Immediate Action Requested

On March 25 and 26, the AASHTO Standing Committee on Research (SCOR) formulated the NCHRP's FY 2015 program. Now, looking ahead to the task of establishing project panels for new projects, we are forwarding the scope statements (see attached) and asking for your help in identifying individuals with expertise directly relevant to the research proposed for each project.

Although the FY 2015 projects are tentative (they have not yet been approved by States' ballot), we are soliciting now for nominees to meet future deadlines and will appreciate anything you can do to provide information as soon as possible but **not later than June 23, 2014**. To aid you in distributing appropriate project statements to qualified individuals, individual descriptions of each new project are attached.

To ensure proper consideration when making nominations, we need as many details as possible on your nominee's affiliation, title, address, and, most importantly, technical areas of competence related to the particular problem (a brief resume would be helpful). We also encourage submittals via e-mail which can be addressed to ablackwell@nas.edu. Please make sure that only business-related addresses, phone numbers, and e-mail contacts are provided. To help us to identify nominees who are members of historically underrepresented groups, we encourage the nomination of women and members of minority groups. Please use the attached form if a resume is not available; the form is attached in 2 formats, a PDF format and a Word form for ease of completion on-line. Contacts to determine an individual's interest in serving will be made from this office after we have matched available expertise with that required by the nature of the project.

Panels for the new projects are scheduled to meet beginning in August through September. Panel members are prohibited from submitting or participating in preparation of proposals on projects under their jurisdiction. They serve without compensation but are paid travel and subsistence expenses. Travel insurance is provided at no cost to the members. In many cases, only two meetings are held in the life of a project, and these normally occur in Washington, D.C. The first meeting is to develop a project statement that is used to solicit proposals; the second meeting is to select a research agency from among those submitting proposals. Other meetings may be dictated by project circumstances; however, they are few and usually at least a year apart.

Membership on each panel will number approximately eight, and panels operate under the guidance of a permanent chairman--see attached "Functions of NCHRP Panels". The NCHRP staff serves as the secretariat.

We are grateful for your support of the NCHRP by providing nominees each year. With the nominees continuing to outnumber the available positions by about four to one, we have been able to establish panels outstanding in their ability to play a fundamental role in the accomplishment of successful research. Please realize that if your nominee(s) is not selected, that there are several factors to be considered when forming well balanced and objective panels. Although expertise is the primary factor, we also attempt a proper balance in terms of geographic areas, organization or agency types (e.g., public and private agencies, universities, associations, local and state government), and gender and ethnic diversity.
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SUMMARY OF APPROVED RESEARCH PROJECTS

♦ Project 01-56

Defining Comparable Pavement Cracking Data

Research Field: Design
Source: Maryland
Allocation: $300,000
NCHRP Staff: Edward T. Harrigan

Many state and local agencies collect downward pavement imagery using highway-speed data collection vehicles with subsequent processing of these images using proprietary semi-automated crack detection and classification software to identify pavement cracking for use in asset management. Additionally, other agencies use visual collection methods to document cracking distresses. These data are currently used for two primary purposes: (1) state reporting of pavement cracking condition for fuel performance reporting, budgeting, and project selection, and (2) reporting of cracking data to the Federal Highway Administration (FHWA) through the Highway Performance Monitoring System (HPMS).

There are a multitude of state and local methods for defining, classifying, and reporting cracking data derived from these “automated” methods. Additionally the HPMS stores resulting cracking data for use in modeling the performance of pavements on the National Highway System. The HPMS requires states to (1) estimate percent area with fatigue type cracking for all severity levels for asphalt concrete (AC) pavements in the wheel paths, and the percent of slabs with cracking in portland cement concrete (PCC) pavements; and (2) estimate the relative length in feet per mile of transverse cracking for AC pavements and reflection transverse cracking for composite pavements where AC is the top surface layer.

There are significant differences between the methods each agency uses to sample, detect, measure, and report cracking type, quantity, location, and severity, which cause the results to be incomparable between states, even when similar data collection technology is used. When reporting for HPMS, most states have to employ separate procedures (different than their production state crack detection processes) to produce this data set. FHWA is under increasing pressure to define performance goals for the National Highway System. Therefore, standardization of pavement cracking data must take place before a performance goal relative to pavement cracking can be implemented. The nature of pavements is not so diverse that common terms to describe distress types cannot be developed.

The first phase of this research is to define common cracking measurement terms for potential standardization. Regardless of the collection method, states manage, analyze, and report cracking data electronically, thus providing support for the development of a standard file format. The second phase of this research is to conduct a software needs assessment to aid in the procurement of a production cracking evaluation software. As part of the needs assessment, input must be received from end users including state and local pavement management practitioners, researchers, and FHWA. The engineering software should be designed to (1) detect and rate cracking data from commonly collected downward imagery in standard terms, allowing for high speed automated or manual rating; (2) input visual cracking data; and (3) report using a standard file format. The proposed research will be used to standardize the collection and reporting of cracking data. The standard terms could serve as the basis for future federal performance measures, and will establish focus and common language to compare cracking performance of pavements in and among different agencies. The needs assessment will be used for future procurement of software by agencies which collect and report cracking data and will be made available to the public.

The development of repeatable performance measures is an essential foundation for establishing a performance-driven asset management plan, as required in MAP-21. Pavement cracking is a core component of measuring the performance of pavement, and measuring the improvement gained through most pavement preservation activities (which often do not improve IRI). The resulting research will build the foundation for creating and maintaining cracking evaluation software to be used by pavement asset managers, pavement
engineers, and the FHWA, and will create resulting common comparative metrics; similar to the way ProVAL has been used aid in consistently reporting the International Roughness Index. Pavement cracking deserves similar attention, particularly with recent emphases on performance-driven asset management and cost effective preservation treatments that primarily improve cracking.

The objective of this research is to develop the framework necessary for software to be developed that will identify and report pavement cracking in comparable terms across diverse pavement networks. Accomplishing this objective will require the following tasks: (1) Conduct a literature review to identify the state of the practice across state agencies. (2) Conduct a software review to identify features used by pavement evaluation practitioners. (3) Survey state, local, and federal agencies and industry to incorporate the state of the practice related to (a) cracking terms and measures presently used, and those desired to be used by state pavement asset managers; (b) cracking terms and measures desired by FHWA for future use; (c) software features desired by pavement management practitioners; and (d) software features desired by FHWA. (4) Develop a needs assessment document describing the common cracking measures to be used, features and algorithms to be incorporated into alpha and beta versions of software for cracking detection, rating and reporting. This research shall be coordinated with that of the proposed Transportation Pooled Fund Project titled “Improving the Quality of Pavement Surface Distress and Transverse Profile Data Collection and Analysis.”
The proliferation of access points and lack of adequate supporting street networks have significantly reduced the safety and efficiency of our nation’s highways. To address these issues, a growing number of state and regional transportation agencies across the United States are engaging in corridor access management planning as a basis for retrofitting corridors to address access management and multimodal needs and upgrade arterial performance. These corridor plans incorporate a number of tools that include both regulatory (e.g., overlay districts) and design (e.g., driveway spacing) elements. Some states, including Michigan, New York, Arizona, Minnesota, and Kansas, rely heavily on corridor management plans as a means of advancing the safety and efficiency of their highway system and overcoming access management problems at the local level.

In addition, there is increasing recognition that the location, design, and management of access to and from major roadways must serve all transportation modes and achieve an appropriate balance among those modes. Major urban roadways must accommodate many types of vehicles—buses, passenger vehicles, trucks, and sometimes rail transit—while also accommodating pedestrians and bicyclists. However, few states have adequate guidance on what constitutes an effective multimodal corridor access management plan, or how to facilitate the actions needed to implement the plan. As a result, the plans may not adequately address different types of arterials and contexts.

Research also suggests that a clear implementation strategy is needed. Without such a strategy, the plans may never be implemented or may be undermined by inconsistent decisions and dissension among the implementing agencies. One solution is to provide effective guidance to state transportation agencies and local governments on how to develop and implement a multimodal corridor access management plan that coordinates the various modal considerations and integrates transportation, land use, and network planning considerations along major arterial corridors.

There is a far more limited understanding of the operational impacts of access management (particularly with treatments in combination). Although improvements in travel speed and traffic flow have been documented, there is a need to better understand the circumstances under which access management treatments have a positive operational impact. There is also a need to better understand the impacts of multimodal accommodations on arterial access management. Specifically, there is a need to understand how improvements in access management relate to average travel speed, travel time reliability, and preserved highway capacity.

The objectives of the research are to identify and document current best practices for multimodal access planning and design along major highway corridors; develop examples showing how to effectively accommodate bus rapid transit and local bus service, as well as pedestrians, bicyclists, and autos in the location, design, and management of access; develop methodological guidance on multimodal access management planning and implementation methods; present the results in the form of multimodal access management guidelines and practices for specific highway functional classes; and identify the expected operational impacts of access management treatments with respect to a range of access related variables along various urban street segments. This operational impact research effort should build, calibrate, and validate simulation models to provide agencies with a simple method for determining the effect of a range of access management guidelines on capacity of urban street corridors.

The final report will provide a clear, step-by-step framework for the planning process, including: corridor designation and partnering agreements; data collection and analysis; alternatives analysis and plan development; policy analysis and implementation planning; public involvement best practices; and funding strategies. The report will also include tools that can be directly applied by state transportation agencies in coordination with
local governments and regional planning agencies, such as: model scope of services, model intergovernmental agreement, checklists for assessing and updating multimodal access management policies, design criteria, and regulations, and model cross-access agreement and sample access permit with alternative access conditions.

The development of multimodal corridor access management guidelines and best practices is timely to further facilitate Integrated Corridor Management (ICM) implementation. The guidelines and best practices developed will help avoid ill-planned and poorly laid-out access projects that are not amenable to integrated corridor operations. At a time when more and more ICM projects are being planned, access management should play a role in shaping the future. The guidance can be used 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 better operations, safety, and sustainability. This research would be useful to national level policymakers, state DOTs, and metropolitan planning organizations that are the major stakeholders of ICM development and implementation.

Note: The AASHTO Standing Committee on Research directed that Problem No. 2015-G-17, “Operational Impacts of Access Management,” be included in this research.
The Human Factors Chapter 2 in the *Highway Safety Manual* (HSM) published by AASHTO provided a strong synthesis on human factors as they relate to driver behavior. FHWA evaluated rural high-speed divided highways and found a need for improved wrong way movement signing and pavement marking, including DO NOT ENTER, WRONG WAY, DIVIDED HIGHWAY, and ONE WAY signing. The present language in the 2009 *Manual on Uniform Traffic Control Devices* (MUTCD) and the supporting figures are not always consistent and do not address safety differences among ramps, rural high-speed divided highways, rural low-speed divided highways, urban low-speed divided highways and streets, and urban higher-speed divided highways. Also, analysis is needed to evaluate the correlation between crashes and median widths. The 2009 MUTCD required that a ONE WAY sign be placed on the near right and far left corners of the intersection and that they shall be visible to each crossroad approach for median widths of 30 feet or more (Section 2B.40, paragraph 04 of the 2009 MUTCD). Figure 2B-15 of the MUTCD also shows that additional near right and far left are required in the median. This results in a total of four ONE WAY signs being required for this application for a driver approaching the divided highway section and turning left. This was primarily focused at rural high-speed divided highway facilities. Also, with the increase in wrong way movements that are being seen around the country at freeway and expressway ramps, Figure 2B.18 in the MUTCD should be evaluated for optional versus required wrong way movement signing. In addition, markings, delineators, reflectors, and other devices in Part 3 (Markings) of the MUTCD needs to be evaluated as to a need for additional language or figures. Presently Part 3 does not contain any language specific to wrong way movements at freeway/expressway ramps.

*NCHRP Report 650: Median Intersection Design for Rural High-Speed Divided Highways* evaluated median intersection design for rural high-speed divided highways and made recommendations related to the figures in the MUTCD and the AASHTO Green Book. *NCHRP Report 650* recommendations related to the MUTCD were:

1. Provide signing for minor road drivers related to gap selection (i.e., LOOK signs)
2. Provide language that allows for freeway-style guide signs, diagrammatic signs, and dynamic warning signs
3. Add a double yellow centerline and stop bars within the median
4. Add median width dimensioning
5. Modify figures 2B.10 thru 2B.13 to provide for different combinations of median widths and left turn lane types (four conditions)
6. Add a figure for offset left turn lanes
7. Add a figure for wrong way signing for less than 30 feet median width
8. Add a figure showing standard signing and marking plans for nontraditional expressway intersection designs
9. Add a figure showing standard warning and/or guide signing for TWSC rural expressway intersections
10. Add a figure for J turn intersections, offset T intersections, jug handles, and offset right turn lanes
11. Redefine MUTCD definition of median width to match AASHTO Green Book (3) definition (i.e., include the median turn lanes in measure of median width)

These recommendations from *NCHRP Report 650* had been addressed in the Regulatory and Warning Sign Technical Committee proposal of the NCUTCD dated January 2012, ONE WAY signing and wrong way movement signing. However, NCUTCD Council indicated that this report addresses rural high-speed facilities related to one way signing needs but does not look specifically at safety applications for all traffic control devices related to wrong way movement at both rural high-speed facilities and urban applications where the
median is wider than 30 feet and may be a high or low-speed street or highway. Also, *NCHRP Report 650* does not address rural applications that are lower-speed. Is the same number of one way signs needed for all these applications? Are additional markings needed? What about freeway ramp locations regarding improved safety needs?

The objectives of this research are to:

1. Evaluate divided highways and streets as well as ramps related to improved safety and reduction of crashes by the use of traffic control devices including signs, pavement markings, delineators, reflectors, and other devices in the MUTCD such as beacons and/or flashing LED units within the sign, and enhanced conspicuity of standard signs in Section 2A.15 of the MUTCD.

2. Determine the number and location of ONE WAY signs required and the number and positioning of DO NOT ENTER and WRONG WAY signs at both divided highways and freeway/expressway ramps, recommended or optional for divided highways in urban locations or in rural lower-speed applications. Evaluate the median in terms of signing needs related to ONE WAY, DO NOT ENTER, WRONG WAY, STOP, and YIELD signs. Is a median greater than 30 feet considered two intersections? What impact should the median width have on signing/marking requirements?

3. Provide actual recommended text and figures for the MUTCD for Parts 2B and 3.

The research may be conducted in phases: **Phase I.** Conduct a concise literature review to document the use of the sign and findings. Draft a summary report of the results of the literature reviews, providing an objective overview of the status of present MUTCD language and sign details shown in the MUTCD and FHWA sign code book. Are they consistent and uniform with each other? What are the voids that need additional research? **Phase II.** Conduct the needed research utilizing test subjects at various divided urban and rural highways as well as freeway/expressway ramps to support the signs in the MUTCD. Utilize both rural lower-speed roadways and urban lower and higher-speed roadways. Provide recommendations on what changes are needed in the MUTCD Section 2B.37, 2B.38, 2B.40, 2B.41, 2B.42 and Part 3 (Markings) and figures related to ONE WAY signing and wrong way movement signing and marking.
Project 03-118

Safety and Operational Impacts of Traffic Signal Phasing

Research Field: Traffic
Source: AASHTO Highway Subcommittee on Traffic Engineering
Allocation: $600,000
NCHRP Staff: B. Ray Derr

The FHWA has identified intersections as one of four primary focus areas for improving safety and reducing crashes. In the United States, it is estimated that signalized intersections comprise less than 10 percent of the total number of intersections, but more than 30 percent of intersection fatalities occur at signalized intersections. One of the most important factors impacting both the safety and operations at a signalized intersection is signal phasing. Little research has been done in recent years related to the safety and operational aspects of signal phasing. Although there is some guidance in national manuals (such as the FHWA Signal Timing Manual), much of the information is based on rule-of-thumb concepts with little to no empirical underpinning. Selection of the optimal signal phasing can have the benefits of improving safety, reducing congestion, and reducing emissions.

The objective of this research is to evaluate the safety and operational aspects of traffic signal phasing. The research should develop specific recommendations and guidelines to allow practitioners to select appropriate traffic signal phasing that will allow for rational decisions related to the trade-offs between safety and operational efficiency.

Tasks anticipated in this project include the following: (1) Literature review, including tracing back recommended signal phasing practice in popular national publications, such as those published by FHWA, AASHTO, or ITE, to the original source (if applicable). (2) Identify and prioritize issues worthy of further research (e.g., use of protected/permitted versus protected-only left-turn phasing, use of protected/permitted left-turn phasing for dual left-turn lanes, phase rotating by time of day or traffic demand, type of pedestrian signal phasing, omission or prohibition of permitted phases upon actuation of pedestrian detection, concurrent vs. split phasing, relationship between cycle length and crash frequency). (3) Identify the safety and operational metrics that will be used to evaluate the highest priority issues. (4) Develop and conduct research to address the highest priority issues. (5) Develop guidelines to assist practitioners in selecting appropriate traffic signal phasing.
Project 03-119
Assessment of Small and Medium Sign Supports, Work Zone Devices, and Luminaires to MASH

Research Field: Traffic
Source: AASHTO Highway Subcommittee on Design
Allocation: $600,000
NCHRP Staff: Mark S. Bush

Recent testing of Small and Medium Sign Supports and Work Zone Devices has been problematic with both of the test vehicles required in the 2009 AASHTO Manual for Assessing Safety Hardware (MASH) at both the Texas A&M Transportation Institute (TTI) and the Midwest Roadside Safety Facility (MwRSF) at the University of Nebraska-Lincoln. Many of these devices have previously been successfully full-scale crash tested to NCHRP Report 350: Recommended Procedures for the Safety Performance Evaluation of Highway Features. Only the small car (1800-lb, Geo Metro or similar) test was performed under NCHRP Report 350. MASH requires testing these types of devices with both a small car (2420-lb, Kia Rio or similar) and a pickup truck (5000-lb, ½-ton Dodge Quad Cab or similar). Occupant Impact Velocities (OIVs) and Occupant Ridedown Accelerations (ORAs) have not been a problem because of the increased weight of the test vehicles, even with the commensurate reduction in impact speed in Test 3-60. However, the change in frontal geometry (i.e., bumper heights, increased frontal area, and wraparound distances) and increased ground clearance has changed the interaction between the vehicle and object struck. In general, small and medium sign supports used to pass over the top of the impacting vehicle with limited to no vehicle contact. With the newer MASH vehicles, they are now interacting with the windshield and roof of the current test vehicles and failing the occupant compartment intrusion and/or penetration requirements of MASH. Similarly, vehicle interactions with portable work-zone devices are causing unacceptable windshield and roof penetrations and/or deformations as well as floor pan penetrations. No testing has been conducted to date on luminaires (light poles) under MASH, but this recent testing on other breakaway and portable devices at least raises the question as to the expected performance of breakaway luminaire poles under the MASH impact safety criteria. The addition of objective vehicle intrusion and deformation criteria has also brought into question the future usefulness of pendulum/bogie testing of breakaway supports.

Most indications of potential problems have been identified with recent testing at MwRSF and TTI. However, because of the reduced occupant compartment deformations, particularly in the roof crush, older accepted tests under NCHRP Report 230 and NCHRP Report 350 would be failed under MASH. Under acceptance letter SS08, the perforated tube would clearly fail under today’s guidelines when it was previously deemed marginally acceptable. Similarly, potential previously successful tests under NCHRP Report 230 and 350 on luminaires may be problematic under MASH test conditions. Subsequent MASH testing with a pickup truck on the perforated steel tube sign supports under NCHRP Project 22-14(03), Bullard, et. al. (TTI-2010) demonstrated unacceptable occupant compartment intrusion at the top of the windshield. Under Texas DOT Project 9-1002-12-5, Dobrovolny et. al. (TTI-2013) also found unacceptable performance with the 7-ft mounted temporary work-zone sign when impacted at 90 degrees by the MASH pickup due to cutting of the roof sheet metal and subsequent occupant compartment intrusion. Schmidt et. al. (MwRSF-2011) published Analysis of Existing Work-Zone Sign Supports Using Manual for Assessing Safety Hardware Safety Performance Criteria. The testing reviewed in this paper indicated work-zone devices previously tested and accepted under NCHRP Report 350 were subjected to testing with the MASH small car and pickup, four (4) with the car and four (4) with the pickup. Five (5) of the eight (8) devices failed due to occupant compartment intrusion and/or penetration. Sicking et. al. (MwRSF-2010) under TRP-03-225-10 published Safety Investigation and Guidance for Work-Zone Devices in Freight Transportation Systems Subjected to Passenger Car and Truck Impacts with New Crash Standards. The report further documents the results of this work-zone sign support testing and evaluation program using MASH test vehicles.

The objective of the research is to identify currently accepted small and medium sign supports, work-zone devices, and luminaires under prior crash test standards that either are or will likely be problematic under the
current MASH crash test standard. With the complexities of the problems identified, a two-phase approach may be considered under this project. The initial phase may incorporate a survey that will serve as an in-service performance evaluation of these products and will help assist in the urgency of a second phase within the project scope. If the survey results in Phase one identifies that there is insufficient field data, the second phase will examine possible modifications to the MASH requirements on occupant compartment deformation that may need to be proposed to AASHTO. This second phase will also greatly assist states in the prioritization of upgrading possibly deficient hardware. Furthermore, the results of the research will likely assist the states with selecting, retrofitting, and modifying those designs to garner improved safety performance. Possible guidance will also be provided to assist industry with providing similar improved proprietary products used by the various states.
Project 05-21

Safety and Performance Criteria for Retroreflective Pavement Markers

Research Field: Traffic
Source: AASHTO Highway Subcommittee on Traffic Engineering
Allocation: $675,000
NCHRP Staff: William C. Rogers

NCHRP Project 17-28, “Pavement Marking Materials and Markers: Safety Impact and Cost-Effectiveness,” was completed in 2007. A summary of the work was published as NCHRP Research Results Digest 305.

The research produced findings that were controversial among many researchers and practitioners. Eight years later there are still debates and arguments regarding the results. It is safe to say that the report has left state safety engineers with mixed messages about the effectiveness of raised retroreflective pavement markings (RRPMs). While the study limitations have been pointed out in numerous areas, the only conclusion that can be agreed on by all is that more research is needed.

More research is needed to better understand the safety impacts of RRPMs (both snow-plowable RRPMs and surface-mounted RRPMs). RRPMs are intended to complement pavement markings during rainy nighttime weather. However, they perform in dry nighttime conditions too. Both conditions should be considered.

Research is also needed to determine the minimum performance levels required of RRPMs. There is practically no guidance here, even though the FHWA is making strides to develop minimum pavement marking retroreflectivity levels.

In addition, and based on the need to improve curve safety, the 2009 MUTCD introduced a table of required traffic control devices for curves based on speeds but did not include RRPMs in Table 2C-5. Many southern state DOTs that use RRPMs regularly feel that this Table 2C-5 is incomplete because it does not include considerations of RRPMs.

The objective of this research is to identify the visibility performance requirements of RRPMs for nighttime drivers, particularly during inclement weather, and develop guidelines appropriate for the MUTCD. The research should consider pavement marking condition and retroreflectivity, spacing of RRPMs, minimum maintained service levels, and how RRPMs can be combined with other delineation traffic control devices to achieve adequate nighttime visibility of the highway, especially by drivers 65 years of age or older.
Goods movement is an important part of our national economy, with freight traffic growing faster than passenger traffic. The growth in freight traffic is leading to urban congestion and traffic delays, resulting in hours of delay, increased shipping cost, wasted fuel use and greater mobile source emissions of greenhouse gases (CO₂) and criteria pollutants such as oxides of nitrogen (NOₓ) and air toxics such as diesel particulate matter. A limited amount of observed national data is available on goods movement. What data are available are too coarse for understanding urban freight movement or characteristics of freight vehicles operating within designated non-attainment areas. Urban areas have developed passenger vehicle forecasting models and have applied the same modeling principles that rely on demographic and economic variables to forecast freight traffic. Urban freight models based on demographic and economic variables have had limited success in forecasting urban freight traffic, due to the complex logistical chains influenced by many variables.

There are at least three distinct segments of urban freight traffic—long haul, drayage, and local distribution. It is believed that vehicle fleet characteristics differ between the operating segments, but, typically, only local freight registration data exist at a level of detail needed to support RTP, TIP, and SIP assessments. Long haul operators traveling through non-attainment areas often use vehicles registered to other locations. Local distribution fleets are mixed. Locally owned distribution fleets are locally registered, while vehicles servicing national chains can rely on third-party distributors using vehicles registered in various localities. The drayage fleet providing urban area intermodal connections is normally a locally owner operator with local vehicle registration. The registration data are used as a proxy in allocating urban freight activity by vehicle age. All three urban freight segments (long haul, drayage, and local distribution) have distinct operating characteristics in the number and length (miles) of trips. The lack of freight fleet age characteristics hinders the ability to properly account for national and state emissions control policies in place by freight vehicle model year. The lack of data to drive modeling estimation results in inaccurate base year emissions inventories and limits the ability to design and implement effective policies to reduce freight-related emissions.

The objective of this work is to research, develop, and pilot enhanced data collection and analysis methods that capture freight activity and freight fleet characteristics to assist in improving air quality modeling. Work products will be a guidebook with recommended methods of collecting improved activity data, and a case study illustration of the use of the methods. The data collection methods will be used to improve identification of fleet characteristics for the three urban freight segments (long haul, drayage, and local distribution). In addition to improving the ability to model activity, emissions, and air quality, the enhanced data collection methods will assist in strategic planning. Understanding how activity, vehicle starts, and idling differ for freight shippers provides for the opportunity to develop national, state, and local policies designed to reduce freight-related mobile source emissions.
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, 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, online incident tracking systems, and bicycle counting technology have given transportation practitioners new techniques for assessing bicyclist route choice and the systemic impacts that result from those choices. This research will analyze bikeway designs in the context of contrasting urban area types including a dense large-city downtown and exurban areas characterized by 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 inform practitioners at state departments of transportation, regional planning agencies, and cities about the types of bicycle facility designs that are most preferred by bicyclists and focus on:

1. Analyzing the relationship between urban bicyclist demographics and attitudes and bicyclist facility type preferences, including a review of existing studies to guide this research on potential correlations between those factors;

2. 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 will include a variety of U.S. locations and at least one dense large-city downtown and one or more smaller cities whose downtown is served by a major arterial or state highway.

A review of the existing literature confirms that such research is both unique and necessary. While a volume of research has been completed assessing traveler preferences for facility types, past efforts are typically missing either specific route choice information (in the case of stated preference studies) or fully detailed traveler information (in the case of route choice studies). This makes assessing the impact on the system (potential changes in bicycle demand) difficult to quantify while also obscuring specific facility preferences by market segment. The proposed research will overcome these limitations by addressing traveler characteristics, traveler attitudes, and physical environment factors (route and facility) simultaneously. The work must leverage both new techniques and the best of past research to deliver a unified statistical examination of bicyclist preferences across multiple market segments and physical contexts.

The following research documents, in-progress research, and recent application efforts will set the foundation for this proposal. These citations also illustrate the context of this proposed research task in the natural evolution of understanding and application:

1. Estimating Bicycling and Walking for Planning and Project Development (NCHRP Project 08-78: 2011-in progress)—Among other tasks, the project will develop and validate transferable methods of estimating demand for bicycling and walking travel and include the results in a new guidebook for practitioners for estimating such activities at a variety of geographic scales.

2. Pedestrian and Bicycle Transportation Along Existing Roads (NCHRP Project 07-17: 2011-in progress)—This research is developing planning methods for evaluating needs for improving both bicycle and pedestrian conditions on existing roadways, and will produce methods to inventory pedestrian and bicycle conditions and needs.
3. Association of Monterey Bay Area Governments Bicycle Model Development (2011-in progress)—AMBAG is developing a new bicycle model using route choice and other data for investment analysis.

4. Discrete Choice Analysis of Bicyclist Cross-Sectional Behavior (2011)—This research utilized a binary logit model approach to determine influences on bicyclist route choices including factors such as cross-section, pavement condition, and weather condition.

5. San Francisco Transportation Authority Bicycle Model (2010)—Practitioners collected bicyclist route choice data to estimate and implement a citywide bicycle assignment model.

6. An Analysis of Bicycle Route Choice Preferences in Texas (2010)—Research utilized a web-based stated preference survey to assess what network characteristics (such as facility type, roadway characteristics, or operational characteristics) and cyclist demographic characteristics most affect traveler route choice.

7. Portland Metro Bicycle Model (2009)—Practitioners and academics collected bicyclist route choice data to estimate and implement a regional bicycle assignment model.

8. Bicycling, Bicyclists, and Area Type: Findings from the 2005 Philadelphia Metropolitan Bicycle Travel Survey (2009)—An intercept survey was conducted of adult bicyclists to determine trip characteristics and purpose as well as bicyclist characteristics and preferences. A regression analysis determined correlation of survey measures to traveler preferences.

9. Promoting Transportation Cycling for Women: The Role of Bicycle Infrastructure (2008)—Research examined facility design and influence over female cycling for transport in Melbourne, Australia.


11. RI DOT 2002 Bicycle Transportation User Survey: Developing Intermodal Connections for the 21st Century (2004)—A user preference survey was developed regarding factors that encourage or discourage bicycle use.

12. Commuter Bicyclist Route Choice: Analysis Using a Stated Preference Survey (2003)—Empirical model to assess the importance of “route-level” (travel time) and “link-level” (pavement quality) factors on user preferences to inform bicycle facility planning.

13. Characterizing the Personal Attributes and Travel Behavior of Adult Commuter Cyclists (1998)—Research in Ottawa and Toronto, Canada on cyclist safety and travel habits as well as traveler preference, largely based on self-reported collision and fall information. Research estimated bicycle commute levels, facility catchment areas, and effective policies to increase bicycle commuting.

In practice the transportation field has a long history of conducting travel diary surveys to examine traveler behavior and of understanding transport facility usage by automated counting of vehicles and transit passengers. These efforts capture some information about bicyclists but usually incidentally or indirectly; surveys have small samples of bicyclists and lack route data while vehicle counters usually do not detect bikes. More recent developments have produced both stand-alone Geographic Positioning System (GPS) instruments and GPS-enabled personal cellular phones that enable traveler route tracking applications. Developers have also produced permanent and temporary counting devices that can count bicyclists on roads and trails.

Survey and System Data Gathering
Several U.S. cities have or are undertaking the collection of detailed bicyclist route choice surveys collected via smartphone. In addition, other cities have implemented systematic bicycle counting programs using new and traditional techniques. State DOTs have also begun to implement bike count programs.

Existing Data Applications and Limitations
Existing work has had useful outcomes: Several cities use bike counts to gauge the overall success of bike-friendly programs and investments; at least two cities have deployed bicycle route choice models to augment their traditional travel demand models for investment study purposes with other bike models in progress; travel surveys with large bicyclist subsamples are informing in-progress research on estimating bicycle demand.
Existing work, though, has been limited by fragmentation caused by limited resources and the relative infancy of bicycle data gathering. Route choice data has not been accompanied by complete traveler demographic information; stated preference surveys have been conducted without any revealed preference or count support; and counting systems are deployed but usually not in before/after studies.

Existing Findings on Facility Preferences
Past revealed preference work has enabled statistical tests of various hypotheses about facility preferences. Although certain facility preferences have been found to be significant, the findings are inconsistent across different places. Sample sizes have often been only large enough to treat bicyclists as one group rather than allowing segmentation by demographic or attitudinal factors. Few if any studies have linked attitudes to demographics and actual route or facility choices. The NCHRP Project 08-78 research cited above will hopefully enlarge the base of knowledge regarding facility preferences and will serve as a key foundation element for this work.

This research will build upon the results of existing work—particularly the first seven citations above—by designing comprehensive data gathering activities in selected locations and focusing on discovering bicyclist facility preferences. This research will extend NCHRP Project 08-78 by adding stated-preference and primary data-gathering, and will leverage the results of NCHRP Project 07-17 by utilizing its facility inventory methods (or the fruits of others’ applications of those methods). The evaluation method outcomes of NCHRP Project 07-17 may also inform the design of this study’s data gathering and modeling components. The results will be a detailed statistical examination of bicyclist preferences for facilities that simultaneously controls for physical attributes (facilities, weather, etc.), traveler attributes, and traveler attitudes. The work will also examine potential relationships between count data (the data most agencies are likely to have) and the more survey-oriented data techniques to help practitioners better understand and apply their count data.

The goal of this research is to comprehensively examine bicycle facility types from the viewpoints of bicyclists and create results that can be applied to facility design choices in practice. The primary outcomes sought are (1) thorough understanding of bicyclists’ facility preferences, stratified by key demographic factors and controlling for objective factors such as design and weather, and (2) validation of bicycle route choice data by count or other observable performance measures plus a better understanding of count data applications via the collection of count data simultaneously with other data.

Objective 1—Identify supporting data and choose study locations. Proposers are encouraged to partner with public agencies that could serve as potential study locations.

a. Identify detailed spatial data for existing streets and existing bicycle facilities at an “all-streets” level of detail.

b. Identify existing and past bicycle count locations and longitudinal data (see also objective 3 below).

c. Identify existing bicycle route tracking and counting data gathering efforts.

d. Identify bicycle facilities both in place and planned for construction to assess the possibility of before-after data gathering, preferably including relatively recent bicycle facility design types.

e. Finalize the definition of the study geographies, with multiple representative places in a variety of U.S. locations and including at least one dense large-city downtown and at least one smaller city served primarily by a state route.

f. Conduct additional data gathering sufficient to spatially represent existing streets and bicycle facilities for the remainder of the research.

Objective 2—Conduct coordinated stated- and revealed-preference bicyclist route and facility choice data gathering.

a. Design and conduct GPS-tracked bicycle route choice data collection in the study areas. A key goal running throughout this and subsequent items is to control as completely as possible for the variety of explanatory factors in both the traveler and the physical environment;
b. Design and conduct, in full coordination with the route choice data gathering, comprehensive demographic data gathering for the respondents to the route-choice effort (including previous household location).

c. Design and conduct, in full coordination with the route choice and demographic components, a stated-preference component addressing respondent attitudes toward different facility options and, preferably, respondent attitudes toward other potential explanatory factors such as preferences for physical health.

d. Estimate statistical models appropriate to test the significance—separately and in combination—of traveler characteristics, traveler attitudes, and physical facility and environmental characteristics on bicyclist facility type preferences.

e. Report findings on detailed demographic and attitudinal factor significance on traveler preferences for specific facility types in the context of overall route choice.

Objective 3—Validate route choice data and assess correlation of count data with route choice data gathering.

a. Design a bicycle counting effort, preferably to be conducted in parallel with the route choice effort in Objective 3, that will obtain a robust count sample across the study areas.

b. Conduct the bicycle counts as designed, using any permanent count devices available and deploying additional counting techniques as needed.

c. Report count findings in the context of the route/facility choice data from Objective 2, and report inferences as appropriate on how practitioners can better collect and use their count data to inform public policy decisions.

Objective 4—Make research results useful to practitioners.

a. Compile the research findings into a practical guidance document designed to help practitioners estimate the potential travel effects of different bike facility investment choices in their own jurisdictions (e.g., by calling out particular market segment preferences for particular bike facility designs).

b. Make suggestions in the guidance document on how to best work with agencies to continue and enhance means of collecting both route choice and count data.

c. Create a sketch-level tool that allows practitioners to quickly estimate the facility preferences of bicyclists given sufficient demographic information and demonstrates the quantitative outcomes of the research (e.g., a spreadsheet or website that estimates probable facility preferences for a specified population). The focus of this tool is on supporting public-agency decisions.

This project will assess cyclist preferences for different bicycle facility types and move toward a better understanding of the safety outcomes of bicycle facility options. The proposed guidance document and sketch tool deliverables will assist transportation practitioners in choosing which bicycle facilities meet their policy goals in an urban context.
Many pavement engineers and researchers believe that the current Superpave fatigue parameter (G*sin δ) is not a good indicator of binder fatigue performance. Unfortunately, there is not a clear alternative to this approach to controlling the fatigue performance of asphalt binders. One or more specification tests that do in fact relate to fatigue performance are needed to provide a more effective binder specification. It is widely accepted that the primary factor affecting the fatigue performance of asphalt pavements is structural design: the thickness of the various layers composing the pavement system. However, other factors, including the characteristics of the asphalt binders used in the hot-mix asphalt (HMA) layers of the pavement can significantly affect fatigue performance. If the factors influencing binder fatigue resistance can be identified, characterized, and specified effectively, it should be possible to improve asphalt pavement economics by building thinner pavements while using asphalt binders with improved fatigue resistance.

During the 1950s and 1960s, paving engineers began to suspect that asphalt cements at that time with disperse relaxation spectra (generally meaning asphalt cements that were heavily oxidized or ‘blown’ during production) were often prone to premature failure due to severe early fatigue cracking. Several test methods were developed for identifying these materials and proscribing their use in highway construction, the most widely used being the establishment of minimum ductility values relative to the penetration grade. During the development of the SHRP binder specification, this test was eliminated because of its empirical nature. Within the new specification, the requirements for binder creep modulus and m-value (log-log slope of the creep curve) indirectly discourage the use of oxidized/blown asphalts or other binders exhibiting disperse relaxation spectra. However, it is not clear that this approach has been effective in limiting the use of oxidized asphalts and similar materials, or providing asphalts with acceptable fatigue resistance. Furthermore, it is not even clear that oxidized asphalts are in fact more susceptible to fatigue damage than other binders; in most laboratory testing, oxidized asphalts show better fatigue resistance than non-oxidized binders. It is however possible that the poor field performance of oxidized binders might be the result of poor healing properties or damage tolerance. It is also possible that the performance of HMA containing oxidized asphalt binder is a function of pavement structure; oxidized binders used in HMA in thin pavement structures might in fact exhibit premature fatigue failure, while the same binder used in thick pavement structures might perform quite well.

Recently, continuum damage theory (CDT) has lead to an improved understanding of the fatigue behavior of HMA mixtures. CDT provides a powerful tool for characterizing and modeling the crack initiation phase of fatigue damage in viscoelastic materials such as HMA and asphalt binder. Two important concepts related to CDT are damage tolerance and healing rate. Damage tolerance is the ability of a viscoelastic material such as HMA or asphalt binder to undergo micro-damage without exhibiting crack initiation or macro-cracking. Healing rate refers to how quickly (if at all) a material damaged by fatigue loading will recover. In practice, the fatigue behavior of both HMA and asphalt binder will depend on the damage rate, the damage tolerance, and the healing rate. Because aggregate is not a viscoelastic material, the viscoelastic behavior and the fatigue behavior of HMA must depend largely on the properties of the asphalt binder used in its production. Developing tests to characterize these properties in asphalt binders would provide a much better means of controlling the fatigue performance of both asphalt binders and HMA pavements.

An important aspect of fatigue performance not addressed by CDT is crack propagation. As with CDT, significant recent advances have been made in understanding crack propagation and other aspects of the fracture properties of HMA. Again, as with CDT, much less research has been performed on the ways in which asphalt binders affect the crack propagation in HMA. An important component of this research is to investigate the relationship between various binder properties and crack propagation rates in HMA mixtures.
The objectives of this research are to (1) develop methods for direct measurement of fatigue damage rate, damage tolerance, healing rate and crack propagation rates for asphalt binders and validate these methods with field performance data from LTPP and other sources; (2) as necessary, relate these fatigue properties to more easily measured rheological properties, such as phase angle, loss modulus, storage modulus, rheological type, and flow activation energy; (3) identify potential surrogate tests for characterizing the fatigue behavior of asphalt binders; and (4) determine whether or not the current performance-graded binder specification (AASHTO M 320) directly or indirectly controls one or more aspects of fatigue performance.

Accomplishing these objectives will require the following tasks: (1) Review the literature concerning relationships among binder rheological properties, fatigue and fracture properties, healing rate and field performance. Explain these relationships with a working theory that can be evaluated through laboratory binder and mixture testing and an analysis of existing data on field performance. (2) Develop and execute a laboratory test plan to evaluate the relationships between various binder rheological properties and the fatigue, fracture and healing properties of both asphalt binders (including virgin, modified, RAP, and RAS binders) and HMA mixtures. Include an evaluation of the effectiveness of AASHTO M 323 to control the properties of asphalt binders clearly related to the fatigue and fracture performance of HMA mixtures. (3) Develop and execute a plan for analyzing the effect of binder rheological properties on the fatigue resistance of HMA pavements using existing data from studies performed using, at a minimum, accelerated loading facilities and LTPP Specific Pavement Studies. (4) Determine what changes are warranted, if any, in AASHTO M 323 to ensure that asphalt binders will not significantly contribute to premature failure of HMA pavements due to poor fatigue and/or fracture properties.
The Detection and Remediation of Total Soluble Salt Contamination Prior to Coating Structural Steel

Bridge steel protective coatings typically fail in localized areas of a bridge. The failed areas normally comprise less than 5 percent of the coated surface area. Identification and remediation of soluble salts (chlorides, sulfates, and nitrates) could greatly extend the service life of protective coatings by eliminating those areas of premature coatings failure.

Current test methods are not effective in evaluating problematic soluble salt levels in bridge steel when the soluble salts are concentrated randomly (i.e., in pits). This may allow retention of high localized concentrations that will promote premature failure in subsequent coating applications. A second issue is the identification of practical, effective methods for surface preparation of existing bridge steel substrates to minimize or eliminate these localized “hot spots” prior to coating application. Studies have shown that pressure washing, abrasive blasting, or a combination of the two are not effective in removing soluble salt “hot spots.”

Effective soluble salt contamination identification and remediation is essential to maximizing the life of structural steel maintenance coatings. This research supports the performance management and research strategic focus areas of the Subcommittee on Maintenance, Bridge Technical Working Group.

The objective of this research is to develop methods to identify and remediate total soluble salt contamination prior to coating structural steel. Accomplishing these objectives will require the following tasks: (1) Identify and quantify existing methods for the location/distribution of soluble salts on steel. (2) Develop new methods for identifying the location/distribution of soluble salts on steel surfaces. (3) Identify effective soluble salt remediation method(s). (4) Develop training for bridge owners in the identification and remediation of soluble salts in order to achieve accurate field use of the methods.
♦ Project 12-104

*Evaluation of Element-Level Inspection Quality*

Research Field: Design
Source: AASHTO Highway Subcommittee on Bridges and Structures
Allocation: $350,000
NCHRP Staff: Waseem Dekelbab

The Visual Inspection method is, by far, the predominant evaluation technique used for element-level bridge inspection and rating AASHTO CoRe elements, the new National Bridge Elements, and Bridge Management Elements. Recent legislation (MAP 21) requires that states report element-level inspection data for bridges carrying the National Highway System to the FHWA in the future.

The element-based inspection system rates discrete bridge elements and records quantities of the element in a set number of condition states. This primarily is done by visual estimates of the quantity of the element in each condition, with some verification by measurement when the element is accessible. This information is used to monitor and forecast bridge element deterioration and to make bridge maintenance, preservation, rehabilitation, and replacement decisions, so it is of utmost importance that there is a good understanding of the reliability of the inspection processes and data collected.

The objective of the research is to evaluate the reliability of element-level bridge inspection data and to provide recommendations to current practices to improve element inspection information going forward.

Note: The AASHTO Standing Committee on Research directed that this project should support MAP-21 requirements.
A number of issues must be addressed to ensure that Accelerated Bridge Construction (ABC) in seismic regions not only minimizes traffic disruption and reduces congestion with its shorter onsite construction times, but also meets prescribed ductile seismic system performance criteria required in these regions of the country. Furthermore, prefabricated bridge elements must be constructible and cost-effective and produce economical long-lived structures with minimal maintenance requirements. The FHWA and many state DOTs are actively promoting accelerated bridge construction to minimize construction related impacts to the traveling public and to enhance work zone safety. Many successful applications of ABC techniques using prefabricated elements have been realized as documented in the 2009 FHWA Connection Details for Prefabricated Elements and Systems Manual and the 2011 FHWA Accelerated Bridge Construction Manual.

However, as identified during the ABC Connections Domestic Scan 11-02, utilization of ABC techniques has been more limited in moderate-to-high seismic regions of the country. Significantly, the AASHTO Guide Specifications for LRFD Seismic Bridge Design currently prohibit or limit connections that splice longitudinal column reinforcement in plastic hinge zones, significantly hampering the utilization of prefabricated elements to achieve the benefits of ABC. To address this limitation, there is a need to identify reliable connections that are capable of performing to the exacting specifications required in seismic-prone areas. The proposed research would build off the work already done by comprehensively reviewing past research results of the most promising details, and performing additional testing as necessary to fill knowledge gaps for the development of design specifications for connections that facilitate accelerated bridge construction in seismic regions. The objective of this research is to perform supplemental gap-closing testing of the most promising current technologies in order to develop design specifications for implementation of ABC methods in regions of the country with moderate-to-high seismic hazards.
State highway agency equipment fleets represent a significant capital investment and require recurring maintenance and operational expenditures. Fleet assets are vital to the delivery of agency programs, projects, and services. Properly sized fleets provide maintenance forces with necessary equipment while minimizing the capital investment. Efficient management of these assets and their utilization can yield significant savings. Integrating utilization strategies into the management of an equipment fleet can improve performance in all facets of fleet operations. This is particularly true in determining when to add, reassign or remove assets from the fleet in order to minimize capital investment while meeting the equipment needs of the agency.

The AASHTO Equipment Management Technical Services Program (EMTSP) complements the ongoing work and priorities of the AASHTO Highway Subcommittee on Maintenance Equipment Technical Working Group (TWG). The EMTSP Strategic Plan includes eight clear and measurable goals inclusive of actions, specific deliverables, and timelines. Three of the goals (Goal 2, Promote awareness of available equipment technologies; Goal 4, Advance fleet management best practices; and Goal 8, Develop and promote common performance measures for equipment fleet management) are supportive of timely and cost-effective equipment asset management. In support of Goal 8, the EMTSP Oversight Panel formed the National Performance Measurement Working Group with the task of identifying and promoting a set of equipment fleet performance measures. The AASHTO Subcommittee on Maintenance (SCOM) Equipment TWG submitted Resolution 12-03, Equipment Fleet Management Performance Measures, to the AASHTO Standing Committee on Highways (SCOH) where it was unanimously passed. This resolution established four distinct fleet performance measures, one of which is Utilization.

Also, NCHRP Project 20-07, Task 309, Challenges and Opportunities: A Strategic Plan for Equipment Management Research, was conducted in response to a research problem statement submitted by the AASHTO Highway Subcommittee on Maintenance in support of the EMTSP Strategic Plan Goal 5, Maintain and support the equipment fleet management research roadmap. This NCHRP project was to identify areas in which equipment management research is needed, to synthesize related research work, to identify gaps, and to develop a research implementation plan with a prioritized listing of topics in each of the identified areas. One of the resulting challenges was to, on an ongoing basis, measure, monitor, and report on asset utilization levels in order to facilitate the management of the size and composition of the fleet and its suitability to the highway agency’s business needs.

Various methods are used to determine the appropriate minimum utilization criteria for the diverse classification of assets within equipment fleets. Many methods include customary practices with broad applications that are not accurate or reliable for every situation. Some merely replicate other fleets’ practices. An accurate and reliable process for determining utilization guidelines for each of the various classes of equipment using sound economic principles is needed by the highway agency equipment fleets to make timely and cost-effective decisions on fleet size and composition to meet the state’s mission and level of service. These principles should include determining total cost of alternatives to agency ownership of the asset. Alternatives should include rental of additional assets or utilizing already existing assets by sharing among multiple work units.

The typical highway agency equipment fleet consists of hundreds of equipment classifications with only a percentage of those classifications appropriate for tracking utilization. Fortunately, these classifications represent the majority of the financial investment of the total fleet. Utilization standards can only be applied to assets where usage is tracked and reported. Utilization standards must be based on data that is attainable and timely.
For most fleets, utilization tracking is limited to units with odometers or hour meters, however, some fleets also track asset utilization based on the time the asset is committed to a project.

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 along with other key factors to determine the optimum utilization metrics (e.g., mileage, engine hours, and/or project use) for each of the various equipment classifications. This would help the fleet managers make more accurate and timely equipment utilization management decisions, thereby reducing ownership and maintenance costs of highway equipment.

In order to achieve this objective, the following tasks are required: (1) Conduct a literature review and synthesis of completed and active research in the area of equipment fleet utilization processes, including both public and private fleets with equipment similar to state fleet composition. (2) Conduct a synthesis of the current equipment utilization management practices used in highway agency equipment fleets and document best practices identified. (3) Conduct a synthesis of state DOT equipment fleet managers to determine what problems and concerns they encounter in developing utilization criteria for the optimum utilization of equipment in their fleets. (4) Using information collected in Tasks 1, 2, and 3, 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 utilization criteria (e.g., mileage, engine hours, and/or project use) for each of the various classifications of equipment in the agencies’ fleets. The solution must provide a standard process using normal office hardware that can be used by all highway agency equipment fleets. The process of uploading data into the solution must be in a manner such that it can easily be performed by typical highway agency equipment fleet management staff without the assistance of information technology professionals. This solution shall contain the following functions (a) Establishing agency-specific utilization guidelines for the various classifications of appropriate equipment that may be applied to entire classifications or to individual units. The methodology should include the factors that may affect the outcome of the guidelines such as the total cost of the alternatives to ownership of the resource. This total cost of the alternatives may vary depending on location, availability to rental equipment, availability to idle agency assets, etc.; (b) Establishing agency-specific guidelines for measuring equipment utilization levels using the statistics produced through such measurement and suitable benchmarks/guidelines, and for investigating instances of apparent underutilization of assets and taking or recommending remedial action where appropriate to “right size” the fleet; and (c) Implementing these guidelines into a process for highway equipment managers to systematically identify and facilitate the reassignment or removal from the fleet of underutilized equipment assets.
Project 14-34

Performance-Based Winter Maintenance: Developing a Toolkit of Measures, Standards, and Monitoring Tools

Research Field: Maintenance
Source: AASHTO Highway Subcommittee on Maintenance
Allocation: $300,000
NCHRP Staff: Amir N. Hanna

The authorization of MAP-21 shows a trend toward performance-based standards in many areas of highway operations. Performance-based standards have several advantages: linking resource inputs to outputs and to the benefits that highway operations provide to society, providing more standardized highway-user experience, and promoting innovation and reduced need for oversight resources. The transition from methods-based or input-based to performance-based standards presents many challenges. Key among these are developing a rationale to set the level of service and estimating how the level of service relates to costs or other constraints.

Some highway agencies with significant exposure to winter weather have developed performance-based systems for winter maintenance using measures such as Bare Track or Bare Pavement Regain Time, and some are currently exploring automated systems to monitor the inputs and outputs or levels of achievement, or more outcome-focused measures such as traffic flow. The service standards, however, were developed on the basis of resource or funding levels rather than with a focus on the desired results. Other agencies or those with less exposure to winter conditions focus on inputs such as the number of plows on the road, tons of salt applied, or frequency of service.

Significant progress has been made in the past 3 years in developing output- and outcome-focused approaches to setting service levels. For example, Maintenance Decision Support Systems that predict the Bare Pavement condition that will result from a given plowing and salting strategy open the possibility to predict how much it will cost to meet alternative Bare Pavement Standards. Other models have been developed that estimate the safety and mobility levels that will result from different levels of performance and the associated monetary benefits to society. Others provide tools and approaches to setting performance standards that balance benefits with costs (e.g., Aurora-Ontario and Iowa studies, and NCHRP Project 20-07(300) estimating the benefits). In time these models and tools can be applied to establish standards and levels of service appropriate to any road management agency.

The completed studies provide some of the basic tools that are needed to develop performance-based management systems for winter maintenance but they are limited in several respects: (1) Research is based at locations with intense winter weather and heavy traffic conditions; model coefficients may require adjustment in areas with milder weather and lower traffic. (2) Each performance measure results in a unique benefit-to-cost relationship; proposed new measures must be calibrated to existing measures to avoid unexpected changes in highway user experience of safety and mobility levels. (3) Performance monitoring resources vary dramatically by highway agency; performance measures must be adapted to the monitoring and oversight resources available to the highway agency.

A significant research effort is needed to develop the theories and models into a handbook format to inform road management agencies of choices that are appropriate to their location, traffic level, climate, and resources. In addition, each choice of performance standard must be associated with a suite of quantitative measures and relevant monitoring tools and reports that are understood by the public and accepted by federal funding agencies.

The objective of this study is to develop a handbook on performance measures, performance monitoring tools, and performance-based standards that can be used by any road or highway maintenance agency to develop a performance system that is customized to its climate, road and traffic characteristics, and road user needs.
There are two non-destructive evaluation (NDE) methods used for volumetric (through-thickness) evaluation of complete joint penetration (CJP) welds in steel bridges: radiographic (RT) and ultrasonic (UT). Recent advances in ultrasonic testing include the development of phased-array ultrasonic technology (PAUT), which allows for efficient detection and characterization of flaws, with the option of automated data collection and imaging. Criteria for categorizing discontinuities found by RT and conventional UT as acceptable or rejectable are codified in the AASHTO/AWS Bridge Welding Code (D1.5) based on workmanship standards. However, these acceptance criteria do not reflect full use of the capability of PAUT and furthermore are not based on the effect that these discontinuities might have on the performance of the structure, particularly the resistance to fatigue and fracture. Some discontinuities that are not allowed by AWS workmanship criteria are potentially not harmful and may not decrease service life. The objective of this research is to improve NDE of CJP welds on steel bridges.
Much effort has been focused on load rating of bridges for vehicular loads. However, most bridge design is focused on the gross truck weight, while the response of typical culverts is driven by the response to a single axle and often a single wheel. Research is needed to evaluate the impact of truck loads on the culvert population and to evaluate the LRFR procedures for rating culverts addressing the loading conditions specific to culverts.

The structural response of a culvert is controlled by the interaction of the culvert with the surrounding soil. Some load is carried by the culvert and some by the soil. As shown by NCHRP Report 647: Recommended Design Specifications for Live Load Distribution to Buried Structures, the mechanics of this interaction are different among concrete, metal, and thermoplastic culverts. Also not captured by simplified design methods common in use today is the fact that as the load increases the relative distribution of load to the culvert relative to the soil can change. These subjects need to be investigated for heavy truck loads to ensure that culvert capacities are properly evaluated for rating. Overly conservative rating procedures result in expensive replacements or upgrades, while less conservative rating procedures could result in premature deterioration and even failures.

The research objective is to develop design procedures, design aids, and guidelines for agencies to evaluate culverts for large live loads and especially to load rate culverts accordingly. These results will form new and revised sections to the AASHTO LRFD Bridge Specifications and the LRFR Manual.
Deaths and injuries attributed to hydroplaning continue to be reported on high-speed roadways. Particularly in major urban areas, roadways with several lanes of travel in a single direction are being constructed and the general assumptions related to hydroplaning potential are becoming more prevalent. Current guidance information available to designers is often based on the AASHTO publication “A Policy on Geometric Design of Highways and Streets” and/or Section 8.2.2, “Hydroplaning” of FHWA’s Hydraulic Engineering Circular Number 21 (HEC-21), “Design of Bridge Deck Drainage.” In particular, HEC-21 provides a formula for quantifying the potential for hydroplaning conditions to exist. Using typical values for the parameters used in the formula, hydroplaning should be expected for relatively moderate rainfall conditions on wide freeways where vehicle speeds are 65 mph or greater. For the roadway designer, it becomes very difficult to provide a design for wide freeways that conforms to the currently documented guidance and procedures. Superelevation transitions, areas of relatively flat gradient, roadway sag points, etc., are common locations where attaining desirable surface drainage design criteria can become problematic. To date, there has not been adequate research and evaluation of wet weather accidents on wide pavements to verify either the presence of the hydroplaning conditions suggested by the published guidance, or the actual occurrence of hydroplaning at the level that would be expected. This proposed project would be comprised of three primary components: first, a review of accident data typically available from DOTs for wet weather incidents on multi-lane facilities to determine if there are common or notable patterns suggesting hydroplaning; second, a field examination of a limited number of wide pavement locations during precipitation events to observe both pavement conditions and driver behavior under conditions that would be predicted to generate hydroplaning, based on HEC-21 criteria; and last, a report that contains the findings from the first two components with recommendations and design considerations for mitigating or avoiding potential hydroplaning conditions. The report should also provide a comparison of the findings to the conditions that would have been predicted from currently documented procedures.

The objectives of this research are to:

- Compile information contained in traffic incident files related to wet weather accidents on multi-lane freeways, specifically those where a report of hydroplaning or skidding was noted;
- Summarize the incident information and determine common factors, or those factors from which a significant change in accident rates would be likely;
- Examine driver and vehicular behavior at selected wide pavement locations during precipitation events of sufficient magnitude to expect hydroplaning based on the HEC-21 criteria;
- Identify and document potential causative factors and provide a recommended set of considerations and practices, and/or identify validity/verifiability of current documented design guidance; and
- Perform a risk analysis to identify the risks associated with pavement design parameters, rainfall intensity and vehicle characteristics (speed, tire pressure, weight, etc., to the extent that these parameters can be captured).
Selecting a design speed for interchange ramps can greatly influence project costs, right-of-way needs, and the potential project environmental and social impacts. This is particularly true for system interchanges and service interchanges with loop ramps or flyover type ramps. General ramp design considerations are presented in Chapter 10 of the AASHTO Green Book, including considerations for selecting ramp design speeds. The ramp design speed is established as a fixed percentage of the connected highways (Green Book Table 10-1). For example, the “lower” range values are set at approximately 50% of the connected highway design speed. The ramp design speed is designated to apply to the controlling alignment element on the ramp proper, regardless of whether the ramp is a free-flowing system connection or a service-interchange ramp that terminates at an intersection.

There are many contextual factors that should be considered in selecting an appropriate ramp design speed. The rationale, and perhaps oversimplification, of the existing guidance is frequently called into question. Additionally, the application of the design speed along all portions of a ramp and across the spectrum of interchange forms is questionable and does not sufficiently take into account the inherent speed profiles of different ramp types. Due to the lack of substantial research in establishing this rationale, design practitioners find it difficult to implement flexibility in the design. The research is needed to provide enhanced guidance that will directly impact future ramp design practices for use nationally in the design of interchanges. The potential payoff is the selection of more cost-efficient, safer, and contextually appropriate interchange designs.

The objective of this research is to develop enhanced guidance on selecting an appropriate ramp design speed based on a combination of contextual considerations and quantitative information as well as to examine the definition of ramp design speed, specifically the portion(s) of the ramp to which design speed should be applicable.

An evaluation framework, including appropriate performance measures must be established. The following contextual factors that may have significant influence of the selection of an appropriate ramp design speed should be considered. These factors may include:

- Differences for system vs. service interchanges
- Differences for entrance vs. exit ramps
- Degree of constraint, impact, and right-of-way cost
- Effects of ramp grade
- Use of transition curves into the sharpest (controlling) ramp curve
- Presence of ramp meters
- Differences in ramp access design (tapered vs. paralleled, presence of auxiliary lane, different types of traffic control at ramp terminals, etc.)

The research should examine the safety and operational aspects of ramp design speed selection over a full range of interchange forms, ramp types, and area environments (rural vs. urban). The geometric design dimensions resulting from the suggested ramp design speeds (such as minimum radius of curvature) must also consider driver expectations and behaviors over a range of traffic conditions and the functional classification of the two interchanging roadways. Development of this enhanced guidance will require the examination of field data and site observations supplemented with safety modeling considerations and traffic operational simulations.

The research should examine the performance and feasibility aspects related to the applicability of design speed on various portions of ramps and connections, taking into account the different characteristics and speed...
profiles exhibited by different ramp types in different interchange forms. Right-of-way footprint and construction cost implications associated with current and potential alternate policies should be investigated as they might apply to representative interchange sites. Speed transitions within ramps—particularly those inherent to certain service-interchange circumstances but also those that may exist on system connectors—should be studied for performance and policy implications.

The issues associated with selecting an appropriate ramp design speed are complex and need research to offer modern perspectives and insights on safety performance and economic trade-offs associated with this important design choice. The final report should include enhanced guidance to design practitioners and propose appropriate changes to AASHTO policy if the results support a change.
Interaction Effects between Freeway and Surface Street Facilities: System Considerations in a Highway Capacity Context

As system-level transportation considerations become increasingly prevalent among highway agencies and municipalities, analysts are ever more in need of accurate methods to measure and predict operations—and operational interactions—across multiple facility types. Recent editions of the Highway Capacity Manual (HCM) have improved analysts’ ability to consider the disparate elements of Freeway Facilities (Chapter 10) and Urban Streets (Chapter 16) in their respective system contexts, but the HCM is generally silent on the interactions between these two major facility classes. In fact, the structure of the HCM, with its separate Uninterrupted Flow and Interrupted Flow volumes, tacitly precludes analyses of these interactions. This artificial separation does not reflect motorists’ daily experiences, which typically involve transitioning from one facility type to another—multiple times—on any given trip. Thus, the lack of a methodology to analyze the operational characteristics of these transitions inhibits an assessment of common real-world conditions and could result in designs that fail to address certain congestion problems.

Interactions between freeway and surface-street facilities typically take place at interchanges. On-ramps and off-ramps are the transition areas—and thus the operational links—between the two types of facilities. At the surface-street (downstream) end of an off-ramp, where flow becomes interrupted, queues related to oversaturated intersections (or oversaturated merge movements) have the potential to extend beyond the ramp and affect upstream operations on the freeway mainline. Conversely, at the freeway (downstream) end of an on-ramp, merge congestion or oversaturated mainline conditions can result in ramp queues extending upstream toward the interchange ramp terminal, affecting operations at the surface-street intersection(s). These interaction effects are not explicitly accounted for in the HCM.

In addition, with the rise of Active Transportation and Demand Management (ATDM) strategies, and with an increasing industry focus on improving transportation system reliability, operational treatments that affect freeway-arterial connections are becoming increasingly popular. For example, the design of a ramp meter must balance two potentially competing objectives: (1) smoothing freeway mainline traffic flow, while (2) minimizing queuing impacts to the upstream interchange ramp terminal. Other treatments, such as HOV bypass lanes, can also affect both freeway and surface-street components of the transportation system. Although the HCM is beginning to address ATDM and reliability, it currently focuses on the effects of these strategies solely at the freeway end, generally ignoring potential interactions with the surface street.

At a higher level, system performance measures are typically computed and reported separately for freeway and surface-street analyses, even when such analyses are part of the same study. In fact, the Level of Service (LOS) concepts for Interrupted Flow and Uninterrupted Flow facilities are based on different measures—delay and density, respectively. The need to study interactions between these two facility classes suggests a related need for a unifying framework to allow evaluation of system improvements (and comparison between alternatives) in meaningful ways. The introduction of travel time and travel time index as performance measures in reliability analysis for both freeways and arterial streets is an important step toward that objective.

Many microscopic simulation software packages are designed to allow analysis of freeways and surface streets simultaneously, and the current state of the practice is to use simulation for such analysis. However, unlike many of the other elements of microscopic simulation, freeway-surface street interactions have no deterministic analog in the literature and in the HCM, and thus lack the performance benchmark that the HCM is able to provide for separated facilities. Standardized analysis methodologies are needed to close this gap and to provide unifying guidance.
The objectives of this research are to: (1) review existing studies relevant to the operational interactions of freeways and surface streets and make the study data easily accessible; (2) develop a framework to bridge Volumes 2 and 3 of the HCM in a manner that facilitates deterministic operational analysis of these interactions; and (3) develop methodologies to analyze these interactions in ways designed to be incorporated into the HCM.

The end products of this research will be: (1) a comprehensive synthesis report of existing studies and data on operational interactions of freeways and surface streets; (2) new and enhanced methodologies to analyze these interactions and a Final Report describing them; and (3) a computational engine (i.e., computer software-based tool) or engines to implement these methodologies. A desirable future outcome from this research is for the methodologies to be formally incorporated into a future edition of the HCM.

It is expected that the research will include the following tasks: Task 1. Conduct a comprehensive synthesis (literature review, surveys, interviews, etc.) of existing practices and methodologies related to the analysis of operational interactions of freeways and surface streets, both in the U.S. and internationally. The synthesis should also cover relevant ATDM strategies. Develop a comprehensive synthesis report. Task 2. Develop a conceptual framework for bridging Volumes 2 and 3 of the HCM in order to (a) facilitate crossover Uninterrupted Flow/Interrupted Flow analyses and (b) provide a unified framework for measuring and reporting Uninterrupted Flow/Interrupted flow performance measures. Task 3. Develop a Methodology Enhancement Plan and Data Collection Plan for the effort needed to validate, test, and expand the relevant Interrupted Flow and Uninterrupted Flow procedures of the HCM to facilitate operational analysis of the interactions between freeways and surface streets. The Methodology Enhancement Plan should determine the needs and priorities for improving the relevant HCM-based methodologies, develop an experimental plan for enhancing the methodologies, and develop a detailed schedule and level of effort required. The Data Collection Plan should determine the data needs based on the Methodology Enhancement Plan, including the amount and types of data needed (field, simulation, survey-stated preference, and/or human factors data), and a detailed schedule and level of effort required. Task 4. Perform data collection following the approach detailed in the Data Collection Plan developed in Task 3. Data shall be cleaned, organized, and documented in a form suitable to proceed with Task 5. Task 5. Enhance and further validate the relevant HCM methodologies to incorporate operational analysis of the interactions between freeways and surface streets, following the approach detailed in the Methodology Enhancement Plan developed in Task 2. Task 6. Develop a computational engine (i.e., computer software-based tool) or engines, and/or modify relevant existing computational engines, to automate the calculation procedures developed in Task 5 and implement the framework developed in Task 2. Task 7. Develop a final report describing recommended methodologies for the analysis of interactions between freeways and surface streets. The report should include a chapter having text consistent with the formatting of the HCM, with guidance on how the text should be incorporated into the relevant portions of the HCM.
**Project 15-58**

*An Assessment of Safety and Geometric Design Criteria for Diverging Diamond Interchanges*

Research Field: Design  
Source: AASHTO Highway Subcommittee on Design  
Allocation: $500,000  
NCHRP Staff: B. Ray Derr

The use of Diverging Diamond Interchanges (DDI), also referred to as Double Crossover Diamonds (DCD), has become more prevalent throughout the United States over the past 3 to 5 years. Overall, DDIs are gaining momentum within the interchange design community. However, only a limited amount of guidance on the design of these types of interchanges exists. The first DDI in the US was constructed in 2009 by the Missouri Department of Transportation (MoDOT). The DDI design accommodates left-turning movements at signalized, grade-separated interchanges of arterials and limited-access highways while eliminating the need for left-turn phasing. On the arterial, two-phase traffic signals are installed at the ramp terminal intersections to shift traffic over to the left side of the roadway between the nodes of the interchange. Once on the left side of the arterial roadway, vehicles can turn left onto limited-access ramps without stopping and without conflicting with through traffic.

Currently, there are no existing guidelines/standards for design of this type of interchange. The design is extremely dependent on site-specific conditions which are demonstrated by the variations in the design elements of the DDIs constructed to date. Additionally, there is relatively little accident history available as no DDIs existed in North America prior to 2009. Analysis of the actual safety and operational performance of DDIs has been limited to a handful of in-service DDIs. An assessment of the current design process and safety analysis is needed to ensure that recent advances and emerging issues are appropriately leveraged and/or reflected in design practices, guidelines, and policies.

The research objective is to identify, review, and evaluate the geometric design features and the associated safety and operational performance of in-service DDIs across the US. This information will then be utilized to develop recommendations for the AASHTO Technical Committee on Geometric Design for consideration as future geometric policy and guidelines. Two basic questions will be addressed: (1) What are the essential design characteristics of a DDI and how should an engineer utilize this information in the design of a DDI and (2) What are the safety and operational benefits of utilizing a DDI and how might the designer utilize this information in their design?

Tasks in this project would include: (1) Perform a critical and comprehensive review of available data relevant to DDI design. (2) Discuss lessons learned with DOTs with in-service DDIs such as MoDOT, UDOT, KYTC, NYSDOT, TDOT, etc. in order to gain their perspective on DDI design and related safety and operational issues. (3) Assess whether, and to what extent, the current design process reflects the explicit consideration of performance (e.g., pedestrian treatments, safety) and promotes efficient, if not optimal, combination of design elements to yield designs that are cost-effective when considering life-cycle benefits and costs. (4) Develop geometric design criteria and guidelines for Diverging Diamond Interchanges. (5) Develop a work plan to analyze the information obtained from the research. (6) Execute the work plan following prioritization and approval from the panel. (7) Develop a report to document the research and provide recommendations for future geometric design policy and guidelines for design of DDIs.

Note: It is expected that this research will be incorporated into NCHRP Project 03-112, “Spacing, Signal Timing, and Performance of Diverging Diamond Interchange and Adjacent Intersections.”
When horizontal curves are bound by barrier walls or other potential sightline impediments (i.e., retaining walls, parapet walls, abutments, piers, columns, and sound barrier), especially in high-speed roadways and system ramp connections, designers compensate for the impact to driver sight distance in various ways including lowering design speed, increasing shoulder width, providing additional signage, or other mitigation strategies. There are drawbacks to each of these mitigation strategies. Lowering the design speed can result in decreased superelevation without any other visual cues for the driver to lower their speed. Another adverse result can lead to extra wide shoulders (ranging from 16 feet to 20+ feet) along the inside of the horizontal curve when the barrier/visual impediment is located on the same side. Providing extra wide shoulder increases costs (especially if on structure), may increase ROW needs, and may encourage erratic behavior from drivers who believe the additional area was intended for parking or as an additional driving lane (this can lead to operational and safety implications). In addition, these concerns may prevent agencies from installing HOV lanes to manage capacity problems. Because of these conflicting factors, many agencies have used the design exception processes to address the tradeoffs for sight distance in such situations.

This research would examine these situations to determine whether criteria for horizontal sightline offset could be developed to better address these conflicting factors. The research should evaluate this condition and determine what criteria will provide an acceptable design. Research should examine existing research, current design criteria, performance, and safety of existing locations with such geometrics; identify mitigation techniques; and determine whether the design criteria should be revised.

The researchers should take into consideration the impact of the vertical alignment in addition to the horizontal offset to the wall or impediment. The researchers should also examine the geometrics under various traffic conditions. Dense traffic may be another impacting factor in determining the HSO criteria. In the case of barrier wall and parapets, glare screens may also be a desirable design element.

The objective of this research is to provide horizontal offset design criteria for curved alignments adjacent to barrier and similar types of impediments that may impact the driver’s line of sight. The research would be helpful to the transportation design professional and facility owners. The findings may lead to modification of the design criteria and could reduce costs, reduce ROW needs, and eliminate some future design exceptions. The results of the project should be developed in a manner that allows it to be directly used within future updates to the AASHTO Green Book.
The *AASHTO Guide for the Development of Bicycle Facilities* was published in 2012 but written in 2009 based on a plan developed in 2004. The bicycle transportation field is evolving rapidly so it is important to ensure the guidance is current. Even while the AASHTO guide was being developed, new types of bicycle facilities and treatments were being considered and installed in the United States. As evidence of this, the Institute of Transportation Engineers (ITE) published *Separated Bikeways* in 2013 and the National Association of City Transportation Officials (NACTO) published the *Urban Bikeway Design Guide* in 2012 that included several design elements not included or only briefly mentioned in the AASHTO Guide (e.g., bike boxes, green lanes, cycle tracks, bicycle signals).

In August 2013, the FHWA issued a Bicycle and Pedestrian Facility Design Flexibility memorandum supporting the use of the AASHTO Guide, NACTO Guide, and ITE report to “further develop nonmotorized transportation networks, particularly in urban areas.” Many state DOTs would like to see additional research on innovative bicycle treatments so that they can make better informed decisions at the project level, including consideration of the tradeoffs between the different modes of traffic using the road. The AASHTO Guide covers all aspects of bicycle planning and design for on-road and off-road bikeways, including fundamental operating characteristics of bicyclists and geometric design. It is referred to in the FHWA memorandum as the “primary national resource for planning, designing, and operating bicycle facilities” so there is a need to keep it accurate and up to date.

The objective of the research is to update the *AASHTO Guide for the Development of Bicycle Facilities* and develop a draft guide suitable for review and balloting by the AASHTO Technical Committee on Nonmotorized Transportation.
The AASHTO Highway Safety Manual (HSM) is rapidly becoming a key safety management and evaluation tool for state and local highway agencies, MPOs, and design and traffic consultants. The HSM was developed largely through NCHRP research and the first edition was published in 2010. As the first edition was being developed, it was clear that high priority research could not be completed without delaying publication. An example is the safety prediction models for freeways and interchanges developed under NCHRP 17-45—while this research is important, the decision was made to publish the first edition without this material. Several other research efforts to develop models for additional facility types for inclusion in the HSM are underway and, like the freeways and interchanges chapters, they are considered critical to increasing safety knowledge and practice.

The HSM has fostered significant advances in analytical methods in highway safety and this evolution continues with new knowledge, safety performance functions (SPFs) and Crash Modification Factors (CMFs) being developed on an ongoing basis. Users and researchers now have gained sufficient experience with the HSM and have outlined priorities for enhancements to HSM chapters, procedures, and models. An example of current research to address user needs is the FHWA decision tree to determining whether to develop a state-specific safety performance function or to calibrate the functions provided in the HSM and its potential inclusion in the next edition of the HSM. Beyond applying the HSM in specific situations such as network screening, crash diagnosis, and design exceptions, state departments of transportation and other users are developing their own safety performance functions, policies, and agency-wide training programs and pursuing other implementation activities that more completely test the information in the HSM.

There is also a significant amount of research underway through NCHRP, FHWA, and pooled fund initiatives. This research is further developing and promoting the quantitative, data-driven approach to safety. These research efforts are not specifically developing new chapters for the HSM or enhancing models already in the manual, but are expected to result in advances that are suitable for inclusion in the manual or other AASHTO documents such as the AASHTO “Green Book.” Incorporating this material throughout the HSM will take specialized knowledge and research skills in order to appropriately identify, evaluate, refine, and include this knowledge in a manner ideal for practitioners using the manual.

Substantial HSM-related research has been completed and other research has begun since the first publication in 2010 in an effort to prepare a second edition of the HSM to address unanswered questions and to incorporate recent and upcoming research results into appropriate locations within the HSM. This research would represent an important advance in safety management and evaluation capabilities for highway agencies.

The objective of the research is to prepare the second edition of the HSM in a form ready for publication, incorporating new chapters on safety prediction for freeways and interchanges; new safety prediction procedures for six-lane arterials, one-way arterials, new intersection types and roundabouts; increased consistency in the form and presentation of SPFs and CMFs; improved treatment of roadside design issues; and a thorough updating of the entire manual based on user feedback and needs.

The first edition of the HSM has been successful in transforming the way in which safety is considered by highway agencies and their consultants in safety management of the roadway system and in the project development process. Key documents like the HSM should be updated periodically to keep the state of practice in line with the state of knowledge. A key step in making the extensive new research listed above available for application by highway agencies is to synthesize and organize the research results and draft materials in the second edition of the HSM. The proposed research will lead to a second edition of the HSM in 2018, 8 years after the first edition. The production of the second edition of the HSM is urgent because it would be undesira-
ble for more than 8 years to elapse between publication of the first and second editions of the HSM, since both the science of safety and HSM implementation are relatively new and rapidly developing areas.

Note: The AASHTO Standing Committee on Research directed that the project should identify and fill gaps, synthesize existing research, and ensure that the results are compatible with the HSM format. This project shall also be coordinated with NCHRP Project 17-72.
Highway safety practitioners were given a significant tool in 2010 with the publication of the first edition of the *Highway Safety Manual* (HSM). In Part D of the HSM, crash modification factors (CMFs) are provided for a variety of treatments. These CMFs provide practitioners with the means to estimate the safety effects of countermeasures. By the time the next edition of the HSM is published, many more important CMFs will have been developed. It is critical that the next edition of the HSM include these CMFs in order to continue to push forward this significant tool.

There are also questions that have arisen since the first edition of the HSM. In question are the criteria governing the rules for inclusion of CMFs in the HSM change, should more than one CMF be presented for a particular countermeasure, and should the uncertainty of a CMF continue to be expressed with “adjusted standard error” or should some other measure be used. Recent research has indicated that the adjusted standard error of the CMF estimate does not adequately represent the uncertainty associated with the CMF, especially when CMFs from multiple studies (for the same treatment) are combined and/or the CMF is based on information from locations that are not very similar to each other. To this end, there is a need to establish inclusion criteria for CMFs in the next edition of the HSM and guidelines on how CMFs should be presented in the next edition. This research should make use of information from recent studies that discusses methods to more appropriately represent the uncertainty associated with CMFs. Finally, CMFs for inclusion in Part D of the next edition of the HSM need to identified, assembled, and documented.

A major resource for this effort will be the FHWA CMF Clearinghouse. The Clearinghouse presents all published CMFs, even those of poor quality, which are identified as such by their star ratings. By contrast, the HSM only includes CMFs of high quality that meet the established inclusion rules. The Clearinghouse does not adjust the CMFs or the standard errors, and presents them as they are reported by the study author(s), along with a star rating to indicate the reliability of the CMF. Since the publication of the first edition of the HSM, more than 1,500 CMFs have been added to the CMF Clearinghouse. If additional research on the safety effectiveness of countermeasures continues at the current rate, it can be expected that at least 1,000 more CMFs will be added to the CMF Clearinghouse by 2018, the anticipated publication date for the next edition of the HSM. These CMFs, or at least those rated highly in the Clearinghouse, need to be assessed for inclusion in the HSM.

The objectives of the project are to reassess and, if appropriate, revise the criteria for including CMFs in the HSM, develop guidelines on how CMFs should be presented, and identify and document the CMFs to be included in the next edition of the HSM.

Note: The AASHTO Standing Committee on Research directed that this project be coordinated with NCHRP Project 17-71.
Project 17-73

Developing a Systemic Safety Analysis Tool for Pedestrians

Research Field: Traffic
Source: AASHTO Standing Committee on Highway Traffic Safety
Allocation: $300,000
NCHRP Staff: Lori L. Sundstrom

Over the past decade, pedestrians accounted for approximately 12 percent of all traffic fatalities in the United States, amounting to more than 4,500 deaths per year. Worldwide, pedestrians suffer the largest share of the 1.2 million yearly traffic fatalities. As people are being encouraged to walk more for their transportation needs in order to reduce environmental impacts and improve public health, transportation professionals are obligated to make walking as safe as possible. Many of the risk factors and the spatio-temporal distributions of crashes that involve pedestrians are inherently different from crashes that involve motorized vehicles only. Moreover, the set of potential safety improvements for pedestrians are typically dedicated only for pedestrian safety applications. In light of this, many of the existing safety practices cannot be applied to improve pedestrian safety without significant modifications.

To date, there are two approaches used by state agencies to allocate safety resources. One is the hotspot approach which focuses on identifying and recommending improvements for high collision concentration locations, while the other is the systemic approach which seeks improvements that can be implemented at various sites across the network, based on specific roadway features that are associated with a particular crash type. Systemic improvements typically have a lower per-site cost as they are implemented at multiple locations across the network. Currently, the hotspot approach is the dominant funding mechanism for most state agencies in the United States. However, some agencies are increasing the proportion of funding allocated to systemic road safety improvements to complement the hotspot approach.

The systemic approach is valuable for facilities that have relatively low crash frequencies (e.g., rural roads) and are therefore less likely to be flagged as hotspots and be considered for safety improvements. Similarly, pedestrian crashes exhibit lower crash frequencies; using this approach, few resources are allocated to conduct site investigations to improve pedestrian safety. In addition to that, pedestrian data are often missing essential elements (e.g., exposure) that are needed for hotspot identification methods.

In light of this, there is an urgency to increase the knowledge base available to public agencies and others for identifying systemic prevention mechanisms for pedestrian fatalities and injuries. These needs are related to Strategies 3 and 4 of Goal 4 of the AASHTO Standing Committee on Highway Traffic Safety (SCOHTS) Strategic Plan; these strategies are related to promoting national safety research and developing analytical tools that evaluate safety performance.

Road safety researchers and professionals have already identified the value of the systemic approach to safety. The FHWA Office of Safety has acknowledged four benefits of the systemic approach: Solves an Unmet Need in Transportation Safety; Uses a Risk-Based Approach to Prevent Crashes; Results in a Comprehensive Road Safety Program; and Advances a Cost Effective Means to Address Safety Concerns. The FHWA Office of Safety has also outlined the core steps needed to implement this approach and a report describing a tool that helps states learn about and apply the systemic approach to safety is about to be released. The project proposed would follow these steps, but would develop and enhance it with a focus on pedestrian safety.

The proposed project would also build on the findings described in NCHRP Research Results Digest 345 which presents the results of NCHRP Project 17-18(19). The study conducted a survey practice of all 50 states to review how states are allocating resources using black-spot (i.e., hotspot) analysis methods and systematic (i.e., systemic) methods.

The Rural Road Safety Policy, Programming, and Implementation Joint Subcommittee; Low-Volume Roads Committee; and Transportation Safety Management Committee of the Transportation Research Board sponsored a Human Factors Workshop at the 2013 Annual Meeting titled: Systemic Safety Program Improvement
Location Prioritization: Processes and Risk Factors. The workshop described the Systemic Safety Project Selection Tool and several pilot studies that are using the tool.

The objective of this research is to develop a tool to conduct systemic safety analysis for pedestrians using analytical techniques to identify road features that are high-risk for pedestrians and recommend the appropriate and cost-effective systemic pedestrian safety improvements. The research would be conducted through the following tasks:

1. Develop an analytic method to identify prevalent pedestrian crash types and the predominant facilities for these crashes. The conjecture here is that there is an association between specific crash types and design attributes that can be identified.

2. Develop a procedure to select the appropriate safety improvements given the pedestrian crash type and the attributes of the facility.

3. Develop a technique to calculate the benefit-cost ratio of systemic pedestrian safety improvements. This technique would ideally consider the economies of scale of implementing the same improvements across multiple locations.

4. Develop a prototype tool that incorporates the above tasks.

These objectives also meet Strategies 3 and 4 of Goal 4 of the SCOHTS Strategic Plan.

This project is a necessary step in the development of pedestrian road safety plans that could eliminate thousands of pedestrian fatalities and injuries. The project would also allow agencies to allocate the appropriate resources for pedestrian safety improvements despite the shortage of data. Moreover, the tool could also be used to improve global pedestrian safety since similar safety and data challenges are relevant around the world.
Entrained Air Void System in Concrete Structures and Pavements

Entraining air in concrete continues to challenge users and producers. On the one hand, concrete failures are still being reported due to inadequate air-void systems subjected to cyclic freezing and thawing in a saturated condition. On the other hand, low compressive strength resulting from excessive air content or excessively close spacing of air voids continues to occur. Both problems reflect the difficulties practitioners are having in achieving a consistent air-void system in in-place works. This is either due to variability in materials or practices, inadequate understanding of the differences in behavior of the various materials that can be used (i.e., air-entraining admixtures), or changes in the mixture during processing (i.e., after the batch has been tested and accepted). Furthermore, there is debate regarding the amount of air and the required characteristics of the air-void system needed for frost resistance for modern concrete, with some questioning whether entrained air is needed at all in high-performance mixtures.

In addition the quality of the air-void system in the final as-constructed structure is often not determined; the use of new cementitious systems and chemical admixtures and their potential interactions may increase the risk of problems; and the possibility and effects of compromises to an initially satisfactory system due to secondary deposits is still not well understood. Considerable work has and is being conducted, but problems are still occurring in the field. There is a need for a review to be conducted to pull together what is known, to identify the missing pieces, and to develop and execute a research program to fill the gaps in knowledge.

This work will increase understanding of the air-void system in concrete and help answer questions such as: Should specifications for different environments, air-entraining admixture formulations, and concrete systems (SCM’s, HPC) be based on the spacing factor or some other parameters; how is an acceptable air-void system achieved; how should materials, construction, and processing effects be measured (in both the fresh and hardened states); and what are the mechanisms of deterioration, prevention, and repair?

Phase I of this study would be to conduct a broad review of the topic, including past and current research, and to prepare a “State of the Science” report and a recommended Phase II work plan. The report would be written to meet the needs of those involved in building transportation structures or pavements, providing the best current information to improve modern construction. The Phase II work plan will identify areas where further work is required and include specific recommendations for the tasks required to conduct the remaining research. Phase II tasks would be dependent on the findings of Phase I, but would include laboratory investigations, field evaluations, and analysis of the findings. This work is expected to (1) establish the relationship between total air, spacing factor, specific surface area, strength, w/cm ratio, and freeze thaw for modern concretes and provide relevant guidelines for adoption by specifiers; (2) develop a new method to determine air-entrained parameters in hardened concrete by using image analysis or other technology driven technique; (3) compare the results of these methods to those obtained from existing methods (e.g., ASTM C457); (4) establish a new air parameter criterion for durable concrete based on these new measurements; and (5) develop proposed AASHTO standards/guidelines for the new method.

Note: The AASHTO Standing Committee on Research directed that this project be coordinated with the pooled fund study being led by Oklahoma DOT.
Society is demanding value for money in public investments while at the same time increasing the influence of stakeholders and permitting agencies on project outcomes. Managing stakeholders, permitting agencies, variable ground conditions, constructability, and technical issues requires innovation and openness to change when delivering capital projects “on time and within budget.” Program planners and decision-makers need a comprehensive understanding of the range of possible outcomes in a project and/or program to make intelligent decisions.

Within the transportation sector, strategies to stimulate innovative approaches designed to improve the reliability of project development and delivery should consider a range of alternative delivery methods, risk-based cost and schedule estimating, value engineering, constructability reviews, and alternative technical concepts. Project development and delivery strategies involve risk transfer (but not always in a cognitive fashion). Most strategies involve an effort to push teams to think and behave differently, generating alternative solutions, estimating costs and benefits, and championing new ideas.

Over the past decade or so, the AASHTO Value Engineering Technical Committee has endeavored to improve the quality and cost-effectiveness of projects to meet the AASHTO Highway Subcommittee on Design’s strategic plan. Value Engineering (VE) is a proven method of achieving a common understanding of project needs, helping to stimulate innovation while maximizing the use of resources to achieve project objectives. At the project level, the goal of a VE analysis is to achieve an optimum balance of project function (e.g., safety, operations, and environment), quality, and risk and cost consciousness; however, VE can be integrated more effectively with other techniques to stimulate innovation and identify strategies for managing and allocating risk. Identification of major schedule and cost risks is not sufficient by itself to ensure successful project development and delivery. A technique to develop risk management solutions to allocate risk in the manner that has greater probability to achieve value for money is the missing link.

Budget constraints, increasing project complexity, and stakeholder involvement are driving an ongoing need to address innovative techniques in project development and delivery. This research project will generate a best practices guideline for use by any transportation agency to stimulate innovation and achieve value for money while adequately addressing risk. It will provide decision-makers, program and project managers, and VE practitioners with a structured approach to integrate Value Engineering into the Risk Management framework, thereby enhancing opportunities for generating and applying innovative and effective project delivery strategies.
Partnering highway construction contracts is popular throughout the country and has been in use by state DOTs for over 20 years. Many, if not most, DOT construction contracts contain general provisions regarding the partnering process. The Ohio and Texas DOTs conducted research studies on the effectiveness of partnering in the mid-1990’s; findings indicated that there were quantifiable benefits for employing partnering on traditional design-bid-build contracts. Since that time the nature of the procurement environment has undergone significant changes due to the adoption of alternative contracting methods (ACM) such as best-value award (BVA), construction manager/general contractor (CMGC), design-build (DB), public-private partnerships (P3), alternative technical concepts (ATC) and others that were not prevalent during the time periods covered by the Ohio and Texas studies. The Federal Highway Administration’s Every Day Counts (EDC) initiative has significantly increased interest in ACMs by reducing the state share for federal-aid projects delivered using ADMs.

The result of the above is a clear need to invest in contractual relationships to avoid delays and extra costs due to contract disputes as DOTs seek to accelerate the delivery of highway projects to rapidly renew the deteriorated infrastructure. Partnering is a tool proven to provide a means to improve the contractor-owner relationships by providing a framework for communication and problem solving with the goal of win/win outcomes. The partnering process aims to foster a team environment where challenges are addressed as a group and disputes are resolved early, hoping to create a positive impact on project cost, time, and quality performance.

Therefore, the objective of this research is to revisit the conclusions reached by ODOT and TxDOT two decades ago on partnering DBB projects and expand that result to account for the contract relational changes inherent with ACMs. The research will quantify the costs and benefits of the partnering process on a national level. It will also identify successful partnering efforts, and develop effective practice guidance and training materials.

The literature shows that the growth of partnering is directly related to the growth in claims and litigation regarding construction contracts throughout the nation. In the late 1980’s, the US Army Corps of Engineers (USACE) led the way for public agencies to begin using this new business practice as a means to avoid disputes and consequently reduce the ultimate cost of delivering public facilities. To verify the success of partnering, projects must be measured. One pitfall in past efforts to measure partnering performance involves the collection and interpretation of statistics regarding partnering. In public agencies, there is a tendency to credit partnering for project successes even when there was no tangible evidence of any improvement over the status quo. This was caused by the intense personal investment public project managers and contractors make during partnering sessions. While there is no doubt that enhanced communication greatly improves a project’s management/dispute resolution environment, US formal partnering programs are based on a nonbinding, “work friendly” agreement, called a partnering charter, which carries no contractual authority and is unenforceable if violated.

Therefore, US partnering is merely an exercise in interpersonal relationship building that, while usually successful and deemed valuable by most practitioners, does not materially alter the manner in which the partnered project is delivered.

P3 is one ACM that uses a contractual form of partnering and its use is increasing because it also provides access by public agencies to private capital. Countries like Australia, New Zealand and the United Kingdom use an ACM that is also “partnering,” but this ACM is neither a P3 nor a DB contract. The method employs a contractual “pain/gain sharing” mechanism to regulate the relationships between parties and codifies the jointly developed project goals as an enforceable contract requirement. US ACMs like BVA, CMGC, DB, and ATCs
increase the level of integration in the project delivery process and the literature has shown that all require a higher level of trust and collaboration between parties to be successful.

A 2012 Caltrans study found that only a handful of agencies have “mature” (as defined by the consultant) partnering programs and that very few states have undertaken formal research studies to assess the impact of partnering on construction project performance (such as project costs and schedules). The study also discovered that very few formal research projects have been conducted using quantitative project performance data to assess the impact of partnering; those that did date back to the 1990s. The sunset of the AASHTO Standing Committee on Quality left the Partnering Subcommittee’s considerable work on partnering measurement unfinished. No comparable committee is known to currently exist within the AASHTO or TRB committee structure. The 2005 *AASHTO Partnering Handbook* appears to be the only national guidance or research focused on highway construction partnering. There are no known national research activities on this topic under way.

The objective of this research is to revisit the conclusions reached by ODOT and TxDOT two decades ago on partnering DBB projects and expand that result to account for the contract relational changes inherent with ACMs. The research will quantify the costs and benefits of the partnering process on a national level. It will also identify successful partnering efforts, develop guidance-based effective practices and training materials. Lastly, it will recommend changes and updates to the 2005 *AASHTO Partnering Handbook*.

The FHWA EDC program has succeeded in accelerating state-level adoption of ACMs. Thus, many states are implementing these contracting methods for the first time and it is critical that they understand the impact of the ACMs on their design and construction industry partners. Partnering workshops are not free and many DOTs have assumed additional in-house support staff expenses to implement partnering on a programmatic basis. DOT upper management needs hard data on their cost effectiveness to make high level policy decisions to justify implementing or perpetuating an agency-wide partnering program. ACMs have materially altered the risk of cost and time growth due to disputes in many ways for the better through early contractor involvement, but ACMs also increase the pace of work increasing the risk that any dispute could have a major impact on partnered project cost and schedule performance. The results of this research could potentially advance the US partnering process to incorporate aspects of the contractual partnering methods in use overseas. Additionally, it would also test the conventional wisdom that all projects benefit from formal partnering, potentially freeing up funds dedicated to partnering for specific types of projects where there appear to be no tangible return on that investment. Implementation would be through furnishing updated material for inclusion in both AASHTO, FHWA, and state-level partnering guidance documents as well as training materials which could be used to rapidly disseminate the findings of the research.

Note: The AASHTO Standing Committee on Research recommended that this research should build upon NCHRP Project 20-07, Task 362, “Quantifying the Costs and Benefits of Partnering on Projects Delivered Using Traditional and Alternative Contracting Methods,” and consider NCHRP Problem Statement 2015-D-03, “Validating the Outcome of Partnering on Major Capital Projects.”
The planning, implementation and maintenance of asset management systems (AMS) and practices requires a significant investment and commitment of time. There is extensive literature available on the theoretical benefits of putting asset management principles into practice, however, there is very little information that examines the actual return on investment (ROI) from implementing asset management practices and systems. Replacing disparate, outdated information management systems, data bases and spreadsheets with the robust analytical tools now available makes sense to agency engineering and information technology stakeholders, but developing the business case for convincing decision makers can prove to be challenging. The first questions many executives ask when presented with a request to procure an asset management system and implement asset management practices are what will it cost, how long will it take, and what is the expected return on investment?

One of the problems in the evaluation of ROI is that costs are loaded on the front-end while benefits continue to grow and accrue over time as use of the systems matures and processes improve. Cost factors involve both capital and operational expenses, and in some cases there can be savings from old business practices and systems replaced by the new AMS. Benefits are often much harder to define monetarily than costs since they are both tangible and intangible. Nevertheless, many agencies will already have or be able to collect the data required for the analysis. Not every type of cost and benefit will apply to each agency, but the manner in which costs and benefits are identified, categorized, measured and treated in the analysis must be easily understood and applied.

The objectives of this research are to a) develop a framework and methodology for calculating the return on investment ROI for implementing or expanding an AMS and associated asset management practices, and b) apply that framework and methodology to illustrate its use in transportation agencies representing different levels of asset management maturity.

The research results will both help agency personnel to demonstrate the business justification for investments in asset management systems and practices and highlight best-practice examples of implementation. The research results will both provide a useful management analysis tool and add to the body of knowledge on the benefits of effective transportation asset management.
Extreme weather events and a changing climate can result in significant costs to transportation agencies and to the traveling public. State DOTs as well as other public infrastructure agencies are increasingly challenged with difficult decisions about whether, when, and to what extent to incorporate adaptation measures into their existing and future facilities to provide more resiliencies in the event of extreme weather or in response to climate change concerns such as sea level rise. Adaptation measures could include hardening existing facilities, increasing maintenance practices, strategically placing spare materials in preparation for extreme weather, etc. Given the potential costs and benefits involved in enhancing the strength of transportation facilities, the decision to implement adaptation measures is dependent on a variety of factors such as the criticality of the facility to the overall transportation system, the likelihood of significant traveler delay in the event of facility closure, and the economic importance of the facility to freight, tourism, or other commercial or social interests.

State DOTs would benefit from an analytical framework that would assist them in making more informed decisions about the overall costs and benefits of implementing adaptation measures for extreme weather events and climate change. This framework will help state DOTs identify what factors to consider in making decisions about implementing adaptation measures and would ultimately help state DOTs improve the cost-effectiveness of their transportation investments. This work is especially important at a time when state DOT are fiscally constrained and immediate corrective measures to roadway assets following extreme weather are usually above planned budget expenditures.

State DOTs are tasked with making sound investments of taxpayer dollars while also building, operating, and maintaining reliable transportation systems in the face of increasing extreme weather events and climate change. This decision framework will assist state DOTs in making informed and supportable decisions regarding their implementation of adaptation measures for extreme weather events and climate change. The pay-off would come in making better long-term decisions based on a more holistic analysis of the cost and benefits of implementing adaptation measures.

The following related research was found in the TRID database:


None of this research develops a step-by-step framework that assists transportation practitioners in identifying the types of costs associated with extreme weather events and climate, the types of adaptation measures that could be implemented to increase resiliency to extreme weather events and climate, and then the types of costs and benefits associated with these adaptation measures. However, the research above does contain information that would be helpful in developing such a framework.

The research objective is to develop an analytical framework that will assist state DOTs in analyzing the overall costs and benefits of incorporating adaptation measures in their existing and future facilities in response
to extreme weather events and changing climate conditions, such as sea level rise. This framework might eventually be developed into a live tool.

The following tasks are suggested to meet the research objective:

1. Identify the overall structure of the framework (e.g., step 1: identify the type of costs associated with extreme weather/climate; step 2: identify potential adaptation/resiliency measures; step 3: identify potential costs and benefits associated with these adaptation measures).

2. Review the results of completed research, case studies, and pilot projects (e.g., the FHWA Climate Change Resilience Pilots) that address the costs of extreme weather and adaptation decision-making and investments to help inform the development of the framework. For example, MassDOT, NYSDOT, and WSDOT will be evaluating costs and benefits of adaptation strategies as part of their FHWA Climate Change Resilience Pilots. Focus review particularly on those cases where the costs and potential benefits of implementing adaptation measures were quantified.

3. Based on the results above, as well as an independent analysis of the key factors that need to be considered, complete the overall framework that would guide DOTs and other decision-makers through the process of costing out the overall cost-benefits of implementing adaptation and resiliency measures.

Whenever possible for each factor or decision-point, provide a hyperlink or reference to case studies or proven methodologies for quantifying the overall economic costs. Examples could include economic analyses of traveler delay time, freight interruption, and/or loss of tourism caused from facility closures or interruptions; also include hyperlinks to case studies or methodologies that quantify the benefits of increased investment in adaptation measures. WSDOT’s I-90 Snoqualmie Pass East Project is one example of an economic analysis that could be included.
Impacts of Connected and Automated Vehicles on State and Local Transportation Agencies

The advent of automated vehicles will significantly change fundamental planning, design, and operational characteristics for the road network. Industry leaders expect that Level 4 vehicle automation (under NHTSA and SAE definitions) will be available on the market by 2018. Fully autonomous, driverless vehicles (SAE Level 5 automation) could be on the market by 2025. NHTSA considers that connected vehicle technologies (e.g., V2V, V2I) are included in the continuum of vehicle control automation.

For Level 4 automation, “the vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip.” (NHTSA, Preliminary Statement of Policy Concerning Automated Vehicles) Level 5 automation is essentially the same as Level 4, but without any driver supervision (e.g., there is no expectation that the driver will be engaged). These vehicles will be much safer than current models and will significantly increase a road’s throughput capacity.

At some level of market penetration, the number and nature for vehicle trips will change. Level 5 would allow a commuter to be dropped off at the office door and the empty vehicle sent back to the driver’s residence so that other family members could use it. A group of people could collectively own a pool of vehicles from which one could be summoned by a phone call. This could result in increasing the number of vehicle-trips, changing the activities at curbside, and decreasing the need for parking.

TRB held a workshop on the Future of Road Vehicle Automation in July 2013. Some of the key issues related to infrastructure that were identified include: local versus centralized traffic control, roles of public and private sectors, goals and business models, precision and accuracy for vehicle positioning, use of crowd-sourced data, application-specific requirements for connectivity, accommodation of multimodal traffic (including detection of pedestrians and bicycles), social equity and other policy issues, implementation plans for managed lanes, compliance with and enforcement of vehicle standards, deployment scenarios for commercial and transit vehicles, impacts on the distribution of origins and destinations and trip-making behaviors, traffic control device requirements (including pavement markings), performance measurement and management systems, and region-specific needs.

The AASHTO Highway Subcommittee on Systems Operations and Management is currently developing a strategic plan through a 20-07 project. At a workshop in September 2013, connected and autonomous vehicles were identified as an issue to be included in the Strategic Plan. Deployment of these vehicles will have a profound effect on the transportation system and state and local DOTs need timely information to adapt to them.

The objectives of this research are to (1) assemble and maintain information useful to state and local transportation agencies in planning for connected and automated vehicles, (2) identify critical issues associated with connected and automated vehicles that state and local transportation agencies and AASHTO will face, (3) design and conduct research projects to address those issues, and (4) conduct related technology transfer and information exchange activities. It is expected that this effort will be coordinated with the Operations Center of Excellence being developed by AASHTO, ITE, and ITS America.

It is expected that this special project will be overseen by a panel representing state, local, and federal DOTs, AASHTO, and ITE. Consideration will be given to private-sector participation on the panel. The panel would probably meet twice a year to discuss matters of common concern, review progress on completed and ongoing efforts, and select new topics for research and technology transfer activities. The panel will report annually to the AASHTO Standing Committee on Research on their progress and plans.
Note: This project is contingent upon the AASHTO Standing Committee on Research’s approval of the plan from NCHRP Project 20-24(98). The plan is expected to identify research topics for a multi-year program.
Transportation agencies need reliable and accurate information to make good decisions about development, operation, and upkeep of the systems for which they are responsible. The system’s users and other stakeholders similarly need information to derive the greatest benefit from the system and the agency’s efforts. Effective information access, display, and sharing are critical for both agencies and stakeholders.

Open government initiatives, the increasingly interdisciplinary nature of work within agencies, the growth of collaboration with external partners, and growing demands of state and national information reporting are adding complexity and urgency, as well as specific requirements, to the challenges of making information available to those who need it. The volumes of information are expanding exponentially, and trends toward open government, data transparency, and performance measurement are driving change in information management systems and strategies. Budget reallocations and other shifts in agency priorities can cause information on websites, and sometimes the website itself, to disappear unexpectedly, creating uncertainty and promoting interest in creating more reliable sites to store information.

Transportation practitioners are creating portals and clearinghouses to help communities of interest find relevant information. The AASHTO Research Advisory Committee Task Force on Transportation Knowledge Networks conducted a review of successful practices to support information portals and found significant discussion of web portals, but portal managers need more explicit guidance to better meet objectives and reduce the labor currently necessary to manage information portals.

The objective of this research is to develop guidance to support development and management of information portals to serve transportation agencies and their stakeholders. The guidance will address issues such as the following:

- Timely documentation of business needs the information will support
- Design of information systems and websites to facilitate networking and collaborative use of data and information
- Cost-effective development and management of sustainable information portals
- Uses of visualization and other information delivery methods to aid communication
- Uses of social networks in transportation
- Appropriate use and management of intellectual property

Guidance will help transportation agencies and stakeholders clarify objectives of a portal, design elements that help automate a site’s data collection, support reporting and visualization, reduce labor necessary for management, enhance content findability, and promote stability of information access.
Project 20-104
Capturing Project Knowledge Developed with Consultants

Research Field: Special Projects
Source: Georgia
Allocation: $250,000
NCHRP Staff: Andrew C. Lemer

AASHTO reports that the key determinant in effective consultant management is the development of in-house expertise to manage the advice and contributions of external advisers. However, increasing reliance on consultants can erode core areas of expertise within the public agency, not only curtailing the agency’s range of internal competence but also threatening the agency’s ability to manage external resources effectively. The issue is particularly important as some state transportation departments adopt across-the-board consultant utilization rates of up to 80%. Innovative program delivery offices also rely extensively on outside consultants to develop projects through alternative delivery methods such as design-build, CMGC, and P3.

Some studies indicate that as much as 80% of knowledge related to a project’s design is tacit and based on direct experience. Increasing reliance on consultants then has at least two important consequences. First, agency employees may fail to develop experiential project knowledge when consultants take on knowledge-intensive roles. Second, the reliance on unique technical skills from the consulting community effectively limits development of public sector staff capabilities, risking increased costs of hiring and managing consultants.

The objectives of this research will be (a) to identify and compare patterns of knowledge retention in knowledge-intensive, consultant-dependent areas of project delivery, including conventional DBB and alternative project delivery options such as design-build, CMGC, and P3; and (b) to identify effective agency practices for capturing and using knowledge from projects developed with external consultants. Research products may include cataloging of effective knowledge-capture and management practices, knowledge-management templates to enhance findability, and guidance on training, project reviews, lessons-learned debriefings, and other methods to enhance capture and sharing of tacit knowledge.

Note: The AASHTO Standing Committee on Research directed that the scope be broadened. For design-build and other innovative contracts, harvesting good ideas from the designers would be valuable and the contract language needs to facilitate this.
Crash test procedures for median barriers has seen much progress in the last four years as evident by the publication of *NCHRP Report 230*, *NCHRP Report 350*, and most recently the 2009 AASHTO *Manual for Assessing Safety Hardware* (MASH). Objective guidance for the implementation of crash tested median barriers, however, has been lacking. In 2009, the TRB published *NCHRP Report 638* which provided guidance for the selection of roadside longitudinal barriers. Another project is nearing completion to provide guidelines for the selection of Test Level 2 through Test Level 5 Bridge Railings; however, guidance on the selection and placement of median barriers is lacking.

Currently the AASHTO Roadside Design Guide (RDG) is the only national guideline available for states that choose not to prepare their own guidelines for roadside design. The RDG offers subjective guidance for the selection of median barriers, citing a higher percentage of heavy trucks in the traffic flow, adverse geometries, and higher accident rates as conditions that may warrant barriers with a performance level higher than Test Level 3, however thresholds for these values are not provided. Objective guidance on the selection and placement of median barriers would complement recently developed objective guidance for barriers and bridges and would help define these subjective thresholds while helping to balance public funds with improved safety.

Median barriers can be divided into test levels, as defined by MASH, which represented the type of vehicle the barrier is designed to redirect. Each test level has three general categories, namely flexible, semi-rigid and rigid. The less rigid a barrier is the less energy is required to be dissipated by the vehicle; hence accelerations imparted to the occupants inside the vehicle during an impact are lower with respect to such barriers when compared to rigid barriers. On the other hand, flexible barriers have been shown to have large deflections making these barriers ineffective choices for narrow medians.

The guidelines will be based on traffic volumes, roadway geometry, median slopes, median placement, and barrier type (i.e., shape, material, rigidity, etc.). It is anticipated that the research would develop charts with associated site specific adjustment factors for the selection of the appropriate test level median barrier. Different charts will likely be developed for the selection of median barrier type and placement in the median. It is anticipated the results will be integrated into the AASHTO Roadside Design Guide.

This research will lead to updates of the median barrier chapter of the Roadside Design Guide, assisting designers in selecting median barriers for installation on existing or planned divided highways.
Knowledge of the erodibility of geomaterials is essential to the analysis of problems related to soil erosion which include bridge scour, embankment overtopping erosion, and stream stability. Erodibility directly influences the scour and erosion potential of geomaterials under hydraulic loads. This is a primary source of concern for highway bridges where scour has been the leading cause of bridge failures in the United States, contributing to approximately 60% of failures since 1970.

A geomaterial’s resistance to erosion is dependent on several mechanisms, including the material structure and the inter-particle forces that develop. Erodibility is generally defined as the relationship between the erosion rate and the shear stress imposed by flowing water at the soil/rock–water interface. Another key element that describes erodibility is the erosion threshold parameter. This parameter, termed the critical shear stress, is defined as the hydraulic shear stress corresponding to an erosion rate that, for all practical purposes, is negligible. Erosion is considered not to occur below this threshold.

While there are specialized devices available to measure erodibility, their use can be expensive due to the following: (1) requirement of site-specific material sampling; (2) the need of specialized and experienced test operators; and (3) potential high cost of the testing equipment. In an attempt to overcome the high costs associated with erosion testing, researchers in the past have attempted to develop relationships between geotechnical properties of geomaterials and erodibility. Some of the geotechnical properties that have been studied include unit weight, plasticity index, shear strength, void ratio, fines content, water-chemical composition, and sodium absorption ratio. These investigations did not yield meaningful results possibly due to: (1) lack of emphasis on the influence of material structure on erodibility; (2) use of datasets from multiple sources where test conditions and procedures may have varied significantly; (3) inadequate number of datasets that contain both information on erodibility and geotechnical properties to meaningfully investigate their relationship, for example by using statistical regression techniques; and (4) inappropriate application or lack of knowledge of available statistical methods that are best suited to analyze the data. All these factors have led to very limited guidance available on the relationship between erodibility and geotechnical properties.

The objective of this research is to determine relationships between erodibility and fundamental geotechnical properties that can be used as cost effective means to assess site-specific erosion resistance of geomaterials. Accomplishing this objective will require the following tasks: (1) Perform a literature review on the past research conducted in this area. (2) Conduct a survey of state DOT practices on typical geotechnical properties measured in the laboratory and in-situ, and also specifically how erodibility is quantified. (3) Perform a survey on the available methods of laboratory erosion testing. (4) Select geomaterial types and the fundamental geotechnical properties that are to be included in the study. (5) Select erosion testing procedure that is to be adopted for the study. (6) Perform erosion tests using the selected laboratory erosion testing procedure to measure the erodibility of geomaterial samples. (7) Perform laboratory and/or in-situ tests to obtain the fundamental geotechnical properties of the geomaterials such that each geomaterial sample has both erodibility and geotechnical properties. (8) Perform a survey on available statistical techniques applicable to the data. (9) Develop correlations and relationships between erodibility and geotechnical properties using sound statistical techniques. (10) Present results in a simple and meaningful manner that can be readily used by the engineering practitioner.
Mitigating the risk of differing geotechnical site conditions is never simple, but in a design-build (DB) contract awarded before a complete subsurface investigation is completed, it becomes even more difficult. The Federal Highway Administration’s (FHWA) Special Experimental Projects No. 14—Alternative Contracting (SEP-14) was introduced in 1990 and by 2009 had authorized over 400 DB highway projects. In June, 2010, the FHWA announced its “Every Day Counts” (EDC) initiative to address the rapid renewal of the nation’s rapidly deteriorating infrastructure. The program is designed to accelerate the implementation of innovative practices, such as DB contracting, that are immediately available. MAP-21 further increased the momentum developed in EDC I and EDC II by cutting the state matching share of federal-aid funded highway projects in half if the DOT chose to use DB project delivery. While DB project delivery is a proven tool for accelerating badly needed renewal projects, it does so by awarding the contract before design is complete. Typical DB highway projects often provide only a small fraction of the necessary geotechnical investigation required by the State DOT Geotechnical Manual of Instruction at the time of bid. These DB contracts require the DB Team to conduct the full subsurface site investigation and geotechnical design report in final design therefore gaps in the assessment of the geotechnical conditions may occur. Since current DB case law has shown that the agency cannot effectively shed differing site conditions risk, efforts are needed to mitigate the risk of both cost and time overruns if actual conditions are found to differ significantly from those portrayed in the projects DB request for proposal (RFP). In the past 12 months three $1.0 billion-plus major bridge projects with challenging foundation conditions were awarded as DB project. The projects are the Gerald Desmond Bridge in California, the Tappan Zee Bridge in New York and the Ohio River Bridges in Kentucky/Indiana. NCHRP Synthesis 429: Geotechnical Information Practices in Design-Build Projects found that while there are a number of successful approaches for managing DB geotechnical risk, there is no substantive implementation guidance. Providing adequate high-quality geotechnical information is especially important for the DB delivery approach. The synthesis identified a number of gaps in the body of knowledge that are preventing many states from adequately addressing geotechnical risk in the project delivery method selection process and from taking full advantage of DB project delivery once it is selected.

The main research objective is to benchmark the state-of-the-practice in geotechnical design and construction practices in DB projects and combine it with existing research on construction procurement and project delivery procedures, processes and policies. This study will assemble a set of effective practices and develop a guidebook that can be utilized by agencies to implement geotechnical risk management measures based on statutory and/or policy requirements for inclusion in agency DB policy for DB procurement. The guidebook should include a methodology to compare geotechnical ATC design alternatives on a basis of both potential cost and time savings. It should also incorporate guidance that allows DOTs to be able to justify the selection of a higher cost alternative on a basis of offsetting environmental/social benefits.
The rolling compaction of earth material for roadway construction is one of the primary construction activities to prepare subgrade and build embankment, base, and subbase of highways. Current standards of state highway agencies require contractors to build uniform pavement structural layers, but with no means to check and quantify it continuously. Usually, the typical sampling of every 1000 ft. for dry density and moisture content as quality assurance tests at selected point locations is expected to represent the entire section. The implementation of intelligent compaction technology has the potential to address this problem. Roller Integrated Compaction Monitoring (RICM) [i.e., intelligent compaction (IC) or continuous compaction control (CCC)] refers to the compaction of road materials, including subgrade soils, aggregate bases, stabilized materials, and asphalt-paving materials, using modern rollers equipped with an integrated IC or CCC measuring system. The technology continuously records the roller’s location and reaction to layer stiffness and plots the result during compaction operations, so the field-generated data and plots can provide useful information for quality control/quality acceptance (QC/QA) of compaction operations.

However, the current intelligent compaction technology depends solely on the roller measurement values (MVs), which “are a composite reflection of typical base, subbase, and subgrade structures with a surface to top-of-subgrade thickness of less than approximately 1 m (3.3 ft.).” The roller MVs are also “influenced by layer thickness, relative stiffness of layers, vibration amplitude, and drum/soil interaction issues.” These characteristics have become an obstacle for the further advancement and implementation of IC technology. Possible solutions to overcome this obstacle require a better understanding of the dynamic properties of earth material during rolling compaction. Such an understanding is essential to advance the current IC technology and make it implementable to maximize benefits for highway construction. In order to achieve this objective, a laboratory testing procedure that simulates rolling compaction should be identified or developed, and the testing procedure should be verified and validated with various earth materials. Through a comprehensive laboratory study, parameters that can better reflect the properties of earth material during rolling compaction can be identified. These parameters should be measurable during the field rolling compaction to improve or modify current integrated IC or CCC measuring systems.

There is a big difference in response to rolling compaction between un-compacted and compacted earth materials. Loose earth materials will be compacted and structured by absorbing the compaction energy (work) exerted by rolling compaction through the change of internal microstructure. Limited studies indicate that the ability of earth materials to absorb external energy is affected by the material types, conditions, and environment. This capability of earth materials can be investigated through unsaturated/saturated soil mechanics. Finally, this study will be of paramount importance for understanding the dynamic properties of various earth materials during rolling compaction.

The objective of the research is to identify or develop a laboratory testing procedure that simulates rolling compaction of earth materials in order to study their properties during this dynamic process. Based on the study findings, recommendations to improve current IC technologies are expected. The improved IC technology should be able to measure the properties of a layer being compacted. It can be predicted that deformation or deflection measurements on compacted layers might be needed in addition to resistance. Therefore, this study should evaluate and compare various available in-situ measuring mechanisms. Prototype development for this study should seek the participation of manufacturers.

Building uniform pavement structural layers has always been the desire of highway engineers as it will secure a long pavement service life. Improving the construction quality of earth materials in highway construction will help in realizing this desire and have a fundamental impact on highway engineering since it will allow state
highway agencies to use highway funds more cost effectively. The successful execution of this study will make IC technology a more suitable tool for state highway agencies to continuously check and quantify the compaction quality of earth material. It will promote and expedite the implementation of intelligent compaction technology in highway construction so a better construction quality can be achieved. Therefore, the potential for a payoff from the achievement of project objectives is significant and cannot be overestimated.
In reaction to ever growing public concern and complaint about construction noise, FHWA developed the *Roadway Construction Noise Model* (RCNM) in February 2006. The RCNM model, which was the first major update on the subject in over 35 years, was based on the construction noise model developed and utilized at the Central Artery/Tunnel Project (The Big Dig) in Boston. It has since gone on to be recommended for use by FHWA, state and municipal noise regulations (e.g. NYC Construction Noise Regulation) as well as numerous project-specific noise specifications. It has become the de-facto reference source for construction equipment noise emissions and predictions, and is routinely used by projects for planning and environmental assessment, construction noise mitigation plans, regulations development, specification enforcement, and legal cases involving construction noise.

However, RCNM has limitations and uses simplified assumptions (e.g. equipment usage factors) that limit its flexibility and accuracy. An improved version is needed to make the model more flexible and accurate for use in urban, suburban and rural environments. For example, the construction equipment noise database in RCNM provides only broadband Lmax A-weighted levels, the calculation of time-dependent noise metrics is done by estimation, and there is no accounting for excess attenuation provided by ground effects and air absorption losses. Also, the current version of RCNM only allows for rough estimates of noise reduction from barriers and other obstacles, so an enhanced algorithm is needed to account for such attenuation. The result is that the model can overpredict construction noise levels and result in a high level of uncertainty for the effectiveness of noise reduction efforts.

An improved tool is needed for predicting construction noise levels and the effects of noise reduction efforts to reduce the potential for public complaints and ensure compliance with state, local, and project-specific noise restrictions. The tool could be either an update to the existing RCNM or the development of a new model. An improved tool would include an updated equipment noise emission database on a spectral basis; the ability to predict time-dependent noise metrics of interest such as Lmax, Leq, L10, L90, and others; and improved capability for use over greater distances and terrains. This research will help state transportation departments reduce public complaints, reduce noise control costs, avoid litigation, and improve project delivery.

The objectives of this proposed research are to expand and/or establish a new construction equipment noise emission database in spectral format by measuring equipment noise emissions from numerous equipment engaged in construction operations as available from project job sites nationwide; expanding the equipment noise emission database to include standard time-dependant noise metrics such as Lmax, Leq, L1, L10, L50, L90, and L99; expanding the model’s calculation algorithm to include ground attenuation effects and air absorption, on a spectral basis, to make the model more accurate over greater distances; developing an algorithm module to calculate noise reduction (insertion loss) due to barriers, berms, and intervening objects on a spectral basis; and developing a user’s guide to reflect and describe use of the tool.

Reducing construction noise is an ongoing challenge, especially for major construction projects. The challenge is both for addressing public concerns and ensuring compliance with state, local, and project-specific noise restrictions. Examples of these challenges resulting in high compliance costs, extensive coordination with local officials, and robust public response strategies include the Big Dig project, T-Rex project, Wilson Bridge project, Alaska Way Viaduct project, and World Trade Center Rebuild project. Construction noise is a controllable public impact and need not be viewed as simply an unavoidable inconvenience. An improved construction noise modeling tool would allow for more accurate and reliable construction noise predictions and impact assessments on a proactive basis, thus allowing project sponsors to implement appropriate noise mitigation
measures. Further, improved accuracy and the ability to model specific project circumstances in greater detail would reduce mitigation costs.
Project 25-50
Prioritization Method for Proposed Road-Rail Grade Separation Projects along Specific Rail Corridors

Research Field: Transportation Planning
Source: Washington
Allocation: $350,000
NCHRP Staff: Lawrence D. Goldstein

While safety continues to be a high priority in the development of road-rail grade separation projects, state and local decision makers need more robust criteria when prioritizing these projects for funding and construction. This situation is particularly acute when considering the impacts along a rail corridor that is experiencing a significant increase in the number of train movements, or where the operating speed or train length has increased. Changes in traffic and level of service can create greater impacts to existing road-rail grade crossings along an affected corridor. For example, increasing use of rail to transport energy products, such as crude oil, has caused train movements to increase dramatically in several regions of the U.S. An exhaustive list of criteria that balance economic and social benefits could facilitate a programmatic response in prioritizing grade crossing separation projects along rail corridors experiencing increasing train movements or changing operating conditions. In addition to increasing train volumes, limited funding availability suggests the need for a more precise way to evaluate merits of proposed grade separation projects.

Developing road-rail crossing improvement project programs focused on rail corridors is not new. For example:

• North Carolina’s DOT has historically focused on improving at-grade road-rail grade crossings through its “Sealed Corridor Program.” NCDOT seeks to improve on the past program with creation of the Piedmont Improvement Program which, among other improvements to rail infrastructure, aims to construct 13 road-rail grade separations, with an ultimate goal of eliminating 50 such crossings.
• Harris County, Texas, took a corridor approach when faced with increasing rail traffic, in, out, and through the metropolitan Houston region. The county partnered with freight railroads and other stakeholders to incorporate grade separation projects into proposed rail capacity improvement plans along seven freight corridors. The purpose of this effort was to ensure that grade crossing safety and mobility would not be impacted by increasing train traffic in the region.

When evaluating criteria and application priority, this study should consider a broad range of potential impacts along a typical rail corridor. Most corridors operate through urban, suburban, rural, and small-town environments. Each environment will experience impacts that may need to be addressed differently. Benefits should include improved safety, mobility, economic development, and environmental benefits attributed to specific projects.

Research has been done on identifying benefits of grade separation projects; however, these studies have usually focused on safety: either increasing safety at existing road-rail grade crossings or quantifying impacts of crashes at road-rail grade crossings. When studies have focused on prioritization, they have tended to focus on metropolitan-only or small community-only benefits. This approach has not produced a prioritization method that can be applied on a rail corridor that is experiencing increasing impacts that result from a surge in train movements or changing train operational conditions.

A study prepared for the Victorian Department of Transport proposed a multi-criteria approach to prioritizing the 177 at-grade railroad crossings in Melbourne, Victoria, Australia. That study proposed a four-stage assessment, first looking for road-rail grade crossings that fit criteria for closure. The remaining crossings were then assessed for future safety and congestion issues along with other economic, social, environmental, and multi-modal criteria. The third stage doubled the benefit-cost ratio of the economic criteria. The last stage categorized the crossings into three groupings with priorities. This study focused more on evaluation of differ-
ent crossing conditions, including recommendations for crossing closure. It did not provide a quantifiable approach to prioritize the crossings for grade separated projects.

A study performed for the City of St. Cloud, Minnesota, looked at using a specific tool (MicroBENCOST) to create a benefit-cost framework for a particular grade separation project in a small community. The study documented other tools used to generate benefit-cost analysis. The study looked at economic and safety criteria and challenges to collecting the input data needed. While this study focuses on a real world example of a project affecting a small community, its focus is on one project and was not intended to prioritize a list of projects.

An Israeli study focused on the development of evaluation criteria for creation of grade separation projects. To test criteria, this study used data from 20 road-rail crossings collected over a 5-year period. The project found that 30 sites out of 216 were found to warrant grade separation. This study, however, did not provide a method to prioritize those 30 crossings.

An additional study performed by the Texas Transportation Institute looked specifically at the impacts of delays to traffic within the metropolitan Houston area. That study created a model to quantify the monetary costs of mobility, fuel consumption, safety, and air quality impacts to vehicle delay at road-rail grade crossings. Those impacts were projected out 10 and 20 years, incorporating an ability to consider operational changes as well as impacts of infrastructure improvements. The project focused on developing a model for capturing and evaluating benefits of a particular project. While it took a regional approach, it did not focus on prioritization of projects.

The research objective for this study is to develop a prioritization procedure for comparing and evaluating proposed road-rail grade separation projects along specific rail corridors. Recommended work elements include the following:

- A benchmark system to evaluate previous work, including preparation of an exhaustive list of criteria for consideration
- Framework for criteria scoring
- A scheme that will prioritize both urban and rural road-rail separation projects
- A baseline score for project funding consideration
- High-level review of challenges with data availability
- Selecting a representative rail corridor to use as a case study
Project 25-51

Limitations of the Infiltration Approach to Stormwater Management in the Highway Environment

Research Field: Transportation Planning
Source: AASHTO Standing Committee on the Environment
Allocation: $500,000
NCHRP Staff: Nanda Srinivasan

Reducing runoff volumes using infiltration of stormwater has drawn increasing interest in recent years given its ability to reduce stormwater volume, increase groundwater recharge, reduce peak flows, and lessen the transport of nonpoint source pollutants. Some state DOTs are being required by regulatory agencies to utilize infiltration best management practices (BMPs) for their transportation projects unless infiltration BMPs are proven to be infeasible. The focus of infiltration BMP research to date has generally been on the ability of infiltration to reduce the volume of stormwater runoff; little attention has been given to the other potential environmental effects of using infiltration BMPs. These potential effects may include issues of water balance (e.g., groundwater mounding) and the introduction or mobilization of contaminants into groundwater. While infiltration has quickly become the BMP of choice, there is a growing concern that requiring infiltration BMPs may be inadvertently leading to other environmental consequences.

Literature has shown that heavy metals and hydrocarbons are generally captured by the upper layers of soil, but breakthrough of these contaminants can occur due to sorption of the soil. Research is needed to better understand the capabilities of infiltration BMPs in different environmental settings and to identify the potential limitations and overall environmental effects of infiltration BMPs.

The focus of this research is to better understand the full range of effects caused by the use of infiltration BMPs. Specifically, this research effort would include:

- Conducting detailed evaluations of the effects of climate, soils, topography, receiving water, and other local conditions on the effectiveness of infiltration best management practices to remove pollutants of concern in highway runoff. This would include field testing and monitoring.
- Analyzing and documenting the potential risks associated with the use of infiltration such as the potential for groundwater contamination. This would include an assessment of the conditions under which the risks are most likely to be realized.
- Providing recommendations for the appropriate use of infiltration when treating stormwater as well as potential methods for improving the effectiveness of and reducing any risks from infiltration BMPs.
Guidelines for the Consideration of Atmospheric Effects for Improved Noise Modeling

Research Field: Transportation Planning
Source: North Carolina
Allocation: $270,000 (Additional $30,000 from Federal Highway Administration)
NCHRP Staff: Lori L. Sundstrom

It is widely accepted that the propagation of sound waves from a highway traffic source can be significantly affected by complex meteorological phenomena. Specifically, studies show noise level increases by as much as 5–10 decibels as a result of changes in vertical gradients of wind speed and temperature that lead to refraction (i.e. bending of sound waves). To put this increase in noise levels into perspective, a 5-decibel increase is generally regarded as a noticeable change by a healthy human ear while a 10-decibel increase is perceived as a doubling of sound. While studies exist that prove meteorology significantly affects received sound levels, state departments of transportation lack guidance on how and when to account for meteorology in traffic noise prediction modeling and abatement assessments. Research is needed to identify the most critical atmospheric parameters that affect received sound levels, how to obtain and effectively model those parameters, and how best to implement policy for the consideration of atmospheric effects in traffic noise modeling. Development of such guidance would improve modeling confidence and facilitate the design of more effective abatement measures for noise sensitive receivers adjacent to highway traffic noise sources. In addition, knowledge from this study could help state DOTs with discussing variations in measured noise levels at specific locations with the public. NCHRP Project 25-34, “Supplemental Guidance on the Application of FHWA’s Traffic Noise Model (TNM),” will, in part, synthesize the state of practice in addressing the effects of wind and temperature inversions upon traffic noise dispersion. However, NCHRP Project 25-34 research will not extend so far as to develop best practices for incorporating atmospheric effects in noise modeling. The research proposed in this problem statement will provide these practices and recommendations and will provide a timely follow up to Project 25-34. A final report for Project 25-34 is anticipated in time to serve as the starting point for this proposed research project.

The main objective of the proposed research is to develop a set of best management practices for considering atmospheric effects in noise modeling, which provides guidance and makes recommendations on: (1) The most critical atmospheric parameters that affect sound propagation from a highway traffic noise source; (2) Resources and avenues for obtaining said parameters as well as how much data should be obtained and evaluated; (3) When atmospheric effects should be considered and when they may be disregarded in noise prediction modeling and abatement assessment (e.g. should states model the “average” or “prevailing” condition? Define “prevailing”); (4) How atmospheric effects could be incorporated into the U.S. Federal Highway Administration (FHWA) Traffic Noise Model (TNM) and future policy, which will identify the necessary modeling input parameters if it is determined that atmospheric effects should be included; and (5) How atmospheric effects could be considered when using the current, and any future versions, of TNM that only account for neutral conditions and atmospheric absorption (i.e. make recommendations on how FHWA and states may consider atmospheric effects in their current policy). In order to meet the research objective and develop a comprehensive set of best management practices, the following tasks should be performed, at a minimum: (1) Perform a literature review to establish the importance of the effects of atmospheric conditions on sound propagation and identify the most critical parameters that affect sound propagation. The literature review should also quantify the magnitude of the effects that have been documented. (2) Survey state DOTs and their consultants to identify the current state of the practice to see how states handle atmospheric conditions when modeling and designing abatement. (3) Perform a literature review and evaluation of other available models and standards that account for more complex atmospheric conditions than what TNM currently considers. (4) Develop case studies that cover a range of potential scenarios and provide steps on the processes for obtaining meteorological data for the study area and how to evaluate that data and determine if it should be used in modeling.
In general, most state DOTs have limited ownership of rail lines located in their state. Private owners are increasingly filing for abandonment of rail lines with the federal government. If states do not acquire or preserve these lines, the land may be purchased by someone who will remove the lines. When rail lines are removed from the ground these rail rights-of-way are no longer exempt from the public hearing and environmental processes and may be lost forever. Even if a line is not currently used, it is desirable to preserve it for potential future use since establishing a new line or re-establishing removed tracks is much more difficult and expensive than bringing an older line back into use.

As rail rights-of-way become abandoned and or salvaged they may be lost forever, giving rail-served customers no other choice than to relocate (causing local job loss) or shipping by truck. Multimodal choice allows for economic competitiveness and creates public benefits such as improved environmental conditions (emission reductions, fuel savings, reduced roadway damage and repair costs, safety, community and environmental justice) and logistical efficiencies. Every load of freight moved by rail reduces commercial vehicle miles traveled along with the concomitant improvements to safety and emissions.

Research is needed to examine what states have done to create successful rail preservation programs and also examine where they have not been successful. It will also be useful to create national guidance for preserving freight rail corridors and service, capture trends in the abandonment of freight rail lines and the critical elements of state DOT rail preservation programs, with a focus on preserving intact rail rights-of-way for future freight use.

The objective of the research is to develop a guide for state DOTs that describes current state rail preservation programs and provides a template that could be used to proactively preserve key rail rights-of-way as a model for program development for those states not currently involved in rail preservation.
Problem No. 2015-E-01
Scour At Spill-Through Bridge Abutments

Research Field: Soils and Geology
Source: Federal Highway Administration
Allocation: $600,000
NCHRP Staff: David A. Reynaud

Though the problem of bridge abutment scour at bridge waterways has been extensively studied, prior studies inadequately addressed the central issue of how spill-through abutments erode and actually fail during waterway scour. Recent investigations suggested that abutments erode and fail in two main modes during scour, but one common mode has been largely overlooked (this mode relates to erosion of the abutment at the waterline in the vicinity of an abutment’s upstream corner); and abutment failure always involves a combination of hydraulic and geotechnical processes. Present design and monitoring practice does not address the combination of hydraulic and geotechnical processes that lead to the two abutment erosion and failure modes. Consequently, existing abutments remain prone to erosion and failure during abutment scour; some countermeasures indeed are of limited effectiveness because they address only one of the two failure modes.

The objective of this research will be accomplished in two phases. Phase I will determine the mode(s) of abutment erosion at spill-through abutments, develop a relationship for estimating the forces that cause erosion, and provide design recommendations for scour countermeasures. These products will be developed collaboratively using both geotechnical and hydraulic engineering. Phase II will produce a report, “Guidelines for a Collaborative Approach to Prevent Bridge Scour” that documents the use of both hydraulic and geotechnical engineering in a collaborative process to determine the failure mode(s) and scour countermeasures for abutments of all types.

Present design practice and review of design practice focus only on estimating a maximum depth of abutment scour, and determining the layout of possible countermeasures to mitigate the consequences of this scour. This focus is insufficient. It neither indicates how this scour-depth estimate actually leads to abutment failure, nor how it should be used to design the principal components of abutments (the earthfill embankment and the abutment column). Moreover, it overlooks the second, and possibly the most common, erosion and failure process.

A recent preliminary study indicates that hydraulic and geotechnical processes interact to erode boundary material (channel, riverbank, floodplain, and abutment embankment) and expose bank and embankment material to sequences of erosion and failure at several locations (often at the same time), notably: At the toe of the abutment; and at the waterline along the abutment’s upstream corner, where flow velocities, velocity gradients, and turbulence levels are especially high. Erosion at this location may eventually lead to breaching of an abutment’s embankment.

Prior studies have missed this second erosion and failure mode. However, a preliminary re-assessment of field-case and laboratory examples reveals that this mode likely occurs commonly and is responsible for a high proportion of abutment failures. Moreover, the review suggests that existing scour countermeasures may not impede this process. In particular, riprap placement on abutment spill-slopes often appears not to withstand it.
Problem No. 2015-F-03
Quantifying Environmental Benefits of Bridge Preservation

Research Field: Maintenance
Source: AASHTO Highway Subcommittee on Maintenance
Allocation: $500,000
NCHRP Staff: Nanda Srinivasan

With passage of the Moving Ahead for Progress in the 21st Century (MAP-21) legislation, transportation agencies are granted new flexibility and new responsibilities for the stewardship of the nation’s transportation infrastructure. The Act requires agencies to implement new performance management capabilities to provide a more explicit and quantitative linkage between funding and performance of the system. Over the past 10 years, agencies have begun the development of such capabilities by means of Transportation Asset Management (TAM), a strategic and systematic process of maintaining and managing infrastructure assets throughout their life cycle, focusing on business and engineering practices for resource allocation and utilization. TAM uses data and analysis to improve decision making, with the objective of providing the required level of service in the most cost effective manner.

As a part of TAM implementation, agencies have developed quantitative procedures for measuring and forecasting many of the benefits of bridge preservation, including condition, life cycle cost, safety, risk, and mobility. Little has been done so far, however, on environmental effects.

Bridge preservation can positively impact the environment in several ways. Timely coating system and joint seal maintenance can prevent the deposition of hazardous paint and other materials into waterways. Bridge deck maintenance can reduce traffic noise, speed change cycles, and truck detours. Timely preservation work may also reduce work zone disruptions and other negative aspects of bridge operations and life cycle.

While sustainability is increasingly important as a transportation policy goal, there does not yet exist a way to measure and forecast the effects of bridge preservation on the environment, and thus no way to manage environmental sustainability as a program objective for maintenance planning, priority setting, and resource allocation purposes. There is a need to develop such a capability for inclusion in the emerging new generation of bridge and maintenance management systems.

This project would support the performance management and research strategic focus areas of the Subcommittee on Maintenance Bridge Technical Working Group.

The objective of this research is to develop a set of procedures and models to estimate the environmental benefits of bridge preservation activities, suitable for use in bridge and maintenance management systems. The procedures should use typical data found in bridge inventory and management systems, along with the results of up-to-date research.