

**National Cooperative Highway Research Program
Projects in the Fiscal Year 2011 Program**

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SUMMARY OF APPROVED RESEARCH PROJECTS

◆ Project 01-50

Effect of Geosynthetics on Structural Pavement Design

Research Field: Design
Source: AASHTO Joint Technical Committee on Pavements
Allocation: \$600,000
NCHRP Staff: Amir N. Hanna

Properly installed geosynthetics have been proven to generate cost savings and improved performance of aggregate base courses used in highway pavement construction. Other advantages include the ability to extend pavement service life without increasing pavement thickness and without sacrificing performance. While many agencies are currently using geosynthetics, there is a significant lack of understanding of the fundamental properties of these materials; thus, designers are often forced to rely on conservative estimates when considering the contribution of geosynthetics in the performance of the pavement structure. A deeper understanding of the interactions between geosynthetics and aggregate base courses is needed, as well as a more fundamental method for incorporating the properties of geosynthetics into existing pavement design practices. To this end, the effects of geosynthetics should be quantified with respect to (1) the improvement of subgrade and/or base stiffness (i.e., resilient modulus) and (2) the improvement in tensile capacity of unbound materials.

Several ongoing studies are currently in progress to establish the material properties of geosynthetic materials. A number of readily available test methods exist for the purpose of characterizing geosynthetics and their interactions with aggregate base materials. Geosynthetic-aggregate interface properties are most often measured using pullout methods or direct shear tests, which focus on the conditions at failure. However, such properties have not been adequately characterized for typical service conditions, resulting in relatively conservative empirical relationships. While a national guide of practice has not yet been established for geosynthetics, a number of AASHTO and ASTM methods exist and are generally used for this purpose, although the current AASHTO guidelines acknowledge that insufficient information is available at this time for a complete characterization. A 2007 FHWA publication includes guidance for the use of geosynthetics in roadways and pavements, and includes recommended minimum standards for the properties of ultimate multi-rib tensile strength and ultraviolet (UV) stability. While junction strength is also acknowledged as an important property, sufficient data was not available to recommend firm specifications. Additionally, minimum tensile modulus values were not included.

The objective of this research is to develop a design methodology and guidelines on when, where, and how to use geosynthetic materials within a pavement structure. The guidelines will target design engineers and practitioners in the pavements and materials engineering community, with a focus on the most basic engineering properties of geosynthetics as they relate to structural pavement design. It is anticipated that the design principles contained in the guidelines could be readily incorporated into the Mechanistic-Empirical Pavement Design Guide (MEPDG).

The initial task of this research effort will include a thorough review of available literature regarding geosynthetics, their laboratory-measured properties, and documented field performance. Because many “best practices” for the use of geosynthetics have been documented in previous research, the lessons learned from these efforts should be considered prior to developing the detailed laboratory work plan for characterizing geosynthetics. Additionally, a number of studies have demonstrated the field performance of geosynthetics; these findings should be incorporated into the scope of the work as appropriate, with additional field trials performed to validate the initial conclusions developed.

A large portion of the work will revolve around the development of specific techniques for considering the effects of geosynthetics on the pavement performance prediction models contained in the MEPDG. The results of this research will provide a solid engineering basis for estimating the structural effects (benefits) of geosynthetics when properly placed within a pavement structure, effectively replacing the “rule of thumb” design

procedures currently used. By more accurately characterizing the effects of geosynthetics, pavement structures may be constructed more efficiently while also providing a greater degree of design reliability.

◆ **Project 03-100**

Roundabout Corridors—A Study in Performance and Efficiency

Research Field: Traffic
Source: Kansas
Allocation: \$300,000
NCHRP Staff: Lori L. Sundstrom

Roundabouts are being recognized as an intersection control strategy that fulfills the goals of sustainability, complete streets, context-sensitive design, and improved public safety. In the last few years, highway agencies have constructed several arterials using roundabouts in series rather than traffic signals. While the agencies have reported success, there has been no comprehensive peer-reviewed research to document the performance and efficiency of this strategy—using roundabouts in series on an arterial rather than traffic signals.

Anecdotal and limited research has indicated significant safety improvements. However, detailed mobility performance studies addressing measures of travel time, average speed, and delay are lacking. Highway agencies do not have complete research to assist them in analyzing the differences between a roundabout corridor and a signalized corridor with a reasonable level of efficient progression and ITS support.

The need and interest for highway agencies to select roundabouts in series is increasingly compelling. One of the critical issues is design liability. Without regard to travel efficiency, safety research has consistently shown that traffic signals have six to nine times the injury crash rate compared to a roundabout. In some states and municipalities where design immunity is minimal, the liability of selecting a traffic signal for intersection control over a roundabout is increasingly a concern. Several states and municipalities and at least one Canadian province have roundabout-first policies.

A literature search found few documents related to “efficiency of roundabouts in series on an arterial.” However, there are several corridors where roundabouts in series are in design and construction phases to support a research effort. There are several corridors where a series of five or more have already been completed. Their locations are diverse and important to arterial performance research. Locations include Waterloo, Ontario; San Diego, California; and some arterial routes on the New York State DOT system. Several roundabout corridors are in the stages of design. These will be ripe for research.

The objective of the research is to compare the performance of arterials with traffic signals to arterials with roundabouts. The performance of traffic signal systems is well researched, and many software models exist to provide this study with good material. Field research on roundabouts in series would be conducted in several established locations. It is suggested that arterial corridors with three, or preferably four or more consecutive roundabouts be studied. All modeling would be field calibrated using no less than four roundabout arterials. The research would report both on the level of accuracy of the models as well as on the performance measures and data collected from field studies.

The use of roundabouts in series is rapidly expanding, and performance information is lacking. The lack of national research on performance is requiring agencies to conduct their own individual analysis at their expense, and often at a lower level of research quality. Lacking comprehensive research, some agencies are not selecting roundabout strategies because they lack information regarding the overall efficiency of such strategies.

◆ **Project 03-101**

Support for the AASHTO IntelliDriveSM Strategic Plan

Research Field: Traffic
Source: AASHTO Highway Subcommittee on System Operations and Management, AASHTO Highway Subcommittee on Traffic Engineering
Allocation: \$500,000
NCHRP Staff: B. Ray Derr

The U.S. Department of Transportation's (DOT's) IntelliDriveSM program is focused on advancing connectivity among vehicles and roadway infrastructure in order to significantly improve the safety and mobility of the U.S. transportation system. The program is working toward a future vision where vehicles and infrastructure are connected to enable crashless vehicles, and where access to real-time data on the status of both vehicles and the roadway transforms transportation system management and operations to dramatically improve performance.

IntelliDrive is being developed through coordinated research, testing, demonstration, and deployment. The federal research investment is targeted to areas that are unlikely to be accomplished through private investment because they are too risky or complex. Other stakeholders, including the states, the automotive industry and its suppliers, and consumer electronics companies, also are researching and testing IntelliDrive technologies and applications so that the transportation community can realize the full potential and vision of IntelliDrive.

The IntelliDrive program is a major initiative of the Intelligent Transportation Systems (ITS) Joint Programs Office (JPO) at DOT's Research and Innovative Technology Administration (RITA). The ITS JPO's goal is to advance the program to a deployment readiness state by 2014. In order for state transportation departments to fully benefit from this effort, AASHTO has formed an IntelliDrive technical working group that developed a strategic plan and action plan for the development and deployment of IntelliDrive. A pooled fund project has been established to begin work on the plan.

The objective of this project is to support the AASHTO IntelliDrive Technical Working Group in developing and deploying the IntelliDrive system and augment the funds in the IntelliDrive pooled fund project.

◆ Project 03-102

Auxiliary Turn Lane Design Guidance and Policy Upgrades

Research Field: Traffic
Source: AASHTO Technical Committee on Geometric Design
Allocation: \$400,000
NCHRP Staff: B. Ray Derr

There are approximately 6 million traffic crashes annually (2006). Fifty-three percent of these occur at intersections (3.1 million crashes). Auxiliary turn lanes have been clearly identified as a significant countermeasure to address these crashes. The draft Highway Safety Manual (HSM) suggests that 64.6 percent of rural intersection crashes are susceptible to remedy by auxiliary lane—i.e. those crashes that involve another vehicle in a maneuver other than a rear-end crash. Additionally, the HSM suggests that 66 percent of urban multilane stop control and 55 percent of fatal and injury intersection crashes are susceptible to remedy by auxiliary lane.

Auxiliary turn lanes at intersections generally have a traditional or offset design. The design components of a traditional turn lane consist of the length needed to store an appropriate number of waiting vehicles, a vehicle deceleration area, and the taper needed to develop the full lane width. Offset turn lanes have similar components but they are developed in a manner different from traditional designs. The guidance and practice used throughout United States for traditional and offset turn lane designs and application also vary by intersection location (e.g., rural or urban), traffic control (e.g., stop-control or signal-control), and/or turn lane type (e.g., right- or left-turn). The AASHTO *Policy on Geometric Design of Highways and Streets (Green Book)* contains criteria for geometric design of auxiliary turn lanes.

While acceptable for current practice, the basis for the design and policy elements of these features is recognized as needing more support. There is, therefore, a general need to confirm, update, and/or expand upon the operational and safety assumptions and basis for the design of traditional turn lanes that are in the AASHTO *Green Book*. The soon-to-be-published HSM includes the overall safety basis for left and right turning lanes at intersections but does not identify crucial aspects of positive offset, angled vs. parallel auxiliary lane design, etc. In addition, it may also be appropriate to propose or update guidance for when and where left- or right-turn lanes are justified from both an operational as well as a safety basis. Finally, similar guidance or policies and detail are needed for offset right- and left-turn lane design. There is a high level of variability in the application of offset turn lanes in the United States. An investigation and proposal of acceleration and deceleration speed change lane design guidance may also be appropriate. It is expected that the results of this research will be used directly in an update to the AASHTO *Green Book* and therefore be made directly available to practitioners across the country.

The objective of the research is to confirm, strengthen, and/or update the current design guidance for turn lanes at both unsignalized and signalized intersections in urban and rural areas. Some specific tasks in relation to this objective include:

- Confirm, strengthen, and/or update lengths for perception-reaction time, taper, deceleration, and storage length for various design speeds.
- Develop new and more detailed design guidance as appropriate or needed for the implementation and design of offset left- and right-turn lanes.
- Provide guidance on situations when turn lanes should be installed for the greatest operational or safety benefits.
- Reconsider and make recommendations for changes for the design of acceleration and/or deceleration speed change lanes at intersections as appropriate.
- If a change in design policy is recommended, propose draft text for the next AASHTO *Green Book*.

◆ Project 03-103

Update of the Traffic Signal Timing Manual

Research Field: Traffic
Source: Colorado
Allocation: \$600,000
NCHRP Staff: B. Ray Derr

Based on the acknowledged need for consistent national guidance on developing and maintaining effective signal timing, the 2008 *Traffic Signal Timing Manual (STM)* provided a basic synthesis of signal timing practices in the U.S. The manual covers fundamental signal timing as related to intersection design, vehicle detection, and coordination of signalized intersections. The *STM* is an important first step, but there are many advanced concepts that need to be addressed in greater detail that are not well documented. These require some research and evaluation to provide substantive direction that will take practice to the next level. The current manual acknowledges some of these in its last chapter, “Advanced Signal Timing Concepts,” discussing traffic signal priority, traffic responsive control, and weather considerations, among others.

Improvements due to signal timing are not always quantified because the applications are not always fully documented by before-and-after studies. This is true for topics such as traffic signal priority, emergency vehicle preemption, and special controller functions such as conditional service and simultaneous gap out logic. Despite better detection equipment, microscopic traffic simulation, and signal control logic, associated benefits have not been adequately captured in the literature. The proposed research would incorporate advanced applications and their quantified performance into the *STM*, moving the industry from current application to state-of-the-art practice.

The objective of the research is to develop a guide for advanced signal timing concepts that will expand the scope and depth of the *STM*. Research and evaluation will be conducted to address the following topics relating to operating traffic signals: detector design, pedestrian treatment, improved coordinated operation, oversaturated conditions, overlaps, and diamond interchanges, plus advanced applications including traffic signal priority, weather impacts, adaptive signal control, and performance monitoring and management. Material developed will be applicable to automobile, truck, bus, bicycle, and pedestrian operations in a signalized arterial environment. The revised guide should consider the pedestrian walking speed requirements of the new Manual on Uniform Traffic Control Devices and present new strategies for accommodating pedestrians at traffic signals. The revised guide should be suitable for publication as an AASHTO guide.

Several key issues that need to be considered by the research are:

1. Assessment of non-motorized user needs (pedestrians and bicyclists);
2. Detection designs that maximize versatility in operation, monitoring, and maintenance of the signalized intersections;
3. Effective use of overlaps to facilitate the movement of compatible approaches and movements;
4. Timing diamond interchanges and alternative intersection designs to improve efficiency and safety;
5. Monitoring the performance of signalized intersections;
6. Discussion of new pedestrian/vehicle detection and tracking technologies and their impact on signal timing plans;
7. Use of the controller as a data collection device;
8. Emission-focused policy for signal operations;
9. Surrogates of safety in designing timing plans;
10. Discussion of advanced timing topics: transit focused timing plans, traffic responsive control, adaptive control, and dealing with weather impacts;
11. Railway-highway traffic signal interconnection and design of preemption (physical layout, time/phase plans to assure clear crossing at train arrival);
12. Signal preemption for emergency vehicles (time/phase plans—avoiding yellow traps in preemption transition).

Note: The AASHTO Standing Committee on Research directed that aspects of Problem No. 2011-G-24, "Pedestrian Operations and Safety at Signalized Intersections," be included.

◆ **Project 05-20**

Guidelines for Guide Sign Visibility

Research Field: Traffic
Source: AASHTO Highway Subcommittee on Traffic Engineering
Allocation: \$600,000
NCHRP Staff: Edward T. Harrigan

A frequent dilemma facing highway agencies is deciding how to most effectively provide visible overhead guide signs. There are no guidelines that agencies can reference to help decide how to provide sufficient visibility of overhead guide signs. For instance, it seems that there is a general belief that it is adequate to turn off guide sign lighting in rural areas with flat terrain if highly retroreflective sheeting materials are used. However, there is little consensus in other areas such as suburban and urban areas where the visual background and roadway geometries are more complex. The only official national guidance in the MUTCD, which states "All overhead sign installations should be illuminated unless an engineering study shows that retroreflection will perform effectively without illumination."

There are many factors that must be considered such as: (1) capital and maintenance costs of fixed sign lighting; (2) lighting technologies, lighting levels, lighting characteristics (e.g., SPDs); (3) retroreflective sign sheeting materials and colors; (4) visual complexity of the surrounding roadside environment; (5) presence and amount of roadway lighting; (6) traffic volumes; (7) sign position with respect to the approaching traffic; (8) roadway geometry; (9) minimizing unused uplighting; and (10) sign detection and sign legibility.

Other influences that need to be considered include vehicle headlamp aim as newer headlamps provide less illumination to overhead guide signs, an increasingly older driver population, mixed vehicle types, sign spacing less than desirable (800') due to closely spaced interchanges, weather such as snow, dew, and fog, etc.

Currently, agencies rely on unsubstantiated information or conduct non-scientific nighttime demonstrations with agency personnel. Because of the lack of guidelines, many agencies repeat these efforts in order to make decisions. There is typically little documentation provided and little control over the efforts.

Research is needed to develop a set of guidelines that can be used by agencies trying to determine the most effective way to provide visible overhead guide signs (and overhead street name signs). The guidelines should be a comprehensive stand-alone document that agencies can use to assess the visibility of guide signs (and overhead street name signs) with currently available options and future technologies. The guidelines should be independent of material properties and related to luminance or some other measure of visual performance. To the extent possible, the guidelines should be supported with relevant crash data and life cycle costs.

To accomplish this objective, the following tasks are recommended: (1) conduct a literature review to document any state or other national guidelines and research regarding guidelines, legislation, policies, and practices regarding efforts to establish guidelines for visible overhead guide signs (including overhead street name signs); (2) assess the available measures of visual performance; (3) draft a summary report of the results of the literature reviews, providing an objective overview of the status of overhead guide sign visibility concerns and considerations, to include a recommended research plan for the second phase of the research that outlines the preliminary guidelines and identified research needs to complete the guidelines; (4) conduct the approved research plan to support the completion of the guidelines, including field testing with full scale signs with and without lighting, sign visibility, sheeting type and the interaction of sheeting type and lighting; (5) develop a metric for assessment of the sign performance; (6) develop recommended guidelines for visible overhead guide signs; and (7) develop a final report with revised guidelines and suggested updates to AASHTO's lighting policies.

◆ **Project 07-17**

Methods to Improve Physical Conditions for Pedestrians and Bicyclists Along Existing Roads

Research Field: Traffic
Source: AASHTO Joint Technical Committee on Nonmotorized Transportation
Allocation: \$400,000 (Additional \$100,000 from Federal Highway Administration)
NCHRP Staff: Christopher J. Hedges

Conditions for pedestrians along existing roads have wide-ranging impacts on whether public transportation services are used, whether students walk to school, whether people walk to local services; and, perhaps most importantly, whether people walk for general health. In addition, walking is frequently not a choice, i.e. a person does not have any option that does not include being a pedestrian along (or on) a roadway. With the almost exclusive reliance on the automobile for decades, pedestrian accommodations were not given a high priority. During this time period, sidewalks were not included on many arterial, collector, or even local roads. These and other factors resulted in lack of pedestrian accommodations on a large portion of the road network in the United States. In addition, sidewalk segments along roadways are often not connected; i.e., the sidewalk network is fragmented. The absence of sidewalks along existing roads is the most obvious missing accommodation. Further examples are missing accommodations for safe crossings, for those waiting for transit services, for students walking to school, etc.

When needs are addressed with limited resources, the basic steps to fulfilling these needs include identifying the problem, quantifying the problem, identifying cost-effective solutions, prioritizing needs, securing funding, and ensuring implementation. These steps are well established for highway improvements on the federal, state, and local levels, where well-developed methodologies, processes, and dedicated funding sources exist to address problems with the highway network to serve vehicular traffic. Such processes and funding are rarely in place for improving conditions for pedestrians. In addition, walking and biking needs are often considered together and frequently the same group or professional deals with both modes within an organization. Therefore, there is a need to establish formal processes for planning and programming pedestrian improvements along existing roadways.

The objective of this research is to identify and analyze institutional barriers to improving physical conditions for pedestrians along roadways. In the first phase of the research, the most critical institutional arrangements relating to improving pedestrian accommodations will be identified and described. Key topics include: (1) ownership of pedestrian issues at the federal, state, and local levels, (2) methods to identify problems with pedestrian accommodations, (3) methods to prioritize needs, and (4) frameworks for funding and implementation.

The second phase of the research will evaluate how effective current practices are in addressing conditions for pedestrians. In this phase, the magnitude of the problems will be quantified. In addition, best practices will be identified and documented. Finally, recommendations for improving institutional environments to support improved accommodations for pedestrians will be developed.

Note: The AASHTO Standing Committee on Research directed that the research include issues involving bicycles, snow maintenance, and ADA requirements.

◆ **Project 08-81**

Collecting Accurate Motorcycle Travel Data to Reduce Rising Fatalities on the Nation's Highways

Research Field: Transportation Planning
Source: California
Allocation: \$300,000
NCHRP Staff: Christopher J. Hedges

Motorcycle fatalities and the related fatality rates have been significantly increasing over the last 10 years based on total registrations as a proxy for volumes and usage/exposure. This has become a serious safety issue for the National Highway Transportation Safety Administration (NHTSA) and the Federal Highway Administration (FHWA). According to available proxy data, between 1996 and 2005, motorcyclist fatalities increased more than 110 percent and currently account for more than 10 percent of all motor vehicle traffic crash fatalities. The best measure of exposure risk for motor vehicle crashes is fatality rate based on actual vehicle volumes and vehicle-miles traveled (VMT), therefore it is critical that timely, complete, and accurate volume and VMT data are collected and reported in order to determine accurate incident and fatality rates and to monitor trends. VMT data (and particularly motorcycle VMT) have been the focus of discussions at recent Highway Performance Monitoring System (HPMS) reassessment workshops documented in the HPMS Reassessment Safety Issue Paper indicating the importance of research on accurately determining VMTs at the national level.

To date, there has not been significant research into the accurate detection of motorcycles. Most current detection systems primarily focus on the collection and classification of trucks and automobiles. These systems frequently misclassify motorcycles or miss them altogether, making the data unacceptable for mandated reporting purposes. Research is needed to identify and analyze detection methodologies that are currently and may potentially be used to obtain accurate motorcycle volume and VMT-related data, with special attention given to accuracy, installation, and operation of available equipment. It should also contain an analysis of the methodologies available to assist transportation professionals in calculating incident and fatality rates when less than comprehensive motorcycle volume and VMT data is available and should potentially focus on the adjustment factors available for use in related calculations. The document should also contain analyses of ongoing detection efforts; both those that have been or continue to be successful and those that have not.

The results of the proposed research would be used by transportation agencies at all levels to assist them in determining the policies and decisions necessary to improve the safety of the transportation system for all, thereby saving lives and reducing incident-related delay and improving mobility.

◆ **Project 08-82**

Real-Time Information: Quantifying Traveler Benefits and Effects on Transportation Demand

Research Field: Transportation Planning
Source: California
Allocation: \$300,000
NCHRP Staff: Nanda Srinivasan

One approach to mitigating traffic and the resulting strains on the transportation system is to shift focus from supply to demand. When provided with good information and sufficient motivation, users of a transportation system can make decisions that will result in reduced demand on the system, decreased gridlock, increased transit ridership, and reduced need for additional lanes.

A range of information systems provide travelers with the real-time data to influence travel demand. Information on traffic and weather conditions is accessible pre-trip via phone, Internet and other sources. Data provided to travelers while en route via 511, roadside message signs, and onboard information systems can have an even more immediate impact on travel behavior.

Consensus among transportation agencies is that these and other real-time traveler information systems can be an effective tool to reduce transportation demand and provide direct benefits to transportation users. Still lacking, though, are the quantified benefits of such systems. Several research questions remain to be addressed.

The proposed research will evaluate the value of traveler information services and address if the value can be quantified. The research will also evaluate the benefit of collecting, processing, and sharing real-time data given limited transportation agency budgets.

The results of this research are expected to be immediately implementable, providing transportation agencies with the critical information needed to perform benefit-to-cost analysis, to analyze expected impacts on demand, and ultimately to justify investment in new or continued deployment of real-time traveler data systems. Transportation agencies will have assurance that they are targeting their limited funds toward technologies that are most likely to improve the nation's highway system and deliver maximum benefit to travelers.

◆ **Project 08-83**

Analytical Travel Forecasting Approaches for Project Level Planning and Design

Research Field: Transportation Planning
Source: Maryland
Allocation: \$470,000 (Additional \$30,000 from Federal Highway Administration)
NCHRP Staff: Nanda Srinivasan

As transportation professionals seek to address future transportation needs, they are often faced with complex issues that necessitate a rich understanding of those factors likely to impact travel choices—often with limited insights available from observed data. Analytical tools must then be developed and applied at a suitable level of spatial and temporal detail to help inform investment decisions. Areas that lack demand-based models are faced with a different set of challenges, where observed counts are often used as the primary basis for generating facility-specific forecasts in the future.

The emergence of post-processing techniques during the 1970s and 1980s adequately supported planning and project development needs for mobility-enhancing projects, where the most pressing analytical questions centered on facility usage levels. But with the saturation levels of congestion on existing roadway systems, the focus especially in urban areas seem to be more on managing travel demand and operational efficiency. The temporal aspect of the extent of congestion is difficult to capture with existing techniques. For heavily congested urban study areas and corridors, it is important to capture the effects of peak spreading at a project level. There also seems to be a need to develop post-processing tools to evaluate residual demand and peak spreading. Study of unconstrained demand and effect of capacity constraints on travel demand is another added layer of information that needs to be analyzed to develop purpose and need justifications for transportation projects as well as land use density changes. More recently, increasingly restrictive funding environments for transportation projects coupled with an emerging interest in the contribution of transportation to climate change have resulted in a heightened consideration of transportation alternatives that better manage travel demand and contribute to operational efficiency. Corresponding improvements in transportation methods are needed that are capable of providing plausible, defensible forecasts to support planning and project development for transportation projects while providing a sound analytical basis for describing transportation impacts that may not be adequately addressed with current post-processing methods.

The specific objectives of the project are: (a) conduct a national review of project traffic forecasting guidelines established at the federal, state, and local level and identify the strengths, limitations, and examples of their application, and update current methodology guidelines, such as NCHRP 255, based on findings; (b) expand the project traffic forecasting methodology guidelines to incorporate appropriate new data sources and system level methods such as GIS, OD matrix estimation, dynamic traffic assignment, and network simulation, etc. for the purposes of addressing common project development purposes, needs, and impacts with particular attention to land development and congestion; and (c) develop guidelines to factor peak-spreading, diurnal distribution of travel, and capacity constraints for project level planning.

◆ **Project 08-84**

Long Distance and Rural Travel Transferable Parameters for Statewide Travel Forecasting Models

Research Field: Transportation Planning
Source: Virginia
Allocation: \$200,000
NCHRP Staff: Nanda Srinivasan

In the last 15 to 20 years, many state departments of transportation have undertaken the development of statewide transportation planning demand models. To date, over 30 states have developed or are developing such models. These models are often used to help formulate policies, to prioritize projects, and to identify the potential revenue streams from toll road, intercity rail, and other major transportation investments. Some of these models can provide input to urban models due to their ability to capture market segments not well represented in urban area forecasting tools. Because these models play such a significant role in the planning process, careful and thoughtful evaluation of how well statewide models reproduce existing travel markets as well as their sensitivity to major market segments and behavioral responses is an increasingly important consideration for state and federal DOTs.

Most of these statewide models are built upon practices originally developed for urbanized area forecasting. In the context of statewide forecasting, rural trip making and long-distance intercity travel constitute important market segments; much more so than in urban models. Information describing these markets, and how they vary from state to state, are sparse, and many states do not have the resources to initiate original data collection to develop a set of model parameters. Yet these same states have a pressing need to have confidence in reasonable data for rural and long-distance travel. Furthermore, for the states where local data collection has occurred, they have little basis to assess how reasonable their findings are compared with findings from other states.

A research project is necessary to develop and document transferable parameters for long-distance and rural trip making for statewide models. It is envisioned that this document would act as a supplement to the NCHRP “quick response” guidance on model parameters and highlight reasonable sets of parameter ranges for rural and long-distance trip making. It will be widely used by state departments of transportation and consultants developing statewide travel forecasting models. This research project shall complete the following tasks.

1. Identify several roadside origin-destination surveys conducted by state DOTs, obtain survey data and/or study reports, and analyze long-distance trip patterns.
2. Explore 2008 NHTS data once available to see how differences in rural and long-distance trip making occur in various states and identify any explanatory variables that could be used to adjust average values and reflect conditions in a particular state.
3. Obtain access to all ATS data sets and identify trip purposes, average trip lengths, vehicle occupancies, and other statistics typified by long-distance travelers.
4. Explore existing statewide model data sources and likely ranges of rural/intercity travel market parameter values.
5. Identify and summarize non-traditional data sources for rural/intercity travel markets.
6. Document findings.

◆ **Project 08-85**

The Comprehensive Economic Effects of Highway-Rail At-Grade Crossing Crashes

Research Field: Transportation Planning
Source: AASHTO Standing Committee on Rail Transportation
Allocation: \$350,000
NCHRP Staff: Andrew C. Lemer

Most analysis of the need to invest federal-aid safety funds into safety improvements at highway-rail at-grade crossings has focused on preventing fatalities, injuries, and property damage at specific priority locations. Little information has been developed about the quantifiable overall financial and social impacts of a crash involving a train and one or more motor vehicles at an at-grade crossing. Lacking such information, highway and rail system decision-makers cannot effectively consider the economic benefits of public investments to improve or eliminate at-grade crossings.

While the number of at-grade crossings crashes and fatalities is a small fraction of the number of crashes and fatalities on the roadway system overall, the literature shows that a fatality is at least 20 (often more than 40) times more likely than in other crashes, and costs directly associated with the motor vehicle occupants are substantial. Other costs also accrue, such as damage to rail equipment and infrastructure and injuries to rail employees and passengers; damage to goods, especially intermodal and containerized shipments; investigative costs borne by public agencies and railroad operators; delays to transport on both affected railroads and roadways resulting from temporary, accident-caused closures, including damaged right-of-way; and clean-up of hazardous materials spills. The magnitudes of these additional costs are not well known.

The 20th century highway system was laid mostly at grade on top of a 19th century rail system which has been adapted to the 21st century, leaving thousands of modal intersections that would be unjustifiable and inconceivable were the systems built in the 21st century. Recent reductions in rail track mileage, increases in rail traffic volumes, and changes in the operating strategies of freight railroads have resulted in more and longer trains concentrated on fewer route miles, slowed rail freight movement, obstacles to highway movement, increased safety risks, and bifurcation of communities, all exacerbating urban traffic circulation problems and leading to increased motorist non-compliance with warning devices and harmful outcomes.

Because the entire transport system is now highly interdependent, maintaining its fluidity is a local, regional, state, and national goal. In addition to direct costs, there can be substantial indirect costs resulting from necessitated, unplanned changes in transport systems and rerouting of goods. Shipments can be transferred via trucks to highways or passengers to private automobiles and buses as an alternative when the transport system has been compromised.

The National Highway Safety Administration and Federal Railroad Administration regularly provide reports which contain estimated (perhaps underestimated) costs resulting from crashes. Additional economic literature examines the potential savings from intermodal rail shipments and just-in-time deliveries. However, the lack of comprehensive understanding of the costs arising from vehicle-train collision impedes estimation of cost-effectiveness of grade-crossing changes such as elimination of a crossing, installation of active warning systems, and grade separation. Research is needed to provide a broader examination of costs associated with continued grade-crossing crashes and develop a cost model that takes into account direct costs from multiple perspectives that accrue as the result of a vehicle-train collision.

The objective of this research will be to conduct such an examination and develop a usable model for evaluating the benefits of crossing changes intended to reduce crash costs. These costs must include those stemming directly from delays to rail and highway shipments along with societal costs resulting from these delays. Additionally, attention needs to be given to the role of hazardous materials incidents along with increased pollution resulting from delays and rerouting. The cost model will be helpful in making decisions regarding upgrading or eliminating at-grade crossings.

The research to accomplish this objective might include the following tasks: (1) review of pertinent literature on costs of crashes and economic effects of interruptions in shipments of goods; (2) identification of the

components of a crash that produce costs including (a) direct costs of damages and injuries to vehicles, trains, and goods carried, (b) costs of investigations to rail carriers and the public sector, (c) indirect costs resulting from injuries, and (d) time and costs resulting from delays; (3) development of a model that recognizes these costs and provides a simplified method of incorporating them into cost-benefit analyses of highway-rail grade crossing upgrades; (4) determination of how the model can be used specifically to enhance the Federal Highway Administration crossing-improvement resource allocations; (5) application of the model to a set of specific but typical incidents to show how the model can be used by decision makers; and (6) preparation of a summary report documenting the research findings.

◆ Project 08-86

Capacity Modeling Guidebook for Shared-Use Passenger and Freight Rail Operations

Research Field: Transportation Planning
Source: AASHTO Standing Committee on Rail Transportation
Allocation: \$500,000
NCHRP Staff: Lori L. Sundstrom

In February 2009, at the urging of President Barack Obama, Congress passed the American Recovery and Reinvestment Act (ARRA), which provides \$8 billion in all-federal funding to states, groups of states, compacts, and public agencies for intercity and high-speed rail development. High-speed rail development has become a signature element of Obama's transportation vision. In April, President Obama released the U.S. Department of Transportation's (USDOT) high-speed rail strategic plan, "Vision for High-Speed Rail in America," which outlines the administration's strategy for ARRA passenger rail funding. This document defines four categories of high speed rail service, and shared-use, passenger, and freight corridor operations predominate in three of the four categories.

The ARRA high-speed rail funding flows through the program structure established in the Passenger Rail Investment and Improvement Act (PRIIA) enacted in October 2008. The PRIIA legislation reauthorizes Amtrak and puts states in a key implementation role for the first time by providing significant grant funding with an authorized level of \$3.4 billion in state grant funds over 5 years.

States have responded to the new ARRA high-speed rail program by submitting over \$57 billion in applications for the \$8 billion in funding currently available. The great majority of these funding proposals involve the introduction and expansion of passenger rail service on shared-use corridors.

The PRIIA legislation and ARRA high-speed rail funding guidelines call for states and underlying freight railroads on shared-use corridors to reach "arms length" agreements regarding access, the proper level of infrastructure improvements, and other issues before federal project funding is provided. The aim is to attempt to ensure that adequate infrastructure for passenger trains is in place at or near the time when passenger service begins in order to maximize track capacity to accommodate the passenger trains and to provide consistent on-time performance.

"Capacity models" are often used by freight railroads and passenger operators to identify capacity issues in a given shared-use corridor and to determine the level of track, signal, and structure improvements that are required to add additional passenger service in a manner that does not degrade freight operations. These models have the potential to simplify time-consuming negotiations between states operating intercity passenger rail systems, commuter agencies, and freight railroads.

Capacity models are designed to mimic passenger and freight and passenger movements in a given corridor. They are complex in their application, require large amounts of data, require great cooperation on behalf of the host freight railroad, and demand a great deal of experience and understanding to properly interpret outputs derived from them.

While there has been experience on the freight rail industry side, states in most cases have not had the time to develop the expertise to fully understand the proper application of these models, even with the assistance of consultants. The methodology and ground rules for using these models can vary greatly depending on the consultant, the railroad, and the specifics of the corridor and proposed project. At this point in time, there is not a good understanding of the methodology for calibrating and applying these models to equitably address capacity and related infrastructure issues in a manner that protects the public interest while at the same time providing private freight railroads a reasonable incentive for entering into an agreement with a state or commuter agency as required by law.

The objective of this research is to develop a detailed guidebook on capacity modeling techniques for state transportation agency staff and other public entities

This research will require a multi-disciplinary team with extensive and hands-on experience in capacity modeling applications for shared-use passenger and freight corridors. The team should have backgrounds in

freight and passenger operations, engineering, and finance, as well as capacity modeling techniques. The study will need to have the active involvement of the major stakeholders, including the states, freight railroads, Amtrak, and commuter operators. To support and illustrate capacity modeling applications in the guidebook, case studies will be desirable to demonstrate their application. The case studies should be designed to cover the spectrum of geographic areas, freight densities, passenger service operating speeds, infrastructure improvement programs, and ownership-configurations.

This work is continuing effort and outgrowth of work begun under *NCHRP Report 657: Guidebook for Implementing Passenger Rail Service on Shared Passenger and Freight Corridors*. This report addresses the need for capacity modeling but it does not go into detail on capacity modeling methodologies.

In developing the capacity modeling guidebook, there are a number of issues that should be addressed:

1. How should the capacity modeling effort be structured to provide the most information to states on the proper level of infrastructure to be provided on shared-use corridors?
2. What is the public policy and economic rationale and basis for application of capacity models in shared-use corridors?
3. How can the model be best used to determine what amount of infrastructure will be required for a proposed passenger service? This includes: track and tie improvements, new shared-use or dedicated track in freight-owned rights-of-way, passing sidings, crossovers, signals, highway grade crossing improvements and warning devices, culverts, bridges, and drainage improvements.
4. What types of infrastructure improvements generate the greatest capacity improvement per dollar spent?
5. Should these improvements be designed for current capacity needs, future capacity needs, or both? How should costs be allocated if future capacity benefits both freight and passenger rail operations?
6. How can the federal statutory requirements for Amtrak-operated services regarding new services, adding frequencies, and increasing speeds be incorporated and properly modeled?
7. What level of freight growth should be incorporated? How can this best be done?
8. If an incremental improvement for passenger rail service, such as a new parallel track, provides significant capacity benefits for freight rail, should freight rail cost sharing be expected or otherwise accounted for?
9. How can the modeling process be used to best allocate infrastructure costs between the passenger and freight operations?
10. How will operational benefits to the freight railroad be accounted for? How should freight railroad operating rules that affect capacity, especially if there is no easily discernible benefit to passenger rail from those rules, affect cost allocation?
11. What benefits should flow to freight railroads as an incentive to participate in public-private partnerships to provide passenger or commuter rail service?
12. What are the data requirements for such models and how can data best be obtained from the freight railroad or other sources?
13. How should the freight railroad be involved in the modeling process? Is it possible to arrive at a “best practice” in terms of designing a process for modeling?
14. What should be the expectation regarding the cost of such a modeling exercise? How can the modeling effort be structured to minimize these costs?
15. How should the base case be structured? What is the proper test(s) to determine whether the base case has been fully calibrated?
16. What are the limitations of capacity models? Are there capacity models in use now that have been found not to work and that should no longer be used?
17. How can considerations not included in a formal model-based analysis be properly addressed? Is it conceivable to someday arrive at a consistent analysis that would be uniform for all freight railroads hosting passenger service?
18. What is “enough” additional capacity?

This research will produce: (1) a guidebook on capacity modeling and model applications for passenger and freight operations on shared-use corridors focusing on the needs of state transportation agency staff, com-

muter agencies, and other public entities.; (2) analysis and recommendations regarding the public policy and economic rationale for the application of capacity models in shared-use corridors; and (3) one or more case studies on the application of capacity models in shared use corridors.

The concept of passenger and freight operations co-existing in shared-use corridors is central to the further development of intercity passenger rail service in the United States. All current Amtrak service is on shared-use corridors. Virtually all future plans for enhanced intercity passenger rail service developed by states are based on the shared-use corridor concept.

This is not just a technical question, but also a major public policy question. As discussed earlier, federal passenger rail funding legislation mandates requirements for agreements between states and freight railroads on shared-use corridors, but there is no agreed upon analytical methodology as a framework for developing these agreements.

States throughout the country are already proceeding with ARRA funding requests for passenger rail projects on shared-use corridors, and they need a better understanding of the capacity modeling tools that are available to address the level of infrastructure improvements necessary to successfully implement these projects now. States have already found by experience that negotiations with freight railroads on shared-use corridors are complicated and time consuming, and they need to better understand capacity modeling tools and procedures that have the potential to simplify these negotiations.

◆ Project 09-50

Performance-Based Specification for Binders Used in Chip Seals (and other Surface Treatments)

Research Field: Materials and Construction
Source: Virginia
Allocation: \$500,000
NCHRP Staff: Amir N. Hanna

Historically, emulsion specifications have been parochial, as the availability (i.e. type of asphalt available and local suppliers capabilities) has generally driven the specifying agencies' decision on which emulsions to specify. As suppliers, sources, etc. change, new emulsion specifications are developed and promulgated. Today's technology has brought more manufacturing choices and capability to agencies whereby a "performance-based" specification is desired.

Binder specifications for chip seal applications and other surface treatments include emulsions and hot applied liquids. These specifications do not incorporate standard performance grading for the base asphalt. Most emulsion specifications continue to use viscosity-graded asphalt binders or penetration-based specifications. A specification that incorporates a standard grading system will serve to more uniformly describe asphalts and base asphalt for asphalt emulsions specified by federal, state, and local agencies. Applying a more uniform grading system may reduce testing, increase the collaboration between states, and improve the ability to compare actual field performance to this "performance" graded specification. This new specification needs to address testing at temperatures normally seen by surface treatment applications such as chip retention, fatigue at room temperature, ability to penetrate cracks of varied widths, and adhesion at high and low temperatures, and include climate and traffic in the binder selection process. A chip seal and surface treatment binder specification should be applied to both hot-applied binders and emulsion residues. Asphalt emulsion requirements must include a mechanism for acquiring the emulsion residue such that this residue is representative of the binder on the road.

Related research includes the following:

1. Soon after the PG binder specification was finalized from the Strategic Highway Research Program, the Texas Department of Transportation (TxDOT) funded research at the University of Texas Center for Transportation Research on the applicability of the PG binder specification to chip seal binders. Research Report 1367-1, *Performance-Based Seal Coat Asphalt Specifications*, published in 1995, indicated that there was no technical reason that the PG specification could not be used to specify chip seal binders. There are complications, however, in that the Superpave PG binder specification was designed to address HMA distresses, and more sophisticated chip seal binders containing polymer modifiers did not fit into the PG system well. Additionally, traffic and climate were unaccounted for in selection of chip seal binders.
2. TxDOT funded additional research to develop a new specification, based on PG testing equipment, to address chip seal distresses. This research, conducted at the Texas Transportation Institute at Texas A&M University, produced a draft specification, initial validation with field test sections, and specification modification based on the validation. The findings were published in Research Reports 1710-1 and 1710-2 (in 2001 and 2003 respectively). Proposed specifications included initial stiffness requirements to address loss of aggregate early in chip seal life and aged low temperature properties to address low temperature aggregate loss later in chip seal life. Climate and traffic levels were not investigated.
3. *NCHRP Synthesis 342: Chip Seal Best Practices* was published in 2005 to provide a comprehensive review of chip seal practices and experiences as well as to set the stage for the identification of chip seal best practices.
4. NCHRP 14-17 is currently in progress to develop a Manual for the Design and Construction of Emulsion-Based Chip Seals for Pavement Preservation. The manual is expected to recommend specifications and test methods for emulsion properties and residue recovery; however, full development and field validation of new performance specifications is not part of this work.

The objective of this research is to develop and validate a performance-based specification for binders used in chip seals and surface treatments. The specification shall be in a form suitable for adoption as an AASHTO standard specification and shall be implemented nationally. Proposed tasks that are expected to be performed to meet this objective include the following:

1. Synthesize the developments in chip seal asphalt binder specifications.
2. Conduct additional research to fill gaps in the data.
3. Utilize available information to develop an enhanced, performance-based purchase specification for asphalt binders for chip seals.
4. Conduct testing to determine how existing binders will perform under this specification.
5. Validate the proposed specification with field testing.
6. Develop a chip seal binder grade selection algorithm.
7. Work with users and producers to obtain consensus, and implement the specification on a national basis.

◆ Project 10-85

A Guidebook for Construction Manager-at-Risk Contracting for Highway Projects

Research Field: Materials and Construction
Source: AASHTO Highway Subcommittee on Construction, California
Allocation: \$400,000
NCHRP Staff: David A. Reynaud

State departments of transportation (DOTs) continue to experience pressure to deliver highway projects faster, better, and at less cost. This pressure has been recently exacerbated by the demands of the 2009 “Economic Stimulus Bill” which requires that projects be advertised and awarded in extremely short periods of time. SEP-14 authorized a number of experimental project delivery approaches which have successfully been implemented across the nation. One of those was design-build (DB) contracting. The 2006 Report to Congress on the effectiveness of DB showed that approximately 35 states had authorized their DOTs to try DB under the SEP-14 authorization. Many of them subsequently passed legislation that generally authorized the use of DB based on the pilot project outcomes. However, *NCHRP Synthesis 376* found that 63% of the states had only completed one to three projects. Some states, like Ohio, have decided to severely restrict DB usage, and roughly 15 states are not able to utilize it because they do not have the necessary enabling legislation. It can be speculated that those states that are not currently authorized to use DB will probably not be authorized to in the future. Therefore, those DOTs are severely limited in their ability to accelerate their projects and to accrue the other benefits that were found in the SEP-14 Report.

The major criticisms of DB cited in *NCHRP Synthesis 376* were the DOT’s loss of control over the details of design as well as the perception that permitting the construction contractor to have a fiduciary relationship with the designer was inappropriate. The major reasons for using DB contracting found in several recent TRB studies have been the ability to compress the schedule, the early involvement of the contractor in the design process through constructability reviews, and the single point of responsibility for both design and construction achieved in a DB contract. Research has found that traditional project delivery creates additional problems for DOTs when they try to accelerate project delivery. Techniques like the California DOT’s design-sequencing method have not proven to be altogether satisfactory. Thus, DOTs that are unable to use DB need a project delivery method that permits them some of the benefits of DB without giving up control over the design. Construction manager-at-risk (CMR), which is also called construction manager as general contractor (CM/GC), appears to provide just that.

In a CMR contract, the owner contracts separately with the project’s designer and builder. The design contract is modified to create contractual obligations for the designer to proceed with its work in a manner that facilitates the CMR process. The contractor is usually selected on the basis of qualifications and past performance, though some DOTs with CMR experience also include a price function in their selection process. The CMR is awarded a preconstruction services contract which directs it to perform services such as constructability reviews, project estimates and schedules, coordination with third parties, and making input to the design through value engineering and market analysis. At some point the CMR and DOT negotiate a guaranteed maximum price (GMP), and the CMR begins bidding out subcontractor and material supplier work packages. Many agencies allow the CMR to lock in construction prices for features of work with volatile material pricing before the final GMP is established.

NCHRP Synthesis 402, Construction Manager-at-Risk Project Delivery for Highway Programs, found that 30% of the state DOTs it surveyed responded that they had either never heard of CMR or did not understand how it worked. Four states with authorization had not tried it because they had no guidance or experience from which to begin. CMR furnishes a much less radical procurement culture shift than DB because the owner still holds the design contract and hence retains control of the design details. However, the contractor is selected based on its qualifications and is able to influence the design through its preconstruction services contract. One DOT project manager interviewed in *NCHRP Synthesis 402* stated: “CMR allows us to get all the benefits of DB without giving up control of the design.” Therefore, the outcomes from *NCHRP Synthesis 402* clearly show

the need to develop a set of uniform guidelines that individual agencies can use to either implement CMR project delivery or to revise their current procedures to take advantage of lessons learned by DOTs and other transportation sectors such as transit and airports.

The main research objective is to capture the CMR experience available from the eight state DOTs, numerous city and county engineering, and streets departments and public transportation agencies in transit and airport. This study will then assemble a set of best practices and develop a guidebook that can be utilized by agencies wishing to implement CMR contracting in their highway construction programs. Specific tasks of the research to accomplish the main objective include:

Task 1 – Define the state-of-the-practice in CMR through a comprehensive literature search, the collection and analysis of relevant procurement documents (CMR design, preconstruction services and construction contracts), review of enabling legislation and best practices for implementing CMR projects, and barriers to CMR implementation.

Task 2 – Select a representative set of case study projects from public transportation agencies with CMR contracting experience that can be studied in depth to identify both best practices and lessons learned.

Task 3 – Prepare a research work plan that describes the details of the research methodology and methods for identifying best practices and developing conclusions.

Task 4 – Execute the research work plan and prepare an interim research report that articulates the data collection and analysis as well as emerging conclusions, best practices, lessons learned, the advantages and disadvantages of CMR versus DBB and DB, types of projects are good candidates for CMR project delivery, and a proposed outline for the guidebook.

Task 5 – Prepare the draft guidebook for CMR project delivery. Incorporate review comments as required and validate the guidebook's efficacy on actual CMR projects.

Task 6 – Publish the final guidebook and a final research report that details the full results of the research.

Task 7 – Develop training and workshop packages to support adoption or exploration of CMR by interested DOTs.

The intent of this project is to furnish a uniform set of guidelines for the use of CMR project delivery at time when only a few states have codified their programs. This form of alternative project delivery is needed immediately to complete the full set of project delivery tools that DOTs need to be able to deliver their infrastructure improvement programs.

The payoff of this research is likely to be significant in that it comes at a time when a large influence can be applied to the programs of those 42 states that are not using it. The enhanced uniformity will pay dividends in being able to benchmark CMR project delivery and compare project performance metrics between states. It also creates another benefit in that it provides a middle ground between DBB and DB, giving the DOT an option that is not present in most states. Finally, the Utah DOT has documented a savings of 40% in its design costs on CMR projects, which represents an unexpected peripheral payoff of significant proportions if the same holds true across the nation.

◆ **Project 10-86**

Alternate Bidding of Pipe Materials

Research Field: Materials and Construction
Source: AASHTO Highway Subcommittee on Materials
Allocation: \$750,000
NCHRP Staff: Edward T. Harrigan

Traditionally, transportation agencies have developed design and materials specifications, design processes, and construction methods that are driven by describing the type of material and the method of placement and procurement. This development should be enhanced by the opportunity to open up alternate materials to be included in the project development and delivery process, including implementation. The proposed research will develop guidance and performance indicators to the states that allows for alternate bidding practices in which different pipe materials can be assessed during the bidding process.

The objective of this research is to develop guidance that will allow for multiple pipe materials to be included in the bidding process. The research will account for design, materials and construction specifications, and practices that provide for multiple materials to be included in the bidding process for each project and compare each pipe material against each other through a competitive process. The project will develop model performance specifications that describe performance parameters, measures, and tests or verification strategies, and will provide measures to ensure that performance goals are met. The guidance will work within the framework of various procurement and contracting methods.

Note: Statement based on Problems 2011-D-12, “Establish Design Specifications and Test Methods for 100-Year Service Life for Pipe,” and 2011-C-05, “Structural Design Methods for Alternate Pipe Materials Based on Equivalent Risk Factors.”

◆ Project 12-87

Development of System Fracture Analysis Methods for Fracture-Critical Steel Bridges

Research Field: Design
Source: AASHTO Highway Subcommittee on Bridges and Structures
Allocation: \$400,000
NCHRP Staff: Waseem Dekelbab

The development of high performance steel (HPS) has prompted the use of fewer beams in a typical steel bridge superstructure. As the number of beams decreases, the redundancy of the system is reduced, thereby increasing the possibility of system-wide failures. This trend has brought about renewed discussion regarding the traditional definition of fracture critical bridges or members.

Designers and owners have differing opinions on the definition of fracture critical bridges, and many owners will not allow new fracture critical bridges in their jurisdictions even though they are allowed by the AASHTO code (with the appropriate design, construction, and inspection procedures). Interestingly, bridges that would be traditionally classified as fracture critical are often some of the most economical structural configurations.

The AASHTO code does not give guidance on the appropriate methods for system wide fracture analysis. Individual designers have developed methods for this issue; however there is no consensus on the loadings, the approach, and what constitutes failure. Some of the most common debates about fracture critical redundancy are with respect to continuous-span twin trapezoidal box girder ramp bridges, and continuous span two and three girder bridges. These structure types have been used in the past; however, most owners avoid them due to concerns about redundancy.

Questions do arise with respect to redundancy or nonredundancy of existing and even newer bridges which were built using superior steels (especially using any type of HPS), subjected to advanced NDT techniques, and fabricated using higher quality welding procedures than in the past. In addition, those fabricated using the fracture control plan (FCP) are also supposed to be of superior quality than their cousins built prior to the introduction of the FCP. Modern steel bridges are also built with a composite deck slab and are inherently more capable of carrying redistributed loads through alternate paths. Two-girder curved bridges, especially those built since the early 1980s, almost always contain heavy transverse cross-frames capable of carrying significant load from one girder to another. The proposed system analysis methods will provide answers to system redundancy or nonredundancy quantitatively.

The proposed research will focus on the development of defined fracture analysis methods for steel bridge systems. The research will involve the following tasks: literature research of past studies on system-wide redundancy and fracture; study of the effects of energy release at the time of fracture, how this is can be accounted for in the analysis, and development of realistic definitions of failure that are tied to the use of the bridge; determination of the appropriate live load models that need to be applied to the bridge at the time of fracture; determination of the appropriate live load models that should be applied to the bridge after the fracture; determination of the appropriate load factors that should be employed; and development of AASHTO specifications for system-wide fracture analysis for new and existing bridges, including an updated fracture critical member (FCM) definition in context to the findings of this study.

For new bridges, the efficient use of new high-performance steels is being hampered by the concerns of owners and designers about the fracture critical designs. In many cases, more beams are added to spans to improve the redundancy, which make the bridge less efficient and therefore more costly. In several states, multi-span continuous trapezoidal box girder ramp bridges are avoided due to concerns about fracture redundancy.

Existing bridges that are categorized as fracture critical require additional inspections that are costly to owners. Removal of a fracture-critical designation on existing bridges will result in fewer inspections over the lifetime of the bridge.

If a system-wide analysis method is developed, many new bridges and many more existing bridges can be classified as non-fracture critical. This will save owners significant monies in design, construction, and inspection.

◆ **Project 12-89**

Development of New AASHTO LRFD Tunnel Design Specifications

Research Field: Design
Source: AASHTO Highway Subcommittee on Bridges and Structures
Allocation: \$750,000
NCHRP Staff: Waseem Dekelbab

There is limited experience in the state DOTs with new tunnel design. Most agencies rely on consultants who specialize in tunnel work for design and construction assistance. In addition, FHWA has established a goal to have federally funded projects for “structures other than bridges,” like tunnels design by LRFD, by October 1, 2010. The objective of this proposal is to develop specifications, commentary, and guidelines for tunnel design. The proposal focuses on design standards for structural design, geotechnical design, ventilation, fire control and suppression, and public signing. Very little design guidance is provided in the AASHTO LRFD Bridge Design Specifications for Tunnels in Section 12, Buried Structures and Tunnel Liners. The material on tunnels will be removed and included in a new section. Additional specifications and guidance must be developed and included in the new section.

It is expected that the contractor will use existing guidelines, especially those developed by FHWA and the National Fire Prevention Association, to prepare the specifications, commentary, and guidelines. This strategic research need is identified in the AASHTO Highway Subcommittee on Bridges and Structures’ 2005 Strategic Plan for Bridge Engineering, as part of Grand Challenge 4, Advancing the AASHTO Specifications, Grand Challenge 1, Extending Service Life, and Grand Challenge 2, Optimizing Structural Systems.

The objective of the proposed research is to improve the design of highway tunnels by developing specifications and guidelines for road tunnel design. The research will produce a draft design specification and commentary in the format of the AASHTO LRFD Bridge Design Specifications.

There is an urgent need to develop and improve the current methods of tunnel design, operation, and rehabilitation. These improved methodologies will increase the reliability and effectiveness of highway tunnel operations, leading to improved tunnel safety and more effective operation and management of tunnels in state and local tunnel inventories. The results of this research will provide guidelines suitable for implementation by state DOTs.

It is anticipated that the research results will be presented to the AASHTO Subcommittee on Bridges and Structures, T-20 Technical Committee on Tunnels, for consideration and adoption into the LRFD Specifications. The technical committee will work with FHWA and NHI to develop training as needed based on the new specifications.

◆ Project 14-23

Quantify the Information Necessary to Guide Bridge Preservation Decisions

Research Field: Maintenance
Source: AASHTO Highway Subcommittee on Bridges and Structures, AASHTO Highway Subcommittee on Maintenance
Allocation: \$850,000
NCHRP Staff: Waseem Dekelbab

Bridge preservation is a systematic proactive effort to significantly extend the service life of a bridge or bridge elements, usually at the least possible cost. Many transportation departments may have a significant amount of largely empirical data on experiences with bridge preservation and have developed conclusions on the effectiveness of bridge preservation based on those experiences. However, few systematic studies have been done to measure, evaluate, and document the short- and long-term results and effects of bridge preservation actions. No attempts have been made to gather and collate high-quality data, properly analyze the data, and draw conclusions about the costs, effectiveness, and longevity of the preservation action. It is difficult to examine such issues as how long the service life of the bridge/bridge element is extended or what the effects of the various, commonly used preservation actions are on the life cycle costs of bridges. Most conclusions reached by bridge practitioners are on the basis of intuition or simple common sense backed up by some experience. It is difficult to translate these conclusions into coherent and convincing arguments that will persuade legislatures and agency upper management to support and adequately fund aggressive and well planned programs of bridge preservation.

The collection of the data necessary to support analysis of the effectiveness and economics of bridge preservation activities should be addressed in a logical sequence, starting with short-term studies of existing data and moving to future data collection that is targeted at specific elements of the performance of bridge preservation actions. The material collected will be organized into a handbook for bridge owners to use as a guide to the most efficient and effective decisions for the maintenance and preservation of bridges. Recommendations will be made on how this guidance should be included in existing or new AASTHO specifications or guidance.

The objective of the proposed research is to improve the decision process for setting bridge preservation activities and preparation of guidelines. The research will produce recommendations and a handbook for possible adoption by AASHTO.

This problem should be studied in three phases:

- Phase I: Determine what aspects or results of bridge performance are of most importance to different levels of a transportation department and to various road users, and which methods of bridge preservation should be studied as contributors to the chosen aspects of bridge performance. Identify and define quantifiable and measurable metrics that can be used to analyze the effectiveness and cost implications of a bridge preservation program.
- Phase II: Use existing information on bridge preservation actions and programs to analyze existing data and draw conclusions on effects and benefits of bridge preservation actions. Compare these conclusions to those that currently are based on experiences and practices at various agencies in the United States.
- Phase III: Use experimental studies to collect specific types of data that are needed to evaluate the various benefits of specific, commonly used bridge preservation actions. Use the research quality data to refine and improve the understanding of the effects of bridge preservation actions.

There is an urgent need to develop and improve the current methods of setting preservation actions for bridges. These improved methodologies will increase the reliability and effectiveness of highway bridge operations, leading to improved bridge safety and more effective operation and management of bridges in state and local inventories. The results of this research will provide guidelines suitable for implementation by state DOTs.

Note: The AASHTO Standing Committee on Research combined Problem Statement 2011-F-02, “Best Practices for Preserving Bridge Decks,” and Problem Statement 2011-F-03, “Optimal Timing of Bridge Deck Washing to Reduce Chloride Penetration,” with this study.

◆ Project 14-24

Convincing the Stakeholders: Developing a Guide for Communicating Maintenance and Preservation Needs

Research Field: Maintenance
Source: AASHTO Highway Subcommittee on Maintenance
Allocation: \$250,000
NCHRP Staff: Andrew C. Lemer

As transportation budgets remain stagnant or fall and tax dollars become scarcer, legislatures search for ways to reduce spending while preserving public support for government programs. The trend of funding maintenance and preservation operations last has led to a nationwide deterioration of our highway system. Maintenance and preservation of bridges, pavements, and other roadway appurtenances have been shown by some agencies to have an enormous effect on the performance and life of the transportation infrastructure, saving millions of dollars in reconstruction and traveler delays. Being able to communicate these effects more effectively to elected officials, decision makers, other stakeholders, and the public would lead to better understanding of these programs.

There is an opportunity to communicate more effectively the impacts of maintenance and preservation of the nation's infrastructure to elected officials, decision makers, other stakeholders and the public and thereby build support for funding to maintain the nation's highway infrastructure. Some examples of such communication may be found in the literature (for example, work done at Iowa State University and by the Portland, Oregon, Office of Transportation.) This research to be undertaken would address such issues as improving communications about the technical/economic impacts of maintenance and system preservation between agency staff, elected officials, and the public using simple-to-understand principles which convey the message; developing guides with graphics and photos which display condition data and the consequences of delayed response to maintenance concerns; preserving institutional knowledge within agencies through documentation of treatment types and benefits, training of methods to track and report condition as well as training on methods of treatments and best practices and succession planning; establishing a guide of best practices on how to maintain or improve communication between local, state, and federal government agencies, toll authorities, and other highway owners; identifying industry organizations such as contractors, consultants, and trade associations that can help to communicate the message of maintenance and preservation activities to the public; educating engineering consultants and other designers on the benefits of including maintenance and preservation techniques in design and maintenance of roadway assets; and promoting development of transportation system preservation to the academic community.

The objective of this research would be to develop a guide to best practices on how to maintain or improve communication with local, state, and federal government agencies; toll authorities; and other highway owners. The research to accomplish this objective might include the following tasks: (1) identify best practices and successes in communicating the message of maintenance and preservation, studying marketing strategies that exist throughout the United States and around the world as part of asset management, including various infrastructure assets; develop a guide on how to market maintenance and preservation treatments including case studies, pictures, and illustrations of successful marketing campaigns, and recommendations on reaching senior agency executives, legislators, contractors, consultants, trade organizations, academics, and the general public; (3) deliver training workshops on marketing practices, including examples from successful case studies, and develop a mechanism to evaluate workshop effectiveness; (4) develop guidelines on how an agency can create succession planning and preserve institutional knowledge about maintenance and preservation in an agency through documentation of treatment types and benefits, and training of methods to track and report condition; include best practices on training methods for preservation treatments types.

Note: The AASHTO Standing Committee on Research stipulated the project should build upon the results of NCHRP Project 14-20, "Consequences of Delayed Maintenance." The project panel and contractor for this new project should have communications expertise so that the needs of diverse audiences can be addressed.

◆ **Project 14-25**

Guidelines/Methodology for Developing Cost Effective and Cost Efficient Levels of Service

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

State departments of transportation are beginning to evolve to the asset management principles of (1) establishing high-level policy goals and objectives, (2) developing performance measures to accomplish the agencies' goals and objectives, (3) using analysis of options and tradeoffs for investment strategies, (4) using quality information and data to support decisions, and (5) monitoring outcomes to provide accountability and feedback. A key component of this strategy is the development of performance measures and the establishment of level of service for each measure. The setting of level of service(s) by DOTs has for the most part, relied on expert opinion of the highway owner and infrastructure manager. The purpose of this research is to develop a methodology that can be used by highway owners and agencies to determine the appropriate LOS(s) for the assets under their authority, based on factors such as customer input, economics, cost effectiveness, user cost, and/or other pertinent factors to augment "expert opinion."

The anticipated outcome of this research is the development of a guide and methodology that state DOTs can use to determine the LOS that is appropriate for their agency based on factors like customer input, safety, economics, cost effectiveness, user cost, and expert opinion, among other things. It is anticipated that the research will include contacting state DOTs that have established LOSs, conducting interviews with those agencies to understand the process they used, and investigating other non-DOT agencies and/or industries to solicit best practices. Based on that research, a guide and methodology a DOT can use to establish LOS will be prepared.

◆ **Project 15-43**

Update of the TRB Access Management Manual

Research Field: Design

Source: Oregon, Utah, New Jersey, Minnesota, Maryland, Florida, Mississippi, Virginia

Allocation: \$350,000

NCHRP Staff: David A. Reynaud

In 2003, the Transportation Research Board (TRB) published the first national *Access Management Manual*. Since that time, the *Manual* has remained the most accepted and comprehensive national resource on the state of the practice in access management. It has been widely cited by state, regional, and local government transportation agencies updating their access management practices and is increasingly a resource to other nations as well. For example, it was recently translated and published in Chinese under a copyright agreement with TRB.

Since it was published, approximately 3,000 copies of the *Manual* have been sold, and a second reprint of 2,000 copies is underway. The editorial staff of TRB has indicated that based on the current rate of sales, the new stock will be exhausted by 2012. At that time, it is essential that a second edition be ready for publication.

A second edition needs to be produced because the state of the practice has advanced significantly in the years since the production of the first edition of the *Manual*, several major research projects have been completed and will represent an important upgrade of the current *Manual*, the *Manual* is the text for the revised National Highway Institute (NHI) Access Management Course and should contain current and up-to-date information regarding research and access management practices, and the TRB Committee on Access Management (AHB70) has identified gaps in the material covered in the *Manual*.

The objective of this research activity is to develop a revised and updated *Access Management Manual*. This objective will be accomplished by assembling research reports and papers published since preparation of the first edition, obtaining additional examples relative to access management programs and practices of state DOTs and local governments, proposing a revised structure and contents for the new manual, and preparing and submitting a draft of a revised and updated *Access Management Manual* for TRB's consideration, approval, and publication.

Studies done over the last 30 years show access management is one of the most compelling strategies to improve safety on our roadways. Access management is also a cost-effective way to extend the useful life of the existing system of roads and highways. As such, access management practices are essential to a sustainable and energy-efficient transportation system. With reduced funding of transportation and an increased emphasis on highway reconstruction to address growing transportation needs, advancing access management practices is a critical step.

The *Access Management Manual* provides the most comprehensive resource to enable transportation agencies to achieve a sustainable, energy efficient, and safe transportation system, at every level of government. The *Access Management Manual* advances innovation through technical support, training, and education. Technical support is provided to transportation professionals at the state, regional, and local governments as well as to consultants in the development of access management plans, regulations, design standards, and access management practices and procedures. It helps guide access-related decisions during the development and redevelopment of property abutting the nation's major roadways. Education and training functions are addressed through use of the *Manual* as the text for NHI Course No. 133078. (The course is typically taught eight to ten times per year, with up to 30 participants per course offering.)

◆ **Project 15-44**

Mobile LiDAR Standards for Transportation Agencies

Research Field: Design
Source: Washington
Allocation: \$250,000
NCHRP Staff: Edward T. Harrigan

Mobile LiDAR (light detection and ranging) technology has many promising benefits to transportation agencies as a tool for project planning, development, and construction. Several states, including Washington, Oregon, and California, have independently explored using mobile LiDAR on limited applications in order to understand the technology. Currently there are no standards available for states to use in evaluating this technology. This has the potential of creating duplication of effort as well as inconsistent methods in testing, evaluation, and applying the data produced. This research would provide guidance to DOT's program managers, project engineers, and other professional staff on how the technology could be utilized in a range of business practices.

The objective of this research is to create data collection and storage standards as well as hardware and software evaluation standards for states to use in testing, evaluating, and applying mobile LiDAR technology. Having national standards will ensure that the states have guidelines to follow for evaluating this technology for specific applications, resulting in more consistent data for use in national research efforts.

Note: The AASHTO Standing Committee on Research directed that the research focus on application practices and not on establishment of standards.
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◆ **Project 17-49**

Noteworthy Practices in Crash Reporting and Safety Programs on Indian Tribal Reservations

Research Field: Traffic
Source: AASHTO Standing Committee on Highway Traffic Safety
Allocation: \$200,000
NCHRP Staff: Christopher J. Hedges

Safety is a major concern for roadway practitioners across the United States. In many states, Native American population is disproportionately represented in fatalities and crash statistics. Statistics show that in South Dakota for 2005 only 52 crashes out of 737 crashes were reported to the state. The largest number of crashes reported included fatalities. Because less than 15% of identified crashes were reported to the state in 2005, the tribes in South Dakota did not receive adequate attention from state and federal programs that identify and target transportation safety issues. This lack of attention to tribal transportation safety problems will continue until tribal transportation crashes are adequately reported to the state(s). It is suspected that this issue is not confined to reservations and tribes located in South Dakota but is the norm for tribes in most states.

It is therefore imperative to identify tribal crash reporting systems that do report a high percentage of the total crashes on their reservations to their respective state(s). The methods, equipment, and software used and the training provided to those responsible for writing, filing, and reporting the tribal crash reports to the state(s) need to be identified. There exist a number of noteworthy tribal crash reporting programs being used by various tribal governments across the nation. These programs need to be identified to be used as model programs for the rest of the tribes in the nation. None of these programs have been showcased at tribal meetings or through the media. A documentation compiling these programs as case studies with facts, stories, and lessons learned would serve as a valuable tool to assist tribal entities in addressing the tribal crash reporting issues on tribal lands.

Native Americans particularly have the highest risk of motor-vehicle related death of all ethnic groups; for this group with ages between 4 and 44, motor-vehicle related injuries are the leading cause of death. During the time period between 1982 and 2002, according to a study conducted by the National Highway Traffic Safety Administration (NHTSA), 65 percent of Native American fatal crashes involved alcohol, as opposed to 47 percent nationwide during this same time period. In addition, it was found that from 1999 to 2004, 50 percent of Native American drivers in fatal crashes were over the legal BAC limit.

There exist a number of noteworthy DUI prevention programs being implemented by various tribal governments across the nation. These programs have targeted different tribal age groups, presented under a variety of formats, and implemented in conjunction with different events or independently. Many of these programs have been showcased at tribal meetings, through the media, and casual conversations. A documentation compiling these programs as case studies with facts, stories, and lessons learned would serve as a valuable tool to assist tribal entities in addressing the DUI issues, a major cause of fatalities on tribal lands. This document will also be useful to non-tribal local entities, where applicable, that also have been stricken by the DUI problem.

The objective of this research is to develop a document that compiles various effective tribal crash reporting programs and DUI prevention programs that have been implemented successfully on Indian reservations. These programs should be diverse in terms of what they entailed, how they were implemented, who were involved, and where they were implemented geographically and culturally. The project should include the following tasks: (1) Review implemented programs, (2) develop selection criteria, (3) compile a list of programs that meet or exceed the criteria, and (4) coordinate with the programs' authors/champions to obtain permission to use programs as case studies and to obtain further information for report.

◆ Project 17-50

Lead States Initiative for Implementing the Highway Safety Manual

Research Field: Traffic
Source: AASHTO Standing Committee on Highway Traffic Safety
Allocation: \$150,000 (Additional \$150,000 from Federal Highway Administration)
NCHRP Staff: Charles W. Niessner

After a substantial development effort, funded largely from NCHRP research, AASHTO expects to publish the *Highway Safety Manual* (HSM) in the spring of 2010. The HSM will provide new concepts for application by state highway agencies throughout the safety management process and particularly in the estimation of the safety benefits of proposed highway improvement projects. HSM Part B will provide new approaches to each step of the safety management process, including: network screening to identify potential safety improvement project locations, diagnosis of existing crash patterns, selecting of appropriate countermeasures, performing economic analyses, establishing project priorities, and evaluating the effectiveness of completed projects. HSM Part C will provide predictive methods that can be used to estimate the safety benefits of proposed highway improvement projects. Estimating the effect of proposed projects or of several project design alternatives on crash frequencies and severities can now become a routine part of the project development process and will allow safety to be considered on a quantitative basis in project development as other factors such as traffic operations, air quality, noise, and cost are considered. The predictive methods make extensive use of safety performance functions (SPFs) and accident modification factors (AMFs). HSM Part D provides quantitative values for AMFs that represent the expected crash reduction effectiveness for a broad range of countermeasures with the potential to improve safety. These AMFs are intended for use in the procedures of HSM Parts B and C and may also be useful to highway agencies in many other ways.

The HSM has the potential to bring about major changes in the accuracy and completeness of safety analyses conducted by highway agencies. However, like any new analysis tool, the HSM will only be effective if it is implemented by highway agencies. Recent experience has shown that one of the best ways to encourage highway agencies to implement new approaches is to show examples of other agencies that are taking a lead role in implementation. A lead states initiative was used successfully as part of NCHRP Project 17-18 in implementation of the AASHTO Strategic Highway Safety Plan, and peer exchanges are becoming an increasingly common approach to disseminating new information that is ready for implementation by highway agencies.

This research problem statement recommends the organization of a lead states initiative for implementing the HSM. This initiative will bring together representatives of 10 to 12 states that are taking the lead in implementing the HSM in two peer-exchange meetings. These states will benefit directly from the peer exchange and, to provide information and examples to other highway agencies, a user guide for the HSM will be developed based on the experiences of the lead states.

The recommended lead states initiative will help to ensure that highway agencies reap the benefits available from NCHRP's investment in the HSM, most recently in NCHRP Project 17-36, "Production of the First Edition of the Highway Safety Manual." NCHRP Project 17-38, "Highway Safety Manual Implementation and Training Materials," has developed briefing materials and a training course to assist highway agencies in understanding the HSM. This new project will help ensure that highway agencies are implementing the HSM effectively and benefiting from the experiences of other highway agencies.

The objectives of the research are to:

- Identify 10 to 12 state highway agencies that are taking a lead role in implementing the HSM,
- Convene two peer-exchange meetings involving representatives from the selected states and experts familiar with HSM development and implementation,
- Facilitate the exchange of experiences and examples related to HSM implementation among the lead states, and

- Develop an HSM user guide based on the experiences and examples of the lead states to assist other highway agencies in implementing the HSM.

The tasks that should be undertaken in the research are as follows: (1) identify 10 to 12 state highway agencies that are taking a lead role in implementing the HSM and are willing to share their experiences with other states; (2) convene an initial peer-exchange meeting involving representatives of the selected states and other experts familiar with HSM development and implementation; (3) monitor progress by the lead states over a period of approximately one year after the initial peer-exchange meeting; (4) approximately one year after the initial peer-exchange meeting, convene a second peer-exchange meeting involving the same selected states to report on progress, examples, and effective approaches to HSM; and (5) based on the experiences and examples of the lead states, develop an HSM user guide to assist other highway agencies in implementing the HSM. The user guide should serve as a supplement or companion to the HSM and show practical approaches to implementing the HSM procedures in the operating environment of a highway agency.

The recommended research is urgent and has a high payoff potential. NCHRP has made a large investment in development of the HSM, and AASHTO is embarking on a major effort to publish and distribute the HSM. The recommended research will help to ensure that highway agencies reap the benefits from effective implementation of the HSM. These benefits potentially include a more effective safety management process and consideration of safety as a quantitative factor in project development decisionmaking. The lead states initiative will be of direct benefit to the states that participate. The development of an HSM user guide, which could also be published and distributed by AASHTO, will make the experiences of the lead states available to all highway agencies and the highway safety community at large.

◆ Project 17-51

National Strategic Highway Safety Plan Support—Toward Zero Deaths: A National Strategy and Vision

Research Field: Traffic
Source: AASHTO Standing Committee on Highway Traffic Safety
Allocation: \$450,000 (Additional \$150,000 from Federal Highway Administration)
NCHRP Staff: Charles W. Niessner

AASHTO, with the help of many highway safety stakeholders, developed and adopted a Strategic Highway Safety Plan (SHSP) in 1997, and updated this plan in 2005. Each state has its own strategic highway safety plan, as do many safety stakeholder organizations. However, there does not exist one plan that unites all of these common efforts. The U.S. Department of Transportation (specifically through the Federal Highway Administration) and AASHTO have initiated an effort to develop a National Strategic Highway Safety Plan. The national SHSP will be data-driven and will incorporate education, enforcement, engineering, and emergency medical services. Unlike this earlier AASHTO plan, this national SHSP will not be “owned” by any one organization. The national SHSP can be utilized as a guide and framework by safety stakeholder organizations to enhance current state and local safety planning and implementation efforts.

AASHTO and the other national organizations representing state safety agencies have adopted a goal of reducing highway fatalities by half within 20 years. The Standing Committee on Highway Traffic Safety (SCOHTS) Subcommittee on Safety Management has reorganized to focus on this goal, and on development and implementation of a national SHSP.

With the Safety Management Subcommittee and all of its task groups focused on AASHTO’s national safety goal, the development of a comprehensive and complete national SHSP is crucial to achieving the national vision toward zero highway deaths. This will involve a wide range of safety stakeholders and significant effort on the part of the volunteers on the subcommittee. The existing funding for this effort will allow for development of an outline for the national SHSP and a work plan for the development, adoption, and implementation of the national SHSP, but will not provide for additional development and support of the national SHSP.

Tasks supporting the development, adoption, and implementation of the national SHSP include:

1. Outreach to safety stakeholders:
 - a. Identifying stakeholder organizations and contacts within the organizations.
 - b. Planning and holding meetings to obtain input from stakeholders, both initial input on content for the plan, and review of comments once the plan has been drafted.
 - c. Periodic updates on the national SHSP development including a peer exchange in 2011.
 - d. A communication system, such as an email listserv and website.
 - e. Meetings to “unveil” the plan, obtain stakeholder commitments, and assess implementation progress and impact on highway safety.
 - f. Intentional focus on national, multi-disciplinary, senior management, executive, and political leadership.
2. Research:
 - a. Gap analysis (recent plans and efforts compared to recent progress made toward goal).
 - b. Develop research plan for evaluation of additional 4E strategies.
 - c. Evaluation of national SHSP and implementation activities.
 - d. Pre-plan study on emphasis areas akin to the initial focus areas of the 1997 plan.
 - e. Projection of potential savings or impacts (gains and losses) in human and economic terms.
 - f. Legislative impacts and gaps (adding or deleting laws, policies, or practices).
3. Developing the national SHSP:
 - a. Process.
 - b. Vision, objectives, and strategies.
 - c. Performance measures.
 - d. Risk factors.

- e. Steering committee.
 - f. Publishing and printing (electronic access).
4. Marketing
- a. Stakeholders not involved in development.
 - b. State safety champions, and state executives.

Everyone in the highway safety community agrees with the need to reduce the number of fatalities and serious injuries, and many organizations have reflected this by adopting aggressive safety goals such as cutting fatalities in half or moving towards zero deaths. However, even though there is strong support for reducing the number of fatalities and serious injuries on our nation's roadways, there is currently no national comprehensive strategy to get us there. The intent of the effort is to develop a mechanism for bringing together a wider range of highway safety stakeholders to work toward institutional and cultural changes.

The ultimate goal will be to develop a National Strategic Highway Safety Plan that is data-driven and holistic and will support the development and implementation of other federal, state, and local agency strategic highway safety plans as well as strategic safety planning efforts of national associations, academia, and private industry. Even more important than the plan itself is the process through which it is developed. Because the national SHSP must be both comprehensive and cross-cutting, it will need to have input and involvement from a broad base of stakeholders.

◆ **Project 17-52**

Research to Improve the Structure, Process, and Outcomes of the Strategic Highway Safety Plans through Well Designed and Documented Peer Exchanges

Research Field: Traffic
Source: AASHTO Standing Committee on Highway Traffic Safety
Allocation: \$200,000
NCHRP Staff: Lori L. Sundstrom

SAFETEA–LU required all states to develop and implement a Strategic Highway Safety Plan (SHSP), and all states and the District of Columbia accomplished this by October of 2007. The AASHTO reauthorization proposal suggests that all states should engage in a peer exchange during the reauthorization period to invite advice and guidance on improving and implementing their plans. However, a template or model for developing, implementing, and evaluating an SHSP does not currently exist. The Federal Highway Administration (FHWA) has developed the Implementation Process Model (IPM), but it is only now being pilot tested, and an evaluation design has yet to be developed. Because large investments are supporting SHSP implementation, it is timely to identify an explicit process to guide the peer exchanges to ensure they are consistent, science-based, and effective.

Several peer exchanges have been held over the past few years. These events have been large scale, involving all states and focused broadly on SHSP development and implementation strategies. The SHSP peer exchange envisioned in this research would be requested by an individual state; invited peers would constitute a panel that provides consultation and assists the host state in moving forward with SHSP updates, implementation, and evaluation. In this case, the invited “peers” would be identified and recognized for their depth of experience and expertise to ensure the exchange is based on best practice, is fruitful, and is provided onsite to SHSP champions and stakeholders. Guidance documents would include the Federal Highway Administration’s IPM, *A Champion’s Guide to Saving Lives*, and other reports and guidelines.

Research is necessary to develop templates for quickly and efficiently conducting peer exchanges that are in-depth, high quality, and user friendly. This project will identify likely peer exchange panel candidates, necessary state participants, documents needed for preparation, templates for questioning witnesses and reporting, and other supporting materials.

The National Highway Traffic Safety Administration has deep experience in conducting these peer exchanges or assessments. However, the agency also experiences frustration because the reports often sit on the proverbial shelf and lack implementation plans. Thus, the SHSP peer exchanges must build in implementation planning, follow-up monitoring, evaluation of the process itself, and a feedback mechanism for improving the process and products.

This research will develop and pilot test a model template for conducting an SHSP peer exchange. The template will include the type of expertise required of participants, criteria for selecting expert panel participants or invited peers, documentation that is necessary to prepare participants for the peer exchange, an outline to use to document the process, implementation recommendations, and follow-up requirements.

Many states began implementing their SHSPs in 2007 or earlier and, in some cases, the motivation and effectiveness of their implementation efforts have begun to wane. Peer exchanges provide new and more effective ideas and methods for overcoming barriers. They are designed to identify continuing opportunities for improvement. Providing a methodology for conducting effective, productive peer exchanges is timely and needed.

The primary users of the research results are the Federal Highway Administration, the National Highway Safety Administration, the Federal Motor Carrier Safety Administration, the state DOTs, SHSOs, MCSAPs, elected officials, the MPOs and regional planning organizations, and local transportation and land use planners and engineers.

The SHSP peer exchange methodology once developed and pilot tested can be used by all state and local transportation safety coalitions to improve their SHSPs and other regional safety planning processes.

Improving the effectiveness of SHSP investments and procedures could have a substantial impact on driving down motor vehicle related fatalities and serious injuries.

◆ Project 17-53

Safety Evaluation of the 13 Controlling Criteria for Design

Research Field: Traffic
Source: AASHTO Technical Committee on Geometric Design
Allocation: \$600,000
NCHRP Staff: B. Ray Derr

The FHWA has designated 13 specific design elements as controlling criteria for roadway design. The 13 controlling criteria are (1) design speed, (2) lane width, (3) shoulder width, (4) bridge width, (5), structural capacity, (6) horizontal alignment, (7) vertical alignment, (8) grade, (9) stopping sight distance, (10) cross slope, (11) superelevation, (12) vertical clearance, and (13) horizontal clearance.

Federally funded highway construction and reconstruction projects must either meet established design criteria for these elements, or a formal design exception must be prepared and approved. Slightly different procedures apply to RRR projects, but these design elements are still key considerations in design.

With the exception of structural capacity and vertical clearance, safety is a key rationale for these controlling criteria. Yet, the 13 controlling criteria were established at a time when safety relationships for these elements were poorly understood, and these criteria and their application have not been reconsidered as new knowledge has been gained about the relationships between geometric design elements and safety. Research is needed to address key issues concerning these criteria, including:

- What has been learned about the relationships between the controlling criteria and safety?
- Based on current safety knowledge, are we using the correct design elements as controlling criteria? Should some criteria be dropped? Should others be added?
- Are each of the controlling criteria applicable to all roadway types or should the controlling criteria vary by roadway type?

Answers to these questions are needed to ensure that safety receives due consideration in the design process and also that we are not making major investments in the name of safety that, in fact, produce no safety improvement.

The objectives of the research are to (1) compile what has been learned about the relationship of the 13 controlling criteria to safety; (2) identify key knowledge gaps and conduct research to fill those gaps; (3) based on safety knowledge, recommend whether changes are needed in the list of design elements that are considered as controlling criteria; and (4) recommend whether the list of design elements considered as controlling criteria should vary between roadway types.

The tasks that should be undertaken in the research are as follows: (1) Review safety research literature to establish what is known about the relationships of the 13 controlling criteria to safety. This review should include safety research results assembled for the forthcoming AASHTO *Highway Safety Manual*; (2) with the exception of structural capacity and vertical clearance, determine which of the 13 controlling criteria have safety effects that are well understood; (3) for any of the 13 controlling criteria with safety effects that are not well understood, formulate research plans to determine those safety effects; this could potentially include investigations of bridge width, vertical alignment, cross slope, and/or horizontal clearance; (4) execute the research plans developed above; and (5) based on the safety information in the literature and the research results, recommend whether changes are needed in the list of design elements that are considered as controlling criteria and whether the list of design elements considered as controlling criteria should vary between roadway types.

◆ Project 17-54

Consideration of Roadside Design and Roadside Features in the Highway Safety Manual

Research Field: Traffic
Source: AASHTO Technical Committee on Roadside Safety
Allocation: \$800,000
NCHRP Staff: Charles W. Niessner

In the project development process, transportation engineers assess the effect of roadside designs and features on crashes. The *Highway Safety Manual* (HSM) provides scientifically sound information to support this decision making through accident modification factors (AMFs), which analyze the safety effect of specific design elements known to have an influence on the frequency or severity of crashes. Few roadside AMFs exist, and those that do are not typically of the statistical quality deemed appropriate for inclusions in the first edition of the *Highway Safety Manual*. The *Roadside Design Guide* (RDG) provides a probability of encroachment model to quantify the safety of a roadside design and compare the design against other designs. Software support for the HSM is provided through the IHSDM CPM and through RSAP for the RDG.

This project will review the two methods; document inconsistencies in predicting the frequency and severity of run-off-road crashes; update the models to provide consistency and provide guidance to practitioners on the successful implementation of each method at various planning, highway design, and operations stages; explore the possibility of incorporating RSAP with the IHSDM; and identify a critical set of AMFs that would support the quantification of changes to the roadside and the installation or modification of roadside features at the identified stages of the project development process, eliminating the need for the use of subjective hazard ratings. This project will develop these AMFs for inclusion in a future edition of the *Highway Safety Manual*. It is expected that the methods used to develop these AMFs will meet the scientific protocol acceptable for inclusion in the *Highway Safety Manual* and FHWA AMF clearinghouse as an excellent quality AMF.

The development of the improved roadside AMFs has data needs met from the NCHRP Project 17-22 and 17-43 databases and other identified databases. An outcome of this project will be improved roadside safety decision-making tools for transportation agencies.

PHASE 1, Comparison of RDG and HSM Tasks: (1) Conduct a literature review of the development of the HSM, the RDG, RSAP, and the IHSDM methods for the analysis of roadside crashes used by these two different approaches. (2) Survey practitioners, researchers, design consultants, and transportation agencies to assess the current needs as they relate to roadside safety during the planning stage, the design stage, and the management of assets. The survey shall also ask for input about specific roadside concerns or areas of need regarding more AMFs. (3) Identify a minimum of five example problems for analysis using the two methods. (4) Document inconsistencies between the two methods and opportunities to provide consistency through updating data sources, base models, or modification factors. (5) Assess available data sources from completed and ongoing NCHRP projects, as well as other state and federal research or databases. Possible data sources include NCHRP 17-22 and 17-43. (6) Develop a prioritized list of roadside AMFs which should be evaluated for development and inclusion in future versions of the HSM. (7) Review RSAP and IHSDM methods and coding for the possible inclusion of RSAP as a module in the IHSDM. (8) Recommend if it's appropriate to consider both methods for continued parallel development for the safety assessment of the roadside or if one method should be chosen for future development efforts. (9) Document findings in an interim report. The report shall include guidance based on the findings of this phase, about the appropriate inclusion of each analysis method into the planning and design process as well as the life-cycle management of the highway network.

PHASE 2, Development of Roadside AMFs Tasks: (1) Review the protocols for *Highway Safety Manual* AMF development. (2) Develop AMFs for the base conditions outlined in parts C and D of the *Highway Safety Manual*. AMFs shall be developed using the data available from the 17-22 and 17-43 projects as well as other identified sources. Additional data gathering is not anticipated. The prioritized list of AMFs developed in phase 1 shall be reviewed in consultation with the panel. A list of AMFs for development under this project will be produced based on the data available. (3) Develop a list of additional data needs for the

NCHRP 17-43 “Ongoing Data Collection” panel’s or other data collection projects’ consideration of inclusion. (4) Depending on the outcome of phase 1, task 8, inclusion of these findings may be necessary in the RSAP encroachment model as well. (5) Document findings in a final report.

This research will provide a document which will supplement the soon-to-be-released HSM and the existing RDG as a means to determine under which circumstances the designer should employ which method to predict crashes, evaluate the potential benefit of safety improvements for the roadside, and provide more AMFs to supplement those provided in the first edition of the HSM. The urgency is high since there is potential for introducing considerable confusion to the design profession by having two methods for similar purposes that may yield conflicting results. Furthermore, the First Edition of the HSM does not provide AMFs to address most of the typical changes of roadside designs and features that agencies currently undertake and subsequently does not support the quantification of the effect of the roadside on crashes and crash severity within the project development process.

◆ Project 18-16

Self-Consolidating Concrete for Cast-in-Place Concrete Bridges and Tunnels

Research Field: Materials and Construction
Source: AASHTO Highway Subcommittee on Bridges and Structures
Allocation: \$450,000
NCHRP Staff: Amir N. Hanna

Self-consolidating concrete (SCC) is a specially proportioned cement concrete that enables the fresh concrete to flow easily into the forms and around the steel reinforcement without segregation. Use of this type of concrete has gained widespread application in precast, prestressed bridge elements. The benefits are increased rate of production and safety, reduced labor needs, and lower noise levels at manufacturing plants.

The recently completed and reported NCHRP Project 18-12, “Self-Consolidating Concrete for Precast, Prestressed Concrete Bridge Elements,” has provided a very good and sound understanding of the SCC mix designs, testing, and workability, and the properties of fresh and hardened SCC. Although NCHRP Project 18-12 focused on the applications of SCC to precast, prestressed bridge elements, most of the findings are also applicable to cast-in-place concrete (CIP) (ready mixed concrete). Additional effort may be devoted to, but not limited to: (1) QC/QA of CIP SCC production, (2) quality control of the delivered concrete, (3) handling and Transportation requirements, (4) form pressures for taller walls and columns (5) preparation of construction joints, (6) control of heat of hydration, (7) surface finishing and curing requirements, (8) control of cracking, (9) guidelines for developing an SCC mix for bridge decks with cross slope of up to 2% or more, (10) guidelines for SCC placement to optimize the flowability of SCC in the horizontal and vertical directions, (11) guidelines for pumpability of SCC with respect to time and distance, (12) illustration of the benefits of CIP SCC by documenting field experiences of CIP SCC projects in the United States and abroad, (13) recommendations for structural parameters (creep, shrinkage, modulus of elasticity) for use of SCC in post-tensioned CIP concrete superstructures, and (14) recommendations for changes in the AASHTO Bridge Design and Construction Specifications for CIP SCC.

Research is needed to address the factors that significantly influence the design, constructability, and performance of cast-in-place concrete bridges and tunnels using SCC, and to develop guidelines for the use of SCC in cast-in-place concrete applications, including recommended changes to the AASHTO LRFD Bridge Design and Construction Specifications. These guidelines will provide highway agencies with the information necessary for considering SCC to expedite construction and yield economic and other benefits.

In the past 10 years, research in the United States has been focusing on the use of SCC in precast, prestressed applications. The precast/prestress producers have successfully taken advantage of the research findings and economic benefits. The precast/prestress producers have implemented SCC into everyday production to improve consolidation around reinforcement without vibration, enhance surface finish, accelerate placement, produce less wear and tear on equipment, reduce or eliminate vibration, and reduce patching and rework. The use of SCC in the United States ready-mixed market is still in its infancy. The highway agencies and the industry are waiting for guidelines in design and construction specifications to take advantage of the applications of SCC in cast-in-place bridges. Research is needed to improve the understanding of the physical and mechanical properties and the economic benefits of SCC in ready-mixed cast-in-place applications.

The main objectives of this research are to (1) develop guidelines for the use of self-consolidating concrete in ready-mixed cast-in-place concrete in highway bridges and related structures, and (2) recommend relevant changes to the AASHTO LRFD Bridge Design and Construction Specifications. Accomplishment of these objectives will require at the least the following tasks:

Task 1. Collect and review relevant literature, specifications, research findings, current practices, performance, and other information relative to the use of SCC in ready-mixed concrete.

Task 2. Identify and discuss the factors influencing the properties of fresh and hardened SCC in cast-in-place applications.

Task 3. Assess the relevance and importance of the factors and properties to the structural design, constructability and performance of cast-in-place SCC.

Task 4. Recommend laboratory evaluation and testing methods necessary for developing the guidelines. This task should also include testing of full-scale bridge components as necessary to validate the laboratory test results.

Task 5. Submit a final report documenting the research effort, findings and recommendations, including recommended changes to the AASHTO LRFD Bridge Design and Construction Specifications.

◆ Project 20-89

Intellectual Property Stewardship Guide for Transportation Departments

Research Field: Special Projects
Source: South Dakota
Allocation: \$350,000
NCHRP Staff: Andrew C. Lemer

The transportation research community is charged with finding solutions to important problems. Those solutions often involve new processes and technology which represent intellectual property with potential economic value.

Among countries visited in the recent FHWA/AASHTO International Scan on Transportation Research Program Administration, the transportation research community demonstrated a noticeably greater concern for the value and importance of intellectual property than is sometimes evident in the United States. Safeguarding intellectual property was recognized as a critical component of the entire research process to spur innovation, encourage investment for technology development and refinement, and foster commercialization nationally and internationally. Ultimately, intellectual property was seen as a means to bolster national economies by promoting creation of companies that hire new employees and sell new products. Successful management of intellectual property rights was associated with greater trade and foreign investment opportunities globally.

In the United States, transportation agencies have traditionally taken the position that they should retain rights to intellectual property derived from research they sponsor. While the intent of this policy has been to maintain public ownership of intellectual property, a frequent unintended result has been to impede development. Agencies have often lacked the knowledge, resources, and impetus to commercialize technology or license it to others. In the absence of intellectual property protection, private concerns have been reluctant to invest further in its development. In contrast, organizations visited during the scan viewed protection and licensing of intellectual property as an essential enabler of technology deployment.

Furthermore, many transportation agencies in the United States lack effective policies regarding employees' rights to intellectual property. For example, some agencies specify that any new product or idea that relates to agency goals and objectives is owned by the agency, and require employees to assign their intellectual property rights to the government. Undefined policies or policies that preclude employees sharing intellectual property rights create little incentive for innovation.

A significant barrier to more effective management of intellectual property is the lack of understanding within transportation agencies regarding domestic and intellectual property law and policy. Although the Bayh-Dole Act of 1980 (or University and Small Business Patent Procedures Act) governs intellectual property developed in federally sponsored research, it only establishes a general framework. State laws and policies may impose additional requirements that apply to non-federally sponsored research or research performed by government employees. Federal and state agencies often lack expertise on the fairly complicated and sometimes expensive processes needed to secure and protect intellectual property. This situation has worsened in some agencies due to retirements of experienced staff and changes in agency policy. Without the necessary working knowledge, agencies are unable to develop and execute effective strategies for exploiting their intellectual property investments.

An extensive literature addresses issues of intellectual property and technology transfer for federal laboratories and agencies engaged in development of medical, defense, aerospace, and other advanced-technology systems. While a few state transportation agencies have developed intellectual property policies, there is a general lack of knowledge within DOTs regarding identification and management of the resource. Research is needed to develop practical guidance that transportation agencies—in particular, their research and legal offices—can use to effectively manage intellectual property.

The objective of this research will be to develop a guide on effective stewardship of intellectual property for public transportation agencies. The research to accomplish this objective might include the following tasks: (1) review of literature, including domestic and key international law, relating to the management of intellectual

property in the areas of transportation and transportation research; (2) survey of practices of domestic and international transportation agencies to identify best practices as well as unsatisfied needs regarding management of intellectual property; (3) review of similarities and differences among states' intellectual property policies and identify those that may require legislative or policy enhancements; (4) review of practices for managing intellectual property in other technical and scientific disciplines that could be applicable to transportation and transportation research; (5) development of case studies that illustrate effective processes for managing intellectual property; (6) development of a guidance document on effective management of intellectual property for transportation research professionals in state and federal agencies; and (7) development of training based upon the guidance document on effective management of intellectual property for presentation to transportation research professionals.

◆ Project 20-90

Improving Access to Transportation Information

Research Field: Special Projects
Source: Washington, Arizona
Allocation: \$400,000
NCHRP Staff: Andrew C. Lemer

Transportation researchers, practitioners, and policy makers need a reliable information pipeline that captures relevant information in a consistent, comprehensive manner, with planned redundancy. Federal and state transportation agencies invest an enormous amount of time and money in generating information, but researchers and practitioners consistently report difficulties in finding and accessing it. Studies show employees spend 15–35% of their time searching for information. As much as 75% of an organization's information may be unstructured and unmanaged, resulting in wasted funds, lost opportunities, and duplication of effort. The transportation community currently shares information in a variety of ways. The most common method is to create a report or manual that is printed on paper, published on the internet, or both. Some of these reports are also submitted to major collections (such as TRIS or a transportation library) that enter them into bibliographic databases and preserve them. Transportation data is also shared in a variety of ways, and some may be found in central repositories and listings in data clearinghouses.

One of the challenges to finding and managing transportation information is the limited use of common metadata and indexing terminology within the transportation community. Indexing and metadata standards do exist and are used but they are limited in scope and application. For example, the Transportation Research Thesaurus (TRT) is used by most transportation libraries, but the terminology does not yet address all of the terms needed and is not used to organize data resources or agency records. Data providers apply metadata standards, but the actual terms used are quite variable. Web pages use tags that are frequently established by the Web master. Record and document management systems use organizing structures based on the needs of current users of the resources, but it can be difficult to find information for another need. Image indexing systems are highly variable, from no system to strategic metadata and file names. There is no enterprise or industry-wide approach that addresses the broad user need for rapid access to relevant information.

Within most transportation agencies, management of information resources is usually handled by the office creating the information, with no central point of contact to coordinate resources produced by diverse offices. This results in an inconsistent pattern of information capture and storage. While the practices applied may address the immediate need of the office creating the information, they may not support the broader agency information need (such as performance management resources or policy decisions) or the broader information needs of the transportation community (such as research and consideration of national policy). Common challenges within agencies include reports and data not being distributed beyond the issuing department; lack of attention to final disposition of data collected for projects, so that data remain with the private contractor and are not readily accessible to the agency; and information published only on the internet, where changing URLs may make the material hard or impossible to find and deletions occur because of data storage space limits or policy changes. Looking beyond single agencies, challenges include lack of institutional and financial support for joint-use information repositories; difficult and time-consuming efforts required to develop and reach consensus on terminology, information and data formatting, storage, and maintenance standards across the transportation community; and variations in sophistication and resources available to ensure interoperability for information deposit and access across agencies.

The transportation community has made efforts to improve information management, for example producing a business plan for developing Transportation Knowledge Networks (TKN), the TRT, and TransXML. Further research is needed.

The objective of this research will be to investigate feasible and effective practices for capturing information resources within transportation agencies, organizing these resources to enhance their availability, and facilitating their use within and among agencies to support decisionmaking, policy development,

performance management, research, and other information uses. The research to accomplish this objective might include the following tasks: (1) review current practices and identify best practices for capture, preservation, and retrieval of transportation information; (2) compile a resource base of terminology and categorization schemes for transportation information resources, including thesauri, taxonomies, glossaries, and ontologies, including those drawing on related fields (for example, public safety, engineering, and environment); (3) develop a toolkit of resources and practices for agencies to use in more effectively managing their information resources; and (4) identify strategies for expanding the use of effective information capture, preservation, and retrieval practices within the community of transportation agencies.

Note: The AASHTO Standing Committee on Research recommended that two problems be combined to comprise NCHRP Project 20-90: 2011-SP-04, “Accelerating Development of a Common DOT Language,” and 2011-SP-05, “Improving Access to Transportation Information.” The description above encompasses both problem statements.

◆ Project 22-28

Criteria for Restoration of Longitudinal Barriers

Research Field: Design
Source: AASHTO Technical Committee on Roadside Safety
Allocation: \$300,000
NCHRP Staff: Charles W. Niessner

NCHRP Project 22-23, “Criteria for the Restoration of Damaged Guardrails,” has effectively been completed by researchers at Virginia Tech. As part of this project, researchers surveyed the states to determine what, if any, formal guidelines they have for the maintenance of guardrails. The study determined that while some states did have guidelines for evaluating existing guardrails and determining whether maintenance was indicated, these guidelines were typically based on judgment and were not supported by underlying research.

The objective of Project 22-23 was to develop guidelines to assist maintenance personnel in identifying levels of damage and deterioration to longitudinal barriers that require repairs to restore operational performance. To achieve this objective, the researchers evaluated for eleven damage and deterioration modes commonly associated with the standard strong steel post W-beam (modified G41S) guardrail; they evaluated these modes through a combination of component testing, pendulum testing, finite element simulation, and full-scale crash testing. From this testing, draft maintenance guidelines were developed.

Final guidelines for the maintenance of longitudinal barriers will be presented in a final report, due to be completed in May 2010.

It is anticipated that maintenance guidelines for cable barriers will be developed under NCHRP Project 22-25.

The objective of this problem statement is to continue the work begun under NCHRP Project 22-23. While this initial project did groundbreaking work in evaluating the performance of barriers having damaged components, there were limitations to the work that could be undertaken in one study. Among the additional research needs are:

- Evaluation of wood post systems – The 22-23 final report will include maintenance guidelines for strong-wood-post W-beam systems. However, as the testing done under 22-23 was limited to steel-post systems, there is a need to conduct similar testing and evaluation of wood posts and wood post guardrail systems to confirm that these guidelines are applicable to wood-post systems as well.
- Overlapping damage modes – The evaluations under NCHRP 22-23 were limited to one damage mode at a time. Oftentimes, though, more than one mode of damage will be present in a given barrier. An example would be rail flattening in combination with rail deflection. There is a need to better understand the interaction between overlapping damage modes and how these would affect barrier performance.
- Generic End Treatments – Maintenance guidelines for generic end treatments were presented in 22-23, but these were largely drawn from guidelines developed by state DOTs. Similar to the issue with wood posts, these guidelines should be quantitatively tested and evaluated.
- Damage to barriers near end terminals – A previously damaged rail element within the first 50 feet of rail in an energy-absorbing terminal may not properly activate the end terminal in a head-on crash. If these rail units are not straight, the rail element may lose column strength and be unable to resist buckling when impacted end-on.
- Consideration of damage modes to other similar systems such as the recently developed Midwest Guardrail System, a generic W-beam guardrail system with a 31-inch mounting height.

It is anticipated that the research program will involve a combination of component testing, pendulum testing, and computer simulation of crash tests. Full-scale crash testing may be considered if necessary to validate the other methods of analysis, but will not be the focus of research.

The following efforts are considered important to the successful completion of this research: (1) Review the experience of field maintenance staff using maintenance guidelines developed in NCHRP Project 22-23. (2) Identify damage assessment needs which will include the needs identified in the NCHRP 22-23 final report and any additional assessment needs chosen in consultation with the project panel. (3) Propose a research program to qualitatively and quantitatively assess the needs identified earlier in this problem statement. (4) Prepare an interim report that outlines the findings of the above efforts for review and comment by the project panel. (5) Upon panel approval, conduct planned analyses and supporting tests to develop the metrics for assessing longitudinal barrier damage, correlating them to safety performance. (6) Prepare a plan of full-scale crash testing necessary to fully validate the guidelines developed under this project. (7) Prepare a final report to document the research effort and recommended guidelines.

Maintenance personnel are charged with making decisions as to when damaged guardrails needed to be repaired. Prior to NCHRP 22-23, only limited guidance was available to guide such decisions, and there was no supporting research available on which to make such judgments. NCHRP 22-23 has addressed this need, in part, but additional work remains to be done. This project will result in additional guidelines directed at garage-level maintenance employees who make the day-to-day decisions regarding the need to repair guardrail systems. The payoff of improved decisions by these staff will be the ability to focus their maintenance efforts on those barrier installations that truly need repair to maintain their performance under vehicular impacts.

◆ Project 22-29

Performance of Longitudinal Barriers on Curves and Super-Elevated Roadway Sections

Research Field: Design
Source: AASHTO Technical Committee on Roadside Safety, Washington
Allocation: \$600,000
NCHRP Staff: Edward T. Harrigan

Longitudinal barriers are roadside safety devices commonly used to shield errant vehicles from impacting hazards located alongside the traveled way. These barriers have been successfully designed in many different variations ranging from rigid concrete parapets to semi-rigid beam guardrail to relatively flexible wire rope barriers. Historically, the development and testing of longitudinal barriers has been done under the assumption that the barriers are installed in relatively straight sections parallel to the roadway. While the barriers designed under this assumption have performed well, their behavior when installed on curved roadways is largely unknown. However, despite this lack of understanding of their safety performance on curved roadways, longitudinal barriers are commonly installed on super-elevated curves to protect errant motorists.

Curved, high-speed roadways generally employ super-elevation in order to make the roadway curvature easier for vehicles to navigate. Several potential concerns arise when longitudinal barriers are installed on super-elevated, curved roadway sections. First, barriers on curved roadways effectively increase the angle of the vehicle with respect to the barrier during an impact due to their curvature. This increase in the impact angle can cause an increase in impact loading that may potentially exceed the capacity of barriers designed for impacts parallel to the roadway. Occupant risk measures such as Occupant Ridedown Acceleration (ORA) and Occupant Impact Velocity (OIV) may also increase in magnitude. In addition, the increase in impact angle may raise the potential for vehicle instability due to vehicle snag on posts or other barrier elements and may reduce the barrier's ability to capture and interlock the impacting vehicle, thus resulting in the potential for vehicle under-ride or override of the barrier. Finally, the super-elevation creates a sloped roadway condition adjacent to the longitudinal barrier that is not considered in standard longitudinal barrier design. This issue is often addressed in bridge rail installations by installing the barrier normal to the super-elevated road surface. However, installation of beam guardrail and wire rope barriers cannot reasonably follow the same recommendation due to the difficulty of driving or embedding the support posts at angles other than vertical. Thus, the orientation of these types of barriers with the road surface is normally significantly different from their design and tested configuration, and there is concern that the change in orientation could lead to vehicle instability. This issue is further complicated when the barrier is installed perpendicular to the road surface on the inside of the curve or lower side of the super elevation. Vehicles approaching from the upper portion of the super elevation may be "ramped" due to barrier orientation perpendicular to the road surface. Barriers may perform better on the lower edge of the super elevation if they are installed vertical.

A need exists to investigate the performance of longitudinal barriers on super-elevated, curved roadways in order to quantify their performance and provide guidelines for their safe application.

The objective of this research effort is to define performance limits for longitudinal barriers when installed on super-elevated, curved highways according to the safety criteria recommended in the Manual for Assessing Safety Hardware (MASH). These performance limits will then be used to generate guidelines for barrier placement on curves.

The first task is a literature search to identify all previous curved guardrail testing and to identify typical curve geometries and super elevations used by the state DOTs. This background material will provide a baseline for the analysis. In the second task, the researchers will simulate previous curved barrier tests using LS-DYNA to validate the performance of the model with respect to impacts with super-elevated curves and longitudinal barriers. Once the previous crash test simulations are validated, LS-DYNA will be used to simulate the performance of the longitudinal barriers on super-elevated curves. Four longitudinal barrier types should be investigated including conventional height and 31-in. high W-beam guardrail and safety shape and vertical-face concrete barriers. Simulation will be used to identify the critical curve radius and super-elevation that results in

vehicle instability and poor safety performance for the various barrier types. It will also be used to identify critical vehicle types, 1100C or 2270P, for the barrier and super-elevated curve combinations.

In the third task, full-scale crash testing will be conducted on the barrier types and super-elevated curve combinations identified as critical in the computer simulation effort. The testing will be conducted under the Test Level 3 (TL-3) impact conditions of MASH. The results of the initial crash tests will be used to refine the simulation models and to aid in further refinement of the critical radius and super-elevation for each barrier type. For example, if the initial test of the critical radius and super-elevation fails, then the test data will be used to revise the model, and further simulation will determine a new, less severe combination of the critical radius and super-elevation. If the test passes, then the simulation will be used to determine a new, more severe combination of the critical radius and super-elevation. A second round of full-scale crash tests may then be conducted on longitudinal barriers installed at the refined super-elevated curve geometry. In the fourth task, the results of the testing and simulation will be used to develop performance limits for the longitudinal barriers installed on super-elevated curves. In addition, the knowledge gained from the evaluation and testing of longitudinal barriers on curved roadways will be used to make recommendations with regard to the end terminals and transitions on curves. Recommendations will also be made with regard to future research on longitudinal barriers on super-elevated, curved roadways in areas that were outside the scope of this problem statement, including TL-4 barriers and wire rope barriers. In the last task, a final report will be prepared: a summary report to document the analysis, testing, and performance limits generated during the research project.

◆ **Project 24-35**

Quantifying Long-Term Performance of Draped and Flexible Fence Rockfall Protection Systems

Research Field: Soils and Geology
Source: Virginia
Allocation: \$150,000
NCHRP Staff: David A. Reynaud

Rockfall protection systems have been in service along roadways in Europe and the United States for more than 40 years. Rockfall protection systems utilizing steel netting to control the rockfall include ring-net barrier fences, cable-net barrier fences, draped cable-net, draped wire-mesh, and attenuators. Many of the systems are proprietary. These systems are intended to control rockfall and/or reduce the potential for rock debris to fall within highway alignments. The protection systems include components such as wire rings, wire rope, wire rope nets, wire mesh, posts, pins, fasteners, and breaking elements. These components are usually designed and rated based on testing in terms of energy capacity or energy reduction of a single rockfall event with some consideration for serviceability after specific impacts. However, the long-term performance and maintenance issues of these systems are a growing concern since many departments of transportation that have installed these systems are faced with significant maintenance, repair and/or replacement costs once a rockfall event occurs.

The objective of the research is to provide owners and manufactures of rockfall systems with guidelines to evaluate vulnerability and maintenance issues associated with rockfall protection systems that use steel netting. The report will also provide estimates for design life expectancies of various systems. The design guidelines should also include a method to determine when to replace and upgrade these types of rockfall protection systems. Initiation of this work is urgent. The payoff from this research includes a safer highway system, improved prioritization of funds, reduced maintenance and clean-up costs, and reduced life-cycle costs associated with design, construction, and maintenance of rockfall hazard protection systems. Results of the research will be useful to transportation agencies charged with managing rockfall hazards.

In the United States, thousands of rockfalls occur annually along highways; consequently, rockfall protection systems have become an important component of highway safety. Often these protection systems are placed along scenic sections of highways carrying large volumes of traffic, particularly during tourist season and for seasonal recreation destinations. Products from this research, which include a recommended practice for inspection and review of the service life, are needed for better selection of materials and components incorporated into rockfall protection systems. Currently, there are no well-defined provisions or protocols for condition assessment and service life modeling of rockfall protection systems. The recommended practice developed as part of this research would be in a format consistent with AASHTO requirements.

Note: The AASHTO Standing Committee on Research directed that Problem No. 2011-F-07, "Rockfall Fence Testing Guidelines," be incorporated into the scope.

◆ Project 25-34

Improving FHWA's Traffic Noise Model (TNM) by Expanding Its Acoustical Capabilities and Applications

Research Field: Transportation Planning
Source: AASHTO Standing Committee on the Environment
Allocation: \$420,000 (Additional \$30,000 from Federal Highway Administration)
NCHRP Staff: Lori L. Sundstrom

FHWA's Traffic Noise Model (TNM) is a program used by state departments of transportation (state DOTs) and support consultant transportation professionals to predict noise impacts on Federal-aid highway projects. Since its first release, TNM has been routinely updated and upgraded to improve upon the accuracy, functionality, and ease of modeling highway noise, including the design of effective, cost-efficient highway noise barriers.

Since its release in 1998, the TNM has been updated several times—Version 2.5 is the current release, with Version 3.0 under development. The current TNM components include: (1) modeling of five standard vehicle types, including automobiles, medium trucks, heavy trucks, buses, and motorcycles, as well as user-defined vehicles; (2) modeling of both constant-flow and interrupted-flow traffic using a 1994/1995 field-measured database; (3) modeling of the effects of graded roadways; (4) sound level computations based on a one-third octave-band database and algorithms; (5) graphically interactive noise barrier design and optimization; (6) attenuation over/through rows of buildings and dense vegetation; (7) multiple diffraction analysis; (8) parallel barrier analysis; and (9) contour analysis, including sound-level contours, barrier insertion loss contours, and sound-level difference contours.

As evidenced by the ongoing release of TNM updates, the model is intended to evolve to expand its capabilities and to address the new or newly identified needs of transportation noise professionals. It should also be recognized that TNM updates also enhance the consistency and accuracy of noise modeling efforts and, in turn, provide an improved “foundation” for noise mitigation decisions. This improved foundation helps to avoid decisions that are too conservative (i.e., too costly) or too lax (i.e., not reflective of or able to address citizen concerns).

Building upon this established framework for TNM enhancement and reflecting the above improvement needs and objectives, the Standing Committee on Environment (SCOE) recommends research to further enhance traffic noise prediction and provide more rigorous and consistent analysis. To these ends, the SCOE recommends research to identify noise prediction factors of greatest concern or value and to develop information and data to update the TNM to address these factors.

Online searches of TRIS Online (<http://ntlsearch.bts.gov/tris/index.do>) and TRB's Research in Progress database (<http://rip.trb.org/search/>) indicate that the proposed research does not duplicate current or recent research. It should be recognized that state DOTs and FHWA personnel involved in noise analysis and prediction have noted that several factors are not addressed in the TNM and are, therefore, subject to inconsistent determination, analysis, and response. The research recommended herein is intended to address these concerns. This research project's results are intended for use by state DOTs, noise analysts/modelers, and noise mitigation measure designers, and community planners.

SCOE recommends research to expand the capabilities and state of the practice in traffic noise prediction, analysis, and response. Specific tasks to be performed under the recommended research are as follows; a brief discussion of each task is included.

1. Identify additional factors that affect highway noise prediction. This action will entail a brief survey of federal and state transportation agency personnel involved in noise prediction, analysis, and design to identify and characterize the need for and potential benefit of addressing these factors on a consistent and reliable basis.
2. Select those factors that are of greatest concern to transportation noise professionals or stakeholders, or that offer the greatest potential for controlling overly conservative noise mitigation decisions. This action includes identification of issues that are significant contributing factors to undesirable noise levels. The

research product will make recommendations on how to proceed in addressing the issues, whether through additional features in TNM or implementation of BMPs.

Discussions among transportation professionals involved in noise prediction and analysis indicate that these issues may include, but are not limited to:

- a) Effects of structure-reflected and generated noise. Receptors adjacent to bridge structures are often subjected to undesirable noise levels, even after noise barriers are constructed on the structure. The cause of such noise is unclear; for example, does the noise result from vibration of the structure deck, does the noise result from factors related to different structure designs (open beam, box girder, reinforced concrete slab, etc.), or are other factors involved? The research will determine the mechanisms and/or sources of the noise emissions and if there are ways to mitigate the situation. Another issue relates to the degree of influence that may exist due to the open median area between parallel bridges and how this may influence overall noise levels. The research will determine the source or sources of noise/vibration emissions from bridge structures and quantify the differences that may be associated with various bridge designs.
- b) Noise associated with weigh stations, rest areas, service plazas, and toll facilities. Traffic and activities in these areas affect adjacent property owners. Techniques will be developed and evaluated to address noise-producing activities, such as truck idling, express lanes, tollbooth activities (including associated acceleration and deceleration), etc.

Please Note: As research is conducted in the above areas, additional topics and criteria that would improve noise prediction may be identified. It is expected that this information will be captured for further evaluation and use.

3. Determine the parameters and methods to provide a more rigorous and consistent analysis of the selected factors within TNM or other BMPs. Activities include (a) define feasible mitigation measures and design approaches to minimize structure noise; and (b) develop measurement and modeling techniques that accurately address noise associated with these activities. *Please Note:* To ensure effectiveness and usefulness, research efforts and work products will be coordinated with FHWA staff responsible for maintenance and update of the TNM.

The absence of data and tools to provide reliable, rigorous, and consistent noise prediction and analysis for several factors has led to the incorporation of increasingly more conservative mitigation measures to address citizen and stakeholder concerns. These concerns reflect a growing awareness of and demand to address the effects of noise on project-area residents, visitors, businesses, and the environment. Overly conservative mitigation measures (i.e., measures that are not based on data derived from standard methodologies, but on assumptions) can add millions of dollars to the overall cost of a transportation project. These costs are based primarily on increased material and construction charges.

Building on and summarizing the preceding observations and the comments provided in prior sections, SCOE expects that this research will (1) provide the parameters and methods to more accurately, efficiently, and consistently predict and analyze traffic noise impacts; (2) using these standardized, widely accepted methods, help state DOTs determine noise mitigation measure design requirements that address, but do not overcompensate for, noise impacts; and (3) in turn, provide information to enable state DOTs to avoid unwarranted mitigation measure material and construction costs.

As research work products (i.e., noise impact analysis parameters and methods) are developed, the research team will coordinate its efforts with and provide information to FHWA to update the TNM. BMPs identified through this effort will be publicized to State DOTs for incorporation in their ongoing noise analysis efforts. The recommended research will provide information and data to update the TNM and identify BMPs for predicting and analyzing noise impacts. As such, state DOTs will not have to adopt new test methods or revise their current practices or equipment—the research will enhance existing practices and efforts. SCOE has not identified institutional or political barriers to implementation of the anticipated research products.

Note: The AASHTO Standing Committee on Research wants a simpler model if possible, and the effect of quieter pavements should be modeled.

◆ **Project 25-35**

Managing Rights-of-Way for Biomass Generation and/or Carbon Sequestration

Research Field: Transportation Planning
Source: AASHTO Standing Committee on the Environment
Allocation: \$500,000
NCHRP Staff: David A. Reynaud

Right-of-way vegetation management is a major responsibility of state departments of transportation (DOTs). Traditionally, roadside vegetation has been managed for a variety of purposes important to the public, especially safety, but also roadway integrity, habitat, native plant restoration, invasive plant reduction, aesthetics, water quality, and erosion control. Increasingly however, the DOTs are now being asked to also manage their roadsides to address greenhouse gas (GHG) emissions. Biomass production and carbon sequestration are the two most likely ways that DOTs would approach this issue—through planting and management of potential bio-fuel inputs, on the one hand, or through long-term management of vegetation for maximum carbon storage, on the other (although these two goals are not necessarily mutually exclusive). Biomass production and carbon sequestration, when combined with the traditional right-of-way management objectives, will create a huge challenge for DOT vegetation managers. If the challenge is to be met, vegetation managers will need improved lists of native and non-invasive plants appropriate for roadside use; the latest physical, chemical, and biological control techniques that are safe and effective; the latest technology and equipment; ways to supplement the maintenance and operations records that are currently kept; and updated training. For example, in some cases, reducing emissions through modified management practices, such as reduced mowing, can contribute more to meeting GHG goals than carbon sequestration.

Finally, the study will develop a measurement technique to assess the ability of highway landscape management to sequester carbon and provide strategies for good native roadside biomass production techniques that will maximize the eventual carbon credits. This may be accomplished through the following tasks:

1. Conduct a search of existing programs or specific cases of management for biomass production or carbon sequestration on transportation rights-of-way nationally and internationally.
2. Preliminarily assess the issues relative to biomass production and/or carbon sequestration in the right-of-way. Identify issues to be explored, including calculation of baselines and determination of DOT efforts.
3. Submit an interim report to the panel detailing the results of Phase I research. Submit a Phase II research plan for NCHRP review and approval. Review both documents at an interim meeting.
4. Conduct a search for native and non-invasive species information and identify those that are most appropriate for biomass production and/or carbon sequestration on transportation rights-of-way.
5. Search the literature for information on the carbon sequestration capabilities of those species identified in item #4, including how the carbon capturing capability is measured, and for information on potential for biomass/biofuel production. In the case of carbon sequestration, also look at combinations of species/ecosystem management techniques that are likely to produce the highest carbon sequestration.
6. Assess the capability of the selected species in meeting the traditional functions of roadside vegetation (e.g., safety, esthetics, erosion control, native revegetation, avoiding the spread of invasive species).
7. Assess the pros and cons of biomass production and/or carbon sequestration in the right-of-way relative to other avenues of carbon reduction in maintenance at DOTs, looking at published models and approaches, such as Caltrans.
8. Identify how to supplement the maintenance and operations records that are currently kept. Examples include land ownership records, fuel purchases, electricity usage, and mowing statistics. Land ownership records are important in determining the number of acres under the DOT's control and thus potentially available for carbon sequestration. Data such as fuel purchases and electricity usage are important because evidence of emissions reductions can be used to meet GHG goals outlined in a contract with a carbon market.

9. Determine the availability of information on carbon sequestration offset protocols and guidelines for the land-use types (e.g., grassland, native forest) and management techniques that are likely to apply to rights-of-way, to provide GHG benefits in addition to existing practice, and to qualify for carbon credits, which will speak to the marketability of emission reductions.
10. Develop a final report which recommends ecosystem based plant lists appropriate for biomass production and which include the carbon sequestration capabilities of each species (or combination of species). The report will also contain recommended methods for measuring sequestration and possible scenarios for claiming carbon credits. Such a process would hinge on a systematic approach that establishes a baseline level of carbon currently being sequestered in the soils, grasses, and woody shrubs of the right-of-way. Other physical characteristics of the right-of-way, such as precipitation, soil moisture, and standing crop, can help predict how much carbon can be sequestered.

Determining carbon credits will require use of a qualifying accounting methodology by each state DOT project which addresses various established GHG protocol steps and existing guidelines. Offset protocols provide detailed guidance for a project developer on how to: (1) determine if the project meets all eligibility criteria, including regulatory screens, additionality assessments, and other criteria including project duration and location; (2) define the project boundary (e.g., physical location, GHG accounting, and temporal boundaries); (3) select and quantify a baseline, based on existing quantification methodologies and calculation tools; (4) quantify and monitor project GHG emissions and calculate GHG reductions; and (5) meet other protocol requirements such as permanence and leakage measures. Other elements of the protocol may include guidelines for project start dates and duration, and verification and reporting requirements. Establishing acceptable baselines and monitoring procedures for land-use offset projects, especially those involving soils and biomass production, often proves particularly challenging. For example, soil carbon sequestration and emissions are extremely variable and are dependent on rainfall, temperature, crop type, past crop types, soil moisture and organic matter content, soil type, and other factors. Baseline establishment is a difficult and critical step, as is the establishment of rigorous monitoring procedures.

Under a national “cap-and-trade” system, which is an emissions reduction policy that would impose a national emissions ceiling (or cap) that is reduced over time, participation (trading) in a carbon market would help reduce compliance costs for those entities with emissions greater than an established threshold. Under cap-and-trade, these entities are required to either reduce emissions or purchase carbon allowances or carbon offsets to meet the threshold. Various state and multi-state initiatives have set targets and established policy commitments to reduce carbon emissions. Ten northeastern and mid-Atlantic states have formed the Regional Greenhouse Gas Initiative (RGGI), and several western states and two provinces of western Canada have formed the Western Climate Initiative (WCI). As state agencies, DOTs are likely to be asked to participate in these efforts and biomass production and carbon sequestration in the right-of-way is one answer, given the large amount of land area DOTs manage. In order to efficiently and effectively ascertain the costs and the benefits, stakeholders including DOT CEOs/CAOs, maintenance managers, project development and construction managers, and front-line staff such as landscape architects require the described research.

Note: The AASHTO Standing Committee on Research directed that revision to the AASHTO Roadside Vegetation Guide be considered.

◆ **Project 25-36**

Travel Impacts and Greenhouse Gas Benefits of Rural and Smaller Community Land Use Strategies

Research Field: Transportation Planning
Source: Vermont
Allocation: \$650,000
NCHRP Staff: Nanda Srinivasan

Decision-makers need reliable information on the travel, greenhouse gas, and other benefits of land use policies in order to support effective decisionmaking on what is often a very controversial issue. While there has been considerable research on the travel and other impacts of land use policies, nearly all of this research has focused on metropolitan areas—especially larger metropolitan areas where rail transit systems either exist or are proposed to complement and support more compact development patterns. Recent efforts to estimate the nationwide GHG benefits of land use policies all focus exclusively on benefits within metropolitan areas. While the majority of the U.S. population lives in larger metropolitan areas, about 20 percent of the U.S. population currently lives outside of metropolitan areas, and another 5 percent lives in small metropolitan areas of less than 200,000 population. Particularly with the recent focus on land use as a GHG mitigation strategy, there is a pressing need for an evaluation of potential policies to create more efficient land use patterns in smaller communities and rural areas, and the potential GHG and other benefits and impacts of applying such policies in these areas.

The primary objective of this research would be to estimate the potential impacts on vehicle travel and associated fuel consumption and GHG emissions that might be achieved by applying coordinated land use strategies and transportation to reduce vehicle travel in small communities and rural areas. The research would examine the impact of land use and development patterns on key aspects of travel behavior, including trip-making, mode choice, and trip lengths, controlling for potential influencing factors such as income, household composition, attitudes/preferences, etc.

This research would be of use to many potential audiences—state DOT planning staff, transportation analysts, federal, state, and local-level decisionmakers (in both the transportation and land use arenas), and other stakeholders involved in transportation and land use planning and decisionmaking in non-metropolitan communities—to better inform transportation and land use policy development.