashes involving TMAs from 2011-2014 in Virginia were compiled and analyzed. Based on the survey results, driver inattention/behavior, road geometrics/sight distance, mobile operations, and not following the Virginia Work Area Protection Manual are possible contributing factors for TMA crashes. TMA crashes increased from 2011-2014, and most of these crashes occurred on the interstate. A majority of TMA crashes occurred in VDOT's Northern Virginia, Hampton Roads, and Richmond districts. A typical TMA crash involved a contractor TMA vehicle that was struck from the rear by a male driving a passenger vehicle. TMA crashes accounted for less than 1% of all work zone crashes in Virginia from 2011-2014. There is no clear-cut solution to resolving TMA crashes. Although they represent a small number of crashes compared to the overall number of work zones crashes, most of them affect at least two people: the motorist striking the TMA vehicle and the TMA operator. (45 pages)

This report is available for free download (1 MB):
http://www.virginiadot.org/vtrc/main/online_reports/pdf/16-r7.pdf

Item 11

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/