



# Research Digest

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**State Reports**

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## *Item 1*

### **Linking of Mobility Performance Measures to Resource Allocation, Survey of State DOTs and MPOs**

*CO DOT*

*CDOT-2007-13 • 2008*

The objective of this study is to provide a summary of the best practices of state departments of transportation and metropolitan planning organizations (MPOs) throughout the country regarding the linkage between mobility performance measures and resource allocation. The only mobility performance measure currently authorized for the Colorado Department of Transportation (CDOT) to denote congestion is volume to capacity (V/C) ratio. Currently, the V/C is used to identify the segments with V/C ratio of .85 and above which are considered congested.

Because a universal policy linking mobility funding to performance measures among the agencies surveyed and interviewed was not identified, the research team recommends the following process in determining a resource allocation policy suitable to the needs of CDOT. The policy must address the following areas to be effective: system performance, critical deficiencies/needs, resource allocation/investment, and measure effectiveness/return on investment.

Full-text PDF of this report is available for free download from  
<http://www.dot.state.co.us/publications/PDFFiles/resourceallocation.pdf>

## *Item 2*

### **Evaluation of the Integration of CVISN at the Nogales Port of Entry**

*AZ DOT*

*FHWA-AZ-07-535(2) • 2008*

In 1995, the U.S. Congress directed the Federal Highway Administration to describe how and when it would design, deploy, and maintain a commercial vehicle information system network (CVISN). The CVISN conceptualization focused on inspections and safety ratings, out-of-service orders and registration denials, objectives and constraints, and data collection and use. The three CVISN operation capabilities are safety information exchange, credentials administration, and electronic screening. A Level 1 implementation results in basic operation functionality in these three functional areas. A Level 2 implementation results in advanced operation functionality in these three areas. Using data collected by commercial vehicle inspection officers in Arizona, this study evaluates the integration of CVISN at the Nogales port of entry and identifies opportunities for improving operation effectiveness in the future. The study analyzed commercial vehicle port entries and clearance rates from 2005 to 2007 with CVISN. The results indicate that the cost efficiencies of the port's inspection booths could potentially be improved by roughly 30 percent under the current conditions at the site.

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[http://www.dot.state.az.us/TPD/ATRC/publications/project\\_reports/PDF/AZ535-2.pdf](http://www.dot.state.az.us/TPD/ATRC/publications/project_reports/PDF/AZ535-2.pdf)



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## *Item 3*

### **Survey of Traffic Noise Reduction Products, Materials, and Technologies**

AZ DOT

FHWA-AZ-08-584 • 2008

Noise is one of the most pervasive forms of environmental pollution. It is everywhere and affects our lives at home, work and play. By definition, noise is any unwanted or excessive sound. Highway traffic noise is a major issue for transportation agencies. The objective of this study was to identify noise reduction products, materials, and technologies currently available and that may have potential as noise mitigation alternatives. The literature review and survey identified measures that are being used by U.S. transportation organizations as well as international efforts.

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[http://www.dot.state.az.us/TPD/ATRC/publications/project\\_reports/PDF/AZ584.pdf](http://www.dot.state.az.us/TPD/ATRC/publications/project_reports/PDF/AZ584.pdf)

## *Item 4*

### **A Cost Evaluation of Cross-Border Truck Emissions Testing Using Heavy Duty Remote Sensing Equipment**

AZ DOT

FHWA-AZ-08-601 • 2008

The objective of this research study was to perform a thorough evaluation of the feasibility and cost implications for initial system installation and ongoing program and maintenance costs for a Land Port of Entry truck emissions program utilizing Heavy Duty Remote Sensing technology. This study includes funding recommendations to maintain such a program. To meet the study objective, project tasks included the following: 1) Develop a work plan for approval by the Technical Advisory Committee, 2) Review the literature on cross-border truck traffic, truck emissions, and truck emissions testing, 3) Prepare a detailed data collection plan, 4) Implement the data collection plan and provide detailed discussion and analysis to support the proposed testing program's elements and cost components, 5) Prepare a final report and a four-page research note.

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[http://www.dot.state.az.us/TPD/ATRC/publications/project\\_reports/PDF/AZ601.pdf](http://www.dot.state.az.us/TPD/ATRC/publications/project_reports/PDF/AZ601.pdf)



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## *Item 5*

### **Effect of Drainage in Unbound Aggregate Bases on Flexible Pavement Performance**

LA DOT

FHWA/LA.07/429 • 2008

It has been well demonstrated that a positive subsurface drainage is beneficial in enhancing pavement performance and thus extending pavement service life. Typical permeable base materials include asphalt/cement-treated, open-graded aggregates and unbound aggregates. Although asphalt/cement-treated, open-graded permeable bases perform well based on the past engineering practice, they are expensive solutions and less desirable for some roadways when compared to unbound aggregates, especially for low to medium volume roadways. In these situations, it is possible to use a properly graded unbound aggregate that is adequately drainable and structurally stable during the construction and service lifetime after the roadway is open to traffic.

This study is to determine a proper/optimum gradation by conducting laboratory testing for unbound aggregates of Mexican limestone that are commonly used in Louisiana highways. However, there is trade-off between structural stability and permeability of unbound aggregates. The increase of permeability is often at the cost of structural stability or vice versa. Therefore, the criteria for selecting an optimum gradation are: (1) an adequate permeability to drain the infiltrated-water from the pavement as quickly as possible; and (2) a sufficient structural stability to support the traffic loading. The permeability of unbound aggregate is quantified by its saturated hydraulic conductivity while its structural stability is characterized by various laboratory tests on the strength, stiffness, and permanent deformation of the material. A series of laboratory tests, including constant-head permeability, California Bearing Ratio (CBR), Dynamic Cone Penetrometer (DCP), tube suction (TS), monotonic load triaxial tests, and repeated load triaxial (RLT) tests, were conducted on Mexican limestone with different gradations. The gradations under investigation include coarse and fine branches of Louisiana class II gradation, New Jersey gradation medium, and an optimum gradation (fine and coarse branches). The optimum gradation is the result of a series of laboratory trial-error tests.

The results from laboratory tests indicate that: (1) the coarse branch of Louisiana class II gradation outperform the fine counterpart in terms of permanent deformation and hydraulic conductivity; (2) CBR and DCP values may not be good properties to differentiate performance of unbound aggregate with different gradations; and (3) an optimum gradation is identified, which outperforms current Louisiana class II base gradation in terms of both structural stability and permeability.

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## *Item 6*

### **Alternative Performance Measures for Evaluation of Congestion: Congestion Analysis Model Update and Maintenance**

*NJ DOT*

*FHWA-NJ-2007-006 • 2008*

Traffic congestion has numerous negative effects on the movement of people and goods, economic productivity and the environment. These effects include increased travel times resulting in lost wages and decreased labor productivity, wasted fuel and cost associated with it, deteriorating air quality, and drivers' stress, which can adversely affect safety, health, and labor productivity. In recent years these effects have come to the forefront of the public's concern. In order to quantify traffic congestion and its impacts on New Jersey's motorists, New Jersey Institute of Technology (NJIT) developed the Congestion Analysis Model. This is a computer software tool that estimates congestion costs, congestion related travel delay, and mobility indicators for New Jersey highways. The key advantage of NJIT's model over other computer models developed for the same purpose is that it uses the New Jersey Congestion Management System (NJCMS) database to calculate travel delays and other congestion indicators. This project builds on the accomplishments of the previous work on developing congestion analysis software. Specific objectives of this project are to update the calculation methodology, improve software's user interface, redesign the output tables to meet NJDOT's requirements, update software documentation, and provide limited technical support to NJDOT users.

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<http://www.state.nj.us/transportation/refdata/research/reports/FHWA-NJ-2007-006.pdf>



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## **Item 7**

### **Concrete Shrinkage Analysis for Bridge Deck Concrete**

*NJ DOT*

*FHWA-NJ-2007-007 • 2007*

Infrastructure facilities constitute a major part of the national investment. According to the National Bridge Inventory (NBI) (Federal Highway Administration, 2004) there are more than 594,470 bridges and about 150,981 (25.4%) of them are structurally deficient or obsolete. Major decisions are needed to allocate the limited funds available for repair, rehabilitation, and replacement. Over the last decade, the use of High Performance Concrete (HPC) has emerged as an important alternative to deal with deteriorating infrastructure. The concept of HPC in the USA was developed under the Strategic Highway Research Program (SHRP) contract C205. At the end of SHRP program, a major thrust was made for implementation of results. The Federal Highway Administration (FHWA) has initiated programs for the design and construction of HPC bridges and pavements with the aim of reducing both initial construction costs and long-term maintenance costs.

A test has been developed by AASHTO (PP 34-99, The Passive or Restrained Ring Test) that compares the relative cracking potentials of concrete mixtures. This cracking tendency was performed on 16 concrete mixes used for bridge decks by NJDOT to identify those that would exhibit high potential for cracking. Although cracking of bridge decks can be attributed to various causes, this study provided a comparative classification of the cracking potential of each mix. A correlation of cracking potential with various parameters is also established. Results show that mixes with high Coarse Aggregate (CA) to Fine Aggregate (FA) ratio (i.e., CA/FA >1.48) and a CA minimum weight of 1800 lb/cu.yd have lower potential for cracking. It is also shown that rate of free shrinkage correlates directly with the rate of restrained shrinkage, and a limit of 450 micro strain for free shrinkage at 56 days is recommended to reduce the cracking potential of concrete mixes.

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<http://www.state.nj.us/transportation/refdata/research/reports/FHWA-NJ-2007-007.pdf>

## **Item 8**

### **Evaluation of Poisson's Ratio for Use in the Mechanistic Empirical Pavement Design Guide (MEPDG)**

*NJ DOT*

*FHWA-NJ-2008-004 • 2008*

The pavement design industry is moving towards the use of mechanistic principles in designing flexible pavements. To determine the resultant strains in the pavement system using these principles, two material properties are required; 1) modulus and 2) Poisson's ratio. In flexible pavement design, the required modulus can be determined either in the laboratory or in the field. In the lab, the dynamic modulus and resilient modulus tests are used to determine the modulus values of asphalt and unbound materials, respectively. In the field, the Falling Weight Deflectometer (FWD) is commonly used to determine the modulus of the various materials. However, the value of the Poisson's Ratio is usually assumed. This research project encompassed the evaluation of whether or not the Poisson's Ratio can be measured using the same test procedures commonly used to obtain the modulus values for flexible pavement design (i.e. – dynamic modulus test for asphalt and resilient modulus test for unbound materials). The research project also evaluated the sensitivity of pavement performance and the FWD backcalculation procedure when varying the magnitude of the Poisson's Ratio parameter.

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## *Item 9*

### **Assessing Performance of Alternative Pavement Marking Materials**

*LTRC*

*LTR TAR 08-4TA • 2008*

Pavement markings need to be restriped from time to time to maintain retroreflectivity. Knowing which material provides the most economically efficient solution is important. Currently, no agreed upon method by which to evaluate the use of alternative pavement marking materials exists. This study developed a methodology that measures the benefit of pavement marking materials based on the public perceived benefit of retroreflectivity. Using the measured benefit along with the cost of installation and impact on road users during the installation process, a benefit/cost analysis was applied to evaluate different marking materials used on Louisiana interstate freeways, including thermoplastics (both 40 mil and 90 mil), tape, and inverted profile pavement markings.

A Microsoft Excel workbook with built-in macros, named PMValue.xlsm, was developed to allow the comparison of alternative pavement marking materials for a particular application. A simple and user friendly interface enables users to specify basic information about the pavement, traffic conditions, material cost, and application schedule. Results of the analysis are presented in graphical form to assist users in assessing the performance of alternative pavement marking materials in terms of their benefit/cost ratio.

The impact of increasing the starting and six-month retroreflectivity specifications for 90 mil and tape was also estimated. The impact was measured in terms of increased pavement marking service life. The percentage of current markings that would fail the new requirement, based on current data, was also observed. An alternative specification in which the initial retroreflectivity specification is followed by a maximum percent decrease from the initial retroreflectivity in six months was also considered. The suggested specification not only sets the standard for initial retroreflectivity but also sets a limit on the decay rate of retroreflectivity.

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## ***Item 10***

### **Design and Evaluation of a Low-Tension Cable Guardrail End Terminal System**

*NEBRASKA DEPARTMENT OF ROADS (NDOR)*

*TRP-03-131-08 • 2008*

Cable guardrail systems are utilized due to the ease of construction, low vehicle damage, low occupant risk, and low initial installation cost. However, a cable guardrail system must be terminated in an acceptable manner that does not pose a significant risk to errant motorists. A cable guardrail system, developed by the New York State Department of Transportation (NYDOT), was successfully crash tested to the recommendations provided in National Cooperative Highway Research Program (NCHRP) Report No. 350, Recommended Procedures for the Safety Performance Evaluation of Roadside Features, but the terminal incorporated a large cable anchor system and a flared end that limited the use of the cable guardrail system adjacent to slopes. In order to reduce the size of the cable anchorage system and increase the versatility of a low-tension cable guardrail system, a tangent cable terminal, similar to the design developed by the NYDOT, was developed and full-scale vehicle crash tested for use with low-tension, three cable guardrail systems.

Four full-scale crash tests were performed on the cable terminal system. The first test utilized a 2,000-kg (4,409-lb) pickup truck, impacting the cable terminal system at 20 degrees. The other three impacts utilized an 820-kg (1,808-lb) small car, impacting the tangent cable terminal head-on and at a 1/4 point offset. It was determined that the cable terminal system was acceptable according to the criteria provided in NCHRP Report No. 350 for the tests performed and discussed herein.

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<http://www.nlc.state.ne.us/epubs/R6000/B016.0130-2008.pdf>

## ***Item 11***

### **Composite Pavement Systems: Synthesis of Design and Construction Practice**

*VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)*

*VTRC 09-CR2 • 2008*

Composite pavement systems have shown the potential for becoming a cost-effective pavement alternative for highways with high and heavy traffic volumes, especially in Europe. This study investigated the design and performance of composite pavement structures composed of a flexible layer (top-most layer) over a rigid base. The report compiles (1) a literature review of composite pavement systems in the U.S. and worldwide; (2) an evaluation of the state-of-the-practice in the U.S. obtained using a survey; (3) an investigation of technical aspects of various alternative composite pavement systems designed using available methodologies and mechanistic-empirical pavement distress models (fatigue, rutting, and reflective cracking); and (4) a preliminary life cycle cost analysis (LCCA) to study the feasibility of the most promising composite pavement systems.

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## *Item 12*

### **Application of the Stochastic Optimization Method of Optimizing Traffic Signal Control Settings**

*VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)*

*VTRC 09-CR3 • 2008*

Traffic congestion has greatly affected not only the nation's economy and environment but also every citizen's quality of life. A recent study shows that every American traveler spent an extra 38 hours and 26 gallons of fuel per year due to traffic congestion during the peak period. Of this congestion, 10% is attributable to improper operations of traffic signals. Surprisingly, more than a half of all signalized intersections in the United States needs to be re-optimized immediately to maintain peak efficiency. Even though many traffic signal control systems have been upgraded from pre-timed controllers to actuated and adaptive controllers, the traffic signal optimization software has not been kept current. For example, existing commercial traffic signal timing optimization programs including SYNCHRO and TRANSYT-7F do not optimize advanced controller settings available in the modern traffic controllers including minimum green time, extension time, and detector settings. This is in part because existing programs are based on macroscopic simulation tools that do not explicitly consider individual vehicular movements. To overcome such a shortcoming, a stochastic optimization method (SOM) was proposed and successfully applied to a signalized corridor in Northern Virginia.

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## *Item 13*

### **Experimental and Analytical Investigation of Full-Depth Precast Deck Panels on Prestressed I-Girders** *VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)* *VTRC 09-CR4 • 2008*

A bridge with precast bridge deck panels was built at the Virginia Tech Structures Laboratory to examine constructability issues, creep and shrinkage behavior, and strength and fatigue performance of transverse joints, different types of shear connectors, and different shear pocket spacings. The bridge consisted of two AASHTO type II girders, 40 ft long and simply supported, and five precast bridge deck panels. Two of the transverse joints were epoxied male-female joints and the other two transverse joints were grouted female-female joints. Two different pocket spacings were studied: 4 ft pocket spacing and 2 ft pocket spacing. Two different shear connector types were studied: hooked reinforcing bars and a new shear stud detail that can be used with concrete girders.

The construction process was well documented. The changes in strain in the girders and deck were examined and compared to a finite element model to examine the effects of differential creep and shrinkage. After the finite element model verification study, the model was used to predict the long term stresses in the deck and determine if the initial level of posttensioning was adequate to keep the transverse joints in compression throughout the estimated service life of the bridge. Cyclic loading tests and flexural strength tests were performed to examine performance of the different pocket spacings, shear connector types and transverse joint configurations. A finite element study examined the performance of the AASHTO LRFD shear friction equation for the design of the horizontal shear connectors. The initial level of post-tensioning in the bridge was adequate to keep the transverse joints in compression throughout the service life of the bridge. Both types of pocket spacings and shear connectors performed exceptionally well. The AASHTO LRFD shear friction equation was shown to be applicable to deck panel systems and was conservative for determining the number of shear connectors required in each pocket. A recommended design and detailing procedure was developed for the shear connectors and shear pockets.

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## **Item 14**

### **Scenario-Based Transportation Planning with Involvement of Metropolitan Planning Organizations**

*VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)*

*VTRC 09-CR5 • 2008*

The Office of Virginia's Secretary of Transportation identified 21 transportation policies and 42 performance criteria in Virginia's long-range multimodal transportation plan, VTrans2025. A subsequent planning effort, VTrans2035, provided direction for the effort described in this report. Although there has been considerable discussion of the potential impact of the VTrans policies on the Commonwealth as a whole, there has been little effort to characterize the regional and local impact of the policies. Further, the sensitivity of the policies to a variety of assumptions about the future needs to be better understood at statewide, regional, and local levels.

This research effort developed and tested a methodology for scenario-based assessments of the impacts of the VTrans policies for several regions of the Commonwealth of Virginia. The methodology is implemented in an MS Excel workbook that is available for download at [www.virginia.edu/crmes/multimodal2](http://www.virginia.edu/crmes/multimodal2). This report describes a typical application of the methodology for a locality or regional planning organization, e.g., a Metropolitan Planning Organization (MPO) or Planning District Commission (PDC), to assess the impact of statewide multimodal policies across several of its long-range planning scenarios. The report includes a review of scenario-based planning, documentation of future scenarios, preliminary results of a survey of MPOs in Virginia for their best practices in scenario-based planning, an application of the methodology to the Roanoke region of Virginia, and recommendations. A major recommendation is that the methodology be used in VTrans2035 to catalyze and benchmark Virginia MPOs and localities in their respective efforts involving scenario-based transportation planning. The effort provides a cost-effective analysis tool that enables VTrans and MPOs and PDCs to identify and collaborate on the regional impacts of statewide transportation planning. The tool can further be cost-effective for individual MPOs and localities to engage in scenario-based long-range planning as encouraged by the Federal Highway Administration, particularly to guide the assumptions that are input to regional travel demand models.

The developed methodology is being adapted for long-range scenario-based analysis of the Afghanistan Sustainable Infrastructure Plan, with research support from the U.S. Army Corps of Engineers.

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## **Item 15**

### **Development of Performance-Based Guidelines for Selection of Bituminous-Based Hot-Poured Pavement Crack Sealant: An Executive Summary Report**

*VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)*

*VTRC 09-CR7 • 2009*

This report summarizes research presented in separate technical reports, papers, and journal articles that collectively document the development of a systematic process to aid in the selection of appropriate bituminous hot-poured sealants for pavement cracks and joints. This report brings the results of this cumulative research together to introduce a set of tests and performance parameters for sealant at installation and service temperatures; an aging procedure to simulate sealant weathering; and most important, a simplified chart with thresholds for all performance parameters for the straightforward selection of crack sealant.

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## *Item 16*

### **Laboratory Evaluation of a Warm Asphalt Technology for Use in Virginia**

*VIRGINIA TRANSPORTATION RESEARCH COUNCIL (VTRC)*

*VTRC 09-R11 • 2008*

Rising energy costs and increased environmental awareness have brought attention to the potential benefits of warm asphalt in the United States. Warm-mix asphalt (WMA) is produced by incorporating additives into asphalt mixtures to allow production and placement of the mix when heated to temperatures well below the 300°F+ temperatures of conventional hot-mix asphalt (HMA). Potential benefits such as reduced plant emissions, workability at lower temperatures, extension of the paving season into colder weather, and reduced energy consumption at the plant may be realized with different applications.

Trial installations of WMA, including two sections using the Sasobit WMA additive, have been investigated in Virginia. This study presents the results of laboratory testing to evaluate the performance of the mixtures used in the two Sasobit trial sections. The evaluation included comparisons of compactibility, volumetric properties, moisture susceptibility, rutting resistance, and fatigue performance between the HMA and WMA mixtures used in each section. Mixtures produced in the laboratory under conditions of varying temperatures and aging periods were tested, and the effects of temperature and aging were evaluated. The long-term performance of the two test sections was also modeled using the Mechanistic-Empirical Pavement Design Guide. Few differences were found between the HMA and WMA mixtures evaluated. The performance of WMA and HMA was similar when evaluated for moisture susceptibility, rutting potential, and fatigue resistance. The MEPDG-predicted distresses supported these conclusions; the predicted long-term performance of WMA and HMA was comparable. From these results, the recommendation was made that the Virginia Department of Transportation develop a special provision for the use of WMA.

Despite its benefits, direct cost savings from the use of WMA are unlikely to be seen by VDOT. Currently, one concern with the use of WMA is the initial cost, which varies depending on the technology used. The use of WMA technology requires either additives, a recurrent cost, or asphalt plant modifications, requiring capital investment. Over the long term, the use of WMA could save VDOT considerable dollars if the reduced aging of the mix translates into longer life; however, this has yet to be proven as WMA has not been employed for a sufficient time period to allow an evaluation of this benefit.

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## *Item 17*

### **Quantifying Incident-Induced Travel Delays on Freeways Using Traffic Sensor Data**

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WS DOT) TRANSPORTATION  
NORTHWEST REGIONAL CENTER X (TRANSNOW) WASHINGTON STATE TRANSPORTATION CENTER  
(TRAC)

WA-RD 700.1 • 2008

Traffic congestion is a major operational problem for freeways in Washington State. Recent studies have estimated that more than 50 percent of freeway congestion is caused by traffic incidents. To help the Washington State Department of Transportation (WSDOT) identify effective countermeasures against such congestion-inducing incidents, a thorough understanding of travel delays caused by incidents is essential.

By using traffic data extracted from archived loop detector measurements and incident log data recorded by the WSDOT Incident Response (IR) team, this research project developed a new algorithm for quantifying travel delays produced by different incident categories. The algorithm applies a modified deterministic queuing theory to estimate incident-induced delay by using 1-minute aggregated loop detector data. Incident-induced delay refers to the difference between the total delay and the recurrent travel delay at the time and location influenced by the incident. The uniqueness of the delay calculation in this study is the use of a dynamic traffic-volume-based background profile, which is considered a more accurate representation of prevailing traffic conditions. According to the test results, the proposed algorithm can provide good estimates for incident-induced delay and capture the evolution of freeway traffic flow during incident duration. Because actual traffic data measured by loop detectors were used in this study to compute vehicle arrival and departure rates for delay calculations, the estimated incident-induced delay should be very close to the reality. Additionally, the proposed algorithm was implemented in the Advanced Roadway Incident Analyzer (ARIA) system. ARIA is a database-driven computer system that automates all the computational processes. More accurate incident delay information will help WSDOT improve its understanding of congestion-inducing incidents and select more effective countermeasures against incident-related traffic congestion on freeways.

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