<table>
<thead>
<tr>
<th>Project Number</th>
<th>Problem Number</th>
<th>Title</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-53</td>
<td>C-03</td>
<td>Modeling Influence of Unbound Base or Subgrade Material on Pavement Performance Prediction using Mechanistic-Empirical Analysis</td>
<td>3</td>
</tr>
<tr>
<td>01-54</td>
<td>C-15</td>
<td>Pavement Design Guide to Prevent Damage to Asphalt Pavements from Water Intrusion</td>
<td>4</td>
</tr>
<tr>
<td>01-55</td>
<td>F-08</td>
<td>Porous Friction Course Design and Maintenance</td>
<td>5</td>
</tr>
<tr>
<td>03-111</td>
<td>F-06</td>
<td>Effectiveness of Work Zone Transportation Management Plan Strategies</td>
<td>7</td>
</tr>
<tr>
<td>03-112</td>
<td>G-10</td>
<td>Operational and Safety Considerations in Making Lane Width Decisions on Urban and Suburban Arterials</td>
<td>10</td>
</tr>
<tr>
<td>03-113</td>
<td>G-25</td>
<td>Spacing, Signal Timing, and Performance of Diverging Diamond Interchange and Adjacent Intersections</td>
<td>11</td>
</tr>
<tr>
<td>03-114</td>
<td>G-21</td>
<td>Operational and Reliability Impacts of Active Traffic Management Strategies</td>
<td>12</td>
</tr>
<tr>
<td>08-93</td>
<td>B-04</td>
<td>Guidebook on Agency Risk Management Strategies, Methods, and Tools</td>
<td>14</td>
</tr>
<tr>
<td>08-94</td>
<td>B-06</td>
<td>Establishing Application and Policy Sensitivity in Travel Demand Models</td>
<td>16</td>
</tr>
<tr>
<td>08-95</td>
<td>B-07</td>
<td>Using Cell Phone Data to Improve Travel Demand Models</td>
<td>17</td>
</tr>
<tr>
<td>08-96</td>
<td>B-10</td>
<td>Integration of Freight Considerations into Smart Growth Design</td>
<td>18</td>
</tr>
<tr>
<td>08-97</td>
<td>B-20</td>
<td>Using Oversize/Overweight Data to Develop Multistate, Multimodal Alternative Freight Corridors</td>
<td>19</td>
</tr>
<tr>
<td>08-98</td>
<td>B-23</td>
<td>Measuring Truck Bottlenecks</td>
<td>21</td>
</tr>
<tr>
<td>08-99</td>
<td>B-24</td>
<td>Truck Freight Benefit Methodology</td>
<td>22</td>
</tr>
<tr>
<td>08-100</td>
<td>B-27</td>
<td>Methods for Analyzing Environmental Justice Issues Related to Tolling Mechanisms</td>
<td>24</td>
</tr>
<tr>
<td>09-56</td>
<td>D-05</td>
<td>Determination of the Influences and Causes of Differences and Variability of Asphalt and Aggregate Correction Factors in Ignition Furnaces</td>
<td>26</td>
</tr>
<tr>
<td>09-57</td>
<td>D-07</td>
<td>Experimental Design for Field Validation of Tests to Assess Cracking Resistance of Asphalt Mixtures</td>
<td>27</td>
</tr>
<tr>
<td>09-58</td>
<td>D-08</td>
<td>Recycling Agents Used For Asphalt Mixtures Containing High Recycled Asphalt Binder Ratios</td>
<td>28</td>
</tr>
<tr>
<td>10-94</td>
<td>D-10</td>
<td>Prevention of Galvanized-Induced Weld Cracking in Highway Structures</td>
<td>30</td>
</tr>
<tr>
<td>10-95</td>
<td>D-11</td>
<td>Acceptable Heat Affected Zone Toughness of A709 Bridge Steel</td>
<td>31</td>
</tr>
<tr>
<td>10-96</td>
<td>D-12</td>
<td>Civil Integrated Management: Benefits and Challenges</td>
<td>33</td>
</tr>
<tr>
<td>12-98</td>
<td>C-09</td>
<td>Guidelines for Tolerances for Prefabricated Bridge Elements and Systems</td>
<td>34</td>
</tr>
<tr>
<td>12-99</td>
<td>C-10</td>
<td>Guidelines for Calculating Dynamic Effects in Large-Scale Bridge Moves</td>
<td>35</td>
</tr>
<tr>
<td>12-100</td>
<td>C-11</td>
<td>Identifying and Addressing Failures of Small Movement Bridge Expansion Joints</td>
<td>36</td>
</tr>
<tr>
<td>12-101</td>
<td>C-21</td>
<td>Recommended AASHTO LRFD Specifications and Method of Structural Analysis for Bridge Structures with Energy Dissipation Mechanism in Their Columns</td>
<td>37</td>
</tr>
<tr>
<td>12-102</td>
<td>C-22</td>
<td>Development of an Accelerated Bridge Construction Design and Construction Guide Specification</td>
<td>38</td>
</tr>
<tr>
<td>Project Number</td>
<td>Problem Number</td>
<td>Title</td>
<td>Page No.</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------</td>
<td>----------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>14-33</td>
<td>F-01 &amp;</td>
<td>Performance Measures That Consider the Contributions of Preservation to Pavement Performance and Service Life</td>
<td>41</td>
</tr>
<tr>
<td>14-33</td>
<td>C-04</td>
<td>Performance Measures That Consider the Contributions of Preservation to Pavement Performance and Service Life</td>
<td>41</td>
</tr>
<tr>
<td>15-52</td>
<td>C-01</td>
<td>Developing a More Flexible and Context-Sensitive Functional Classification System for Geometric Design</td>
<td>43</td>
</tr>
<tr>
<td>15-53</td>
<td>C-07</td>
<td>Roadside Design for Conflicts in Proximity to Bridge Ends and Intersecting Roadways</td>
<td>45</td>
</tr>
<tr>
<td>17-65</td>
<td>G-01</td>
<td>Two-Lane Highway Operational Performance and Design Effects on Safety</td>
<td>46</td>
</tr>
<tr>
<td>17-66</td>
<td>G-09</td>
<td>Evaluation of Opposite Direction Crashes and Appropriate Countermeasures</td>
<td>47</td>
</tr>
<tr>
<td>17-67</td>
<td>G-17</td>
<td>Identification of Factors Contributing to the Decline of Traffic Fatalities in the United States</td>
<td>48</td>
</tr>
<tr>
<td>17-69</td>
<td>G-39</td>
<td>Development of Strategic Plan for Transforming Traffic Safety Culture</td>
<td>52</td>
</tr>
<tr>
<td>17-70</td>
<td>G-40</td>
<td>Roundabout Crash Prediction Method for the <em>Highway Safety Manual</em></td>
<td>55</td>
</tr>
<tr>
<td>20-96</td>
<td>SCOR-A</td>
<td>Guidance for Transportation Executives on Planning and Programming Information Investments</td>
<td>57</td>
</tr>
<tr>
<td>20-97</td>
<td>SCOR-B</td>
<td>Improving Findability and Relevance in Transportation Information</td>
<td>58</td>
</tr>
<tr>
<td>20-98</td>
<td>SCOR-C</td>
<td>A Knowledge Management Primer for Transportation Agencies</td>
<td>59</td>
</tr>
<tr>
<td>20-99</td>
<td>SP-02</td>
<td>Communication Resources for State Departments of Transportation</td>
<td>60</td>
</tr>
<tr>
<td>21-10</td>
<td>E-08</td>
<td>AASHTO <em>Manual on Subsurface Investigations</em> – Manual Update</td>
<td>63</td>
</tr>
<tr>
<td>22-30</td>
<td>C-23</td>
<td>In Service Evaluation of End Terminals</td>
<td>64</td>
</tr>
<tr>
<td>24-41</td>
<td>E-03</td>
<td>Defining the Boundary of Geosynthetic Reinforced Soil Behavior</td>
<td>66</td>
</tr>
<tr>
<td>24-42</td>
<td>E-07</td>
<td>Techniques for Installation of Filters under Water</td>
<td>67</td>
</tr>
<tr>
<td>25-46</td>
<td>B-08</td>
<td>Developing Clean Truck Freight Corridors</td>
<td>68</td>
</tr>
<tr>
<td>25-47</td>
<td>B-15</td>
<td>Strategies to Reduce Agency Costs and Improve Benefits Related to Highway Access Management</td>
<td>69</td>
</tr>
<tr>
<td>25-48</td>
<td>B-28</td>
<td>Streamlining Project Level Air Quality Analysis through Development of New Tools/Interfaces</td>
<td>71</td>
</tr>
</tbody>
</table>

**PROJECTS CONTINGENT ON THE AVAILABILITY OF FUNDS**

<table>
<thead>
<tr>
<th>Problem or Project Number</th>
<th>Title</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-16</td>
<td>Understanding Urban Bicyclist Facility Type Preferences and Facility Type Impacts on Transportation System Performance</td>
<td>72</td>
</tr>
<tr>
<td>B-29</td>
<td>Refinement of the Wildlife Passage Assessment System Methodology</td>
<td>74</td>
</tr>
</tbody>
</table>
SUMMARY OF APPROVED RESEARCH PROJECTS

Project 01-53
Modeling Influence of Unbound Base or Subgrade Material on Pavement Performance Prediction using Mechanistic-Empirical Analysis

Research Field: Design
Source: AASHTO Highway Subcommittee on Design, AASHTO Highway Subcommittee on Materials
Allocation: $400,000
NCHRP Staff: Amir N. Hanna

Performance of a pavement is known to be closely related to properties of the underlying materials. This understanding applies both to flexible and rigid pavements. However, the results of mechanistic-empirical (ME) analyses show low sensitivity to the properties of underlying layers. There is a need to evaluate this apparent counter-intuitive outcome. The unbound layers, both aggregate base and subgrade, are known to be nonlinear and anisotropic but are currently modeled as linear elastic. Would models that are more consistent with the known material properties of these unbound layers improve the observed lack of sensitivity?

Sensitivity of ME analysis to design input parameters has been studied under the NCHRP and by state agencies. Both NCHRP Project 1-47 “Sensitivity Evaluation of MEPDG Performance Prediction” and University of California Pavement Research Center study for California Department of Transportation (Caltrans) “Sensitivity Analysis of 2002 Design Guide Rigid Pavement Distress Prediction Models” illustrate the lack of expected impact of foundation properties on the results of analysis for both pavement types and rigid pavement, respectively. An independent study on the performance of a rigid pavement on an aggregate base by Caltrans, “Use of Aggregate Base Under Rigid Pavements,” confirmed the lack of sensitivity of rigid pavements to the type of base. Also, the Applied Research Associates (ARA) online bug report indicates cases that have been reported on this topic.

The objective of the research is to enhance ME prediction models to capture true impact of foundation properties on performance prediction of pavements. The final report should contain a complete literature review on this topic and include data, calculations, and analyses to support its conclusions. The general conclusion of the report should include (1) underlying reasons for the low sensitivity of performance results to foundation properties for both flexible and rigid pavements and their subcategories and (2) clear recommendations to revise the prediction models to fix the problem. Also, the outcome of the report should provide instructions and propose a procedure to implement the revisions in the ME software.

The proposed tasks are: (1) complete literature review and verification of the problem and select the most promising models for improved characterization for performance testing; (2) develop a database of both material characterization and performance data; (3) evaluate the models from Task 1 over a full range of unbound material conditions, environment, and loadings and compare with existing models in DARWin-ME; (4) recommend an improved model if supported by findings, with full consideration given to any new data elements that would be required in DARWin-ME if the model is implemented, and recommend draft changes to the Manual of Practice (only sections impacted by the proposed model need to be addressed; and (5) submit reports for each task and a draft final report. The database developed in Task 2 must be provided as a deliverable.
Practicing engineers need to be able to effectively use the knowledge that is currently available to mitigate the potential for water intrusion and damage of asphalt pavements. Despite the wealth of moisture damage information in the technical literature, there is a need for a pavement design guide that addresses best practices to prevent damage to asphalt pavements from water intrusion. These best practices are documented in numerous sources and practiced by experienced pavement engineers; however, the information has not been assembled in one convenient location. The target audience of the guide is practicing engineers, and the guide should focus on design factors that engineers need to consider when developing strategies to maintain or rehabilitate pavements. Many, if not most, of the best practices to ameliorate moisture damage are already documented in the literature. Thus, it is anticipated that no laboratory experiments are needed to accomplish this work. Rather, the work effort will encompass summarizing the information from the technical literature and existing DOT practice into a pavement design guide.

The objective of this research is to develop a pavement design guide for the practicing engineer dealing with the prevention of damage to asphalt pavements from water intrusion. The guide will cover topics such as internal and external pavement drainage, destructive and non-destructive testing for in-situ properties, field surveys, roadway geometry, Darcy’s Law, and others. Appropriate discussion of each topic should be included to enhance the understanding of the practicing engineer. The guide will target practitioners in the pavements and materials engineering community. It is anticipated that the design guide would be incorporated as a Standard Practice into the AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing.

Accomplishing this objective will require the following tasks, at a minimum: (1) summarizing information from the technical literature; (2) capturing the current state of the practice in state DOTs through an electronic survey; (3) following up the electronic survey with select telephone interviews; (4) conducting site visits to meet with knowledgeable DOT and other personnel; (5) producing the guide in the form of an NCHRP research report; (6) formatting the guide as a Standard Practice in AASHTO format for submission to the AASHTO Subcommittee on Materials; and (7) conducting regional training and webinars on the pavement design guide for practicing engineers.

Note: The AASHTO Standing Committee on Research directed that rehabilitation be included in the scope of work.
Porous Friction Courses (PFC) and related asphalt mixtures, formerly referred to as open-graded friction courses (OGFC), have been used in the United States for more than forty years because of their many safety benefits. These mixtures are especially desirable because of open aggregate gradations and resulting high air void contents that provide functionality in terms of drainability/permeability that allows water to be quickly removed from the surface of the roadway, thus reducing the potential for vehicles to hydroplane. These PFC mixture characteristics can also provide additional environmental benefits by reducing the charge in pollutants in stormwater runoff and additional safety benefits by reducing splash and spray, by improving pavement marking visibility and skid resistance in wet weather, and by providing noise reduction.

Despite the many benefits, the use of PFC mixtures has been somewhat limited in part because of a lack of a standard mixture design method, premature failure by raveling and/or stripping, and loss of functionality by clogging with debris. When PFC mixtures become clogged, they suffer a loss of drainability/permeability that compromises the primary benefit of these mixtures and can lead to premature failure. Recent improvements in Europe have produced mixtures with higher air void contents that maintain their functionality through periodic maintenance with special equipment. Other recent research has shown environmental benefits from PFC mixtures due to their ability to filter pollutants transported and dissolved in waste water runoff, although maintenance of adequate functionality is required.

In addition to the need to develop improved maintenance methods, the performance of PFC mixtures can also benefit from the development of a standard mixture design method that balances durability in terms of resistance to premature failure by raveling and/or stripping and functionality in terms of both drainability/permeability and noise reduction. This new design method should be based on the latest technology available, including recent developments in Europe, and make use of the Superpave gyratory compactor for producing laboratory samples. As part of the standard mixture design method, drainability/permeability must be measured using an accurate, standard method to maintain the primary functionality benefit of PFC. Recent work has shown that the multitude of test methods and equipment available often give different results. Therefore, the need arises to evaluate and recommend standards for the use of the permeameters for designing, modeling, and quality control of PFC mixtures.

The proposed research will investigate the most appropriate options to enhance the functionality in terms of drainability/permeability and environmental benefits in terms of filtration of PFC mixtures and maintain them over a longer period of time. Specialized equipment, such as that being used in Europe, and other potential methods should be evaluated for cost effectiveness in terms of balancing durability and functionality in the areas of both drainability/permeability and noise reduction.

Available mixture design methods should be reviewed for their effectiveness and potential for adaptation for use with the Superpave gyratory compactor. Tests to assess the durability and long-term performance of PFC mixtures should also be included in the mixture design procedure to balance durability and functionality. Currently, the European Cantabro wear test is the best method available, but the development of a micro-mechanical model that would include analysis of internal structure may be better able to predict mixture durability.

The objectives of the research are to develop (1) a mix design method for PFC mixtures based on the Superpave gyratory compactor, (2) performance criteria for the new-generation PFC asphalt mixtures, and (3) effective pavement maintenance methods to restore functionality in terms of drainability/permeability and prevent premature failure. The mix design procedure shall include performance standards that balance durability and functionality in terms of both drainability/permeability and noise reduction and methods to assess noise
reduction and pollutant retention/filtration ability of PFC mixtures and assess their friction properties. The maintenance methods shall encompass effective periodic cleaning of the void structure, as well as periodic application of special seals to prevent raveling, and shall quantify their effect on the environmental filtration benefits of PFC mixtures.
Project 03-111  

**Effectiveness of Work Zone Transportation Management Plan Strategies**

Research Field: Traffic  
Source: Federal Highway Administration  
Allocation: $650,000 (Additional $100,000 from Federal Highway Administration)  
NCHRP Staff: Lori L. Sundstrom

A transportation management plan (TMP) consists of a set of coordinated strategies that are implemented to manage the work zone impacts of a road project. TMPs outline specific strategies to be employed that will help achieve project goals associated with traffic mobility, safety of motorists and workers, and other operational targets. TMPs are important to clearly defining and communicating the comprehensive plan for project management to internal state DOT staff, contractors, the public, and the media. Many TMP strategies have been implemented by practitioners, but practitioners and researchers are often uncertain of their relative effectiveness. Agencies could develop better, more effective, and more economical TMPs if they had more data on the effectiveness of the TMP strategies available for a given project. Effectiveness information could help practitioners better understand which TMP strategies are most likely to improve work zone safety and mobility in various circumstances, and where, when, and how to implement particular strategies to maximize effectiveness.

The strategy information included in earlier guidance documents has tended to be more high-level and general, such as a strategy description, suggestions of applicable situations for use of a strategy, general information on possible benefits and challenges, and in some cases a few real-world examples. While this information provides a good starting point, for many strategies it could be built upon by compiling and analyzing the results of existing studies or further evaluating the effectiveness of each strategy in the field. Previous research has identified that the assessment of TMP strategies is both feasible and currently being conducted to some degree in highway agencies throughout the United States. Highlighting the results of TMP strategy evaluations that have been done, and completing additional evaluations to determine strategy effectiveness, will enable work zone practitioners to better understand the effects of implementing specific TMP strategies on different work zones and will help practitioners select more effective and economical TMP strategies.

The overall objective of this study is to synthesize existing TMP strategy evaluations, conduct additional TMP strategy evaluations, and provide a mechanism to disseminate information on TMP strategy effectiveness to work zone practitioners. This information could be accessed by work zone practitioners in highway agencies around the country to learn about successful TMP strategies. It could provide cost efficiencies to practitioners by adopting only those strategies found most effective. Such a source of information could also be used in the justification of strategy selection and development of more effective TMP strategies.

Research of published literature and discussions with practitioners indicate that assessment of the effectiveness of TMP strategies is feasible, useful, and occurring to some degree. While some strategies are being evaluated, there is no nationwide effort to combine or share the results from these evaluations. Based on the research, some of the important issues indicating the necessity of the proposed research are briefly discussed below.

**TMP strategy evaluation is occurring around the country.** Agencies understand the benefit of evaluating the effectiveness of TMP strategies. The evaluation of TMP strategy effectiveness is feasible and is occurring to some degree at the federal, state, and regional levels. The types of evaluation activities vary in type and scope, with the most common being research on the use and success/effectiveness of a specific strategy under specific conditions. The most commonly addressed strategies are various traffic control devices, followed by intelligent transportation systems (ITS), speed management approaches, queue management methods, and the use of portable changeable message signs.

**Having more information about TMP strategy effectiveness would be useful.** Practitioners have indicated that additional guidance on the effectiveness of various TMP strategies would be used. By learning about the effectiveness of strategies used in other locations, practitioners can save time and money by selecting the most effective strategies for use in their jurisdictions.
Several measures of effectiveness (MOEs) have been evaluated or are of interest for evaluation. The MOEs used to rate TMP strategies fall into four key areas: safety; mobility; construction efficiency (including cost) and effectiveness; and public perception and satisfaction.

States use a variety of practices for TMP strategy selection, deployment, and evaluation. State practices vary considerably with respect to the selection of strategies to be included in TMPs; strategy deployment methods; how (or if) data are collected to measure strategy effectiveness; the types of data collected; data analysis methods; and information sharing within an agency. There are no standard approaches or rules-of-thumb for identifying strategies to use on a project. Some agencies have created a checklist of strategies for designers, other staff, and consultants to consider on all projects; however, the list is usually not tailored by type of projects and does not provide guidance in selecting strategies.

TMP strategies are often selected without comprehensive information on a strategy’s potential benefits and disadvantages. When identifying specific strategies to include as part of a TMP for a project, practitioners must first determine the potential impacts of the work zone and then determine which strategies to use to remedy or mitigate these impacts to motorists and workers. A host of strategies exist for any known impact, as do their specific deployment techniques. State DOTs select specific TMP strategies for several reasons, including (1) level of certainty that a strategy will perform in a way and at a level that meets the operational and safety goals of the project; (2) federal regulations or industry requirements, such as the Manual on Uniform Traffic Control Devices; (3) relative cost and cost effectiveness; (4) time and effort needed for implementation, project parameters and needs; and (5) political or regional needs.

The knowledge level of practitioners varies widely regarding the selection of appropriate TMP strategies compatible with project-specific conditions and desired outcomes. In some cases practitioners select TMP strategies from a toolbox of applications developed by their respective agencies, and they employ the strategies without having a good understanding of how the techniques will contribute to mobility and safety nor for which situations the strategies are best used. For most practitioners, the main criterion for selecting strategies is their past experience with using the strategy on similar projects. States with more experience in developing TMPs and assessing strategies generally have a better understanding of how well certain strategies work.

A variety of evaluation approaches and data sources would be useful. There is value to including both qualitative and quantitative data sources in evaluation of TMP strategy effectiveness to capture the depth of information from qualitative approaches and the objectivity of quantitative data. While quantitative data alone is useful for drawing conclusions and comparing results of strategy assessments, TMP strategy effectiveness and factors for implementing TMP strategies are often qualitative in nature (e.g., practitioner knowledge of the strategy or location, past experience). Most published research on TMP strategy effectiveness relies on quantitative data analyses, but decisions made by work zone practitioners rely heavily on qualitative information. It is critical that qualitative assessment information be captured and well represented in assessing the overall effectiveness of a TMP strategy.

The overall objective of this study is to provide additional guidance to work zone practitioners on the selection of TMP strategies by synthesizing the results of existing TMP strategy evaluations, conducting additional TMP strategy evaluations, and providing a mechanism to disseminate information on TMP strategy effectiveness to work zone practitioners. Some of the research tasks may include (1) synthesizing previously completed TMP strategy evaluations, (2) surveying practitioners to identify frequently implemented TMP strategies and the level of evaluation currently being done on these strategies, (3) performing case study evaluations on individual TMP strategies, (4) studying the synergistic behavior of multiple strategies on the same project, (4) developing a TMP strategy clearinghouse to share evaluations and initially populate it with information on existing evaluations, and (5) developing or enhancing crash modification factors in the national clearinghouse.

Over the past five years, an average of 760 people have died and more than 37,000 people have been injured each year as a result of motor vehicle crashes in work zones. In total, there were 87,606 crashes in work zones in 2010. Over the past five years, an average of 110 workers have died and more than 20,000 workers were injured in road construction work zones each year. Work zones on freeways are estimated to account for nearly 24% of non-recurring delay. To reduce these crashes and delay, and their resulting effects on lives and
the economy, a better understanding of the effectiveness of work management strategies is needed. Having a better understanding of strategy effectiveness will enable designers to develop project designs and TMPs/traffic control plans that allow for safe, effective, economical maintenance of traffic through work zones. Achieving reductions in work zone crashes and delays through more effective work zone management would also benefit regional mobility and the economy.

The information on TMP effectiveness generated by this research could be accessed by work zone practitioners in highway agencies around the country to learn about successful TMP strategies. It could provide cost efficiencies to practitioners by adopting only those strategies found most effective in other locations. Additionally, such a source of information could be used in the justification of strategy selection and development of more effective TMP strategies. A challenge for work zone practitioners is that information on the successes of TMP strategies is not widely disseminated between highway agencies and sometimes not widely disseminated between regions or districts within a single highway agency. Results from this research should be prepared and documented in formats that allow for widespread dissemination to work zone practitioners. Possible formats include an online database, updates to the crash modification factors (CMF) clearinghouse, fact sheets, webinars, and guides.

Note: The AASHTO Standing Committee on Research directed that appropriate aspects of Problem No. 2014-G-19 be included. The research objective of 2014-G-19 is to gather data and evaluate the component effects of a multi-system approach to improve work zone safety. A multi-system approach involves evaluating the use of various methods of speed and queuing reduction, and improving work zone visibility, by using active and passive methods including local public campaigns, ATMS broadcatings and messaging, use of changeable message sign trailers with radar providing event prompted displays and use of on-site police officers with and without roving units for speed and queuing control.
A few recent projects have examined the relationship between lane width and safety. The study by Potts, Harwood, and Richard (2007) found no general indication (with a few exceptions) that the use of lanes narrower than 12 feet (3.6 m) on urban and suburban arterials increased crash frequencies. This finding should encourage use of more narrow lanes, which would provide several benefits including decreasing total crossing distance for pedestrians or (for existing streets) reassigning space to allow installation of on-street bike lanes or a raised pedestrian safety island. Narrower traffic lanes may also encourage slower driver speeds and reduce overall project costs. While the results from the Potts et al. study should encourage more use of narrow lanes, there were several caveats to the study findings. In addition, some are questioning whether there was adequate consideration for freight and transit. An example provided is that a 10.5-foot bus width envelope (including mirrors) does not fit well within a 10-foot lane. The City of Phoenix uses wider exterior lanes (12 feet including gutter) and narrower interior lanes (10 feet) to address the transit concerns, and has done so for 30+ years on most fully improved arterial streets. The Potts study did not examine streets with wider curb lanes. In addition, transit and truck use on the arterial was not a key factor in the study. While the Potts study provided excellent insight into lane width/safety relationships, additional research is needed to answer supplementary questions.

This research project will investigate the effects of lane width on operations and safety of urban and suburban arterials with specific consideration of transit, freight, on-street parking, bicycle usage, and shared vs. exclusive lane use. The objective of the project is to create a guidance document that can be used by cities, counties, and states to identify the most efficient use of a given pavement width as a function of available space and anticipated use by transit, bicycles, on-street parking, and/or freight. The guidance will consider the previously listed factors and will consider additional relevant factors such as posted speed; lane usage (e.g., turn lane or through lane); on-roadway neighboring space usage (e.g., turn lane, bike lane, on-street parking, shoulder width, curb and gutter, or another lane next to lane of interest); off-roadway neighboring space usage (e.g., proximity of objects such as utility poles, trees, or street furniture on the roadside); sustainability for traffic growth, impact on maintenance/reconstruction activities; and other factors as identified during the project. The consideration of these factors is to provide an appreciation of how the neighboring space affects operations of the given lane and whether an uneven distribution of lane widths is appropriate. The guidance document should also discuss the consideration of all transportation modes/user types (passenger cars, trucks, buses, bicycles, and pedestrians, as a minimum). An assessment of appropriate lane widths in the design process should consider the volumes of individual user types present (or anticipated) at any specific site. Consideration of all users should reflect the existing or anticipated proportion of usage. This research is geared toward both new construction and reconstruction.

The research team is to identify and recommend text changes to those sections of the AASHTO Green Book that should be revised because of this research. In addition, the safety results are to be provided to the FHWA-sponsored website on crash modification factors. The research should provide crash modification factors for urban conditions and safety relationships between lane width and pedestrian and bicycle crashes.
 Engineers are looking to alternative interchange designs to find ways to increase throughput and safety while reducing delay and the ever-increasing footprint of the roadway. The ability to decrease the overall footprint of the interchange is especially critical to transportation organizations struggling with project needs and limited budgets. Freeway interchanges are typically very expensive to build as they require significant bridge work. As the number of lanes increase to support traditional interchange designs, the costs increase dramatically to accommodate widening bridge structures.

Many states have started building diverging diamond interchanges (DDIs), also known as double crossover diamond interchanges (DCDs). This design relocates traffic movements between the two signals that make up the interchange to the left side of the roadway as opposed to the right side as is the typical design in the United States, Canada, Mexico, and other countries. This effectively eliminates the left-turn movements from crossing opposing traffic to access the freeway on-ramp, thereby reducing the number of conflict points from 26 for a conventional diamond interchange to 14 for a DDI. There are currently 15 DDIs built and operational in the United States and approximately another 50 DDIs in the design stage throughout the United States.

In spite of the fact that DDIs are becoming very popular in the United States, there are still many questions about their geometric and signal designs which have not been answered. Research proposed here addresses some of these unanswered questions by proposing research issues which should, when addressed, provide guidelines for optimal (geometric and signal) design of DDIs. This design effectively allows the two signals at the interchange to run as simple two-phase signals, reducing the impacts of lost time from multiple phase changes and clearance intervals. However, the coordination between the intersections is complex, especially when affected by an adjacent signalized intersection outside the interchange. The spacing of the signals that are part of the interchange is critical to the success of the design, yet very little quantifiable research has been done on this subject. Queues within the DDI are also a significant factor in terms of the design and signal timing.

This research should develop a foundation of guidelines for the effectiveness of the DDI for factors related to spacing, volumes, and adjacent intersections. The work should incorporate evaluation of queuing impacts both within the interchange signals and the approaches to the interchange. The work must include exploratory research into signal timing tactics and operational strategies to most efficiently move vehicular and pedestrian traffic through the interchange. Further, this research should provide a comparison to traditional diamond interchanges and single-point urban interchanges to compare and contrast the operational performance of each design for multiple alternative volume patterns.

Specifically, the research should address the performance of a DDI with adjacent signalized intersection(s) outside the interchange. The performance should be evaluated for alternative volume patterns such as heavy through movements, heavy left turns to and from the freeway, and heavy turn movements at the adjacent intersections. This evaluation should be conducted through detailed simulation analyses in a model that is well calibrated to real-world conditions.

The project should be coordinated with related efforts underway by the Federal Highway Administration.
Recent initiatives in the United States and Europe have pointed to the largely untapped potential of Active Traffic Management (ATM), which is the dynamic management of recurrent and non-recurrent congestion based on prevailing conditions for the purpose of improving trip reliability, safety, and throughput, while maximizing the efficiency of the existing transportation system. Some examples of ATM strategies include dynamic lane use control, dynamic speed limits, queue warning, and adaptive ramp metering.

One common theme from recent workshops conducted by the Federal Highway Administration on ATM has been that public agencies are highly interested in ATM strategies; however, a major barrier to deployment is uncertainty about the operational, reliability, and safety impacts and resulting benefits. Key questions that agencies need to answer before funding ATM systems include: (1) What are the impacts seen by agencies that have deployed ATM systems? (2) How do these impacts translate into benefits both to the traveling public and to the deploying agency(ies)? (3) How can we estimate the impacts of alternative ATM systems in our state? (4) What benefits and impacts can be reasonably expected on specific roadways in our state if deployed? The literature does not present clear answers to these questions. For this reason, further research on understanding the operational and reliability impacts of ATM strategies is needed. In this context, operational and reliability impacts refer to changes in driver behavior that directly affect macroscopic traffic flow parameters such as capacity (breakdown flow rate and queue discharge flow rate), free-flow speed, and jam density, as well as traffic measures of effectiveness such as speed, density, throughput, and delay. Both the mean and variability of these parameters and measures of effectiveness are important to understand and quantify, as many reliability performance measures (e.g., 95th percentile travel time) are dependent on the variability of the impacts.

Another area of interest in regards to ATM strategies is the life-cycle costs and resources required to operate and maintain ATM systems. In this time of budget and staffing uncertainty, agencies need to consider issues such as: (1) operations and maintenance resource and management demands and challenges associated with ATM systems; (2) medium- to long-term sensitivity of ATM effectiveness and benefits to operations and maintenance resource levels and vigilance; (3) integration of life-cycle costs (including life-cycle replacement cost) into sustainable financial programming of ATM systems; and (4) acknowledgement of human resource demands (agency or contractor staff) for operations and maintenance functions required for ATM effectiveness. Although improved safety is typically one objective of ATM strategies and further research on the safety impacts of ATM strategies is needed, the scope of this proposed research is limited to addressing the operational and reliability impacts of ATM strategies. Developing a safety analysis methodology would have considerably increased the complexity and scope of this research and would be best served as a separate research effort.

The FHWA is currently sponsoring research that will develop an HCM/deterministic-based analysis methodology to estimate the operational and reliability impacts of ATM strategies. This work represents an extension of the Strategic Highway Research Program Project L08, “Incorporation of Travel Time Reliability into the HCM,” and will serve as a solid framework for estimating the operational and reliability impacts of ATM strategies and systems. However, while this framework will be robust, the work will require further expansion to incorporate a wider range of ATM strategies (including those for arterial streets), the synergistic impacts of multiple ATM strategies, and the differential impacts of applying more comprehensive ATM strategies. It will also need more robust validation to a wider range of operational conditions.

The objectives of this research are to: (1) review existing studies on operational and reliability impacts of ATM strategies, and corresponding life-cycle costs, resource requirements, and institutional and management challenges with operating and maintaining ATM strategies and make the study data easily accessible and (2) validate and expand the current ATM HCM-based analysis methodology to incorporate a wider range of ATM strategies, including those for arterial streets, and make the study data easily accessible.
strategies, synergistic impacts of multiple ATM strategies, and the relative impacts of applying ATM strategies further along the active management continuum (e.g., moving from fixed time-of-day ramp metering to adaptive, system-wide ramp metering). The end products of this research are: (1) a comprehensive synthesis report of existing studies and data on operational and reliability impacts of ATM strategies, (2) an enhanced ATM HCM-based analysis methodology procedure and a final report, and (3) a computational engine (i.e., computer software-based tool) that implements the enhanced methodology. Desirable future outcomes from this research are for the methodology to be formally incorporated into a future edition of the HCM and for results to be incorporated into other national references such as the *FHWA Operations Benefit/Cost Analysis Desk Reference* and the *FHWA Freeway Management and Operations Handbook*. The results of the research should be useful to transportation agencies in developing cost-effective configurations for an ATM system.

Note: The AASHTO Standing Committee on Research directed that aspects of Problem No. 2014-G-22 be considered and that a cost-effective configuration be looked at.
The concept of risk generally involves the identification of uncertain events that may occur and the likely consequences, often undesirable, to be expected if they do occur. Effective strategic risk management involves identifying the various risks to an organization’s achievement of its objectives and then devising ways to mitigate, avoid, transfer, or be prepared to accept these risks. Risk management is a common practice in many private sector fields such as banking, insurance or information technology. A 2011 NCHRP survey indicates that while most U.S. transportation agencies practice risk management in their construction projects, only a very few have begun to apply it to broader programs or to their agency as a whole.

U.S. transportation officials are required to manage the wide range of risks to their agencies’ objectives and programs stemming from the changing social, economic, political, and technical dynamics at the local, state, national, and global levels. The Congressional requirement within Moving Ahead for Progress in the 21st Century Act (MAP-21) for risk-based asset management plans has accelerated the need for U.S. transportation agencies to understand and apply the principles of risk management throughout their organizations.

This growing interest in risk management within the transportation industry prompted an international scanning study in 2011 to review transportation agency risk management practices around the globe. The scan team found that leading agencies in Australia, England, Germany, the Netherlands, and Scotland have mature risk management policies and procedures integrated throughout their organizations. Their practices generally follow the ISO 31000 Risk Management—Principles and Guidelines, a guideline that has yet to be implemented in most transportation organizations. Comprehensive risk management supports these countries’ internal decision making and effectively communicated to stakeholders the threats and opportunities facing their agencies in managing and improving of the transportation system. When considering how to apply its findings to improve the practice of risk management in this country, the scan team identified the development of a comprehensive guidebook on risk management strategies, processes, and tools as an immediate high priority.

TRB, AASHTO and FHWA have all sponsored small, exploratory studies on the subject of agency risk management. In 2011, NCHRP conducted project 20-24(74) for the AASHTO chief executive officer’s committee titled “Executive Strategies for Risk Management by State Departments of Transportation.” This resulting report benchmarks the use of risk management techniques and identifies executive strategies that may be useful to DOT leadership for enterprise-wide risk management. The research conducted a thorough review of transportation, planning, business management and organizational strategy research to identify current risk management practices, emerging methods, and trends. The study presents a comprehensive survey with responses from 43 DOTs to identify risk management strategies. It provides a good foundation but does not provide tested strategies, processes, and tools. A second exploratory study was conducted by NCHRP in 2011 titled “Guide for Managing NEPA-Related and Other Risks in Project Delivery.” This study reports on expediting NEPA decisions and other practitioner strategies for addressing high-risk issues in project delivery. It examines numerous aspects of program and project management, including the risk management process. The report presents case studies to illustrate the risk management concepts. Also in 2011, the FHWA International Programs Office sponsored the previously mentioned risk management scan that collected lessons learned from mature risk management agencies around the world. These studies are supported by industry guidelines from the International Standards Organization, the Project Management Institute, and some excellent work done by FHWA and the state departments of transportation of California, Minnesota, New York, and Washington State. While the exploratory studies have been completed and some risk management standards from other industries exist, there is no comprehensive guideline for transportation agency risk management strategies, processes, and tools.
The objective of this research is to develop a comprehensive guidebook on risk management strategies, processes, and tools aimed at promoting the consistent and effective application of the risk management in state and regional transportation agencies throughout the country. The guidebook should (1) speak to DOT and other transportation agency executives through a discussion of the benefits of risk management as well as strategies for implementation; (2) guide chief risk executives and program managers on methods for developing programs and measuring their effectiveness; and (3) provide staff with tools to apply in these programs.

The guidebook should build on the findings of the previous exploratory research and international scan tour findings. It should include case study examples as available from related research.

Accomplishment of the project objective(s) will require at least the following tasks.

**Task 1.** Conduct a literature review of current and recent research into enterprise risk management practices in transportation agencies, nationally and internationally.

**Task 2.** Develop a critical review of the state of the practice, including notable practices and key problems, issues, and deficiencies. Identify case study examples that will be cited and described to demonstrate best practices.

**Task 3.** Prepare a report summarizing the findings of Tasks 1 and 2. Based on those findings, identify a preliminary framework for institutionalizing a comprehensive risk management program in a transportation agency; the possible strategies, policies, and tools to implement risk management throughout the agency; and the case study examples that will be cited and described in the guidebook.

**Task 4.** Meet with the NCHRP project panel via teleconference to discuss the preliminary framework and work plan for developing the guidebook and receive panel-member suggestions on framework and work plan approach. Prepare memorandum documenting the meeting and decisions made.

**Task 5.** Prepare a preliminary annotated outline of the guidebook.

**Task 6.** Prepare and submit an interim report that documents the work performed and findings from Tasks 1 through 5. Present the information in the interim report including the preliminary annotated outline at a meeting of the NCHRP panel.

**Task 7.** Based on panel review and feedback, develop a draft of the guidebook, including the framework; strategies, policies, and tools; and case study examples.

**Task 8.** Submit the draft guidebook to the NCHRP panel for review and comment. Solicit preliminary individual panel member’s review via shared email. Share and discuss individual reviews further via teleconference. Prepare a memorandum documenting the discussion and the resulting decisions.

**Task 9.** Based on the results of Task 8, revise the preliminary guidebook and present the final draft to selected professional practitioners to obtain input and feedback.

**Task 10.** Based on practitioner review and feedback, revise the guidebook. Prepare and submit a final report including the final guidebook for panel review and approval.

This work should be coordinated with the foundation from the following standards and research reports: (1) *NCHRP 20-24(74)* Executive Strategies for Risk Management by State Departments of Transportation, (2) *NCHRP 183 Guide for Managing NEPA-Related and Other Risks in Project Delivery*, and (3) *FHWA International Scan Report on Transportation Risk Management: International Practices for Program Development and Project Delivery.* This project should be coordinated with the ongoing research for NCHRP Project 8-36, “Successful Implementation of Enterprise Risk Management in State Transportation Agencies.”

As the growth in demand for transportation system improvements continues to outpace available revenues, the need for agency leaders to identify and manage the resulting risks has risen to the level of urgency. Within less than three years, all state transportation agencies will need to respond to MAP-21 requirements for risk-based asset management plans. Effective risk management cannot be accomplished through a silo approach; a guide to agency-wide application of risk management will fill a critical gap in knowledge transfer.
Travel demand models are increasingly being asked to address new policy and planning questions. Though many advances and innovations in travel modeling techniques have been developed in recent years, selecting and applying these techniques appropriately is challenging. A research project is necessary to develop resources for state transportation agencies and metropolitan planning organizations (MPOs) that (1) will help them evaluate the capabilities and limitations of their existing models with respect to specific policy and planning questions and (2) will assist them in scoping model development or improvement projects so as to attain the desired policy sensitivity.

This document will supplement FHWA, FTA, TRB, and NCHRP documentation of available travel modeling techniques. The specific contributions of this project will be: (1) design and scoping recommendations regarding how to evaluate or align the technical structure of a model (such as assumptions, model structure and technical specifications, scale of the model, and level of detail) with specific performance measures and policy requirements and (2) an evaluation tool that supports practical application of the recommendations.

The proposed research will help analysts ensure that a model is appropriate for the analysis of the impact of specific common types of policies and projects at the geographical scales that might be of interest to state agencies or MPOs. The products of this research will be widely used by state transportation agencies, MPOs, and consultants who must scope and develop travel forecasting models.

The research will involve investigating the data, modeling methods, and validation required to address pressing planning issues such as performance-based planning, managed lanes, toll revenue forecasting, air quality and climate change, new transit modes, walk and bike activity forecasting, freight planning, environmental justice and welfare analysis, benefit-cost and economic impact analyses, or other planning issues which models are now asked to address and which go far beyond the forecasts of highway volumes that models were originally designed to produce. The research is not intended to develop or deploy new or untested technologies. Rather, the research will comprehensively evaluate currently deployed and available practices with the goal of making the best and most appropriate among those more widely available and usable. The research will also evaluate development cost and time and identify possible tradeoffs between cost, speed of development, and accuracy and precision of results.

The guidebook generated from the research will assess the suitability of various model designs and techniques to address contemporary planning and policy issues. This assessment will allow agencies to identify issues that current models are not well suited to address and will assist them in identifying potential techniques or enhancements which will provide desired sensitivity. The guidebook will address appropriate use of model design alternatives such as trip-based versus tour-based, aggregate analytic versus disaggregate micro-simulation, behavioral versus statistical, commodity flow versus logistics versus direct generation freight models, long-term versus short-term choices, spatial and temporal aggregation level, ordering of model components, feedback/convergence mechanisms, data synthesis versus collection, etc.

The proposed evaluation tool will present the research results using flowcharts, decision trees, or similar techniques in such a way as to facilitate evaluation of existing models and scoping of new model development or model updates.
Travel surveys have become very expensive to conduct, with costs over $500/household for some GPS-based surveys. The public has become fatigued from being over-surveyed. Difficulties in obtaining long-distance travel data from surveys have been well documented. Stopping traffic to conduct roadside cordon origin to destination (O-D) surveys has become increasingly difficult and is impossible in some states. O-D data are the basis of travel demand models, which are the primary tool for project evaluation, benefit-cost analysis, air-quality conformity analysis, and development of project level design traffic. These models are developed from increasingly old data due to the issues noted above. States’ traffic analyses and benefit-cost analyses are becoming poorer even as we are developing more advanced methods due to the expense and burden in collecting up-to-date O-D data.

Large-scale cellular data have recently become available to transportation professionals. This dataset is extremely appealing to travel professionals due to its potential to refresh travel demand models and provide much more detail than is able to be collected using small studies. This dataset could allow for better analyses, especially for benefit-cost, and allow state DOTs to spend their dollars efficiently. Planners need O-D data in order to determine travel patterns between various traffic analysis zones. Traditional methods of estimating O-D patterns are large-scale, episodic, sampled surveys including household travel surveys, roadside interviews, and license plate video recognition methods, generally conducted once a decade. But in situations of financial constraints and shrinking budgets, these surveys have become more limited. By the time the survey data are collected and processed, the O-D data obtained becomes almost obsolete. Response rates to surveys continue to decline. Therefore, using passive methods to collect travel behavior are of increasing interest.

Crowdsourcing of travel speed on roadway links has not raised alarms of protecting privacy, as individual IDs are not included and the origins and destinations are not identified. Cell phone tracking with mechanisms in place for privacy protection may be an alternative source for travel demand modeling including identification of home-to-work flows by time of day, trip length distributions by time of day, and flow patterns for home-based and non-home-based trips.

Cell phone tracking data are not likely to replace traditional survey methods in capturing the linkages between demographic characteristics and travel behavior, but will provide more robust information about activity space, stability of travel, travel patterns for trips originating outside of the study area, and small area O-D data.

This study will explore examples in Raleigh, NC, and Lexington, KY, and possibly other locations to build home-to-work as well as other O-D matrices. A robust way to examine the results and applicability to other locations is needed.

It is anticipated that this study will develop recommendations on what data are available, their cost, and their usability for a range of planning and modeling applications. Results from this study will be used for all sizes of MPOs and DOTs. This will potentially replace roadside cordon surveys and will greatly enhance the understanding of long-distance travel. Furthermore, these data could be further used in route choice models, which are still in the research stage as large-scale datasets have historically been wanting. This will greatly add to project-level analysis, which has been using large-scale data to look at project-level decisions.
Land-use activities (zoning, urban growth limits, etc.) are often disconnected from decisions regarding investments in the freight system. Understanding how land-use decisions can impact goods movement demand will become increasingly important with the Smart Growth movement. Proactive design for freight movement within dense urban areas is needed to improve mobility and to avoid increased congestion, pollution, and costs associated with delay. For those who transport and deliver goods, the critical last mile in an urban, higher density, and/or mixed use setting can often be the most challenging aspect of the trip, contributing to delay and reduced reliability. As more communities are being designed for mixed use, higher density land uses, and other components of Smart Growth, the delivery of goods and services are either minimally addressed or are simply overlooked. Going beyond zoning and addressing the needs of shippers, transport providers, and receivers in the design, development, and phasing of such projects is critical for both commerce and sustainability principals to coexist for these communities. Cost savings can be had when these issues are addressed early in the process rather than after land-use decisions are in place when changes can be cost-prohibitive.

This study will examine U. S. and international community development practices in urban settings that efficiently design for the coexistence of freight movement and the Smart Growth tenant of “walkable communities” and then create best practices and recommendations for proactive design and phasing. It may eventually be used by planners and decision makers as a national best practices guide/reference manual for integrated urban design.

The objective of this research is to provide a user-friendly resource for planners and decision makers to ensure that freight considerations are included in the planning and design process of urban project developments to avoid future transportation system inefficiencies and costs. The study will include best practices, as well as recommended design and phasing for the integration of freight movements.
Project 08-97

Using Oversize/Overweight Data to Develop Multistate, Multimodal Alternative Freight Corridors

Research Field: Transportation Planning
Source: Missouri
Allocation: $500,000
NCHRP Staff: Christopher J. Hedges

Annually, state departments of transportation issue nearly 5 million permits for oversize/overweight (OSOW) truck movements along the nation’s highways system. OSOW freight is typically regulated and permitted on a state-by-state basis, and data collection, management and strategic use of the information is similarly variable across the states. National and regional public sources for OSOW data do not exist. FHWA’s Freight Analysis Framework version 3 (FAF3) provides categories that include some of this data, but it is reported in aggregate along with other members of its commodity category (e.g., machinery – there is no distinction as to whether the machinery is OSOW or not). In addition to the lack of consistent information, heavy haul businesses find the state-by-state permitting process to be cumbersome, complicated, and too frequently resulting in cross state movements that are difficult to align.

The development and use of multistate, multimodal OSOW corridors and an evaluation of their efficiencies is an area that has not been explored in as much detail as OSOW permitting and harmonization, or more general work in the area of modal diversion and shift.

OSOW movements by their very nature are not typical highway loads and thus present significant potential for movement on rail lines and waterways. Given the historical transportation development patterns in the United States, highway, rail, and waterway corridors frequently run parallel and thus provide multiple modal options for OSOW moves. However, without adequate OSOW information on movements and corridors, planners and logistics experts lack information regarding the prominent loads carried and corridors used, and the ultimate origins and destination for these movements. This information gap likely limits efficiencies in developing multimodal, cross state corridors.

There is a need to develop a set of multistate case studies to establish best practices for OSOW corridor data collection and management to more fully utilize the currently collected information on permitted loads. Information on commodities and corridors for these OSOW movements would also be integrated into an analysis of parallel rail and water options to determine alternative route/route mode feasibility, and cost and benefits of moving OSOW loads on parallel multimodal corridors. The research will culminate in a guidebook of strategic best practices and parameters for multistate OSOW freight movement, supported by the multistate case study. Furthermore, research results will stimulate freight policy and industry decision makers to identify multimodal corridor options and improve OSOW corridor system performance, safety, and other public benefits.

The idea also aligns with the developing MAP-21 national freight policy by working to understand multistate corridor moves and the potential means to increase the cost effectiveness, safety levels, and freight efficiencies; and enhance communities and economic development while decreasing environmental impacts of freight movement.

The objectives of this research are threefold. The initial phase of the project is designed to increase the efficiencies in OSOW data collection and management and the strategic use of state OSOW data through an assessment of data collection and management practices across a set of case study states. The second phase of the effort will identify parallel multistate, multimodal OSOW corridors, and then a simulation analysis would be used to compare the feasibility, costs, and benefits of moving the OSOW loads on the available multimodal corridors. The final objective of the research includes development of a guidebook that includes a synthesis of the OSOW data collection and strategic use best practices and parameters. It also would demonstrate the process, as well as provide case study level analysis of the comparative costs, benefits and feasibility of OSOW moves on multistate, multimodal corridors. Preliminary steps to provide for this research include:
1. Identify a select group of state DOTs from various AASHTO regions to participate in the research based on the presence of OSOW corridors that include multiple modes such as a rail, water, and highway option. Also considered are the states’ interest in better utilization of OSOW information, and their efforts to work regionally to increase efficient freight movements. From this group, also create a project coordination team of OSOW service providers and industry representatives to provide feedback on the study process and results. This effort will be coordinated with the AASHTO Subcommittee on Highway Transport and the ongoing efforts to advance harmonization and efficiencies in OSOW moves.

2. Assess current data, data collection, and management and use to identify specific OSOW cargo types, origins, destinations, volumes, and frequencies across state boundaries for the case study states. Based on this assessment, identify common multistate, multimodal freight corridors and appropriate products for multimodal moves.

3. Develop a set of OSOW data collection and management parameters to provide for standardized OSOW permitting and incorporation into future public databases and planning tools.

4. Identify specific parallel routes and development nodes that can accommodate modal shift from identified OSOW corridors. For example, marine highway or rail corridors that parallel an OSOW highway corridor or could provide service to the same origins/destinations.

5. Develop and operationalize a benefit/cost approach to assess alternative modal moves in the case study states.

6. Create a guidebook for state practitioners to assist their efforts in OSOW data collection and strategic use of the information. The document would also provide guidance on benefit/cost analysis and development of an understanding of the availability, use and consequences of multistate, multimodal OSOW freight corridors.
**Project 08-98**

*Measuring Truck Bottlenecks*

Research Field: Transportation Planning  
Source: Washington  
Allocation: $400,000  
NCHRP Staff: William C. Rogers

Truck bottlenecks delay large numbers of truck freight shipments and negatively impact the nation’s economy and productivity. As the domestic freight ton-miles traveled by trucks is expected to increase by 53% in 30 years, reducing truck bottlenecks will be a major solution for increasing highway capacity. In addition, Moving Ahead for the 21st Century (MAP-21) requires states to report on how they are addressing freight bottlenecks. To address this issue, national, state, and regional transportation agencies need a sound methodology to define, identify, and quantitatively measure truck bottlenecks to justify project funding to mitigate the bottlenecks.

Without such methodology, transportation agencies will be unable to address the truck bottleneck issue systematically and fixing one location may simply shift the bottleneck to another location on the network, with no improvement to the overall corridor performance. Without defining bottlenecks by categories based on actual causal factors and locations, project designers will not be able to develop cost-effective solutions to address different types of bottlenecks.

Several national and regional studies have identified and quantified truck bottlenecks, including the FHWA Freight Bottleneck Study, FHWA Freight Performance Measure Program, and INRIX Traffic Scorecard. However, these studies defined truck bottlenecks as congestion related or did not develop a comprehensive classification of truck bottleneck categories. In addition, the measures to quantify bottleneck severity were developed to capture congestion impacts or delays and are unable to measure the impact of other types of bottlenecks, such as weight restrictions, intermittent closures, size restrictions, roadway geometrics, height restrictions, and weather restrictions. There is a need for a comprehensive classification of truck bottleneck types that provides a standard approach for state DOTs to define truck bottlenecks and quantify their impacts.

The objectives of this research are to (1) develop a classification system for truck bottleneck categories based on causal and location factors and definitions of each type of bottleneck; (2) develop appropriate quantitative measures for each bottleneck category to determine bottleneck severity, impact, and ranking; (3) develop a methodology for systematically evaluating the network performance and identifying/locating truck bottlenecks; and (4) provide recommendations for using the results to develop solutions for addressing bottlenecks.
There is a national need for a tool to quantitatively evaluate the benefits associated with truck freight projects. With declining revenue to build and maintain transportation infrastructure, it is important that limited resources are invested in projects that are most needed and provide the greatest benefit to the highway system user. Development of quantitative measures to evaluate truck freight benefits is an important step in the project prioritization process. The recently released MAP-21 legislation calls for the development of new tools and improvement of existing tools to support an outcome-oriented, performance-based approach to evaluate proposed freight-related and other transportation projects, including methodologies for systematic analysis of benefits and costs.

The first phase of this research is underway and will develop a method to quantify the truck freight benefits associated with mobility projects by taking into account changes in truck travel time, operating cost, and emissions in order to calculate economic impacts which include changes in state and regional gross product and changes in long-term employment. This research is being conducted by the Washington State Department of Transportation (WSDOT) with the University of Washington and Washington State University. The results of this research will be applicable to other states (within some data and modeling requirements). To date this research has been unable to incorporate travel time reliability into the benefit estimation due to a lack of resources.

Travel time reliability is frequently cited as an important metric for the trucking community and other users of truck freight services. Three technical teams asked to advise on the Washington State Freight Mobility Plan also identified truck freight benefits as a top priority that should be included in the benefit evaluation. Travel time reliability for all vehicles is commonly measured and reported as a percentile or average (mean) travel time, but currently there is no defensible way to value travel time reliability for just trucks and thus it has not yet been incorporated into the benefit estimation. Travel time reliability needs to be incorporated into the truck freight benefit estimation in order to fully capture truck freight benefits associated with mobility projects in order to provide quantitative data for project prioritization. The methodologies being developed can be applied to any region of interest and the need for quantitative data for prioritization of freight projects is a national level issue.

It is important to differentiate the discussions of and literature related to 1) the measurement of reliability, 2) the estimation of future reliability, and 3) the value of reliability. In addition, the established literature and practice with respect to these three elements is substantially different when comparing passenger travel to freight. While the importance of reliability is well established for both passenger and freight travel, the value of reliability is not. In order to incorporate reliability into the benefit-cost analysis the three tasks must be completed:

1. Metrics must be developed to value and communicate reliability for trucks.
2. Methods must be developed to forecast future reliability, so that the impact of proposed projects on this important metric can be estimated.
3. An estimate of the value of reliability improvements must be developed. This problem statement seeks the funding to conduct this task.

When these three work streams are complete, the ability to measure, estimate, and value reliability will be achieved and therefore could be incorporated into the truck freight benefit cost methodology. The first two tasks are currently underway by WSDOT, the University of Washington (Task 1) and the Pacific Northwest Transportation Consortium (Task 2).
The objective of this research is to estimate the value of travel time reliability to truck freight system users. It is recommended that a combination of direct and indirect modeling be used. An initial, qualitative data collection effort to inform the design of a survey of truck dependent industry sectors and ensure the survey captures the relevant information appropriately. This exploratory phase will be followed by a larger scale survey that will collect direct schedule delay and cost information, as well as responses to stated preference questions directly from the trucking community. The sampling will ensure that a sufficient number of respondents in each industry category are sampled. It is important to capture data from multiple industry categories as more than just traditional trucking firms are concerned with truck travel time reliability; many companies in the manufacturing, retail, construction, and other sectors rely on shipping goods by truck.

The survey results will be analyzed to produce estimates of the value of reliability within industry segments of the truck freight sector. These values will be incorporated into the truck freight benefit-cost methodology, thereby improving the methodology and ensuring that these important benefits are captured in project benefit estimates.
Tolling is being considered increasingly by state DOTs as both a funding mechanism as well as an operations strategy on urban highways. FHWA Office of Innovative Program Delivery offers guidance for state DOTs and MPOs on how to realize the benefits of congestion pricing.

Compliance with Executive Order 12898 is an ongoing DOT responsibility. On May 2, 2012, Sec. La-Hood signed DOT Order 5610.2(a) which sets forth the DOT policy to consider environmental justice (EJ) principles in all DOT programs, policies, and activities. However, these policies do not offer guidance for assessing equity concerns in the context of pricing.

State DOTs seeking to prepare environmental justice analysis as part of their NEPA compliance on projects that involve tolling quickly learn that there is little research to guide the development of sound methodologies. Neither FHWA or EPA have reached consensus on what constitutes an adequate analysis.

Tolling has been identified as possibly having a potentially disproportionate impact on low income populations; currently, however, there is not agreement within the U.S. DOT regarding the types of effects that could trigger a high and disproportionate effect for highway pricing proposals.

Traditional methods of environmental justice analysis often don’t adequately evaluate the possible impacts of tolling on low income communities. Traditional methods begin by determining the racial and income characteristics of the communities within and adjacent to the project footprint (geographic proximity) while proposed tolled facilities generally draw users from the entire region. Non-local, low-income drivers are typically not considered in other traditional EJ analysis.

Traditional methods also often focus on the direct impact of a project on an environmental justice community. But potential tolling effects are very different than site-specific noise or pollution.

There is a growing interest in more detailed assessment of how tolling may affect low-income mobility in general and how to assess the impact on low-income drivers in particular. Some questions are: will the cost of using the route be prohibitive to some citizens? Or will the cost of a more predictable commute time be offset by the time-savings? Will the regional transit and traffic improvements provide further off-setting benefits to EJ populations? In practice, there is little consensus about what types of mitigation measures are appropriate to be used to offset the effects of tolling. Do those mitigation measures need to be targeted specifically to low-income/minorities or can they be mitigation measures that provide benefits to all users?

The objectives of this research are to: (1) identify types of tolling proposals and other congestion pricing situations that trigger need for detailed analysis of effects on low income users; (2) identify project characteristics that lend themselves to particular methods of analysis; (3) provide a baseline for what has been done across the country; and (4) identify the key challenges regarding EJ/tolling issues from the state DOT perspective.

This research should begin by summarizing the results of the limited research that has already been done, then conducting a gap analysis to refine the scope. Initial concepts are that the research will include a review of how different NEPA and other transportation planning processes have evaluated tolling impacts on low income populations. What methodologies have been used to identify the affected populations and what factors are considered when assessing project effects? For analyses identifying disproportionate adverse effects on low-income citizens, were effective mitigation strategies proposed? Are there corollaries with other federally approved pricing proposals (transit fares, user fees)?

Ideally, this research would lead to a consistent methodology developed for how effects to low-income/minorities related to tolling are analyzed. This would ensure consistency between projects in how effects are analyzed.
There is also a need for consistency in understanding how the project benefits can offset effects (i.e., that project benefits that benefit all users, not just low-income/minorities, can offset the effects related to tolling for low-income/minority users).
AASHTO T 308 recommends that correction factors for asphalt mix designs be determined on each ignition furnace used to test the asphalt mix design. Due to some cases where there are numerous asphalt mix designs or numerous ignition furnaces testing a particular mix design, the asphalt and aggregate correction factor is shared between ignition furnaces. There is a concern that sharing correction factors should not and cannot be done. Additionally, there is variability in correction factors determined on the same make and model of ignition furnace, but located at different locations. There is also an absence of any ignition furnace installation and maintenance guidance documents to properly install and maintain the various ignition furnace makes and models to minimize the differences in the asphalt and aggregate correction factors and test results. Finally, there is a lack of a comprehensive and statistically valid verification process to determine the differences in asphalt and aggregate correction factors for ignition furnaces and whether or not they significantly affect test results. A verification process would allow ignition furnace installations and maintenance to be compared to other installed and maintained ignition furnaces in different locations to determine if they are significantly different.

The objectives of this research are to (1) determine what influences or factors affect asphalt and aggregate correction factors in ignition furnaces and their significance; (2) develop an installation and maintenance guidance document for ignition furnaces to minimize or reduce the variability in correction factors between ignition furnaces and ignition furnaces at different locations; and (3) develop and document a statistically valid verification process that acceptance agencies and asphalt mixture producers can use to verify asphalt and aggregate correction factors of different ignition furnaces and of ignition furnaces at different locations.

Accomplishing these objectives will require the following tasks: (1) determine all potential influences in equipment setup or maintenance affecting the determination of the asphalt and aggregate correction factors including, but not limited to, lift, flue length, flue configuration (size and rise/run, assisted air flow (fans), atmospheric weather conditions (humidity, atmospheric pressure, wind speed), room air pressure (positive or negative HVAC pressure), make and model, and maintenance of chamber heating elements, internal balances, door seal, door alignment, cleanliness of afterburner filters, afterburner heating element, blower motor, vent tube cleanliness, circuit boards, and relay switches; (2) determine the significance of each of the influences on correction factors; (3) determine the variability of asphalt and aggregate correction factors with different installation or maintenance factors or elements; (4) develop an installation and maintenance guidance document for proper setup to minimize variability in ignition furnaces both for determination of correction factors and test results; and (5) develop a verification procedure for verifying asphalt and aggregate correction factors of ignition furnaces by different ignition furnaces or by ignition furnaces in different locations that is practical for use by agencies, asphalt mixture producers, and on a mix design basis.
Cracking is the primary mode of distress that creates the rehabilitation for asphalt pavements. Several recent research studies have evaluated and/or recommended a variety of laboratory tests and models to assess the cracking potential of asphalt mixtures. As asphalt mix designs become more complex with different binder modifiers, recycled materials, and warm mix asphalt technologies, many pavement engineers have recognized the need to establish and implement reliable performance tests that can be used to improve mixes and ultimately extend the life of asphalt pavements.

There are several modes of asphalt pavement cracking, such as low-temperature cracking, reflection cracking, fatigue cracking, and top-down cracking, all of which are affected by numerous factors and their interactions. One of the challenges associated with the validating performance tests is correlating the test results and associated models to predict these different modes of cracking with actual measured performance. Accelerated Pavement Testing (APT) facilities and test roads with well documented loading and environmental conditions may be important resources to provide the necessary link to calibrate and validate lab results to field performance and establish criteria for properties and/or test results for use in future asphalt mixture specifications. However, the current practices of operating APT facilities is not coordinated in such a manner to adequately address major issues such as the development of laboratory performance tests.

A project is needed to develop an experimental plan to select candidate laboratory cracking tests applicable for routine use and develop coordinated field experiments, perhaps including APT facilities, to establish lab-to-field relationships and criteria for assessing the cracking potential of asphalt mixtures.

The objective of this research is to develop (1) an experimental plan to select candidate laboratory cracking tests applicable for routine use and (2) an experimental design for a series of coordinated field experiments, perhaps including APT facilities, to establish lab to field relationships and criteria for assessing the cracking potential of asphalt mixtures.

Accomplishing this objective will require the following tasks: (1) Conduct a literature review to identify the most promising laboratory test methods and models to predict different modes of cracking. Summarize the advantages and disadvantages of each method for use in routine practice, including equipment costs, technician training, results interpretation, and time to prepare, test, and analyze data. Recommend tests for further examination in field validation efforts. (2) Design experiments having test pavements/sections with quantifiable loads, base support, climatic conditions, and a range of asphalt mixtures representing properties that are expected to yield good to poor cracking performance. The experiments should consider factors of different climates, loading conditions, aging conditions, and pavement structures. (3) Develop plans for sampling, storage, transportation, and testing of the asphalt mixtures in the experiments. The plan should consider utilizing laboratories that have been involved in the development of the recommended test methods and models as well as laboratories that represent new users of the procedures to aid in refining the methods and establishing precision information. (4) Develop an estimated budget for accomplishing the experiments and ancillary activities described in Tasks 2 and 3.
Economics, energy conservation, emission reduction and conservation of natural resources has provided stimulus to expand the use of reclaimed asphalt pavement (RAP) and recycled asphalt shingles (RAS) in asphalt paving mixtures over the last five plus years. It is not unusual for asphalt paving mixtures to contain 35 percent RAP and other asphalt paving mixtures contain 15 to 20 percent RAP with 5 percent RAS. These mixtures are produced at both conventional hot mix asphalt (HMA) temperatures and warm mix asphalt (WMA) temperatures. The use of these high RAP and RAP/RAS mixtures results in asphalt binder substitution ranges from 30 to 40 percent. From an economic, energy conservation, emission reduction, and natural resource conservation points of view, it is desirable to increase recycled asphalt binder substitution ratios and produce mixtures at both HMA and WMA temperatures.

RAS and RAP binders are very stiff and can create construction and performance issues, and there is little known on how recycling agents influence mixture performance. The use of relatively high percentages of stiff binders from RAP and RAS can cause premature pavement distress in the form of fatigue cracking, reflection cracking, low temperature cracking, aging, and raveling. In addition, workability problems during placement have been noted in cooler weather conditions when asphalt paving mixtures are used with higher RAP and RAS contents. Uncertainty exists relative to the ability of the RAS and/or RAP binders to adequately comingle with the virgin asphalt at both hot and warm mix temperatures. These issues may impact continued increased usage of WMA technologies if the reduced production temperatures do not allow activation of the RAP and RAS binders to comingle with the virgin asphalt.

Asphalt paving mixtures with high RAP and RAS contents sometimes use virgin asphalt binders that are “softer” than the conventional binder typically used for the particular climate and traffic condition. Alternatively, asphalt paving mixtures with high RAP and RAS contents sometimes use recycling agents to “soften” or “rejuvenate” the stiff, oxidized RAP and RAS binder. The use of these softer binders and recycling agents reduces the stiffness of the resulting asphalt paving mixture and improves performance under many conditions. The technology to identify the grade and amount of these recycling agents has been in existence since the 1970s. Unfortunately, most mixture design using RAP and RAS do not make use of this technology and the technology has not been updated to reflect today’s binder specification and mixtures test parameters as well as the use of WMA technology.

Research with recycling agents was largely performed in the 1970s and was limited in nature. In addition, little to no research has been performed with these materials in current typical plant produced HMA and WMA applications. The latest relevant TRID database entry on recycling agent usage with respect to U.S. asphalt binders was conducted and published in 1999 by the Transportation Research Board. These studies only investigated laboratory blended asphalt binders with recycling agents and didn’t evaluate RAP and RAS binders, nor investigate the performance properties of RAS and RAP plant produced mixtures.

Further literature indicates that the inclusion of relatively high percentages of “replacement binders” in asphalt paving mixtures from either RAP or RAS will stiffen the mixtures and potentially result in premature pavement distress. Specifications for “recycling agents” were developed and standardized. These materials have been used as spray applied fog seals to rejuvenate pavements. Some have also been used for hot in-place recycling operations where 80 percent or more of the existing asphalt pavement material is reused. Based on research conducted in the 1970s, the low viscosity recycling agents were used in relatively low percentages and could effectively change the properties of RAP asphalt paving mixtures; but most of the testing only addressed recovered asphalt which may not be representative of the mixture effects. Little research has been done using
mechanistic mixture testing and little is known about how recycling agents affect polymer modified binder mixtures.

The objective of the research project is to define the engineering properties of recycling agents, asphalt binders, and asphalt paving mixtures containing recycling agents with relatively high percentages of RAS and RAP/RAS combinations as asphalt binder replacement in both HMA and WMA production processes. (Note: Generally, current practice limits high percentages of binder replacement to 30 percent binder replacement or less.) These engineering properties should be compared to the engineering properties of equivalent binders and mixtures without recycling agents. Mixture properties should be studied on laboratory mixed-laboratory compacted samples, plant mixed-laboratory compacted, and plant mixed-field compacted samples. Changes in engineering properties with time should be quantified. Short-term laboratory conditioning should be fixed, to the extent possible.

The following tasks are proposed: (1) characterize the asphalt binders extracted and recovered from RAP and RAS stockpile materials; (2) characterize the recycling agents used and identify the key properties of recycling agents needed to ensure pavement performance; (3) characterize the asphalt binders extracted and recovered from asphalt paving mixtures prepared with RAS and RAP/RAS combinations, without recycling agents in both HMA and WMA production processes and compare to predicted blending (based on measured mixture properties and predictive equations such as the Hirsch Model); (4) characterize the asphalt binders extracted and recovered from asphalt paving mixtures prepared with RAS and RAP/RAS combinations, with recycling agents in both HMA and WMA production processes and compare to predicted blending (based on measured mixture properties and predictive equations such as the Hirsch Model); (5) characterize the engineering properties of asphalt paving mixtures containing RAS and RAP/RAS combinations without recycling agents in both HMA and WMA production processes; (6) characterize the engineering properties of asphalt paving mixtures containing RAS and RAP/RAS combinations with recycling agents in both HMA and WMA production processes; (7) predict performance of asphalt paving mixtures containing RAS and RAP/RAS combinations, with and without recycling agents; (8) establish field test sections to study the short term performance of asphalt paving mixtures produced containing RAS and RAP/RAS combinations, with/without recycling agents; (9) update and propose revisions as necessary to AASHTO provisional standards MP 15-09, “Use of Reclaimed Asphalt Shingles as an Additive in Hot Mix Asphalt,” PP 53-09, “Design Considerations When Using Reclaimed Asphalt Shingles (RAS) in New Hot Mix Asphalt (HMA),” and M323 “Superpave Volumetric Mix Design.” The revisions should include the use of RAS and RAS/RAP combinations in HMA and WMA (include characterization of the asphalt binders, characterization of mixtures, and mixture design methods); and (10) develop training/workshop materials including recommended practices based on the results of this project and deliver one workshop.

It is anticipated that the majority of the engineering properties of the mixtures will be performed on plant mixed-laboratory compacted samples. The field test sections will be documented such that long-term performance studies can be conducted using these sections on other/future NCHRP research project(s).
Prevention of Galvanized-Induced Weld Cracking in Highway Structures

Due to corrosion concerns, most state departments of transportation use galvanized poles for their ancillary highway structures (signs and lighting towers). In addition, hot-dip galvanizing tanks in the United States have reached lengths where galvanizing entire steel bridge girders can become more commonplace (acknowledging that some bridges have been galvanized). Numerous research articles have been published identifying that galvanized, welded details do demonstrate a lower fatigue resistance than non-galvanized welded details.

American fatigue research using galvanized components has focused on ancillary sign and luminaries structural details, particularly the tube-to-transverse plate connection. There has been a significant amount of research in past 15 years on the fatigue resistance of this connection. Assuming no weld cracking occurs during fabrication, the service life of sign structures can now be adequately predicted. However, if poles with weld cracks are allowed to go into service, premature failure can be expected. As an example, the failure of a galvanized sign structure at the intersection of Route 460 and I-81 in southwest Virginia occurred after less than two years of service. A failure investigation performed by the FHWA concluded that there was a pre-existing crack in the tube wall at the weld toe of the base plate weld. This crack appears to have occurred during or soon after fabrication of the pole and was not detected through inspection. This crack resulted in brittle fracture of the pole in service.

Some researchers have hypothesized that the reduced fatigue strength may be from the formation of microcracks during dipping due to a type of liquid metal embrittlement exacerbated by the zinc bath chemistry. Currently, there are no controls over bath chemistry in the specifications. It is also possible that the cracks may form from the coupling of thermal and welding residual stresses in a constrained volume leading to localized fractures. In each case, the liquid metal tends to fill and hide any such cracks making them undetectable to surface inspection techniques. Since current practice is to inspect welds before galvanizing, any cracks caused during the galvanizing process are therefore not detected. It has also been shown that galvanizing zinc layers have an inherently low cracking threshold and since it is chemically bonded to the steel, those cracks readily grow into the steel substrate.

There is a need to identify the mechanism(s) responsible for the reduction in fatigue strength so that design codes can account for the reduction in fatigue strength, and fabrication/inspection specifications can be modified to mitigate the issue.

A study is needed to understand the physical, chemical, and mechanical mechanisms of which zinc galvanizing reduces the fatigue strength of welded details used in this nation’s highway bridges and ancillary structures. The project must synthesize changes needed for specifications to (1) understand and mitigate the effects of the fatigue life reduction in fabrication, (2) predict the fatigue life reduction in design, and (3) inspect for galvanized-induced cracks in fabrication.
Project 10-95
Acceptable Heat Affected Zone Toughness of A709 Bridge Steel

Research Field: Materials and Construction
Source: AASHTO Highway Subcommittee on Bridges and Structures
Allocation: $500,000
NCHRP Staff: Amir N. Hanna

Research must be performed to establish the acceptable limits of heat affected zone (HAZ) toughness for all welding processes currently allowed by the AASHTO/AWS D1.5 Bridge Welding Code (SMAW, SAW, FCAW, GMAW, and ESW) using ASTM A709 bridge steels.

It is well established that the most brittle part of a ferritic steel weld is in the HAZ due to its coarse grained structure and carbide dissolution due to the weld thermal cycle. The American Welding Society (AWS) has never prescribed a HAZ toughness requirement for welds used in bridge fabrication. The only qualifications of weld metal prescribed in the AWS Bridge Welding Code (AWS D1.5) are macroetches, side-bend tests, reduced section tension test, Charpy V-notch (CVN), and all-weld-metal tension tests. While the side bend and reduced section tension test do include the HAZ, each is just a statically loaded test. Since bridges are subject to variable loading, fatigue and fracture become a concern and AWS currently does not prescribe a dynamic test that includes the weld HAZ.

Other industries outside of bridge commonly perform HAZ toughness testing as part of their welding procedures. The CVN test may be used; this entails cutting a longer than normal specimen, macroetching it to identify the HAZ location, then cutting out a CVN specimen such that the notch is in the HAZ. While the test does nominally increase the cost to the qualification of a welding procedure, it is recognized in other industries to be integral to the development of sound welding procedures. The use of crack-tip opening displacement fracture testing has also been successfully implemented to measure HAZ toughness.

HAZ toughness measurement was performed in development of the Narrow Gap Improved Electroslag Welding (NGI-ESW) process sponsored by FHWA in the 1980s and 1990s. As plates became thicker and higher strength they required higher heat inputs and this adversely affected the HAZ toughness. In some cases, depending if it was a fracture-critical application or not, the resulting HAZ toughness was inadequate when using the AASHTO requirement for base and weld metal. Unfortunately, NGI-ESW welding process may be unnecessarily penalized because some owners require HAZ testing of ESW but not other processes. Some ESW research has shown in certain situations that it may have inadequate HAZ toughness, leading owners to specify this additional testing, though AWS and AASHTO are both silent on what the HAZ toughness should be. HAZ properties are a function of the base metal, the welding process, and its execution.

Of relevance to this research are two FHWA sponsored projects: Fracture Toughness and Weldability Tests for Submerged Arc Welded Joints, FHWA-RD-87/020 and Heat-Affected Zone Toughness of Electroslag Weldments, FHWA-RD-93-014. The first project investigated the HAZ toughness issue in A514 and A588 steels that were welded with SMAW and SAW processes, identified that HAZ toughness can be lower than the weld metal, and recommended further research to determine the significance of the lower values (note that since this research was performed, HPS steels have been introduced to the market, the A514 material has been removed from the A709 specification, and the project did not evaluate FCAW, GMAW, and ESW welding processes). The latter project investigated the HAZ toughness of electroslag welds. It showed that ESW welds in A36 and A588 could achieve Zone 2 non-fracture-critical toughness, but highlighted the sensitivity of making this measurement and urged the need to minimize the heat input to attain desirable CVN toughness (note that this project was limited to the testing of A36 and A588 steel and just one welding process).

The objectives of the research are to (1) experimentally determine the HAZ toughness of many types of A709 steels using the five allowable welding processes of AWS D1.5. This should explore maximum heat inputs that are allowed by AWS through the use of existing qualified weld procedures for a variety of different types of A709 steels and thicknesses, (2) analyze the HAZ toughness criteria to determine an acceptable target of HAZ toughness since the first objective focuses on current acceptable welding techniques, and (3) recom-
mend changes to relevant AASHTO or AWS documents to enforce HAZ toughness requirements if deemed necessary.
The use of civil integrated management (CIM) by state highway agencies has the potential to dramatically improve the delivery of infrastructure projects. 3D design and building information models in the vertical construction industry are well understood, with numerous documented benefits. Many of these same benefits can be achieved in the public transportation sector. CIM is the utilization of intelligent construction practices coupled with advancements in partnering between owners, consultants, and constructors. The use of CIM by the highway construction industry has proven to aid in the delivery of projects ahead of schedule, thus saving the public money. Alternative contracting methods have tapped the ingenuity of surveying technology, information modeling, utilities investigation and marking, real-time quality assurance, with project management occurring in a real-time data cloud environment. It is possible for these same practices to be applied within more traditional project delivery methods. Potential benefits include effective integration with remote sensing technologies (such as LiDAR); improved design efficiency and collaboration through use of virtual design and construction; improved communication of design with stakeholders through use of visualization tools; more accurate material quantities; improved clash detection; ability of contractors to utilize design models for scheduling, estimating, and automated machine guidance (AMG); and use of an as-built model for post-construction asset management.

There are likely to be many benefits to be realized through the expanded use of CIM, or components of CIM, by state departments of transportation (DOTs). However, there are also a number of hurdles that may impede fuller utilization. Some of these include costs, software interoperability, scalability, legal concerns, and institutional issues. As agencies move to utilize CIM principles for delivery of highway projects, there is a need to better understand the barriers that must be overcome prior to full implementation and to document the return on investment that agencies can expect when utilizing CIM. Several studies have been conducted into discrete areas such as 3, 4, 5, xD modeling, AMG, clash detection, and construction model sequencing. In addition, NCHRP Project 20-6, Study Topic 18-03 (the report expected to be published as Legal Research Digest 58) on legal issues surrounding the use of digital intellectual property in design and construction projects may also have bearing. Other research sponsored by NCHRP, Kansas DOT, and Wisconsin DOT may be relevant as well.

In addition, the U.S. Domestic Scan program (NCHRP Project 20-68A) is conducting a review of leading practices in uses of CIM by transportation agencies and others, which will inform this current research project.

Research is needed to review this previous and ongoing work and to describe comprehensively the state of the practice and opportunities for broader application of CIM throughout the DOT project delivery process, including survey, design, contracting/advertisement, construction, final acceptance and operations/asset management. The objective of this research effort is to fully describe the benefits and potential costs DOTs may experience through the use of CIM and strategies for how fuller implementation may be achieved. The project’s focus will be to demonstrate the return on investment in CIM that agencies can achieve, showcasing as examples agencies and firms that are successfully using CIM. Project results will provide guidance for DOT officials on how CIM may be effectively used with various project procurement methods, equipment, and software resources that support CIM; data quality and storage issues associated with CIM; roles of the DOT and partner participants in project development using CIM; and related matters.

The project may entail a literature review of CIM concepts and applications by DOTs and other segments of the construction industry; a survey of DOTs’ awareness of CIM and readiness for increased CIM use; and case studies on document costs, benefits, and implementation obstacles of CIM in DOT practices. The project report will inform DOTs in determining whether and how to increase their use of CIM.

The project will build on a soon-to-be completed domestic scan.
Many state DOTs and the Federal Highway Administration are actively promoting accelerated bridge construction (ABC) to minimize construction-related impacts to the traveling public and to improve work-zone safety while also maintaining quality. The use of prefabricated bridge elements and systems for ABC is growing fast—literally hundreds of projects are being designed and built every year. For the most part, these projects have been built successfully with few problems. Most construction problems encountered to date involve the fit-up of adjacent prefabricated elements and construction erection tolerances.

There are element tolerance manuals published by organizations such as the American Welding Society, the National Steel Bridge Alliance, and the Precast/Prestressed Concrete Institute (PCI). The manuals primarily deal with the fabrication of individual elements that are surrounded by cast-in-place concrete. PCI also has an element tolerance manual that primarily covers vertical construction. These manuals will most likely form the basis of the recommendations for the revisions to the AASHTO Bridge Construction Specifications.

The objective of this research is to determine acceptable and buildable tolerance specifications that can be added to the AASHTO Bridge Construction Specifications. These will be determined based on research of current construction activities, including activities in other industries such as the vertical construction market.

There is an urgent need to develop guidelines for fabrication and erection of prefabricated bridge elements and systems. The establishment of reasonable element tolerances and construction erection tolerances will lead, in turn, to better projects with fewer problems and lower costs. This will lead to greater acceptance of the use of prefabricated elements and systems and accelerated bridge construction.
The need for guidance and standards involving large scale bridge moves is becoming more evident with the increased use of bridge construction acceleration techniques. The practice of moving an entire superstructure and other major bridge components with a single move has become more common in rapid bridge acceleration technology. Examples of major bridge moves in recent practice include “slide-in” operations and the use of self-propelled modular transporters (SPMTs). Bridge location and site conditions can vary significantly, and can also introduce significant challenges in planning large-scale bridge moves for both transportation system owners and contractors. A few of the common issues that need to be considered in heavy bridge moves include, but are not limited to, the following:

- Profile grade (includes both the structure to be moved, and site terrain/access)
- Longitudinal and lateral bracing requirements
- Vertical dynamic forces acting on the bridge and supporting framing caused by movement.
- Lateral dynamic effects acting on the bridge and supporting framing caused by starting and stopping of the bridge during the move.

There have been several manuals published in the United States regarding the use of SPMTs. None of the manuals address the issues of dynamic forces acting on the bridge and supporting framing.

A detailed literature search and review of current “heavy bridge moves” industry practices and methods used by state DOTs and other national and international transportation authorities, summarizing current practices, is needed. This will include a full review of current strategies and practices that have been published as well as other related guidelines, manuals, and studies.

The objective of the proposed research is to develop guidelines and standards for AASHTO consideration and adoption. The research focuses on structural aspects of heavy bridge moves using SPMTs and “slide-in” methods.
Project 12-100

Identifying and Addressing Failures of Small Movement Bridge Expansion Joints

Research Field: Design
Source: AASHTO Highway Subcommittee on Maintenance
Allocation: $150,000
NCHRP Staff: Waseem Dekelbab

Bridge expansion joints, designed to accommodate bridge movement and rotation are also necessary for keeping moisture and corrosive salts from superstructure and substructure elements. A properly functioning expansion joint provides protection for critical bridge elements such as pier and abutment caps, pedestals, bearings, and beam/girder ends from corrosive agents. Proper performance of bridge expansion joints has a significant impact on the service life of multiple bridge elements and, therefore, the long-term serviceability of the structure. The origins of many extensive bridge rehabilitations and even replacement projects can be traced back to a poor performing expansion joints.

Bridge owners understand the importance of bridge joints and invest significant resources toward the design, specifications, and construction of expansion joints. Nonetheless, the performance of bridge joints has been problematic for bridge owners across the country. Improper sizing of the joint seal, poor substrate preparation, and improper application have been cited as some of the reasons for joint failures. To overcome these failure mechanisms, bridge maintenance engineers, material engineers, and bridge designers modify specifications, develop repair strategies, and seek new or replacement materials. Despite these efforts, problems with the performance of bridge expansion joints persist.

The objective of the study is to identify the reasons for the premature failure of small movement expansion joint systems and provide methods aimed at preventing premature failures. The research should include details on proven procedures, methods, design details, and specifications employed by bridge owners specifically for the repair/replacement of small movement expansion joints using currently available joint systems and materials.

Repair and replacement of bridge expansion joints is commonly a major activity for state maintenance forces and bridge maintenance contracts, and a focus of bridge managers. The consequences associated with failed joints systems is the root cause of much of the demand work on bridges. In some districts, demand work consumes 65% of a given work program. A significant reduction on program demands related to steel coatings failures, deterioration of bearings, section loss of bridge girders, concrete beam end deterioration, and the deterioration of reinforced concrete substructures would be realized as a result of properly functioning expansion joints.
The target seismic performance of highway bridges in the AASHTO LRFD Bridge Design and the AASHTO Guide Specifications for LRFD Seismic Bridge Design Specifications is to prevent collapse in the event of strong earthquakes. Reinforced concrete bridge columns are designed to dissipate earthquake energy through considerable ductile nonlinear action associated with severe concrete spalling and yielding of reinforcement. Proven detailing procedures have been developed for reinforced concrete bridge columns that ensure this type of behavior and prevent total bridge collapse. However, for columns to successfully dissipate energy they have to behave as nonlinear elements with substantial damage and possibly permanent drift to the point that the bridge would have to be decommissioned for repair or replacement. The impact of bridge closure on the traveling public and the economy is tremendous and unacceptable. Therefore, alternative design approaches are needed.

Research has shown that column damage and permanent drift can be eliminated using advanced materials and details. Advanced materials and unconventional seismic details have been developed for bridge columns with the specific objective of minimizing damage and residual displacements in bridges while dissipating earthquake energy. The purpose of this research is to develop analysis methods and design criteria for bridges with energy dissipation mechanisms to keep them serviceable even after strong earthquakes. If a large number of bridges incorporate energy dissipating mechanisms, the result will be damage-free columns and post-earthquake disaster scenarios. Plans to respond to disasters will change favorably.

Despite the superior performance of columns with the innovative materials for seismic energy dissipation, the design guidelines and method of structural analysis are not addressed in the current bridge design specifications. Research is needed to develop stand-alone recommended AASHTO LRFD Design Specifications and method of structural analysis for bridge structures with energy dissipation devices in their columns. In developing these specifications, consideration shall be given to constructability, safety, maintenance and inspection issues. The research will produce design specifications with commentary in the format of the AASHTO LRFD Bridge Design Specifications.
An accelerated bridge construction (ABC) guide specification is needed to compile the growing body of recommended design and construction specification products from various research projects on prefabricated bridge elements and systems for ABC (PBES/ABC). The proposed project is envisioned to be similar to NCHRP Project 12-33, which was initiated in the mid-1980s with the objective of developing LRFD-based bridge specifications and commentary for consideration by the AASHTO Subcommittee on Bridges and Structures (SCOBS). Similar to NCHRP Project 12-33, the proposed project will be the first to draw from recently completed PBES/ABC research and will be followed by future research projects as needed to incorporate PBES/ABC specifications developed in subsequent stand-alone research projects. Many state DOTs and the Federal Highway Administration FHWA are actively promoting ABC to reduce traffic impacts, onsite construction time, environmental impacts, and life-cycle costs; and to improve work-zone safety, site constructability, material quality, and product durability.

The objective of the proposed project is to develop an initial ABC design and construction guide specification for consideration and adoption by the AASHTO SCOBS. The project will focus on the compilation of relevant recommended PBES/ABC specifications from completed research. The guide specification is expected to provide engineers with guidance on ABC practices that result in long-lasting details as verified by research.

There is an urgent need to minimize construction-related impacts on the traveling public while replacing the nation’s transportation infrastructure. A compilation of guidance on the use of ABC will facilitate the design and construction of ABC projects and potentially lower design and construction costs. Providing an ABC guide specification will ensure greater acceptance of PBES/ABC and promote more efficient and effective PBES/ABC application as owners address the challenges of renewing the nation’s aging highway infrastructure.
State highway agency equipment fleets represent a significant capital investment and also require recurring maintenance and operational expenditures. Fleet assets are vital to the delivery of agency programs, projects, and services. Efficient management of these assets, including timely replacement, can yield significant savings, as well as improved performance and reliability. Integrating asset management strategies, such as lifecycle cost analysis, into the management of an equipment fleet can improve performance in all facets of fleet operations, but most particularly in determining the most economical point at which to replace equipment in its lifecycle.

The AASHTO Equipment Management Technical Services Program (EMTSP) complements the ongoing work and priorities of the AASHTO Highways Subcommittee on Maintenance Equipment Technical Working Group (TWG). The EMTSP Strategic Plan includes seven clear and measurable goals including actions, specific deliverables, and timelines. Two of the goals that support timely and cost-effective equipment asset replacement are Goal 2: promote awareness of available equipment technologies and Goal 3: advance fleet management best practices.

NCHRP Project 20-07, Task 309, “Challenges and Opportunities: A Strategic Plan for Equipment Management Research” was the result of a research problem statement submitted by the AASHTO Highways Subcommittee on Maintenance (Equipment TWG) in support of Goal 4: establish and support a dynamic equipment fleet management research strategic plan. The objective of this project was to organize the topical areas in which equipment management research is needed, synthesize related research work that has been completed or is currently underway and identify the gaps, and develop a research implementation plan with a prioritized listing of proposed research topics in each of the previously identified areas. One of the top-prioritized grand challenges resulting from that research was to determine when specific types of equipment assets should be replaced in order to optimize the total cost of equipment ownership to the highway agency.

Various methods and practices are used by equipment fleets for determining the appropriate replacement criteria for each of the diverse classifications of equipment assets within those fleets. Many of those methods include customary practices with broad application that are not strictly accurate or reliable for every situation, and some methods merely consist of replicating other fleets’ practices. An accurate and reliable process for determining equipment replacement cycles for each of the various classes of equipment using lifecycle costing principles is needed by the highway agency to make timely and cost-effective equipment replacement decisions. Since the typical highway agency equipment fleet consists of hundreds of equipment classifications, and replacement cycles must be reviewed and updated frequently as the fleet composition changes, an automated process is needed to minimize staff time involved and to provide accurate and timely results. Some agency fleet managers have attempted to use huge spreadsheets and multiple complex formulas to determine replacement cycles for some of the classifications of equipment in their fleets, but found that such manual processes are much too time consuming and labor intensive to be of any practical use, particularly since the process must be repeated as changes in fleet composition occur.

The objective of the research is to develop an automated, computer-based process that uses highway agency equipment fleets’ equipment asset historical cost and usage data to perform lifecycle cost analyses to determine the optimum replacement criteria (e.g., age, mileage, and/or engine hours) for equipment in each of the various classifications. This would help the fleet managers make more accurate and timely equipment replacement decisions, thereby reducing maintenance costs of aged and worn highway equipment, while cost-effectively improving fleet reliability and operational readiness.
In order to achieve the above objective, the following tasks are required: (1) conduct a literature review and synthesis of completed and active research in the area of equipment fleet replacement using lifecycle cost analysis processes, including both public and private fleets with heavy (construction-type) maintenance equipment and trucks; (2) conduct a synthesis of the current equipment replacement criteria and practices used for highway agency equipment fleets and document best practices identified; (3) conduct a survey of State DOT equipment fleet managers to determine what problems and concerns they encounter in developing criteria for the timely and cost-effective replacement of equipment in their fleets; and (4) using information collected in Tasks 1, 2, and 3 above, provide an automated computer-based solution that uses historical cost and usage data uploaded from highway agencies’ fleet management information systems to produce the optimum replacement criteria (e.g., age, mileage, and/or engine hours) for each of the various classifications of equipment in agencies’ fleets. The historical data needs to include, at a minimum, purchase price, maintenance costs, age, usage (mileage or engine hours), and residual value. The solution needs to provide a standard process using normal office hardware that can be used by all highway agency equipment fleet staff. The process of uploading data into the solution will be in a manner such that it can easily be performed by typical fleet management staff without the assistance of information technology professionals.

Note: The AASHTO Standing Committee on Research directed that software maintenance must be addressed up front.
AASHTO and the Federal Highway Administration have been cooperatively working together to develop performance measures that can be used by state DOTs in order improve the condition of the nation’s highways. There are currently a vast number of performance measures used in the various state DOTs, however the only uniform national measure required to be reported to the FHWA is a measure of pavement smoothness: International Roughness Index (IRI). Most pavement experts agree that IRI used only by itself is an inadequate measure of pavement condition, and due to variations in data collection and analysis methodologies, the reported results have not always been comparable between agencies.

Under MAP-21, Congress has required the development and implementation of uniform national performance measures on certain portions of the nation’s highway system. This research will assist state DOTs and FHWA in the development of uniform national performance measures that consider the contributions of pavement preservation treatments to improve pavement performance and extend the service life of existing pavements.

Some member states have reported that the existing emphasis on pavement smoothness has impeded the ability of their agencies to use certain preservation treatments such as chip seals because the pavement surface roughness may not be improved, despite the cost and life extension benefits that chip seal projects typically provide to hot-mix asphalt pavements. This situation results in the use of more expensive surface treatments that may provide improved smoothness, but do not necessarily provide the same level of life extension benefits in proportion to the costs.

The development of a uniform national remaining service life measure will require that several underlying measures and definitions be widely adopted by the various states. The same holds true for many other potential pavement-related performance measures.

Research is needed to comprehensively investigate, categorize, and tabulate the various pavement-related performance measures that are in use around the nation. Once a good inventory is developed and analyzed, it should be possible to identify the most common performance measures, and then make recommendations as to which ones adequately consider the contributions of preservation to pavement performance and service life.

The objective of this research is to identify performance measures that consider the contribution of preservation to pavement performance and service life that can be incorporated into an AASHTO guide document and easily used by the member states and incorporated into their routine management processes. In addition, a database of performance measures will be developed to track the implementation of the recommended performance measures.

It is anticipated that the following tasks will be performed: (1) investigate and inventory the pavement-related performance measures that are currently in use by each state DOT and other AASHTO member agencies. Identify which current performance measures consider the contribution of preservation to pavement performance and service life; (2) review the findings of Task 1 with the project panel and develop a plan to communicate the findings to the member agencies and industry; (3) seek input for recommendations on a precise set of definitions and calculations that could be used to develop a uniform national methodology for a pavement performance measure or measures that will meet the intent of MAP-21. Prepare recommendations for the topic panel that take into account the input provided, and have them approved by the panel; (4) prepare a report of the research findings and a draft guide document that can be adopted by the member agencies for use in their routine management processes. Share the information developed in this process through the use of
webinars and the distribution of the guide document and report; (5) develop a database to track the performance measures that are used in each state as identified in Task 1 and the changes in the performance measures that result from the completion of Task 4. Provide software user guidelines to each member agency to allow them to provide updates to their information in the database.

Note: The AASHTO Standing Committee on Research requested including the issues discussed in Problem No. 2014-C-04, “Guidelines for Including Pavement Preservation in Life Cycle Cost Analysis,” in this research.
Project 15-52

Developing a More Flexible and Context-Sensitive Functional Classification System for Geometric Design

Research Field: Design
Source: AASHTO Highway Subcommittee on Design
Allocation: $250,000
NCHRP Staff: B. Ray Derr

Since 1984, the AASHTO “Green Book” (*A Policy on the Geometric Design of Highways and Streets*) and other roadway design criteria have been based on a functional classification system of a hierarchical roadway network composed of arterials, collector roads, and local roads. This classification is further broken out by an urban or rural designation. This system, though traditional, is rigid. Definitions of arterials and collectors are fairly well defined, and the determination of urban or rural is based on the census. Once a roadway is classified, the designer uses this information to determine design criteria. It is at this point that the designer, through a context-sensitive approach, determines the appropriate design criteria for the project. This rigid system is also used by planners in distributing funding and establishing project priorities. While this is the accepted method, the so-called flexibility in design is initially constrained by the classification. If a more flexible system could be developed for the initial classification, this would enable the designer to address context at a much earlier stage. This would also aid in the public perception of a more flexible and context-sensitive approach to community needs.

The Federal-Aid Highway Act of 1973 required the use of functional highway classification to update and modify the federal-aid highway systems. This legislative requirement is still effective today. Further, procedures for functional classification in urbanized areas are required to be developed within the framework of the continuing, comprehensive, and cooperative planning process carried out pursuant to Section 134 of Title 23, U.S. Code. The Federal Highway Administration’s 2008 Updated Guidance for the Functional Classification of Highways and the Green Book are the principal sources of guidance to transportation planners and designers on the function of the highway system, including the concept of functional classification, hierarchies of movements and components, functional relationships, access needs/controls, and functional system characteristics.

However, over the past three decades or so this system of highway classification has been under increasing scrutiny and discussion due to its inability to flexibly respond to variances in many factors influencing highway design. These factors primarily address context sensitivity and items such as accommodation of bicycles and pedestrians, transit service, aesthetics, livability, on-street parking, and other relationships to a highway’s surrounding environment. Limited research and guidance is available regarding how these factors are impacted by current functional classification guidelines. Very little technical analysis has been done to correlate and balance the elements of traditional functional classification concepts with the range of “contextual” issues noted above. As a result, many technical papers, presentations, and new guidance documents have been developed by a wide range of interests to offer expanded and sometimes new definitions and characteristics of functional classification beyond those provided by FHWA and AASHTO.

The objectives of this research are: (1) develop a more flexible, context-sensitive methodology for classifying roadways; (2) review the traditional methods of classifying roadways based on function; (3) identify historical problems and perceptions with this method; (4) research alternative methods for classifying roadways; (5) develop alternative methods for classifying roadways; (6) develop alternative methods for determining “urban” and “rural” context; and (7) encourage flexibility in the choice of functional classification. The research will build upon related FHWA efforts and NCHRP Project 15-47, “Developing an Improved Highway Geometric Design Process.”

The research study would first review the traditional method(s) for roadway classifications and identify the advantages and disadvantages to this approach. This would be based on the designer’s use of this method for classifying roadways which would subsequently determine controlling design criteria. This would also be based
on planners’ use of the classification system as a method to determine priorities and availability of funds. Public perception of transportation departments’ use of this classification system will also be reviewed.

The research would investigate alternative methods for classifying roadways. This would include alternatives considered or used by state DOTs and other agencies as well as the “new urbanism” approaches. This would include alternative methods for determining density other than the traditional census definition of urban and rural. This would also include a broader classification of the urban and rural environments such as: town centers, central business districts, suburbs, densely or sparsely populated areas, and developed or natural regions, etc.

The research would develop new methods or combinations of methods that might be used to classify roadways with consideration for geographical context. This would be based on the research of innovative methods to classify roadways and may develop from a combination of various ideas. Emphasis would be placed on expanding on the flexibility approach in the Green Book.

The research would consider how the new method(s) might be used in conjunction with the AASHTO Green Book or other design criteria. This would include consideration of context in the initial selection of the functional classification. [Note, this might be similar to the way design speed is now determined in the Green Book by selecting an appropriate design speed for the facility based on context. An agency could similarly be selecting the “appropriate” classification for the roadway based on context and then use this classification system to subsequently utilize design criteria.]

The research would then conclude with how this new method(s) of classification addressed the goals of this research study. How might designers and planners benefit from this system? How might the public and communities be better served?
A general problem that occurs at many existing highway bridge locations throughout the United States is where the required length of need for guardrail that is required at bridge ends cannot be installed due to conflicts within the existing Right-of-Way (R/W) limits. The conflicts may consist of an existing intersecting private driveway, state or local roadway intersection, or other objects that do not allow the placement of the required guardrail length of need. It is not unusual at some existing bridge sites to have 10 feet or less between the end of the bridge and the conflict. Since most typical Test level 3 (TL-3) tangent or flared guardrail end treatment systems are normally around 37–50 feet in length, there is typically a problem with fitting the end treatment systems and guardrail transitions to the bridge rail at these restricted sites. Additionally, no current short radius guardrail system has been able to meet NCHRP Report 350 or MASH Test Level 3 (TL-3) safety performance criteria for high-speed roadways. In many cases the private or public entity is unwilling to relocate the driveway, intersecting roadway, or other conflict and the state DOT is left with dealing with a safety problem.

Traditional solutions are not very practical and prevent the bridge end and any other hazards around the bridge from being properly protected by a longitudinal barrier. In many cases the state DOTs will require that a design exception be acquired to install anything less than the required length of need with the proper guardrail end treatment. State DOTs that use these traditional solutions are also exposed to greater risk to the public being injured in accidents as these sites and future risk to additional litigation from the accidents. Mitigation to this problem has been a need for more than 20 years and was one of the issues specifically called out in the August 18, 1998 AASHTO/FHWA Agreement on implementing NCHRP Report 350. Previous research with short-radius-type systems has either been unable to meet the TL-3 safety criteria and/or have proven unable to meet the space requirements for many of the intersecting roadway sites. Thus, no effective method for treating these sites is currently available for high-speed facilities.

The primary objective of the research would be to develop safety treatment alternatives for documentation in future update of the AASHTO Roadside Design Guide to be used where intersecting driveways, streets, local roads or other conflicts are placed near a bridge end. The designs should be able to be installed where the intersection or conflict is placed within a short distance from the bridge end. If required the design may also be installed in a short distance down the side intersection conflict.

The resulting research efforts would give state DOTs a safety treatment that could be used at these sites with conflicts near bridge ends. The results may also be implemented as a guideline to be used in the AASHTO Roadside Design Guide. The primary payoff is better information that can be used to properly protect bridge ends under these geometrics creating a safer roadside environment for the public and reduce liability issues for state DOTs.
Safe and efficient two-lane highway service is a vital component of the nation’s transportation system. Many two-lane highways serve as the primary means for rural access to urban areas and the Interstate highway system. Recently, the National Surface Transportation Policy and Revenue Study Commission (NSTPRSC) released a long-term plan to ensure the highway system meets the nation’s mobility needs. Two-lane highways are a unique element of the surface transportation system, because, in many instances, they serve extreme conditions of access and mobility with very little intervention from traffic control devices. Development needs on the urban fringe and rural areas can degrade two-lane highway service. Coupled with the high costs and impacts associated with widening to four-lane highways or freeways, the nation increasingly relies on these highways to serve complex combinations of transportation needs. These needs range from accessing adjacent land, commuting, multi-modal accommodation, and freight movement. In essence, designers and decision makers need the ability to analyze two-lane highway service in complex circumstances to evaluate two-lane highway safety and operational capabilities to meet diverse traveler and freight movement needs. However, the tools to evaluate existing and proposed designs are inadequate for the task.

The most widely used operational analysis tool for design of two-lane highways is the Highway Capacity Manual (HCM). However, the current HCM methodology has several shortcomings that make it difficult to use in an established network. For example, it is difficult to use for evaluation purposes, it does not address some two-lane highway types (especially in developing urban fringe areas), and the performance measures are not easy to check or measure in the field. Collecting sufficient amounts of two-lane highway field data to use exclusively for the development of an analysis methodology is not practical. Due to the lengths of roadway involved and the complexity of passing maneuvers in the oncoming lane, the time and cost of such data collection is typically well beyond the resources of any given research effort. Thus, it will be necessary to also utilize a simulation tool to be able to efficiently complete the development of a new two-lane highway analysis methodology.

For traffic safety, the Highway Safety Manual (HSM) and the Interactive Highway Safety Design Model (IHSDM) work in concert to assess the safety of two-lane highway design features. These features include all of the major segment design features related to vertical and horizontal alignment and auxiliary lanes. They also include intersection features and traffic control safety effects. Only the basic elements of two-lane highway operations are addressed, where TWOPAS provides IHSDM with highway segment performance. Similarly, the HCM only allows for variations in demand, grade, passing zone percentage, passing lanes, and truck lanes. However, there is no way to assess operational effects of intersections or highway alignment improvements. Because of these limitations, engineers and planners have no comprehensive means to evaluate traffic operational performance and the corresponding safety performance for common two-lane highway conditions.

Therefore, the objectives of this research are to: 1) create a calibrated two-lane highway simulation tool that can be used to develop operational models for the HCM and assist in the evaluation of the safety effects of operation in the HSM and IHSDM, 2) test several candidate performance measures and identify the most promising one(s), and 3) develop new performance relationships using the preferred performance measure(s).
Countermeasures, such as rumble strips/stripes, delineators, and barriers have proven to reduce both total crashes and serious injury crashes (NCHRP Report 641); however there is limited guidance on their specific performance. Improved guidance is needed on when and what type of countermeasure is appropriate, and what roadway factors (average daily traffic, horizontal curves, speed limits, access control, etc.) may lead to higher opposite direction crash frequency rates. Additionally, guidance on progression of countermeasures (i.e., rumble strips/stripes to additional separation to addition of barriers) and how these countermeasures could be applied on a systemic basis to proactively address opposite direction crashes is not well documented in AASHTO guidance.

Although many opposite direction crash countermeasures have been studied individually, a full synthesis of the state of the practice in a wide range of opposite direction countermeasures does not exist. Median barrier for divided roads and centerline rumble strips for undivided roads have been the most studied countermeasures, but other countermeasures, such as reallocating lane width to create a small buffer median between opposing lanes, may be appropriate in some applications. The proposed research will provide guidance on the application of effective countermeasures. A comprehensive guide on opposite direction countermeasures combined with a better understanding of what roadway factors increase opposite direction crash risk would aid policymakers to invest cost-effectively in countermeasures to reduce crashes on their road systems.

The objective of this research is to first identify roadway factors that influence opposite direction crashes and their frequency, such as ADT, horizontal curves, speed limits, access control, etc. After determining the locations where opposite direction crashes are likely to occur, the study will quantify the safety performance of countermeasures in place individually and when used together, such as rumble strips/stripes, providing separation between opposing lanes, addition of a barrier, etc., if there are differences between performance of countermeasures on tangent and curved roads, the extent that barrier placement in narrow medians may increase collisions, and if the countermeasures impact other road users (such as bicyclists and motorcyclists) as well as adjacent property owners (i.e., noise from rumble strips/stripes).

The AASHTO Technical Committee on Roadside Safety (TCRS) in conjunction with TRB Roadside Safety Design Committee (AFB20) has identified the need for design guidance on ‘Reducing the Potential for Vehicles to Leave the Travel Way’. The information developed as part of this study would provide specific guidance to be included in the next update of the AASHTO Roadside Design Guide (RDG) and would assist agencies in selecting and prioritizing opposite direction crash countermeasures as part of their safety programs. The information may also be used to enhance the AASHTO Highway Safety Manual (HSM) to refine information on recommended countermeasures and the expected substantive safety associated with each type of application. It is expected that this research will also provide guidance to respond to a National Transportation Safety Board (NTSB) Recommendation (H-06-13) in which NTSB requested AASHTO work with the Federal Highway Administration to establish evaluative criteria for determining when to install median barriers on high-volume, high-speed roadways, regardless of access type.

Note: The AASHTO Standing Committee on Research directed that the study address only two-lane highways.
Identification of Factors Contributing to the Decline of Traffic Fatalities in the United States

Research Field: Traffic
Source: AASHTO Highway Subcommittee on Traffic Engineering, AASHTO Standing Committee on Highway Traffic Safety, Virginia
Allocation: $300,000
NCHRP Staff: Mark S. Bush

AASHTO and its committees actively support improving safety on our nation’s roads, including the Standing Committee on Highway Traffic Safety (SCOHTS) and Standing Committee on Highways Subcommittee on Traffic Engineering (SCOTE). Among various other responsibilities, these groups are charged with measuring and improving safety performance. They are committed to identifying and communicating best practices related to achieving good safety performance results. Research is needed to identify the factors contributing to recent significant declines in highway fatalities, in order to support efforts to promote data-driven, performance-based programs. This research is directly linked to strategic and action plans for these groups, and will support efforts to improve safety programs by increasing knowledge needed to focus safety efforts most effectively.

The United States experienced a steady decline in the number of highway fatalities since 2005, with a dramatic decline starting in 2007, according to data from the National Highway Traffic Safety Administration. Even with the reduction in deaths on our nation’s roads, highway fatalities and serious injuries remain a significant threat to public health. In fact, while we saw a significant decline in fatalities from 2005 to 2010, data from 2011 and early 2012 show a much slower decline in fatalities and even an increase in some states. With the passage of reauthorization of federal transportation funding—Moving Ahead for Progress in the 21st Century (MAP-21)—states will be required to increase focus on safety performance targets, especially those involving fatalities and serious injuries. Safety practitioners need to understand how various factors have affected highway fatality trends, in order to continue to implement programs that make the best use of limited funds and personnel and make progress toward meeting performance targets.

Various explanations have been offered to account for the significant reduction in crashes in recent years. Such factors as increased seat belt usage, safer vehicles, better roads, increased funding for safety infrastructure improvements, the economic downturn, changes in teen licensing laws, enhanced enforcement efforts, and others have been identified as possible contributors to the downward trend in crashes. To date, no comprehensive analysis of crash data and contributing factors has been performed to determine the relative impact of various factors. Such an analysis would seek correlation between the crash data and a myriad of data sources such as levels of highway spending, installation of corridor-wide accident countermeasures, levels of highway enforcement, levels of funding for educational campaigns targeting driver behavior, average percent expenditure on safety features in automobiles, increase in highway safety-related legislation (particularly regarding teen drivers), economic indicators, etc.

The objective of this research is to identify and quantify the primary factors contributing to the recent sustained decline in highway crashes and crash rates in the United States using comprehensive empirical data. The major tasks will include: (1) review relevant research on factors contributing to recent fatality trends, and identify opportunities for applying results to this effort, if appropriate; (2) compile time series data sets for the state and national levels from a variety of data sources; (3) determine appropriate analysis methods; (4) identify the potential contributing factors; (5) analyze the identified factors and their safety effects using empirical data; and (6) interpret and present analysis results. It is recommended that the research proceed in two phases, with the first phase providing recommendations as to a proposed analysis method for NCHRP approval prior to performing the remaining research tasks. It is recommended that data from 2005 and forward be the focal point of the analysis in order to capture both the dramatic decline in fatalities (which began in 2008) as well as factors related to federal funding authorized in SAFETEA-LU.
The United States has seen a steady and sustained reduction in highway crashes and crash rates over the past 16 years. While the steady improvement in highway safety is inarguable, this research will identify those measures and countermeasures that have been effective in bringing about that improvement. Without a comprehensive study of the crash data and the possible contributing factors creating the decline in crashes, it is difficult for highway safety practitioners to know where resources are best directed. The will optimize allocation of safety resources especially within the recent years where there has not been such a dramatic decrease in fatalities. The research will assist states to determine where to most effectively apply their capital, operating, and human resources to reestablish the trend and meet the goal of toward zero deaths.

Project 17-68

Research Field: Traffic
Source: AASHTO Standing Committee on Highway Traffic Safety, Washington
Allocation: $600,000
NCHRP Staff: Mark S. Bush

Research is needed to expand the range of intersection types addressed in the predictive methods in Chapters 10, 11, and 12 of the AASHTO Highway Safety Manual (HSM). These methods address many of the more common intersection configurations and traffic control types, but there are many configurations that still need to be addressed to maximize the utility of the HSM. Moreover, the existing methods do not include the ability to predict the change in the severity distribution as a result of a change in the intersection’s design or traffic control features. Specific examples of intersection configurations and traffic control modes not currently addressed in the HSM include: intersections with all-way stop control, intersections on high-speed expressways, three-leg intersections on rural highways with signal control, three-leg intersections with a commercial driveway forming a fourth leg, and five-leg intersections. The intersection at a single-point diamond interchange is also not currently addressed. Additionally, the methods do not currently address whether intersections located on horizontal curves or near crest vertical curves have higher crash frequencies. This expanded coverage will support the AASHTO SCOHTS’ Strategic Plan (June 2011) by addressing Goal 2, related to institutionalization and further development of the Highway Safety Manual, and Goal 4, Strategy 4 by developing tools that can better quantify changes in safety performance.

The objective of the research is to develop a set of safety prediction methods that are comprehensive in their ability to address a wide range of intersection configurations and traffic control modes in rural and urban areas. The focus of the research will be: (1) address intersection configurations and traffic control types not currently addressed in the HSM; and (2) include supplemental models for predicting the severity distribution as a function of geometric design elements and traffic control features. Roundabouts will not be addressed in this research because a separate project is planned to focus on roundabout safety.

To achieve the objective, the research will have the following tasks at a minimum to produce models and a comprehensive method for predicting the expected safety performance of intersections: (1) through interaction with HSM users and other safety professionals, identify the types of intersection configurations that are not adequately addressed by the HSM, and develop criteria for prioritizing these configurations; (2) identify the geometric design, traffic control, and traffic volume factors that should be included in a safety prediction method for each configuration, and gather data needed to prioritize the configurations; (3) use the information obtained in previous tasks to prioritize the configurations to be addressed in this research; (4) review the predictive methods developed in HSM Part C, so that the results for the new facility types can be used together with results for existing facility types; (5) review the guiding principles established for HSM development, and available guidance concerning measures of safety, research protocols, and other potentially applicable topics; (6) assess alternative modeling approaches and recommend the approach most suited to achieving the project objectives; (7) obtain data for modeling, including existing data and new data, as appropriate; (8) develop and validate models; (9) demonstrate the application of the models to practical examples; (10) develop draft materials for the HSM, including appropriate integration of those materials with the existing method produced for HSM Part C; (11) demonstrate the application of the new methods with a spreadsheet tool; and (12) identify areas for which further research will be needed to enhance the models (citing specific study protocols, data collection alternatives, appropriate analysis techniques, and potential policy implications). The predictive methods developed in this research will include safety performance functions (SPFs), crash modification factors (CMFs), and calibration factors in a format that is consistent with the predictive methods in the existing HSM Part C.

This expanded coverage will support the AASHTO SCOHTS’ Strategic Plan by addressing Goal 2, related to institutionalization and further development of the Highway Safety Manual, and Goal 4, developing
tools that can better quantify changes in safety performance. The research will also develop recommendations how the research results can be implemented through other initiatives. The expected product will be a set of intersection safety prediction methods that can be incorporated in a future edition of the AASHTO HSM.
The AASHTO Standing Committee on Highway Traffic Safety’s (SCOHTS) Strategic Plan demonstrates its commitment to serving as a national leader in the effort to reduce highway fatalities. SCOHTS is supporting the development and implementation of the Toward Zero Deaths (TZD) National Strategy on Highway Safety. While the National Strategy will encourage safety professionals to build upon lessons learned with, and to expand the use of, countermeasures and programs currently in use, a key element of the National Strategy will encourage changing highway safety culture in the United States. This includes both the highway safety culture amongst road users and the safety culture of agencies responsible for the local, state, and national surface roadway systems.

Road users need to make safety-driven decisions related to how they drive, walk, cycle, and ride on the roads. Basing decisions on potential time savings, a perceived lack of impact on other road users, or on an overestimation of their own abilities can lead to actions that harm themselves or others. Traffic safety culture explains “differences in international, regional and demographic crash risk, as well as the propensity to commit high risk behaviors.” Changing traffic safety culture among road users (vehicle, bicyclists, and pedestrians) would result in decisions that recognize potential safety impacts on themselves or other road users based on the new belief that all of their actions need to be based on safety. Changes in road-user traffic safety culture would also foster widespread public support among road users for additional enabling legislation, increased funding, and other resources needed to further implement these countermeasures.

From a professional or organizational perspective, a change in safety culture would give safety a higher weight in decisions that impact the transportation network and its operation. This is not to say that all decisions should be made solely based on safety. However, organizational barriers to accommodating additional consideration of safety data and needs could be bridged to allow for stronger safety input into decisions.

Changing safety culture is a complex challenge because there are many levels of social influence that give rise to a culture. For example, traffic safety culture is a reflection of social influences from local (e.g., family, workplace, community) and more distant influences (e.g., state and national). Moreover, any change in traffic safety culture among road users needs to be embodied by the safety culture of traffic safety agencies to ensure the translation of this cultural change to the roadway system and traffic safety metrics. Finally, any program focused on traffic safety culture should be focused on long-term transformation rather than only short-term change to support sustainable improvements in traffic safety. In this regard, while individual strategies or initiatives such as public information campaigns on specific issues contribute to changing the safety culture, it is necessary to develop a process for transforming the culture so that safety is a factor in every transportation decision whether personal or organizational. The goal should be a systematic and comprehensive national action plan to enable an enduring transformation of traffic safety culture to enable sustainable improvements in traffic safety.

As a foundation to developing this plan, research is needed to understand the current status of highway safety culture in the United States and to develop potential strategies expected to be effective in improving road-user and organizational safety culture. The Transportation Research Board formed a Subcommittee on Roadway Safety Cultures, which first met in 2012. The subcommittee members determined that an important first step to any work in this field will be to conduct a comprehensive synthesis of policies and practice for improving roadway safety cultures. An evaluation of some of the efforts currently underway, in the U.S. and abroad, is needed to both understand their effectiveness and to describe these programs to other safety partners.

In support of the SCOHTS strategic plan goal related to the national TZD initiative, SCOHTS will work on implementing strategies to influence the safety culture to make fatalities and serious injuries, as well as
contributing factors, unacceptable at the national, state, and local levels. Actions related to this goal include developing a plan for implementation by AASHTO of safety culture actions recommended in the upcoming National Strategy, sharing experiences related to improving safety culture within highway agencies and among road users, and identifying additional research needs in conjunction with partners such as the TRB subcommittee. This proposed research would contribute to these SCOHTS activities.

Since 2008, the AAA Foundation for Traffic Safety (AAAFTS) has performed surveys of road users to gain a better understanding of traffic safety culture (Traffic Safety Culture Index). The survey looks at attitudes and behaviors related to impaired driving, cell phone use, speeding, seatbelt and helmet use, and other issues. The report of the 2011 survey states that, similar to their earlier surveys, nearly half of the respondents have been affected by a serious crash, and there is general support by a majority of respondents for efforts to improve safety. However, many respondents also report engaging in unsafe behaviors while at the same time believing it is wrong to do so.

The Western Transportation Institute (WTI) at Montana State University developed a white paper on traffic safety culture to support the national TZD effort. This white paper discusses how safety culture influences behavior, and these concepts can be used to develop methods resulting in changed behavior. This paper recommends the development of a framework to guide efforts in the safety culture area and discusses barriers to making progress in this area, which will provide useful direction to the proposed research.

The Center for Health and Safety Culture at WTI has proposed an action plan framework to address the transformation of the nation’s traffic safety culture. This framework describes the levels of organizations or entities that are involved in the traffic safety system. It suggests that strategies for transforming safety culture will vary across the entities in these levels, which range from national to individual. The recommended activities involved in changing safety culture include assessing current traffic safety culture and identifying common themes among the various entities at all the levels in the traffic safety system, developing strategies for changing safety culture, pilot testing and refining these strategies, and implementing these strategies systemwide. This process will be cyclical, so evaluation of the effectiveness of strategies and identification of additional needs are also key activities.

The Center for Health and Safety Culture at WTI has also been involved in research to measure the traffic safety culture of road users within several states as well as to conduct a pilot study for a survey tool to measure the safety culture of state DOTs.

The objective of this research will be to perform several of the initial steps recommended in the WTI Action Plan Framework for Transforming Traffic Safety Culture. Specifically, this includes:

1. Characterizing current traffic safety culture. Understanding the current traffic safety culture will help provide focus for the action plan. This could include an analysis of existing datasets (e.g., AAAFTS Traffic Safety Culture Index) and a review of relevant research publications on the topic of traffic safety culture. In addition, this could also include further development of existing survey tools to measure common and divergent aspects of state DOTs and other transportation agency safety cultures (e.g., how much agreement is there amongst agencies on the meaning of “traffic safety culture” and which types of programs are related to traffic safety culture).

2. Establishing a general framework to guide the process for transforming safety culture. This would include identifying relevant stakeholders necessary to support the transformation process and a program development model to guide the prioritization, design, and implementation of strategic programs to transform the traffic safety culture.

3. Developing a portfolio of strategies based on the priorities identified. This would include a review of the state of the practice in applying the policies and programs directed at transforming traffic safety culture, with the goal of reducing death and serious injury from traffic crashes. By examining factors related to the context, acceptance, and effectiveness of these programs, safety practitioners and researchers may then be able to identify, modify, or develop future traffic safety culture programs compatible with the context and needs of a specific community or (sub)culture to support effective traffic safety culture programs.
During the research effort, current programs that are, or appear to be, contributing to a change in safety culture should be described, with an explanation of how these efforts address opportunities for specific entities in the traffic safety system. Other efforts to change culture related to specific issues, such as smoking or impaired driving, should also be examined for strategies that could be adapted for use in traffic safety culture efforts. Future research should focus on pilot testing and refining the identified strategies and developing resources that fully develop and engage the proposed action plan for transforming traffic safety culture.

Improving traffic safety culture is a key element in the Toward Zero Deaths National Strategy on Highway Safety currently under development. Though the need for this improvement is accepted, little is known about how to achieve this on a nationwide scale. It is also accepted that it will take a long time to achieve this change. Therefore, it is important that research on this aspect of highway safety begin as soon as possible so that safety partners, including state DOTs, can begin implementing effective strategies. With the development of the National Strategy nearing completion, it is expected that the AASHTO Board of Directors will soon adopt it as the updated AASHTO Strategic Highway Safety Plan. SCOHTS will then be responsible for implementing the Plan, and this will include addressing the safety culture issues. This research is needed to support the efforts both of AASHTO and of individual member departments, and will also help the TRB Subcommittee on Roadway Safety Cultures identify additional research needs in this area.
The AASHTO Highway Safety Manual (HSM) currently includes crash prediction models for traditional intersection forms (e.g., four-legged, signalized intersections) found on rural two-lane roads, rural multilane highways, and urban/suburban arterials. These prediction models allow transportation professionals to assess the benefits of providing turn lanes, modifying intersection phasing, adding intersection lighting, and other such design decisions. Currently, the HSM does not include a crash prediction method for roundabouts; therefore, practitioners are not able to assess quantitatively the crash reduction benefits of providing a roundabout at a specific intersection or to investigate safety effects of complex design decisions at single-lane and multilane roundabouts. Research consistently indicates roundabouts generally provide substantial reductions in crashes. While crash modification factors (CMFs) for roundabouts have been developed, these CMFs do not reflect the safety effects of site-specific roundabout design features. Roundabouts are not addressed at all in the predictive methods in HSM Chapter 10 (two-lane highways) or Chapter 11 (multilane highways); predictive methods are needed for roundabouts on these roadway types. An interim procedure for roundabouts, based on CMFs, in HSM Chapter 12 (urban and suburban arterials) needs to be replaced with a full predictive method.

NCHRP Report: 672 Roundabouts: An Informational Guide, Section Edition begins to address the need for roundabout crash prediction models, but due to the scope of that research, the level of detail needed to address the types of questions noted above is limited. The following are examples of key design questions left unanswered by current roundabout related research:

1. Does the inscribed circle diameter (ICD) of a roundabout influence the number of crashes at the roundabout?
2. Does intersection skew influence crashes at a roundabout?
3. Do the posted speeds on the approaching roadways influence the number of crashes at the roundabout? If yes, what physical attributes can be incorporated into the roundabout design to mitigate such crashes?
4. Do the length and/or design of splitter islands influence the number or type of crashes occurring at the roundabout?
5. Does path overlap on a multilane roundabout entry influence crash frequency? If so, how?
6. Is there a difference in crash frequency on roundabouts with curvilinear exits vs. tangential exits?
7. Does lane width at the roundabout entry and/or circulatory lane width influence crashes at a roundabout?
8. Are the attributes influencing crashes at urban/suburban roundabouts different than those influencing crashes at rural roundabouts? What are those attributes?

These questions need quantitative answers and those quantitative answers need to be incorporated in an HSM predictive method so that highway agencies can take maximum advantage of the potential safety benefits of roundabouts. This research problem statement was identified and developed based on efforts from NCHRP Project 20-7, Task 279, “Development of a Work Plan for the 2nd Edition of the Highway Safety Manual,” and is directly linked to AASHTO SCOHTS Strategic Plan Goal 2, Strategies 2 and 4.

The objective of this research is to develop crash prediction methods for single-lane and multilane roundabouts in a full range of rural and urban contexts for incorporation in HSM Chapters 10, 11, and 12. These methods will be made available to safety practitioners throughout the U.S. and ultimately incorporated into the second edition of the HSM. The highest priority in the research should be assigned to quantifying the safety performance of implementing a roundabout at a particular location so that it can be compared to alternative intersection configurations for the same location. The research should also quantify the safety effects of round-
bout design features, so that highway agencies can choose the most appropriate roundabout design for specific projects.

The research should include the following task activities: Identify literature related to crash prediction models for roundabouts—both in the U.S. and internationally. Assess previous database of roundabouts used in the NCHRP Report 672 research. Assess new sources of data to be able to expand the data set and produce more robust roundabout prediction models for rural and urban/suburban contexts. Determine appropriate modeling procedures and approaches for developing roundabout prediction models that can be integrated into the existing HSM Part C, Predictive Method chapters. Develop and test safety performance functions (SPFs) and distributions by crash severity level and crash types, develop CMFs for specific roundabout features that can be used with the SPFs, and test, refine, and finalize the models and procedures as appropriate. Develop text to be added to HSM Chapters 10, 11, and 12 for the HSM Second Edition. Develop recommendations for incorporation of this material into the HSM and implementation by the highway safety community.

Joint meetings and discussions between AASHTO Safety Management Subcommittee Task Group for Technical Safety Publication Oversight and Outreach, TRB Highway Safety Performance Committee, and FHWA have identified the need for additional crash prediction models to advance HSM implementation and ultimately to further reduce serious crashes on all public roadways. This research problem statement was identified and developed based on efforts from NCHRP Project 20-7, Task 279, “Development of a Work Plan for the 2nd Edition of the Highway Safety Manual,” and is directly linked to AASHTO SCOHTS Strategic Plan Goal 2, Strategies 2 and 4. It addresses the need to identify and develop technical support to assist states in advancing HSM implementation and is considered a high priority to address the states’ needs. The current ability to quantitatively consider the safety effects of decisions made in designing roundabouts is very limited. It is understood in the field of safety that roundabouts generally offer safety benefits; however, the specific, critical attributes that make some roundabouts more successful at reducing crashes compared to others is not understood. Developing crash prediction models that enable practitioners to understand and compare these key design trade-offs will result in better informed decisions and higher return dividends on safety investments.

The expected products of this research are the development of SPFs and crash modification factors that can be used to estimate the severity and number crashes likely at a roundabout (single lane or multilane) under a variety of rural and urban contexts. The results of this research can be incorporated in future versions of the AASHTO HSM, the AASHTO Safety Analyst software, and the Interactive Highway Safety Design Model software. The user community for this research includes state and local agencies responsible for safety management. The results can be used in planning more effective safety programs and projects.
Information technology, software, management practices, expectations, and uses are changing at an
astonishing rate and state DOTs are not well prepared to address and keep pace with these changes. The DOT
must deal with information distributed throughout the organization, within business units, records management
systems, libraries, mainframe computers, servers, and other repositories. The quantities and complexity of
information continue to grow. At the same time, DOTs must work with their existing legacy systems while
trying to modernize and thereby gain the increased functionality, lower costs, and other benefits of evolving
new technology, information-system design, and management practices. Senior DOT officials must consider
such issues to understand their agencies’ information options and make investment decisions. Obsolete, inade-
quate, or inaccessible information pose threats for an agency’s capability to effectively achieve its mission.

Previous work by NCHRP and others has provided some guidance on specific tools or investment stra-
tegies in specific topic areas (for example, NCHRP Report 666: Target-Setting Methods and Data Management
to Support Performance-Based Resource Allocation by Transportation Agencies, NCHRP Report 576: TransXML:
XML Schemas for Exchange of Transportation Data). There is a need for guidance to assist senior
executives seeking to develop a comprehensive understanding of their agencies’ information and information-
management needs, the investment strategies for ensuring the agency’s ability to meet those needs, and the
investments to be made to pursue an effective strategy—for example, in hardware, software, management
procedures, system design, and staffing. The objective of this research project is to develop such guidance,
designed for use by DOT CEOs, other executives, and senior managers. The guidance should be brief, clear,
and direct, accompanied by in-depth supporting material, to help this audience understand the evolution of
information management issues and evaluate information management projects and emergent technology,
independent of specific information applications and platforms.
Improving Findability and Relevance in Transportation Information

Research Field: Special Projects
Source: AASHTO Standing Committee on Research
Allocation: $500,000
NCHRP Staff: Andrew C. Lemer

Information is among the most valuable assets for which a transportation agency is responsible, but finding the right information to support analysis and decision-making is often difficult. The enterprise’s information—collectively also termed content—may exist in many forms, both structured (such as employee or project files stored in databases) and unstructured (for example, reports, drawings, and web pages). Enterprises, public and private, invest in information- and content-management systems designed to collect, retain, and make information available in useful forms when and where it is needed. Experts estimate that 80% to 90% of information is unstructured, that an agency’s employees may spend up to 35% of their time looking for information, and that as many as 70% of enterprise content management systems fail because of underinvestment in the tools needed to find relevant information when it is needed.

These tools include metadata frameworks; taxonomies and other structured vocabularies; format and location conventions (for example, uniform resource locator, URL, or digital object identifier, DOI); practices for engaging subject-matter experts in the work of maintaining information and making it accessible; and more. While the principles and procedures that are developed for information and content management are generally useful in many fields of knowledge, each particular field—medicine, law, finance, transportation, and others—requires adaptations to meet the particular needs of the field’s practitioners.

Some work has already been done within the transportation community to improve information findability, including for example development of the Transportation Research Thesaurus (TRT), the Freight Data Dictionary, and creation of topical web portals such as AASHTO’s Workforce Toolkit or the U.S. DOT Climate Change Clearinghouse. However, for a variety of reasons, the tools available are not serving fully the needs of transportation information creators and users. The scope of what available tools were designed to do is too limited for current tasks. Technology and practices may have evolved beyond the capabilities of the tools. Growth in the amounts of information to be managed may overwhelm current management systems. Information may become obsolete because its owners and curators have too few resources to make corrections and updates that inevitably are needed. Additional work is needed to facilitate finding of transportation information and redirecting the time lost looking for information to other pressing business needs.

The objective of this research is to advance findability of transportation information by (1) establishing a common metadata schema; (2) identifying good practices for content description, facilitating effective participation by subject matter experts; and (3) adapting library science practices to transportation information applications and identifying other management strategies that facilitate information sharing within structured and unstructured data networks.

The common metadata schema for transportation information will describe types of information and the information life cycle (that is, how long information of various types is kept, how it is expected to be used, and the like). Content description would include guidance on common language, key descriptors for information that business units should maintain, controlled vocabularies for consistent use across transportation practice areas, tagging schemes, and the like. Management practices may include web ontology languages, application program interfaces, and simple knowledge organization system applications, whether derived from library science or other information management practice areas.

The project is likely to entail reviews of literature, information standards, and practices in transportation and other fields as well as strategic analysis of current and evolving DOT information needs. One or more pilot tests might be used to demonstrate the use of findability tools developed in the research. The research product will build on previous work and provide guidance for transportation and information management professionals responsible for ensuring that DOT official can find the information they need to make effective decisions.
State departments of transportation (DOTs) are experiencing loss of knowledge: physical and electronic information resources become underutilized or inaccessible through incomplete management; employees depart through retirements, downsizing, and reorganization. Reduction in training programs creates challenges in developing employees’ capabilities. Thinner workforces make it difficult to provide mentoring for new and transitional employees. While some agencies have employed focused recruitment and succession planning to help mitigate knowledge loss and ease transitions, such tactics are not able to address all aspects of knowledge transfer and capture need to stem the loss.

Knowledge management comprises the variety of principles, strategies, and practices used by an organization to identify, collect, organize, preserve, disseminate, share, generate, and apply critical knowledge. Knowledge management embraces a variety of practices to help avoid knowledge loss and promote capture. Knowledge audits, workforce risk assessment, and knowledge mapping help evaluate strengths and weaknesses. Recruitment, communities of practice, information organization, and training provide methods to address areas of weak or at-risk knowledge. Knowledge interviews, targeted use of retirees, videos, and documentation of operational practice and organizational history help capture knowledge.

Many DOTs use some of these practices, but few do so with an enterprise-wide perspective on strategically managing the organization’s knowledge resources. Research is needed to describe comprehensively the value of DOT knowledge management; the strategies, techniques, and tools agencies can use to retain, enhance, and manage their knowledge bases; and the returns on investments in knowledge management.

The objective of this research is to develop a primer on knowledge management for DOTs. The primer will provide guidance on knowledge management practices in many fields; context and resources for effective use of such practices by DOTs; and the specific tactics likely to be effective in addressing the types of knowledge loss DOTs experience. The guidance will assist DOT staff and leadership in assessing the importance of knowledge management to their agencies, developing effective knowledge management strategies, allocating resources needed to support these strategies, and acting to success fully maintain critical knowledge within a DOT. The primer may be supplemented by webinars, sponsored meetings, and other dissemination and outreach activities.
Communication is crucial to the transportation community’s effort to secure adequate funding for transportation infrastructure and to the internal management of transportation agencies, yet external and internal communication by state departments of transportation are two of the least-studied subjects in transportation.

The last public relations guide for state departments of transportation, *NCHRP Report 364: Public Outreach Handbook for Departments of Transportation*, was published in 1994. Since then, the Internet and mobile communication technologies have provided new opportunities to communicate with the public and receive feedback. Advances have been made in the fields of corporate communication (a view that marketing, public relations, government relations and internal communication efforts should be aligned and integrated into strategic plans) and cognitive science (how differing ways of describing gas tax increases can alter psychological responses).

The purpose of the research is to create a website with a collection of resources that will help transportation agency leaders understand the importance of communication, especially external communication, to advancing their efforts to maintain transportation infrastructure, to provide guidance on creating external and internal communication plans linked to strategic plans, to inform them of best practices for managing crisis communication, to show how communication effectiveness can be measured, and what skills to look for in prospective communications personnel. For practicing communications professionals, this collection would include best practices for common communication challenges such as environmental controversies, accident-prone locations, and transportation funding, as well as “libraries” of high-quality examples of communication products, including infographics, illustrations, photographs, videos, website design, and social media messages and design.

The research would include the following tasks:

1. Review existing literature on external communication (including governmental relations, marketing and public information programs) by state departments of transportation and internal communication within DOTs, including *NCHRP Report 364*. Glean the useful information and synthesize it under the following categories:
   - Transportation Communication: An Overview
   - Communication Audits
   - External Communication Plans
   - Internal Communication Plans
   - Crises and Common Communication Challenges
   - Measuring Communication Effectiveness
   - Hiring Communication Professionals
   - Additional Sources of Information
2. Include a general overview of relevant current trends and research in corporate communication and cognitive science under “Transportation Communication: An Overview.”
3. Research methodologies for communication audits.
   - Select a methodology that would be appropriate for assessing communication by and within state departments of transportation. Provide sample documents.
• Survey DOTs to determine if any have performed communication audits (may have gone by another term or been part of a larger assessment of the agency). Develop or identify a principles-into-practice-type case study of this effort and its results.

4. Define external communication, including the concept that various types of communication can compete for prominence and resources within an organization.
   • Discuss how this function is performed at all levels within a DOT, that is, most employees interact with the public in some way.
   • Discuss the growing number of external communication opportunities and the need to select and combine optimal media for different types of messages and audiences.
   • Provide a case study of development and implementation of an external communication plan that is linked to a strategic plan.
   • Identify and provide the best examples of external communication plans.
   • Show some best practices/examples of effective use of new media channels.

5. Define internal communication and emphasize how communication with and among employees affects their communication with external stakeholders. [“The informal flow of information throughout a company is what drives the business,” Ruth Stanat in The Intelligent Corporation, 1990.]
   • Identify and provide copies of the best examples of internal communication plans.
   • Provide a case study of development and implementation of an internal communication plan that is linked to a strategic plan.

6. Review and summarize best practices for communicating during transportation-related crises such as weather events and multiple-fatality crashes.
   • Include materials used by AASHTO to train DOT CEOs to handle crises. If possible, find or create videos in which DOT CEOs discuss crises they have managed.
   • Identify common communication challenges such as transportation funding campaigns, environmental controversies, accident-prone locations and public meetings where controversial issues will be discussed.
   • Provide best practices, examples for challenges identified above.

7. Review best practices for customer satisfaction surveys that measure the effectiveness of DOT external communication efforts.
   • Identify or create a case study where a DOT designed a customer satisfaction survey, implemented it, reviewed the results, and used the results to improve external communication. Discuss the survey cost, drafting of the RFP, and selection of the consultant to perform the survey.
   • Provide examples of well-designed surveys and resulting reports.
   • Review best practices for internal communication survey (can be part of an organization health survey).
   • Identify or create a case study that discusses design of the internal communication survey, implementation, the results, and how results were used to improve management of the DOT. Discuss the survey cost, drafting of the RFP, and selection of the consultant to perform the survey.
   • Provide an example of a well-designed internal communication survey and the resulting report.
   • Discuss how to use Google Analytics or similar software to evaluate the design and use of a DOT website or intranet.
   • Provide a methodology for user-testing website designs. [Steve Krug’s Rocket Surgery Made Easy has a simple, low-cost, in-house method.]

8. Assess skills and abilities needed by communication personnel.
   • Survey DOT officials regarding the skills and abilities they look for in communication personnel.
   • Survey active communication professionals in DOTs on their education, training, and skills.
   • Identify or develop good examples of job descriptions, interview questions, and performance evaluation standards.
9. Just like technical professionals within DOTs, communication professionals benefit from membership and participation in professional organizations and continuing education and training. Provide some case studies of continuing education and training for education for communication professionals and how they ultimately benefitted the DOT.

10. Provide a list of additional resources, including those at http://trblist.org/subjectglossaries.

For all these tasks, there will be a need to scale best practices. What may be possible and effective at a large DOT with a large number of communications-focused personnel may not be possible in states with small staffs.

The AASHTO Subcommittee on Transportation Communications (TransComm) and the AASHTO Communications office would be responsible for hosting, maintaining and updating the website created by this project.

Note: The AASHTO Standing Committee on Research warned that the final deliverable should be a handbook or toolkit, not a website.
Project 21-10

AASHTO Manual on Subsurface Investigations – Manual Update

Research Field: Soils and Geology
Source: AASHTO Highway Subcommittee on Materials
Allocation: $300,000
NCHRP Staff: David A. Reynaud

The AASHTO Manual on Subsurface Investigations was completed in 1988 as a National Cooperative Highway Research Program project. Since that time, substantial changes have occurred within engineering and project development and delivery practices, while the need for fundamental geotechnical subsurface investigation guidance for the state of practice remains essential toward reducing project uncertainties and providing cost-effective geotechnical design and construction solutions. The AASHTO Manual on Subsurface Investigations is frequently referenced within AASHTO documentation and by many state highway agencies as an authoritative guidance manual for conducting subsurface investigations for highway applications. The existing 1988 AASHTO Manual on Subsurface Investigations needs updating to reflect current practices, guidance, and technological advancements within computer processing, automation, instrumentation and exploration and testing equipment and techniques; load and resistance factored design and reliability-based design methodologies; assessment and management of project risks; geotechnical data management; investigations for site-specific seismic evaluations; investigations for the evaluation and performance monitoring of existing structures, foundation systems and geotechnical features; quality assurance; alternative project development and delivery methods.

The objective of this effort is to revise the AASHTO Subsurface Investigation Manual to reflect proven current practices and innovations within geotechnical subsurface investigation in order to advance the state of practice for highway transportation facilities. This objective would be achieved by reviewing the current AASHTO Subsurface Investigation Manual for necessary changes, synthesizing advancements and current practices within geotechnical subsurface investigation, and incorporating proven techniques and practices within the Subsurface Investigation Manual that provide greater value to the design, construction and performance of highway transportation facilities and infrastructure. Methods to quantify and evaluate the relative value of subsurface investigations for highway transportation facilities and existing infrastructure with respect to project risks, costs, and performance shall also be developed and incorporated.

Updating the guidance provided within the AASHTO Subsurface Investigation Manual will reestablish the standard of practice for conducting, contracting and using the information obtained from geotechnical subsurface investigations for highway transportation projects. Highway Agencies adopting these practices will be able to more rapidly and effectively characterize subsurface conditions; better manage and minimize design and construction risks associated with uncertainties and variations of subsurface conditions; and refine geotechnical and foundation designs to provide safe, reliable and cost-effective solutions. As a reestablished authoritative guidance document, implementation will simply involve publishing and disseminating the updated AASHTO Subsurface Investigation Manual for its incorporation within the procedural guidance and processes of state highway agency programs.
Crashworthy end terminals are installed on the ends of highway traffic barriers to develop the strength of the barrier system and to provide crash protection to occupants of vehicles that impact the ends of barrier installations. Impact performance criteria for end terminals are provided in MASH, based on full-scale crash testing. FHWA procedures and regulations require that end terminals installed on federal-aid highway projects generally must meet MASH or NCHRP Report 350 criteria, and also provide requirements for upgrading older barrier end terminals to meet these new criteria under certain conditions.

The AASHTO Roadside Design Guide provides additional guidance on selection and installation of barrier end terminals, again generally based on systems that comply with the MASH criteria or with the earlier NCHRP Report 350 criteria. Simply relying on full-scale crash tests to assess the long-term performance of safety features is risky, and may overlook important aspects of crash safety as well as other aspects of device performance. Crash tests are conducted under specific standardized and idealized conditions, and do not consider the full range of actual impacts that are actually expected to occur in the real world—including such factors as vehicle weight, type, and configuration; impact speed and angle; and vehicle orientation. Further, crash tests do not consider the wide range of environmental conditions to which devices are actually exposed, such as snow and ice, saturated soil conditions, frozen ground, and very high and low temperature ranges. The effects of these conditions are, therefore, generally unknown, although it is not unreasonable to expect that they may affect device performance. Finally, other factors such as device maintenance and repair of minor impacts including minor variations in device installation may also affect real-world performance. The bottom line is that end terminals that perform acceptably in full-scale crash tests may not provide the level of protection expected over the full range of conditions that may be encountered in actual service on the highway; evaluating end-terminal performance in the field over the life of the device is the only real way to judge the long-term effectiveness of the hardware.

Upgrades are based almost entirely on crash test performance, and do not consider how well the end terminals are actually performing in service. State DOTs run the risk of either keeping unsatisfactory hardware in the field or needlessly replacing older devices that are functioning well even though they do not meet the current crash test requirements. As an example, the switch from NCHRP Report 230 terminals to NCHRP Report 350 terminals accomplished in the mid-1990s cost many millions of dollars; yet it is unknown if there was an appreciable improvement in safety even though NCHRP Report 350 terminals certainly have better crash test performance. Limited highway resources make it imperative that any safety features used on new projects, and upgrading of features on existing highways, must be done in the most cost-effective manner possible. The need to fully understand the real-world performance of new terminals, as well as the comparative performance of the wide range of terminals currently in service makes it urgently important to evaluate the actual in-service performance of the full range of barrier end terminals on the nation’s highway system.

The objective of this research will be to (1) work with selected states to conduct an in-service performance study to evaluate the real-world impact performance of the most common barrier end terminals currently in service in this country; (2) develop a list of in-service factors that may affect end terminal performance; and (3) evaluate the comparative crash performance of end terminals currently in service in terms of injury severity, secondary crash involvement, repair costs, and routine maintenance needs.

The completed research will provide information that can be used in making policy decisions about replacements and up-grading new terminals. The AASHTO/FHWA joint implementation plan called for MASH testing to be required for the development of new hardware beginning January 1, 2011. In-service performance evaluations of end terminals will then be possible to determine if a whole-sale replacement of terminal technol-
ogy is required or which NCHRP Report 350 end-terminals can be left in-service. Making good decisions about MASH end-terminal implementation requires that in-service performance evaluations be performed to develop policy.

Note: The AASHTO Standing Committee on Research directed that tort liability implications be considered.
Project 24-41

Defining the Boundary of Geosynthetic Reinforced Soil Behavior

Research Field: Soils and Geology
Source: Federal Highway Administration
Allocation: $500,000
NCHRP Staff: David A. Reynaud

Geosynthetic mechanically stabilized earth (GMSE) and geosynthetic reinforced soil (GRS) have been successfully used for retaining wall support since the 1970s. While both GMSE and GRS incorporate layers of compacted granular fill material and geosynthetic reinforcement connected to a facing element, GRS consists of closer reinforcement spacing, typically 8 inches, whereas GMSE consists of larger spacing. Researchers and practitioners have noted that the observed performance (e.g., vertical and lateral deformation, thrust against the face, capacity, etc.) at both the strength and service limit states for closely spaced GRS is considerably different than that of larger spaced GMSE for a variety of applications, including retaining walls and bridge abutments.

The current AASHTO LRFD Bridge Design Specifications do not distinguish between GRS and GMSE, and recommends the same design methodology (i.e., the Simplified Method) for both technologies. The Simplified Method models the reinforcement as tie-back elements whereby the purpose of the geosynthetic is to provide tensile resistance to the driving forces; however, in GRS, where reinforcement spacing is close, the geosynthetic serves multiple purposes (e.g., to increase confinement, to reduce lateral deformation, to suppress dilation.). The impact of these added functions are not accounted for by the Simplified Method or other proposed design models for GMSE which can lead to overly conservative and costly GRS designs.

The Federal Highway Administration (FHWA) has taken the first steps in differentiating between GMSE and GRS design and construction with separate guidance for each technology; the Simplified Method for GMSE and the Composite Method for GRS. The boundary between the design models is based on reinforcement spacing; however, the composite behavior of reinforced soil likely depends on more than the reinforcement spacing, including reinforced backfill properties, reinforcement properties, facing rigidity, and loading conditions. Before distinguishing the two technologies and implementing changes to the AASHTO LRFD Bridge Design Specifications, the AASHTO Bridge Committee’s T-15 technical committee has expressed interest to FHWA in further defining the boundary of the composite nature of geosynthetic reinforced soil.

This proposed NCHRP project will evaluate the impact of the various related factors on the boundary between GMSE and GRS that result in a difference in performance. Recommendations on when to use a tie-back design model versus a composite design model for various applications will also be developed. The intended research product is modifications to the AASHTO specifications that enable recognition of a separate design model for closely spaced GRS different from that currently used for GMSE design, thus allowing for broader and more cost-effective application of GRS.
The ongoing occurrence of stream channel migration and scour are often cited as the leading cause of bridge failures in the U.S. The growing need for techniques to control stream instability and scour occurrences have spawned considerable research on the benefits of various types of hydraulic countermeasures and a number of publications have been written, including FHWA’s HEC 23, that provide guidance on the applicability and design of different countermeasure types.

A necessary component found in many countermeasure designs is the provision of a filter between the countermeasure and the underlying soil. While the countermeasure protects the soil from the shear stresses that erode the soil particles, a filter has been found to be necessary to prevent the removal of soil particles through the voids and cracks in the countermeasure structure. Installations that do not include a filter often slow down the scour process but ultimately the removal of supporting soil particles results in an undermining and failure of the countermeasure. Geotextiles have become the filter of choice for most designers but granular filters are also possible.

The current technical guidance on countermeasure design includes recommendations for either a geotextile or a granular filter to be placed under the countermeasure. However there is little guidance to construction personnel on actual installation techniques when installing a filter under water. Through interviews conducted in FHWA hydraulic program reviews of state DOTs and from technical assistance calls from bridge owners, it has become apparent that few countermeasure installations in water actually include a filter as shown on the design plans and as recommended in the technical guidance publications.

The DOT construction personnel and the general contractors who perform the countermeasure installations have not been educated on how countermeasures function and the value of an underlying filter. Without this knowledge of the function of a properly installed filter, construction personnel may simply eliminate filters underwater rather than develop creative techniques for installation in flowing water.

The objective of this research is to conduct a study on filter installation techniques in various underwater conditions and develop specific guidance tailored for construction personnel on the function of filters and installation techniques in various depths and velocities of stream flow for placing geotextiles and granular filters under countermeasures. This guidance will include a written description with graphic illustrations of filters and their function. Installation techniques will be described with photographs and will include video illustration of actual installation processes.

FHWA hydraulic program reviews of state DOT filter design and installation practice and technical assistance calls from bridge owners indicate that few countermeasure installations in water include a filter as shown on the design plans and as recommended in the technical guidance publications. DOT construction personnel and contractors have not been educated in the function and importance of filters nor in techniques for installing them under water. Since an appropriate filter is an essential component of countermeasure armoring systems, this practice must be corrected immediately if these systems are to function as designed.
Truck freight movements generate a significant amount of transportation greenhouse gas and particulate emissions, and the amount is expected to increase in the future. At the same time, air quality regulations are becoming more stringent. States are expecting to need to look more closely at reducing truck freight emissions in order to meet new air quality standards.

While emission reduction technologies for heavy-duty diesel trucks are proven, adoption rates have been slow, despite a sometimes short payback period. Research is needed to understand the emissions and fuel reduction technologies available, the challenges to wider adoption of those technologies, where certain technologies best fit driver geography and supply-chain needs, and the potential emission reductions.

The focus on freight corridors is an attempt to capitalize on economies of scale with greater numbers of trucks using freight routes and to address concerns from residents living near heavily traveled heavy-duty truck freight routes who are disproportionately exposed to those emissions.

The research objective is to identify the most appropriate and cost-effective technologies for reducing air emissions and fuel use for heavy-duty diesel trucks operating along heavily used truck routes that serve as freight corridors.

The following tasks are suggested to meet the research objective: (1) Describe existing and emerging emissions reduction technologies, including alternative fuels, and their cost and benefits for heavy-duty trucks; (2) Identify economic, technological, and social challenges to wider adoption of emission reduction technologies; (3) Determine the characteristics of freight routes that fit with technology options and best address the challenges identified; (4) Provide real-life examples based on U.S. metropolitan and/or geographic areas; and (5) Quantify potential emission reductions if clean freight options are adopted.
As indicated in the 2003 TRB Access Management Manual: “Roads are an important public resource. They are costly to build and to improve or replace. In a revenue-constrained environment, effective management of the transportation system is not an option—it is essential. It is simply not practical to allow major arterial roadways to deteriorate under the assumption that they will be replaced or reconstructed in the future. Yet many areas continue to do just that—by allowing closely spaced curb cuts, median openings across a turn lane, driveways in a major intersection, or poorly coordinated traffic signals—thus creating unsafe and congested conditions on major roadways.”

In the past, much of the research on the benefits of access management was related to operational and safety effects. There is limited information available to transportation agencies regarding the economic impacts of access management. Research typically focused on addressing the concerns of business owners that changes in access to their property—such as consolidating driveways or installing raised medians—will lead to fewer customers and reduced sales. Much of this research related to the economic effects focused on non-traversable medians. There has been little documentation of the costs related to poorly managing access.

This lack of information contributes to difficulties that agencies have in administering their access management programs. These difficulties may include an agency having to assume the cost for improvements not assigned to a developer to mitigate adverse effects of development-related traffic. These costs could range from providing a traffic signal, a right- or left-turn lane, or a median where none exists to making major modifications such as widening a highway or constructing a bypass or new interchange. In addition, there are liabilities to an agency, including those related to congestion and crashes, until mitigation can be implemented. There are also land use decisions, such as allowing subdivisions with each property having access to an arterial (e.g., “death by a thousand cuts”), which could have potential costs and liabilities involving public funding for improvements to maintain the same highway performance level. These all represent additional burdens that are especially problematic to agencies in a poor economic environment. This research will provide information and tools to assist agencies in making access management decisions, recognizing asset management implications such as managing assets to achieve the greatest return on the investment made in the transportation system.

The main objective of the research is to develop guidance for public agencies to use in making decisions regarding access management by helping them identify the benefits and costs of access management for maximizing the public’s investment in the highway system. This will help guide agency access-related decisions and assist in the formulation and justification of access management solutions that may offer the best outcome but may require additional time or cost up front, especially in an environment where there are insufficient funds for basic needs and operations. The research will also benefit agencies by providing information that would be used in achieving asset management objectives.

The research will involve identifying strategies used by agencies to be proactive in their access-related decisions to minimize their costs and liabilities. This will include agencies with a wide range of access management programs—from those having comprehensive programs to those that focus their efforts on administering driveway permits. Information will be compiled on cost savings and benefits related to liability considerations from applying their access management criteria.

Recognizing the potential difficulty in estimating costs savings, the research also will compile information to identify the costs and liabilities related to what happens when decisions are made that do not adequately consider access-related impacts. Traffic operations and safety information would be included. This information will be presented in the form of case studies. To the extent available, data will include costs related to right-of-way and traffic crashes. These case studies would be reported anonymously to encourage agencies to
share their experience. This approach was successfully used in *NCHRP Synthesis 404: State of the Practice in Highway Access Management* to report on access management program barriers and difficulties.

Outreach will include state, regional, county, city, and local agencies that represent a wide range of access management and related programs and decision making processes. The research will identify the effects of decisions related to new development, redevelopment, and road improvement projects. To the extent available, the research will reflect information related to agency funding sources for managing access and liabilities emanating from poor access management practices.

Research is expected to include (1) developing the work program; (2) locating and assembling documented information as part of a literature search and review of available access management references; (3) identifying complementary research to identify any synergies with this effort; (4) surveying agencies to obtain information they have relating to economic effect and suggested candidates for case studies—sections of the survey could allow for anonymity (as was done for *NCHRP Synthesis 404*) to help encourage agencies to share their experiences; (5) compiling the information, including the development of the case studies that will demonstrate lessons learned and the costs/liabilities of access management decisions—case studies will include access management projects recently constructed in different environments (e.g., urban, rural, suburban); (6) identifying methods for agencies to apply in making informed, comprehensive access management decisions with consideration of the potential cost/liability of options that would not mitigate adverse effects (for example, the impact of development-related traffic that results in the need for intersection improvements, such as traffic signalization); and (7) identifying areas of future research needs.

The guidance should be useful by professionals at all levels of government to help them make access management decisions in a proactive manner. This research has the potential for a large benefit in terms of cost and sustainability, with a relatively small investment. This research would be useful to national level policymakers, state DOTs, metropolitan planning organizations, regional planning agencies, developers, and others interested in access management.

Note: The AASHTO Standing Committee on Research asked that aspects of Problem No. 2014-G-29 be considered as practical.
Project 25-48

Streamlining Project Level Air Quality Analysis through Development of New Tools/Interfaces

Research Field: Transportation Planning
Source: AASHTO Standing Committee on the Environment
Allocation: $420,000 (Additional $80,000 from Federal Highway Administration)
NCHRP Staff: Nanda Srinivasan

Beginning on December 20, 2012, transportation project sponsors are required to use new modeling software for compliance with the National Environmental Policy Act and transportation conformity requirements. The U.S. Environmental Protection Agency (EPA) has developed a new Mobile Vehicle Emissions Simulator (MOVES) model that will be required for modeling carbon monoxide (CO), course particulate matter (PM10), fine particulate matter (PM2.5), and mobile source air toxics (MSATs). The model will also be used for discretionary greenhouse gas analysis. MOVES requires much higher modeling expertise and more detailed traffic inputs than the previous emissions model, particularly because the FHWA had developed a streamlined graphic user interface for the older model (EMIT).

In addition to the new MOVES model, projects will be required to use a dispersion model CAL3QHC, CAL3QHCR or AERMOD, that most state DOTs are unfamiliar with and generally require more modeling expertise than currently resides within agencies.

The result of these new requirements is that many state DOTs will be unable to perform air quality analysis internally, which will increase project costs. Further, the complexity of the new models will make it difficult to perform quality assurance checks and increase the likelihood that analysis will be inconsistent between projects when performed by external consultants who are also just beginning to learn the new models. Therefore, new user-friendly tools are needed to facilitate air quality analysis and function as a template for consistency between projects.

The goal of this project is to develop a new user-friendly tool(s)/interface(s) that run(s) both the MOVES and dispersion models for criteria pollutants and MOVES-only for greenhouse gases and MSATs. The tool(s)/interface(s) should be built to be able to be updated when changes are made to either the emissions (MOVES) or dispersion (CAL3QHC, CAL3QHCR, AERMOD) models.
The design and engineering of on-street bikeways in the United States is an adolescent field in comparison to the design and engineering of roadways for automobiles. As the field matures, bikeway design types must be understood in relation to their impact on ridership, operations, safety, the surrounding community, and in the way they can engage broad segments of the population in cycling. At the same time advances in GPS data gathering, smartphone data gathering, on-line incident tracking systems, and bicycle counting technology have given transportation practitioners new techniques for assessing bicyclist route choice and the systemic impacts (safety, bicycle volumes) that result from those choices. This project will analyze bikeway designs in the context of contrasting urban area types including a dense large-city downtown and ex-urban areas characterized by rapidly-growing smaller cities served by one or few major roadways (often state routes running through the center of what used to be rural communities). The research will pay special attention to: (1) Analyzing the relationship between urban bicyclist demographics and attitudes and bicyclists' facility type preferences, including a review of existing studies to guide this research on potential correlations between those factors; (2) Assessing the current practices for bicyclist safety data gathering to determine if data is sufficient to assess specific facility effects. Then, (a) if sufficient data exists, studying the effects of on-street facility type on overall safety, or (b) if data is insufficient, recommending improved safety data acquisition practices or extending the research; and (3) Understanding bicyclist route choice effects and resulting system impacts of bikeway installations in different types of urban regions by studying locations where on-street bicycle facilities have been deployed in urban areas. The studied facility types will include relatively new design options the impacts of which are not yet well-understood such as shared bus/bike lanes and sharrows. The area types should include at least one dense large-city downtown and one or more smaller cities whose downtown is served by a major arterial or state highway.

This research will evolve from existing work by designing thorough and comprehensive data gathering activities at chosen sites focused on discovering bicyclist facility preferences and understanding at least the opportunities and needs for employing safety data to discover facility type safety effects. Preferably it will also advance our understanding of the latter, if appropriate by extending the research project. It will leverage both existing and new survey capabilities, using existing usage and safety data where possible and recommending new safety data collection tasks as needed. The results will include a detailed statistical examination of bicyclist preferences for facilities and, as data permits, the safety and system effects that result from deploying different types of facilities.

The goal of this research is to examine holistically bicycle facility types from the viewpoints of bicyclists and the effects of facilities on overall transportation system outcomes. The primary outcomes sought are: (1) An enhanced understanding of bicyclists’ facility preferences, and (2) A more comprehensive picture of the transport system impacts of implementing different types of on-street bicycle facilities in different urban contexts.

Objective 1 – Understand existing bicycle data opportunities
- Review existing data collection efforts, especially those cited above, that have surveyed and/or tracked the route choices of bicyclists in various cities;
- Identify bicycle facilities in place and planned in cities that are potential preference assessment sites;
• Report in detail what incident and usage data exists in the same cities and understand what bicycle counting capabilities exist;
• Determine the potential of combining and repurposing these existing sources to meet the research needs;
• Identify the most productive sites for additional primary facility preference data gathering, at least one in a dense large-city downtown and the other(s) in a portion or portions of the same region consisting of rapidly-growing smaller cities served by one or a few major arterials or state routes.

Objective 2 – Understand bicyclist facility preferences in the chosen locations
• Design and conduct appropriate primary bicyclist facility data gathering in selected sites. For example, combine GPS-tracked actual route choice with standard travel diary data and a stated-preference component addressing respondent attitudes toward different facility options.
• Estimate statistical models appropriate to testing the significance, separately and in combination, of revealed route (facility) preferences, stated preferences, and traveler attitudes;
• Report findings on detailed demographic and attitudinal factor significance on traveler preferences for specific facility types.

Objective 3 – Understand opportunities for applying safety data to understanding bicycle facility safety effects
• Assess existing data and report its potential use in quantifying facility type safety outcomes. For example, a meta-study to understand how safety data is collected in the United States and whether or how it has been and could be applied.
• If possible, assemble and analyze a bicycle safety data set to understand facility effects on safety. If appropriate, the research team can propose to extend the study to further explore and implement means of understanding safety effects.

Objective 4 – Make research results useful to practitioners
• Compile the research findings into a practical guidance document designed to inform practitioners about the potential effects of different bike facility investment choices;
• Make suggestions in the guidance document on how to best work with agencies that collect system and incident/safety data;
• Create a proof-of-concept sketch-level tool (or equivalent) that allows practitioners to quickly estimate the facility preferences of bicyclists given sufficient demographic information and demonstrates the quantitative outcomes of the research. For example, a spreadsheet that estimates probable facility preferences for a specified population.
Movement of wildlife across state highways can result in animal vehicle collisions and unsafe traveling conditions for both the traveling public and wildlife. In the United States, reported wildlife vehicle collisions average about 300,000 per year. Collisions that result in less than $1,000 in property damage are generally not reported and it’s been estimated that between one and two million collisions between vehicles and large animals occur in the United States each year. In addition, wildlife vehicle collisions are increasing while total collisions have remained relatively stable. Roughly 4-10 percent of reported wildlife vehicle collisions result in human injury which translates to approximately 26,000 injuries per year. An estimated 200 people die from wildlife vehicle collisions in the United States each year. The total annual cost associated with wildlife vehicle collisions has been estimated at over $8 billion. These collisions also have consequences for wildlife. For populations of rare wildlife, the loss of individual animals to vehicles can have a significant impact on the survival of the population. Road mortality has been documented as a major threat for 21 federally listed threatened or endangered animal species.

To increase motorist safety and maintain rare populations of animals, transportation agencies need to prevent wildlife vehicle collisions. However, for many species, long term survival depends upon the ability for animals to move about. Using fencing or other barrier types to keep animals off of roads is not acceptable when it results in extensive barriers to wildlife movement. The lowest cost option for providing safe passage for wildlife involves existing bridges and culverts. Due to limited funding, construction of new animal crossing structures can usually only happen at the highest priority locations. Identifying those high priority locations demands an understanding of the distribution and suitability of existing structures. There are tens of thousands of existing bridges and culverts in the U.S. transportation system that currently function or, with modifications, could function to provide safe passage for wildlife. Efficient use of transportation dollars is dependent upon understanding the wildlife passage values associated with existing structures.

In 2011, WSDOT completed a study that produced an assessment methodology for evaluating bridges and culverts for their potential to pass different types of wildlife. This methodology differentiates—for different types of wildlife—between structures that are currently functional, those that could be enhanced to become more functional, and those that are not functional for wildlife passage. It also makes recommendations as to how to make the structures more functional. Now that the assessment methodology has been completed, there are additional steps that should be taken to make it a fully functional tool for all states to use. The first is to field verify the methodology by applying it to various structures in widespread locations which have been monitored through the use of motion-triggered cameras (At a minimum, California, Utah, Montana, Wyoming, Arizona, and Oregon have data from motion-triggered cameras placed at safe passage structures). This will allow for refinement of the tool, adapting it to local wildlife and landscape conditions. The second step it to refine the data collection and storage methodology. Currently the tool uses paper data sheets to collect and store the data. Developing a program that would work on a hand held computer to collect data and a program for storing and tying to a GIS layer will allow for effective storage and retrieval of the data by each state. The intention is to eventually use this evaluation tool for corridor planning, structure enhancement, and as an integral part of highway and bridge project design.

This project will take a recently completed structure assessment tool and will apply it in the field to structures associated with previous remote camera monitoring at locations distributed across the United States. This will allow for verification and refinement of the model. In addition a hand held computer application will be developed and refined along with a data storage method (database) that will tie into a GIS lay so that the information will be ready available for project planning needs. By applying the Passage Assessment System and
implementing the recommendations to shift wildlife movements to enhanced conditions over or under our roadways, at existing structures, will result in low cost improvements that benefit both the traveling public and wildlife.