

National Cooperative Highway Research Program

Fiscal Year 2010

May 2009

Announcement of Research Projects

The annual “Announcement of Research Projects” is no longer mailed to individuals. Instead, e-mail notification is made. Recipients are encouraged to share this announcement with colleagues.

The **National Cooperative Highway Research Program** (NCHRP) is supported on a continuing basis by funds from participating member departments of the American Association of State Highway and Transportation Officials (AASHTO), with the cooperation and support of the Federal Highway Administration, U.S. Department of Transportation. The NCHRP is administered by the National Research Council’s Transportation Research Board (TRB). The NCHRP is an **applied contract** research program totally committed to providing timely solutions to **operational problems** facing highway and transportation practitioners and administrators.

Each year, AASHTO refers a research program to the TRB consisting of high-priority problems for which solutions are urgently required by the states. The AASHTO program for FY 2010 is expected to include 19 continuations, 35 new projects, and 1 project contingent on additional funds becoming available.

This announcement contains preliminary descriptions of only those new projects expected to be advertised for competitive proposals. Detailed Project Statements (i.e., Requests for Proposals) for these new projects will be developed beginning in August 2009.

Please note that NCHRP Research Project Statements for soliciting proposals are available only on the World Wide Web. Project Statements are not mailed. Those who have an interest in receiving Research Project Statements must periodically browse the NCHRP World Wide Web site or register on the

website (<http://trb.org/nchrp>) if you have not already done so. Upon registration, you will receive an e-mail notification of every Project Statement posting and an e-mail notification of new anticipated projects in future years.

Because NCHRP projects seek practical remedies for operational problems, it is emphasized that proposals not evidencing strong capability gained through extensive successful experiences in the relevant problem area stand little chance of being selected. Consequently, any agency interested in submitting a proposal should first make a frank, thorough self-appraisal to determine whether it possesses the capability and experience necessary to ensure successful completion of the project. The specifications for preparing proposals are quite strict and are set forth in the brochure entitled [Information and Instructions for Preparing Proposals](#). **Proposals will be rejected if they are not prepared in strict conformance with the section entitled “Instructions for Preparing and Submitting Proposals.”** The brochure is available on the Internet at the website referenced above.

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IMPORTANT NOTICE

Potential proposers should understand clearly that the research program described herein is tentative. The final program will depend on the level of funding available from the Federal-aid apportionments for FY 2010. Meanwhile, to ensure that research contracts can be executed as soon as possible after the beginning of the fiscal year, the NCHRP is proceeding with the customary sequence of events through the point of agency selection for all projects. The first round of detailed project statements will be available in August and September 2009; proposals will be due in October and November 2009, and agency selections will be made in November and December 2009. This places the risk of incurring proposal costs at the election of the research agencies. Beyond the point of selecting agencies, all activity relative to the FY 2010 program will cease until the funding authorization is known. These circumstances of uncertainty are beyond NCHRP control and are covered here so that potential proposers will be aware of the risk inherent in electing to propose on tentative projects.

**National Cooperative Highway Research Program
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SUMMARY OF APPROVED RESEARCH PROJECTS

◆ Project 01-48

Integrating Pavement Preservation into the Design Process

Research Field: Design
Source: California
Allocation: \$500,000
NCHRP Staff: Amir N. Hanna

State highway agencies increasingly focus their attention on a pavement preservation approach for keeping sound pavement assets longer and effectively addressing poor pavements. Pavement preservation is a proactive approach, and it should be considered in the beginning of the design process because preservation activity will have an impact on the pavement performance and service life. Currently the mechanistic-empirical pavement design guide only considers the process for designing new pavements or rehabilitation. There is no consideration for intermediate treatments to preserve the functional characteristics of the pavement surface prior to rehabilitation. Research is needed to develop a preservation module for the mechanistic-empirical pavement design guide to properly incorporate any planned pavement preservation activities into the design process.

The objective of this project is to develop information that can be incorporated into further enhancements of the mechanistic-empirical pavement design process. The research will develop prediction models for the performance of pavement preservation treatments that could be incorporated in the design process. This objective will be accomplished through the following tasks:

1. Collect all available data and materials associated with pavement preservation treatments.
2. Identify the elements in pavement preservation treatments that need to be incorporated into the mechanistic-empirical design process.
3. Prepare a draft preservation module for the design process and beta test with user agencies.
4. Develop a methodology to evaluate new and innovative treatments.
5. Finalize the preservation module based on feedback from user agencies.

Note: The research being performed under SHRP 2 Project R-26, *Preservation Approaches on High Traffic Volume Roadways* should be reviewed as part of this research.

◆ Project 01-49

Guidelines for Forensic Evaluation of Highway Pavements

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

Careful, efficient, and well planned forensic evaluation of highway pavements is essential to cost-effective management of pavement assets. Such investigation is appropriately undertaken under several circumstances, such as (1) in the event of premature pavement failure for the purpose of understanding the underlying cause or causes of failure; (2) as part of data collection undertaken to support development and/or calibration of performance prediction models, including local calibration of the Mechanistic Empirical Pavement Design Guide (MEPDG); (3) as a part of more general pavement research efforts to obtain the information needed to fully document and understand observed performance; and (4) in the event of pavements that have performed exceptionally well, for the purpose of understanding the factors contributing to their longevity.

Guidance is needed to assist agencies in planning and conducting appropriate and cost-effective forensic investigations that provide the data needed to support well founded conclusions with minimum disruption to traffic and minimum risk to agency personnel, contractors, and the motoring public. This Guidance must identify the procedures and means for adequately planning and conducting a thorough post construction investigation. Guidance for forensic investigation of Long Term Pavement Performance Program test sections has been developed and documented in *Framework for LTPP Forensic Investigations*. The need exists

to build upon this and other available information to develop generally applicable guidance that highway agencies can use in conducting forensic investigation to meet individual agency needs.

The objective of this research is to develop generally applicable guidelines for forensic evaluation of highway pavements. These guidelines will be based on the currently available information and refinements as a result of trial application in several forensic investigations.

◆ **Project 08-77**

Developing Regional Historic Contexts for Post-World War II Housing

Research Field: Transportation Planning
Source: AASHTO Standing Committee on the Environment
Allocation: \$250,000
NCHRP Staff: Lori S. Sundstrom

The purpose of this research is to conduct a demonstration project for developing a model regional or state historic context that determines National Register eligibility and non-eligibility of post-World War II housing in order to avoid delays in project delivery and increased project costs associated with potentially eligible houses affected by transportation projects. This context would be used for evaluating the eligibility of properties located within transportation project areas and replace current piecemeal and project-by-project National Register evaluations.

Huge numbers of post-World War II houses, located in every city, town, suburb, and rural area, are either currently historic (i.e., more than 50 years old) or will soon become historic, and thus potentially eligible for listing in the National Register of Historic Places. If these properties are eligible for listing in the National Register, FHWA and state DOTs will be required to take into account the effects of their projects on these properties, pursuant to Section 106 of the National Historic Preservation Act. The houses eligible for listing in the National Register would also be protected under Section 4(f) of the Department of Transportation Act.

Developing an effective national framework for determining National Register eligibility and non-eligibility of post-World War II housing is

critical. The proposed approach is very similar to that taken when the Interstate Highway System turned 50 years old in 2006 and became eligible for listing in the National Register. The FHWA and the Advisory Council on Historic Preservation (ACHP) proactively implemented a national solution, and the FHWA worked with the ACHP on an administrative approach to addressing the Interstate System and Section 106 compliance.

A demonstration project for developing regional or state historic contexts will provide a standard framework for state DOTs to effectively evaluate the National Register eligibility of post-World War II housing. Further, the use of these contexts will result in lower future project costs and expedited project schedules and will result in fewer interagency conflicts when compared to current, standard property-by-property and project-by-project National Register evaluations.

As postwar suburbs approach 50 years of age, they are being included in local surveys and are being evaluated according to National Register criteria. Several houses having exceptional significance are already listed in the National Register of Historic Places. Because of the passage of time, the number of houses eligible for listing in the National Register will increase dramatically in the next decade, presenting a major challenge to decision makers and preservation planners. Post-World War II housing is ubiquitous across the country, consisting of thousands of properties. This is especially the case for western cities. For example, Tucson, Arizona, has over 40,000 post-World War II houses (Tucson's Post World War II Residential Suburban Development, 1945-1973). The smaller community of Scottsdale, Arizona, has around 14,000 homes from this era (Scottsdale, Arizona Neighborhood Historic Districts Context). The number of post-World War II houses in more rural locations is also substantial. In James City County, Virginia, for example, the pre-1958 housing stock was about 1,400 units. After 1958, this number rose to over 24,000 homes (Tony Opperman, Virginia DOT, personal communication).

The looming Section 106 and Section 4(f) administrative burden associated with these properties will be tremendous. If state DOTs follow standard approaches for identifying and evaluating the National Register eligibility of these post-World War II properties, state DOTs will be evaluating

thousands upon thousands of individual post-World War II houses over the next several years, increasing current Section 106 and Section 4(f) administrative burdens, increasing project costs, and delaying project delivery. State DOT cultural resource management staff workloads could double. State Historic Preservation Office staff will be similarly affected.

Unless post-World War II housing is addressed in a programmatic fashion, each instance of a potentially National Register eligible house will be the subject of negotiation between every state's DOT and FHWA staff and State Historic Preservation Office (SHPO) staff. In addition to providing a cost-effective and efficient means of addressing this distinct housing type, and given that these properties vary little across the country in terms of structure and design, a national approach will provide national consistency and predictability in the implementation of Section 106 and Section 4(f) requirements. At a minimum, the following questions which must be addressed include: (1) the determination of the characteristics that make a post-World War II house eligible, (2) how many modifications and alterations would make a house ineligible, (3) whether individual houses are eligible, (4) whether an otherwise eligible house must be situated in a neighborhood of other post-World War II houses, (5) and how much of a neighborhood needs to retain its original character to be considered a district eligible for listing in the National Register.

After the completion of the demonstration project, the resulting model historic context and associated guidance should be disseminated among all state DOTs and SHPOs. It may also be appropriate to use the results of the demonstration project to develop a national strategy for dealing with this property type in the context of Section 106 and Section 4(f) compliance. The latter would require the involvement of the FHWA, the ACHP and organizations such as the National Council of SHPOs, and possibly the National Trust for Historic Preservation.

Note: The Federal Highway Administration will set aside \$100,000 to assist in the implementation of results.

◆ Project 08-78

Develop Bicycle/Pedestrian Demand Model to Measure Bicycle/Pedestrian Activity and Relationship to Land Use

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

Nationally, there is a substantial lack of credible bicycle/pedestrian demand model data. There are existing data sources such as the U.S. Census Journey-to-Work and the National Household Travel Survey that document bicycle/pedestrian activity, but these sources are for work commute trips and do not indicate how many bicyclists/pedestrians there are at specific locations.

Regional/local counts and surveys are not utilizing consistent methodologies that provide understandable bicycle/pedestrian activity trends and relationships to demographic, social, and physical factors. Inconsistent methodologies and minimal credible counts inhibit transportation professionals in local and regional planning and invest in bicycle/pedestrian infrastructure. Adequate bicycle/pedestrian infrastructure provides safety, economic, and health benefits locally, regionally, and nationally. Land use and infrastructure improvements will potentially increase bicycling and walking activities.

This project will produce a national bicycle/pedestrian demand model and database to measure bicycle/pedestrian activity and land use. The need for a national demand model that can accurately measure bicycle/pedestrian activity trends and provide credible data for smart growth land-use projects has long been recognized. The aim to produce a national bicycle/pedestrian database of count information that can be used to develop a national database/demand model will provide local, regional, and national transportation planners and officials with the information and tools needed to better understand walking and bicycling rates, patterns, relationships, and trends for various areas of the country. This demand model tool can provide improved data analysis of proposed land-use projects that have smart growth attributes such as urban infill, pedestrian, transit-oriented, and mixed land-use developments.

◆ **Project 08-79**

Identifying Credible Alternatives for Producing 5-year CTPP Data Products from the ACS

Research Field: Transportation Planning
Source: AASHTO Standing Committee on Planning
Allocation: \$550,000
NCHRP Staff: Nanda Srinivasan

In 2006, AASHTO approved a new Census Transportation Planning Products (CTPP) program to provide vital home, work place, and journey-to-work data for effective transportation planning and policy analysis. The CTPP will use data from the Census Bureau's new American Community Survey (ACS) to produce 3-year and 5-year data tabulations to support a host of state and local transportation planning efforts, including air quality and environmental analyses, transit studies, policy and investment scenarios, and travel demand modeling. For the past 4 decades the transportation planning community has relied on CTPP data products developed from the decennial Census "long form" for travel demand forecasting, policy analysis and project planning. The CTPP data products were designed by the states and metropolitan planning organizations (MPOs) and represent one of the most used and recognized data sources. In 2005, when the U.S. Census Bureau decided to eliminate the "long form" and replace it with the ACS, the states and MPOs responded with NCHRP Report 588 in an attempt to understand how to use this new data. The research proposed in this problem statement is an outgrowth of that work.

Over the years, transportation planning mandates and requirements have increasingly called for census data at finer levels of granularity for smaller and smaller areas of geography. For example, in travel demand modeling, data is typically required for smaller geographic units defined as Traffic Analysis Zones (TAZs). However, because TAZs tend to be small, data for many geographic areas will be suppressed under new Census Bureau disclosure rules aimed at protecting an individual's confidentiality. Therefore, to meet the critical transportation planning needs for data, credible alternative methods must be identified for producing 5-year small area, TAZ-level data using the ACS.

The objectives of this research are to:

1. Refine and clarify transportation community acceptance, requirements, and needs for synthetic data.
2. Conduct research and identify credible synthetic data techniques.

◆ **Project 09-49**

Long Term Field Performance of Warm Mix Asphalt Technologies

Research Field: Materials and Construction
Source: AASHTO Highway Subcommittee on Materials
Allocation: \$1,500,000
NCHRP Staff: Edward T. Harrigan

The hot mix asphalt (HMA) industry has embarked on a program to substantially reduce mix production temperatures. Reduced mix production and paving temperatures can (1) decrease the energy required to make HMA, (2) reduce emissions and odors from plants, and (3) improve the working conditions at the plant and paving site.

The term warm mix asphalt (WMA) refers to technologies, including various proprietary products and processes, that allow substantially reduced HMA mix production temperatures. Because these technologies were often intended originally to enhance compaction, they may also have positive impacts on HMA performance. Such technologies should make in-place density easier to achieve because they improve the workability of the mix. The majority of aging in an asphalt mixture takes place during mix production when it is exposed to elevated temperatures. By reducing mix production temperature, less oxidative hardening will take place, which should reduce the asphalt mixture's susceptibility to cracking.

WMA technology poses some potential engineering challenges. Reduced hardening during WMA production can increase its susceptibility to permanent deformation. In addition, traffic may not be allowed on the pavement at the conclusion of the compaction process until the mixture cools beyond what is normally required for conventional HMA. Strategies such as the use of higher asphalt binder performance grades and stone matrix mixes can address this issue.

Furthermore, since binders in WMA mixtures may be softer than expected and since some WMA technologies use water as a workability aid, WMA mixtures may be susceptible to moisture damage. This is an issue with some HMA mixtures, of course, but with WMA mixtures there is the possibility of inadequately dried aggregates at the lower production temperatures and/or the introduction of additional moisture to the mix from the WMA technology/process, and this may affect the binder to aggregate adhesion, moisture susceptibility, and performance. The extent to which each of the different types of WMA technologies will impact moisture sensitivity needs to be established in order to provide unbiased moisture performance data and WMA usage guidance to state DOTs, contractors, and asphalt pavement producers.

Acceptance of new technologies depends on their long-term performance and associated life cycle cost analysis as compared to conventional technologies. NCHRP Project 9-47A is identifying new and existing WMA projects from which materials and short-term performance data can be obtained for comparison with HMA. This project will continue Project 9-47A with emphasis on (1) the long-term performance, including moisture susceptibility, of these WMA projects; and (2) methods to assess and remediate any potential WMA moisture susceptibility issues.

The objectives of this research are to (1) develop relationships among engineering properties of WMA mixtures and the long term field performance of pavements constructed with them, (2) provide relative performance measures of pavements constructed with WMA and conventional HMA technologies, and (3) investigate the moisture susceptibility of WMA technologies compared to HMA. Active, close coordination with NCHRP Project 9-47A will be required at all stages of this project.

The following phases (conducted concurrently) and tasks are anticipated to accomplish these objectives:

Phase I, Moisture Susceptibility of WMA

(1) Critically review the literature to identify (i) existing WMA moisture susceptibility studies, especially those which compare laboratory data to field data; (ii) available moisture susceptibility tests; and (iii) existing WMA pavement projects within the

U.S. with available moisture susceptibility test results; (2) define a plan for evaluating WMA moisture susceptibility in the laboratory; (3) evaluate test devices and test procedures (including AASHTO T283, Standard Method of Test for Resistance of Compacted HMA to Moisture-Induced Damage, AASHTO Water Boil Test for loose coated aggregates, Georgia DOT Triple Freeze Thaw Testing, Hamburg Wheel Track Testing, and Stripping Inflection Point) for use in the laboratory study and provide justification for those recommended for use; (4) define a plan for comparing and relating moisture susceptibility laboratory results to field performance; (5) prepare an interim report for Tasks 1 through 5; (6) conduct the Task 4 work plan; (7) evaluate selected WMA field projects for moisture susceptibility and relate laboratory moisture susceptibility test results to field performance; (8) prepare a recommended practice for reducing the occurrence of moisture susceptibility issues with WMA; (9) based on the results of Tasks 6 and 7, recommend (i) changes to existing AASHTO test methods and specifications and, as needed, (ii) new test methods in AASHTO standard format for evaluating the moisture susceptibility of WMA mixtures and pavements; and (10) prepare a final report for Phase I.

Phase II, Long-Term Performance of WMA

(1) Conduct a literature review and survey of state DOTs, as needed, to determine (i) availability of field trial/test sections, both existing and planned; (ii) data available from existing field trial/test sections (with emphasis on those field trials/sections utilized in Project 9-47A); and (iii) information that will allow the selection of laboratory tests to relate laboratory test properties to field performance for rutting, fatigue cracking, thermal cracking, aging, and water sensitivity; (2) identify and select field trial/test sections for inclusion in the study; (3) prepare a detailed sampling and testing plan for determining the long-term performance of the field trial/test sections identified in Task 2; (4) prepare an interim report for Tasks 1 to 3; (5) perform sampling and testing associated with the approved work plan and perform the analysis associated with meeting the objectives of the project; (6) revise structural design and mixture design methods associated with WMA technologies based on the results from Task 5; and (7) prepare a final report for Phase II, includ-

ing a plan for extended monitoring of the performance of field trial/test sections.

Note: The AASHTO Standing Committee on Research combined Problem 2010-D-08, Moisture Sensitivity of Warm Mix Asphalt Technologies with this study and increased the funding request to \$1,500,000.

◆ **Project 10-80**

Conversion of the AASHTO “Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals” to the Load and Resistance Factor Design (LRFD) Methodology

Research Field: Materials and Construction
Source: AASHTO Highway Subcommittee on Bridges and Structures
Allocation: \$500,000
NCHRP Staff: Waseem Dekelbab

In June 2000, AASHTO and the Federal Highway Administration agreed on an implementation plan for the design of highway structures utilizing the Load and Resistance Factor Design Methodology (LRFD). As part of that agreement, all new culverts, retaining walls, and other standard structures on which states initiate preliminary engineering after October 1, 2010 shall be designed by the LRFD Specifications. The current edition of the AASHTO “Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals” contains small sections that implement the LRFD approach, but the Specification is generally based on the Working Stress design methods. Additionally, design, construction, and inspection language is intertwined in the specification and commentary resulting in a document that is cumbersome and difficult to follow.

The entire Specification needs to be converted to the LRFD design approach and reorganized to provide design engineers with a specification that implements the state-of-the-art design approach; separates the design, construction, and inspection criteria into three distinct sections; is consistent with other AASHTO documents; and allows states to meet the above implementation plan.

The goals of the proposed research are closely aligned with the grand challenges of optimizing structural systems, advancing the AASHTO specifications and managing knowledge. These were identified in the AASHTO Subcommittee of Bridges and Structures report “Grand Challenges: A Strategic Plan for Bridge Engineering” published in June, 2005.

The objective is to develop a new edition of the AASHTO “Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals” based on the LRFD methodologies. The resulting Specification would also be logically arranged with distinct sections for design, construction, and inspection/maintenance. Inspection of these structures has not been codified in the past; this is an excellent opportunity to address this issue.

The successful completion of this research is expected to improve the safety and reliability of structural supports nationwide. Agencies will be in a better position to meet the LRFD implementation plan, and the provisions will facilitate the design, construction, inspection, and maintenance of their structural supports for highway signs, luminaires and traffic signals. The probability-based specification will result in structures that are based upon a more uniform set of design criteria. Some structures may be more expensive; however, some may be less. The specification will promote quality construction/fabrication practices and it will also address the current shortcoming of inspection and maintenance or these non-redundant ancillary structures. The combination of these efforts will allow agencies to better assess, manage, and maintain these transportation assets.

◆ **Project 10-81**

Evaluation of Fuel Usage Factors in Highway Construction

Research Field: Materials and Construction
Source: AASHTO Highway Subcommittee on Construction, Virginia
Allocation: \$300,000
NCHRP Staff: Edward T. Harrigan

Price adjustments of selected commodities in highway construction are used in construction contracting as a way of reducing risks to the con-

tractor related to price fluctuations over the life of a contract. The benefits to contracting agencies are bids that better reflect real costs. Fuel is a commodity for which price adjustments are allowed. Fuel usage factors are commonly applied by state and local agencies in calculating the amount of fuel for an escalation/de-escalation contract specification.

The current fuel usage factors were first published in Highway Research Circular Number 158 by the Highway Research Board in July 1974. They were later incorporated into FHWA Technical Advisory T 5080.3, released in 1980, to provide direction on the use of price adjustment contract provisions. These factors have remained unchanged over the past 35 years, despite changes in the purchasing power of construction dollars, construction methods, industry processes, efficiency of equipment, and fuels used. Thus, it is unlikely that fuel usage factors are accurate or effective in addressing the current risk of fuel price fluctuations.

Gasoline and diesel fuel usage factors exist for excavation (gallons per cubic yard), aggregate, asphalt production and hauling (gallons per ton), and Portland cement concrete (PCC) production and hauling (gallons per cubic yard). Of even greater concern, fuel usage factors for structures and miscellaneous construction are expressed in gallons per \$1,000 in construction. Current fuel factors are required, in addition, to consider environmental impacts of construction methods related to lower fuel consumption and emissions, urban heat island mitigation, smog reduction, and lower energy footprint.

The fuel usage factors in FHWA Technical Advisory T 5080.3 are subject to at least three analytically separable sources of error. First, the effects of inflation on construction costs over three decades is primarily of concern for the usage factors for structures and miscellaneous construction because these fuel usage factors were established in gallons per thousand dollars, and the dollar amounts were established in 1980 and have never been revisited. Second, the relationship of fuel consumption to production and hauling of specified quantities of aggregate, asphalt, and PCC have likely been affected by changes in construction practice, use of new and prefabricated materials, improved equipment, and improved fuel efficiency. Third, and last, there have been changes in fuel preference, particularly in the substitution of natural gas for diesel in

asphalt plant operations. While an examination of inflationary trends is a relatively simple analysis, addressing the other impacts is far more complex and challenging.

The objectives of this research are to (1) analyze the effects of inflation in relevant areas of construction, (2) develop a revised table of fuel usage factors for the major categories of highway construction addressed in FHWA Technical Advisory T 5080.3, and (3) develop a recommended method and schedule for future updates to the fuel usage factors. The research findings will be of immediate use to FHWA in updating the information in Technical Advisory T 5080.3.

The following tasks are anticipated to accomplish these objectives: (1) review existing research, including (i) the original study compiled by FHWA and published in Highway Research Circular Number 158, July 1974, (ii) the questionnaire sent to more than 3,000 highway contractors in the United States in 1974 with 400 responses, and (iii) the analysis performed by the Federal Highway Administration's Region 8 office on the data acquired in 1974, to the extent that relevant information is still available; (2) survey the state DOTs to develop a synthesis of current practices by state DOT agencies and document what methods they have developed to address costs related to fuel usage factors issues; (3) analyze inflation effects to develop a construction inflation index that will provide estimates of the present and expected future value of construction, based on the categories in the 1980 FHWA Technical Advisory T 5080.3; (4) identify changes in construction practices since 1980 in the major categories of highway construction addressed in FHWA Technical Advisory T 5080.3 (excavation, aggregates, asphalt concrete, PCC pavement, structures, miscellaneous); (5) based upon the results of the previous tasks, develop fuel usage factors that apply to current construction practices; (6) develop a method and schedule for future updates of fuel usage factors, including identification of data sources and recommended analytical procedures; and (7) prepare a final report and recommendations that provide (i) full documentation of the research methods and findings and (ii) recommendations for the updated fuel usage factors in highway construction.

◆ **Project 10-82**

Performance Related Specifications (PRS) for Pavement Preservation Treatments

Research Field: Materials and Construction
Source: California
Allocation: \$600,000
NCHRP Staff: Amir N. Hanna

Pavement preservation treatments, by their diverse nature, do not lend themselves to traditional methods based specifications. Many states have tried to develop warranty specifications to address this gap. However, warranties still do not necessarily provide the correct strategy for pavement preservation treatments, so construction specifications are moving into the PRS arena. Quality of pavement preservation treatments depends on the contractor operations, personnel, equipment, and methods. With the current specifications and the low bid process, there is no incentive for a contractor to make the extra effort to insure quality. In order to overcome this problem, research is needed to develop and implement PRS that allow contractors to design and construct pavement preservation treatments using conventional materials, rubber asphalt, or other modified materials.

The need for research for the development of PRS for pavement preservation treatments has been cited in many preservation workshops and expert group meetings subsequent to the FHWA's National Pavement Preservation Forum held in San Diego, California in 2001. A recent NCHRP project (Project 20-07/Task 184) supported the need for PRS for pavement preservation but was rated as a low priority need because the major focus in most agencies was to determine what treatments to apply and what type of performances could be expected from those treatments. In response to these research needs, some state highway agencies have developed project-specific PRS for limited preservation treatments. Yet systematic research for the development of more generally applicable PRS is needed. In January 2008, FHWA developed (with state and local agencies, industry and academia) the Transportation System Preservation (TSP) Research, Development, and Implementation Roadmap to fill the current gaps in the understanding of pavement pres-

ervation. The Roadmap contains 38 items of immediate research needs under 6 areas in pavement preservation; the PRS for pavement preservation was identified as the highest priority topic among them. Additional information supporting the need of PRS for pavement preservation treatments is cited in TRB Needs Statement entitled Warranties for Concrete Pavements.

The objectives of this project are to (1) determine which engineering properties need to be measured for performance/acceptance; (2) determine how performance parameters should be measured; (3) determine which pavement preservation treatments lend themselves to incentives/ disincentives clauses, and recommend limits for incentives/disincentives; (4) provide a template for incorporating PRS into treatment-specific projects; and (5) develop a draft manual that provides guidance and measurement techniques for the identified engineering properties. The following tasks are identified for accomplishing these objectives:

1. Conduct an international literature search of current pavement preservation performance-related specifications as applied to asphalt and concrete pavements, and provide a report that describes the benefits of using PRS vs. traditional method-based specifications.
2. Determine the desired attributes that can be measured and the quality of relevant pavement preservation treatments.
3. Determine treatment-specific performance measures and acceptance criteria
4. Determine criteria for the appropriate use of incentives/disincentives.
5. Develop draft provisional standards for PRS, as they apply to pavement preservation treatments, for AASHTO consideration.

Note: The AASHTO Standing Committee on Research requested that this project be combined with Problem 2010-F-09. The research shall include additional tasks to identify and validate testing protocols and acceptance criteria for predicting long-term treatment performance, and consider SHRP 2 related projects.

◆ **Project 10-83**
Alternative Quality Systems for Application in Highway Construction

Research Field: Materials and Construction
Source: AASHTO Highway Subcommittee on Construction, AASHTO Highway Subcommittee on Materials
Allocation: \$500,000
NCHRP Staff: David A. Reynaud

This research proposal addresses the quality management challenges associated with achieving two of AASHTO's goals. Alternative and improved quality management practices are required to maintain appropriate results while accelerating project delivery (objective 1C), and must be part of a comprehensive framework for improved project delivery of all transportation projects (objective 4B).

Evolving industry roles and the adoption of alternative project delivery methods have already changed the conventional construction management practices that public agencies use to ensure appropriate project delivery, contract compliance, and quality assurance. However, many state agencies are applying traditional quality management practices to all of the available project delivery methods. Critical components of these new project delivery methods include the changing relationships among public agencies, contractors, and private engineering firms, including risk allocation processes, general contract administration procedures, and quality control/quality assurance. This research would provide recommendations for alternative quality systems to address the various project delivery methods. The results would include a web-based decision support system for use by the state agencies.

More efficient and effective quality control/quality assurance systems, driven by both contractors and owners, are required due to increasingly higher construction costs and reduced workforce availability and experience levels. Owners are challenged to provide quality and timely results with fewer staff than are inherent in the traditional public agency inspector role. In order to achieve a successful project or operation, quality must be built into all aspects of project delivery and ranges far beyond matters of materials testing. Research and guidance

is required to assist owners with the management of programs that will increasingly be delivered by methods that are still relatively new, and will remain significantly different than the traditional design.

Quality control includes all aspects of project work. As agencies work to accelerate project delivery, in conjunction with AASHTO partners and federal agencies, they must also work to improve and innovate all aspects of project delivery for all kinds of projects (from ITS to new facilities) including quality management functions related to planning and environmental processes, right-of-way acquisition, utility relocation, design, construction techniques, and construction management. Specific tasks requiring oversight or approval include preparatory work activities, design development and construction plans, traffic control plans, transparency of operations, rapid communication of test results and resolution of non-conforming items, and finally auditing practices of contractor quality control and assurance for interim and final deliverables. In a time of diminishing resources and escalating costs better quality process tools can increase our oversight effectiveness. State agencies need assistance to implement new systems that emphasize contractor quality control and assurance. Such assistance will allow the owner to leverage its resources to more systematically have assurance of quality levels thru a verification of contractor quality system processes.

The traditional design-bid-build delivery system in the United States uses construction specifications that result in detailed contractor quality control requirements. Acceptance programs, including verification tests historically have been performed by State highway agency staff. Only recently have contractors been required or encouraged to develop their own quality control plans. However, Federal regulations do not allow the use of the contractor quality control test results in the acceptance decision, unless verified by the owner.

Many international scan teams, most recently the Construction Management Scan team has noted that more formal quality management systems are used by contractors abroad than in the United States. With the exception of Germany, there is a heavy reliance on International Organization for Standardization (ISO) 9001 series methods. Contractors can be rated on their quality management

plans before project award, held to these requirements during construction and be evaluated in post-project reviews.

European countries require ISO 9001 certification, and contractors must develop the project quality plans in conjunction with their companies' certified quality procedures. Typically, contractors are primarily responsible for ensuring that materials and all other contract deliverables meet the required quality levels, and they provide certifications and test results. Tests are conducted as work progresses. All work is subject to owner review, but separate tests normally are not conducted. The set of checks by the owner consists of a mixture of system checks, process checks, and product checks. Most tests are standardized and the contractor has to use the standards. Most standards are legally enforceable. Other items of work that are not materials based such as traffic control device layout and placement or final subgrade elevation tolerances also are included in the quality system criteria.

The research objectives are summarized as follows:

- To define the objectives and benefits of the traditional quality control and quality assurance approach that is part of the FHWA's regulatory requirements. To define the objectives and benefits of alternate quality system requirements included in ISO 9001 (those used in Europe and the United States), Corps of Engineers (COE), Federal Aviation Administration (FAA), Federal Transit Authority (FTA) and other systems, as they are being applied in United States and internationally. Document the advantages and disadvantages of these alternate systems in relationship to the traditional quality control and quality assurance approach.
- To describe how these various systems work to achieve quality assurance objectives.
- To assess their potential impact on current state DOT and industry practices if alternative quality systems were applied to innovative contracting projects let in the best value environment as well as conventional design-bid-build projects let in the low bid competitive environment.
- To develop a plan that assists states in evaluating and deploying these quality systems. It is understood that there may not be a single, pre-

ferred solution but instead, options. The integration and compatibility of the contractor's and owner's programs need to be considered.

- To obtain a consistent definition of quality terminology among FHWA, the state DOTs and the highway construction industry. AASHTO definitions in R10 and ISO definitions need to be harmonized for clear communication.

Tasks

1. Identify and describe quality management systems that are used in the construction industry, with emphasis on the highway construction industry. Examine as a minimum ISO 9001 and the COE approaches. There will be a survey and literature search to include international information as well.
2. Describe and contrast current applications of quality management systems in the U.S., Canada, and Europe, with focus on alternative project delivery strategies, such as: design-bid-build, best value, design-build, and others. This includes those that are in place by contractors and owners.
3. Contrast these quality systems with conventional state DOT and industry practices. Two workshops should be held to allow for group synergy and participation to allow for a comprehensive evaluation.
4. Identify the benefits the contractor might accrue from the adoption of such a system. Consider the paybacks such as consistency, productivity, costs, risk management, employee awareness, on-time delivery, staffing levels, timely completion of testing, improved product performance, better risk alignment, strengthened business capabilities, more consistent management structure across jurisdictional lines, reduced claims, etc. This is a philosophy of "doing it right the first time" approach to construction.
5. Identify the benefits that a DOT might accrue from the adoption of an appropriate system including improvement of products, reduced inspections by optimizing use of staff by reducing duplication of work, reward quality contractors, etc.
6. There may be more than one solution for effective quality systems. If so, then project selection guidelines need to be developed to tie the appropriate quality system to the appropriate type

of project and alternative project delivery methodology. Based on the information gathered, recommend improvements to the traditional quality system that is used.

7. Present detailed case studies of application on various U.S. projects.
8. For each recommended quality system and the appropriate project selection guidelines, describe the potential implications if adopted as a standard practice by state DOT organizations and the highway construction industry. The measurement of success of the quality management system, particularly in the low-bid environment, is one of the potential implications. Recommend ways the traditional quality system could be incrementally improved by incorporating only select portions of the recommended quality system. Recommend adjustments to the quality system to accommodate traditional low-bid contracting, as well as design-build, and best value. Any adjustments needed to accommodate public-private partnership type projects should be addressed.
9. Develop a plan that assists states in evaluating and deploying the appropriate quality system for the alternative project delivery method selected. Identify the barriers to implementation and ways to overcome them.
10. Provide a web-based decision support tool that captures institutional knowledge gained by leading practitioners, and enables state agencies to access past experience and obtain guidance for system development or implementation.

Research in the area of innovation of procurement of construction is urgently needed to find techniques that can ensure quality. With limited resources at their disposal, the research will allow owners to optimize their efforts to ensure quality when these innovative methods of project delivery are selected. Research in this area should have a high benefit/cost payoff due to the large potential cost savings when projects are constructed with effective quality systems.

The payoff of this research will be the establishment of a knowledge base for best practices of quality systems available for a variety of project delivery techniques to supplement existing state DOT knowledge bases. This is a time of great innovation while many owners are experiencing signifi-

cant turnover among their senior design and construction professionals. Establishing a knowledge base will be critically useful for the new generation entering into the work force. The research will identify critical requirements to implement various quality systems (handbook, training, guides, etc.) to disseminate the findings to the highway construction industry. The implementation should include the recommendations in a standard format for AASHTO practice.

◆ **Project 12-85**
Roadway Bridges Fire Hazard Assessment

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

Bridge fires can cause major disruptions in highway operations. Although major fires are infrequent, there are an undocumented number of smaller fires that occur on highway bridges throughout the United States each year which cause varying degrees of disruption and repair and maintenance costs. These incidents stem primarily from vehicle (often truck) fires, but bridges can also be affected by fires in adjacent structures. The recent San Francisco bridge fire has highlighted the need to better understand the frequency and hazard potential of these incidents as well as review available information on potential mitigation strategies and damage assessment and repair techniques.

The objectives of the proposed study are to:

1. Survey fire incidents on bridges in the U.S. in recent years, documenting trends.
2. Quantify design fires (in terms of fuel load probability distribution) for vehicle fires and carry out the resulting hazard assessment.
3. Develop suggested design guidance—spatial separation, protection methods (include reference to combustible elements such as FRP), and detailing to minimize risk (for example, how down spouting can promote damage in fuel spills).
4. Consider impact of truck design (for example, location and protection of fuel tanks).

5. Assemble information on post fire structural assessment and repair techniques.
6. Identify areas where additional data is needed.
7. Develop bridge management practices for use of bridge and highway right-of-way.

The study as planned is a literature review and hazard assessment; no fire testing is contemplated. Reference will be made to the National Fire Protection Association Standard 502, Standard for Road Tunnels, Bridges, Limited Access Highways®. Hazard assessment techniques which have been applied to structures other than bridges can be adapted for use in this study. Actual risk, target risk, and implementation procedures will be assessed.

The recent major fire in San Francisco highlights a major area of concern for State Highway Departments where little or no design guidance is available. Assembly of readily available information for use by the highway community for these incidents will permit the implementation of some potentially straightforward mitigation strategies as well as assessment and repair techniques. The technical data from the research can be used for developing AASHTO guidelines for planning, designing, constructing, maintaining, and inspecting highway bridges; developing guidelines for emergency management; and contributing to a risk-management approach to bridge safety inspection and maintenance.

This proposed research addresses the *Grand Challenges*—Advancing the AASHTO Specifications, Extending Service Life, and Optimizing Structural Systems, among others by developing technical data which can be used to provide performance standards for design and management of highway bridges.

Note: The AASHTO Standing Committee on Research increased the funding request from \$175,000 to \$350,000.

◆ **Project 12-86**
Bridge System Safety and Redundancy

Research Field: Design
 Source: AASHTO Highway Subcommittee on Bridges and Structures

Allocation: \$500,000
 NCHRP Staff: Waseem Dekelbab

A good quantification of redundancy is not currently available to bridge engineers. Construction costs may be needlessly high on some bridges due to member redundancy, and less redundant existing structures may go unidentified. Redundancy, operational importance, and ductility can be considered during design by using load modifiers from the *AASHTO LRFD Bridge Design Specifications* ranging from 0.95 to 1.05 each. However, such factors should be better specified according to system type, and should be on the resistance side of the equation.

A framework for evaluating redundancy in highway bridges is described for superstructures in *NCHRP Report 406*. For superstructures, a “system factor” between 0.8 and 1.2 is applied based on the girder spacing and number of girders in the system. However, the charts are limited to steel and pretensioned I-beam-slab bridges, and only a small general bonus is given for diaphragms. An alternative methodology is provided to generate the system factor using nonlinear analysis and incrementally increasing the HS20 load, but ability to transmit load longitudinally is still not addressed.

Similarly, substructure redundancy is addressed in *NCHRP Report 458*. System factors are provided for confined and unconfined 2- and 4-column piers; spread footings, drilled shafts, and piles in various soil types. A direct redundancy analysis procedure is also provided. Any ability of the superstructure to enhance the substructure redundancy is ignored.

The quantification of redundancy in highway bridge structures is necessary before reliability-based non-collapse criteria can be developed for blast loads, ship-impact, storm surges, or seismic-force effects. A fresh approach is needed to merge past efforts that developed super- and substructure redundancy independently, to quantify the transfer of lateral loads in the superstructures inclusive of multi-cell cross-sections, and to consider the affect of superstructures on substructure redundancy especially in the case of framed structures and super-substructure connections made fixed for live load.

The objective of the research is to combine the techniques presented in *NCHRP Reports 406* and *458*; expand the work to include lateral loads on superstructures, framed systems, single- and multi-

cell boxes; and demonstrate the suitability of the proposal within the framework of the previously defined ultimate (strength), functionality (service), and damaged ultimate (collapse) limit states. The following tasks are envisioned:

1. Review *NCHRP Reports 406* and *458*, as well as Interims to the LRFR Manual for System Factors in Segmental Bridges. Do a literature search to see if any other related studies have since been done.
2. Expand on how the quantity and quality of intermediate and end diaphragms in the superstructure play a role in redundancy.
3. Expand to include single- and multi-cell cross-sections where member resistance may or may not be relevant since a “whole-width” design is often done.
4. Make any necessary updates to the functionality limit state for the recent displacement-based “LRFD Guidelines for Seismic Design of Bridges.”
5. Develop a methodology for accessing the redundancy in both the super- and substructure when the superstructure contributes to the substructure’s lateral load resistance.
6. Perform parameter studies to show that results are reasonable for all structure types, regardless of girder spacing, number of girder webs, number of substructure units, etc.
7. Develop a list of design examples to illustrate the proposed methodology for three limit states and structure types. List to be approved by project panel.
8. Prepare draft specification changes for both design and rating.
9. Present findings to the AASHTO SCOBS T5 Loads and Load Distribution Committee.

The ability to quantify “additional” capacity in bridges due to system redundancy is crucial in understanding bridge performance when subjected to malicious attack, vessel collision, earthquake, or storm surges. Bridge Owners need this information to help determine which existing bridges are most vulnerable due to lack of redundancy, and how to provide adequate redundancy in new bridges.

◆ Project 14-20

Quantifying the Costs and Risks of Delayed Maintenance

Research Field: Maintenance
Source: AASHTO Planning Subcommittee on Asset Management, AASHTO Highway Subcommittee on Maintenance
Allocation: \$700,000
NCHRP Staff: Amir N. Hanna

The cost of delayed maintenance/preservation is often not well quantified or readily apparent. When making budgeting decisions one may be tempted to choose spending less on preventive maintenance strategies in the near-term because the long-term implications of such a decision are not easily understood. However, delaying maintenance/preservation projects (pavements and bridges) could push projects into total reconstruction and substantially increase the total life-cycle costs of providing a structurally sufficient pavement or structure. Also, there are associated risks with delaying/postponing maintenance/preservation activities. This research seeks to develop information to better understand and quantify the risks associated with delaying preventive maintenance activities.

The objectives of the research are to (1) describe the impact and savings of undertaking proactive maintenance/preservation activities early in the life of a pavement and bridge structure as compared to delaying these activities; (2) perform an analysis and recommend when it is best to undertake pavement and bridge preservation actions; and (3) describe and outline the process that can be undertaken by state DOTs to conduct a risk analysis of postponing maintenance/preservation activities on pavements and bridges.

Note: The AASHTO Standing Committee on Research requested that this project be combined with Problem 2010-F-04. The research shall include additional tasks to establish the relationship between the level of service (LOS) of a roadway and the cost of maintenance required to achieve it as well as a method to quantify the cost associated with obtaining an improved level of service. These tasks will

include conceptual development, data gathering, analytical modeling, and trial use of the developed procedures in conjunction with maintenance programs.

◆ **Project 14-21**

Optimization of Resource Allocation for Highway Preservation Needs

Research Field: Maintenance
Source: AASHTO Highway Subcommittee on Maintenance
Allocation: \$350,000
NCHRP Staff: Andrew C. Lemer

State DOTs and the federal government have invested significant resources in building our nation's highway system. All of the asset categories that comprise our highway system, e. g., pavements, bridges, traffic signals, drainage pipes, signs, lights, and more, must be maintained, rehabilitated, and ultimately replaced. As our transportation system has aged, system preservation needs have moved to the forefront in the funding priorities of many DOTs.

However, resources for highway preservation typically have not kept pace with preservation needs. Most transportation agencies lack sufficient resources to attain and maintain desired service levels for all of their highway assets and must try to optimize the allocation of their limited resources to preserve a diverse portfolio of assets. Given large variations in service lives—e. g., the life of a bridge versus pavement markings—variations in asset class management systems, and the breadth of competing funding needs, the problem of optimizing resource allocations to preservation needs is extremely difficult.

A fundamental and practical issue with optimizing resource allocations to the preservation of various asset categories is the identification of common performance objectives that can transcend all of the asset categories that comprise our highway system, and that could serve as basis for optimization. Such common objectives may include, for example, maximizing remaining service life or minimizing long-term costs. A number of optimization models have been developed to assess and help

select the best strategy of preservation or replacement alternatives for a given investment level within an asset category, e.g., in pavement management and bridge management systems, but optimization criteria and practical models to allocate resources across a broad array of highway asset categories do not exist.

The objectives of this research will be to develop objectives and measures of effectiveness that may be used to optimize resource allocation for preservation of assets across the entire range of highway assets for which a DOT is responsible.

The research to accomplish this objective might include the following tasks: (1) preparation of an annotated literature review on optimization criteria and objectives to allocate resources across various transportation asset categories; (2) identification of optimization objectives and criteria that may be suitable to allocate preservation resources across a broad portfolio of highway asset categories; (3) assessment of the potential advantages and disadvantages of the optimization objectives and criteria for use in the intended context; (4) assessment of potential issues associated with implementing the most advantageous optimization objectives and criteria in a practical optimization model within state DOTs; (5) demonstration and documentation of the use of the recommended optimization objectives and criteria in the allocation of resources across highway asset categories through realistic case study examples; (6) identification of specific future research needed to achieve the implementation of allocation optimization models for the preservation of a broad portfolio of highway asset categories within state DOTs.

◆ **Project 14-22**

Effective Removal of Pavement Markings

Research Field: Maintenance
Source: Rhode Island
Allocation: \$200,000
NCHRP Staff: David A. Reynaud

To find an environmentally safe means of removing line striping and other markings without damaging the underlying pavement and altering the visible character of the surface course, or to develop an alternative to paint which will perform ade-

quately under interstate conditions and can be removed without damaging mechanical or chemical action.

During construction projects, it is often necessary to implement lane shifts in order to detour traffic around work zones. Shifting lanes requires obscuring or removing the existing pavement markings and applying new markings along the new alignment. The Manual on Uniform Traffic Devices (MUTCD) requires that all visible traces of the existing marking be removed or obliterated in order to provide a clear line of travel for the motorists. It does not allow for removal methods that will scar the pavement, with no specification for a level of scarring that is acceptable.

Among the primary requirements of permanent marking systems is to create a durable, strongly bonded material. It has to be capable of standing up to several years of wear due to heavy traffic at highway speeds and resist the environment (UV exposure, freeze/thaw, chemicals, etc.). Many of the new systems are epoxy-based and adhere adamantly to the pavement. Black tapes that are applied over the existing markings to hide them tend not to last long enough and/or have different reflective indices than the pavement and so may confuse drivers as to the correct lane to follow. The problem may be exacerbated in wet weather. Chemical systems that are aggressive enough to remove epoxies and other products would raise safety and environmental concerns. As a result, removal generally requires grinding of the markings, which leaves undesirable scarring often mistaken for actual pavement markings under low-light or wet conditions, so the owners of public highways are faced with a very difficult problem.

Research Questions: The problem at hand would need to be addressed for two different circumstances, although there would be some overlap.

Phase I—Investigate how to remove or fully obscure existing markings without damaging the pavement:

1. Are there systems (perhaps organic, like citrus based bituminous solvents) that would be more environmentally friendly?
2. Is there a mechanical process such as a combination of heat and power tools that could effectively remove a sufficient amount of the markings?

3. Is there a method of applying a durable coating over the existing pavement marking that will blend in to the appearance of the pavement, perhaps by using color matching technology? Or could the full width of the pavement be covered completely without losing friction characteristics, in a cost-effective manner?
4. How much is adequate to meet the MUTCD requirements? How much tolerance is there for altering the pavement surface?
5. Would the system developed be of a reasonable cost (relative to existing systems and methods) for materials, equipment, and labor?

Phase II—Develop a pavement marking system that meets durability and visibility standards, but with a designed means for full removal:

1. Can a coating that is durable in a heavy traffic environment still be created such that it can be removed cleanly? Are there existing systems in use for other applications that can be modified to meet this requirement?
2. What would the environmental constraints be for the system?
3. How much is adequate to meet the MUTCD requirements? How much tolerance is there for altering the pavement surface?
4. Can such a coating be designed to be cost effective (relative to existing systems and methods) in both application and removal?
5. If the system is significantly more expensive than current systems, could locations where lane shifts are more likely be identified, so that the use could be restricted to an as-needed basis?

Both systems, after a thorough laboratory evaluation, could be used on a demonstration basis in highway construction projects for testing in field conditions. The use would be for limited runs to minimize the effects on traffic flow in the event that the tests are not successful.

Owners of public highways are faced with MUTCD requirements for pavement markings that cannot be properly met by existing methods. A new system for removal of existing markings and a new one with a controlled means of complete removal would help owners meet the MUTCD regulations and provide safer traffic management. This would

be especially true in work zones where traffic control is critical.

Note: The AASHTO Standing Committee on Research directed that the scope address the development of best practices and a recommended test for MUTCD compliance. Phase II is not envisioned.

◆ **Project 15-39**
Superelevation Criteria for Sharp Horizontal Curves on Steep Grades

Research Field: Design
Source: AASHTO Highway Subcommittee on Design
Allocation: \$500,000
NCHRP Staff: David A. Reynaud

Sharp horizontal curves on steep grades represent a particularly dangerous situation for vehicle operators, especially heavy vehicle operators. Examples where this combination may occur are high-speed interchange movements, switchback curves on mountainous two-lane, two-way roads or high-speed downgrade curves on limited access roadways. At these locations, the complicating factors of vehicle off-tracking, pavement slope, and pavement friction fully tax the driver's ability to provide correct vehicle positioning without compromising control of the vehicle. Accident problems have arisen where, as a result of reconstruction, older highways with 12% to 17% superelevation have been rebuilt using 8% and 10% superelevation in accordance with current standards. Superelevation criteria, and other associated horizontal curve criteria, for situations where steep grades are located on sharp horizontal curves have not been developed.

NCHRP Projects 15-16 and 15-16A, documented in *NCHRP Report 439: Superelevation Distribution Methods and Transition Designs*, evaluated and recommended revisions to the horizontal curve guidance presented in the 1994 AASHTO publication, *A Policy on Geometric Design of Highways and Streets (Green Book)*. The two principal design elements evaluated were the use of superelevation and the transition from a tangent to a curve. The transition recommendations were incorporated into the 2001 edition of the

Green Book and the superelevation recommendations were included in the 2004 edition of the *Green Book*.

NCHRP Report 439 noted that significant roadway downgrades deplete the friction supply available for cornering. This depletion results from the use of a portion of the friction supply to provide the necessary braking force required to maintain speed on the downgrade. The report found that both upgrades and downgrades yield an increase in side friction demand and a decrease in side friction supply. This undesirable combination results in a significant decrease in the margin of safety resulting from roadway grade, especially for heavy vehicles. Superelevation criteria and horizontal curve criteria for this situation were not developed.

The 2004 *Green Book* contains the following: "On long or fairly steep grades, drivers tend to travel faster in the downgrade than in the upgrade direction. Additionally, research has shown that the side friction demand is greater on both downgrades (due to braking forces) and steep upgrades (due to the tractive forces). Some adjustment in superelevation rates should be considered for grades steeper than 5%. This adjustment is particularly important on facilities with high truck volumes and on low-speed facilities with intermediate curves using high levels of side friction demand."

The 2004 *Green Book* further states that this adjustment for grade can be made by assuming a slightly higher design speed for the downgrade and applying it to the whole traveled way. There are no guidelines as to how this adjustment should be made for two-lane or multilane undivided roadways. More definitive guidance on this adjustment, as well as adjustment for other elements of the horizontal curve, is needed.

The objective of this research is to develop superelevation criteria for horizontal curves on steep grades. Other criteria associated with design of horizontal curves such as tangent-to curve transitions, spiral transitions, lateral shift of vehicles traversing the curve, need for pavement widening, and minimum curve radii should also be considered in the development of the criteria. The criteria may be based on quantitative evidence obtained from theoretic considerations and simulations but should be supported by actual field observation.

The research should include a review of current practice, development of a work plan to

achieve the research objectives, collection of data and other information, evaluation of effects of various alternatives and candidate criteria, and preparation of final criteria. The recommended criteria should be documented in the final report and also presented in a form that could be used by the AASHTO Technical Committee on Geometric Design in a future edition of the Green Book.

This research topic was selected by the TRB Committee on Geometric Design, TRB Committee on Operational Effects of Geometrics, and the AASHTO Technical Committee on Geometric Design at their combined meeting in June, 2004 as one of the five highest priorities for research. The research is needed immediately to fill a gap in current superelevation design policy. The superelevation guidance will apply to high speed interchange ramp alignments on descending grades. As such, the research findings will have applications in every State and not just to those with mountainous terrain. Considering the research will apply to interchange movements, this research topic will be of use in the design of highways nationwide.

◆ **Project 15-40**

Designing the Roadway Transition from Rural Highways to Urban/Suburban Highways or Streets

Research Field: Design
Source: AASHTO Highway Subcommittee on Design
Allocation: \$300,000
NCHRP Staff: B. Ray Derr

There is a safety problem in locations where drivers operating in a high-speed rural environment must transition to operating in a low-speed urban/suburban environment as they approach a small community. There are numerous locations where traffic at speeds of 50 mph and higher on a rural highway must slow to 35 mph or less as a driver approaches a small urban area. Roadway features that present visual information that assist in reducing travel speeds are typically minimal or non-existent. Many times this results in inappropriate speeds for a significant distance into the urban area. Some of the AASHTO design criteria are unclear

for intermediate speeds (between 30 and 50 mph) in these areas. For example AASHTO recommends that vertical curbs only be used in low-speed areas, however, it's often used in transition zones posted at 50 mph. Also the need for and/or rate of superelevation can be very different for the same design speed depending on the method chosen to apply any required superelevation. Numerous localities are desirous of developing the transition area into gateways for their communities demonstrating the need for clear and appropriate criteria.

The transition from rural high-speed operations on a highway to low-speed operating conditions in urban/suburban conditions is a safety problem for all roadway users. In this context, the vehicle operator does not recognize the changed environment and adjust the vehicle's speed to a more appropriate level, thus creating the potential for safety problems on the urban street because of the typical high speed at the entry to the urban/suburban zone and for a significant distance into the area. Conveying the need for action on the part of the driver to restrain speed is a challenge for designers and enforcement officials. Some of these roads remain arterials that facilitate longer commutes, frequent local access, bicycle/pedestrian access, and in some cases, on-street parking.

Techniques are not available to assist the designer and enforcement officials in developing and providing for an appropriate design in these intermediate speed transition areas. There is a need to develop various techniques and tools to assist practitioners to provide a safe transition in operating conditions as a driver moves from rural to urban areas. The tools and techniques may involve application of existing tools and techniques, unique designs, signs and markings, as well as treatments adjacent to the roadway. The recent emphasis on context sensitive design/solutions may provide additional insight to potential solutions and their effectiveness relating to the transition area of concern.

The objective of this research project is to develop additional techniques and tools for designers and traffic engineers for application in developing effective designs for urban/suburban projects with intermediate speeds or transition zones from rural to urban/suburban environments.

◆ **Project 15-41**

Updated Headlamp Design Criteria for Sag Vertical Curves

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

Headlamp sight distance is one of four design criteria for sag vertical curves and is the most often used of the four criteria. The current criterion bases the length of a sag curve on the distance illuminated by a headlamp beam that diverges at 1 degree above the horizontal. This criterion was developed in the late 1930s and has remained unchanged since except for a decrease in the headlamp height (from 2.5 to 2.0 ft in the 1965 Blue Book). At the time the criterion was developed, the sealed beam headlamp was established as the standard headlamp system for U.S. vehicles and the sealed beam headlamp continued to be the standard headlamp into the mid-1980s. However, starting in the mid-1980s, vehicle manufacturers began introducing changes in headlamp design with varying headlamp performance. A more detailed research study is needed to update the sag curve sight distance criteria so that it reflects the performance of the modern vehicle fleet.

The design criteria for sag curves have not been investigated in detail in over 60 years. There have been significant changes in vehicle design/performance and in driver perception during the ensuing years. It is appropriate to evaluate the current design criteria to determine whether the basis for design is still valid and whether improvements can be realized through revised design criteria. Revised criteria could improve safety, operations, and/or reduce construction costs. Based on the exploratory research conducted to date, it is expected that this research will produce recommendations for changes in the design criteria for sag curves. The changes could be as simple as a reduction in the 1.0 degree α angle currently used to a more extensive change such as a new criteria based on a different concept for sag curves.

The objective of the proposed research is to evaluate the issues associated with sight distance on sag vertical curves and develop updated criteria that

reflect the conditions associated with modern highways and vehicles. Among the critical factors to be addressed are the performance characteristics of modern headlamps, appropriate headlamp illumination levels for sag vertical curves, and the relation between revised sag curve sight distance criteria and other sag curve design criteria. Other sag curve design criteria also should be considered, particularly with respect to comparisons between the various criteria that may affect sag curve design. The research results should provide specific recommendations for revisions to sag curve design criteria found in *A Policy On Geometric Design of Highways and Streets*, AASHTO.

◆ **Project 15-42**

Use of Bicycle Lanes for Various Roadway Characteristics

Research Field: Design
Source: AASHTO Joint Technical Committee on Nonmotorized Transportation
Allocation: \$300,000
NCHRP Staff: Christopher J. Hedges

U.S. practitioners have minimal nationally recognized guidance regarding the roadway characteristics under which bicycle lanes should be provided or, at least, considered. The current (1999) edition of the *AASHTO Guide for the Development of Bicycle Facilities* describes design of bicycle lanes, but presents virtually no guidance about roadway conditions under which they should be provided, considered, or omitted. On busier urban roadways with operating speeds above 40 mph, usage of bicycle lanes often is observed to be modest; the *Guide* simply observes that “additional widths (more than 5 ft.) are desirable” where speeds exceed 50 mph or truck volume is heavy. It is sometimes suggested that, at some threshold, designation of nearby bike routes should be considered in lieu of bicycle lanes or perhaps on thoroughfares with relatively low speeds or truck volumes, or where on-street parking is allowed, wide curb lanes or shared roadway treatments may be as or more effective than a bicycle lane.

Some state DOTs have adopted policies of (generally) routine provision of bicycle lanes in ur-

ban projects, some consider whether the road is included in the local bicycle plan, and some consult criteria tables in a 1994 study published by FHWA, "Selecting Roadway Design Treatments to Accommodate Bicycles." Selection factors proposed in this report are traffic volume, average traffic operating speed, "traffic mix" (presence of heavy vehicles), on-street parking, sight distance, and intersection spacing. For a given combination, tables identify a "desirable" treatment (wide curb lane, shared lane, paved shoulder, or bike lane) of recommended minimum width (at least as great as AASHTO's). The authors described their recommendations as "preliminary" and anticipated that the tables would be refined as the state of the practice evolved, but no revision has ever been developed.

The objective is to develop design criteria for bicycle lanes based on roadway characteristics including, but not limited to, classification, speed, ADT, number of trucks, the grade of the roadway, and parking. The design criteria will help determine if bicycle lanes should be installed and if so, what would be the recommended width of the bicycle lane, the adjacent travel lane, and, if applicable, parking.

◆ **Project 16-05**
Development of Cost Effective Treatments of Roadside Ditches to Reduce the Number and Severity of Roadside Crashes

Research Field: Design
Source: AASHTO Highway Subcommittee on Design
Allocation: \$400,000
NCHRP Staff: Charles W. Niessner

Roadside ditches or swales are an integral feature of highways, especially two lane rural highways. They are critical for control of storm water runoff on highways. Where space allows, shallow swales are used, but when right-of-way is limited, ditches with deeper and sharper drops are used. These features can be obstacles to errant motorists that leave the roadway. The Fatality Analysis Reporting System (FARS) indicated in 2006 1,260 fatal crashes occurred where a ditch was the first harmful event. It is not possible to differentiate be-

tween ditches and swales in the data. There has been a trend over the past 15 years that over 1,000 fatalities annually can be attributed to ditches.

The *AASHTO Roadside Design Guide* provides some guidance on preferred configurations for ditches. This guidance is based on the results of limited testing and simulations conducted in the 1970s. There is variation in the practices across the states for designing and maintaining ditches and, for many miles of roads, the ditches are a remnant of older highways that have never been updated to current standards.

The limited right-of-way often dictates the configuration of ditches and in many cases the preferred configurations are not practical. Enclosed drainage systems are expensive and result in additional requirements for treatment and discharge of the runoff. Installing a barrier between the travelled way and the ditch reduces the available clear zone, is impractical in respect to cost in many cases, and presents additional problems, such as terminal design and sight distance, when driveways are allowed. Since ditches are part of a drainage system, other elements such as culverts, inlets, and holding basins require structures that become roadside obstacles (e.g., headwalls, riprap, and curbs).

An urgent need exists to reduce the number and severity of crashes involving roadside ditches, through a deeper understanding of the factors involved in crash events, the evaluation of vehicle dynamics, and the identification and cost-benefit assessment of treatment options. With this information, cost effective countermeasures can be identified and implemented to mitigate ditch crashes.

The objectives of this research are to:

- Develop deeper insights into the interaction of factors that influence the nature of crashes involving ditches.
- Analyze the influence of varying ditch configurations on vehicle dynamics and their role in the severity of crashes.
- Identify cost effective treatments for roadside ditches that will reduce the number and severity of crashes.
- Develop improved guidance for ditch design and maintenance for inclusion in the Roadside Design Guide.

This effort should focus on identifying treatments for ditch design and maintenance as other efforts are already focusing on the related topic of keeping vehicles on the roadway.

To meet the project objectives the following tasks would be performed:

- Review domestic and international literature with a focus on ditch design and countermeasures that have been tried and evaluated. Consider undertaking a review of agency standards (i.e., on-line) and conducting a survey to identify innovative treatments that may not have been documented.
- Analyze collisions involving ditches to give context to the types of collisions involved (e.g., rollover, curve related, pavement edge scuffing) so that the counter measures can be focused. Attempt to get needed insights on these crashes from existing sources of data.
- Model dynamics of vehicles traversing ditches to evaluate the vehicle reactions to different cross sections and treatments. These efforts should build upon the results of current work.
- Develop a range of alternative treatments for ditches based upon knowledge gained in the literature review, contacts, and crash analyses. Organize a “brainstorming session” with knowledgeable professionals to identify other potential treatments.
- Formulate guidelines for the deployment of ditch treatments that consider the risk factors, costs, feasibility, road geometry, and traffic.
- Undertake a cost effectiveness analysis for high- to low-cost alternatives to enhance guidance relative to available budgets. Identify the expected benefits of these treatments to allow rational selection of alternatives.
- Draft new guidelines for the design and treatment of ditches in priority locations. Review these guidelines and the rationale for them with the panel and a select group of knowledgeable engineers.
- Prepare a final report that documents the efforts undertaken and thought processes that led to the guidelines.

◆ Project 17-46

Comprehensive Analysis Framework for Safety Investment Decisions

Research Field: Traffic
Source: AASHTO Standing Committee on Highway Traffic Safety
Allocation: \$600,000 (Additional \$150,000 from Federal Highway Administration)
NCHRP Staff: Charles W. Niessner

The diverse safety community in the United States continues to make substantial, incremental progress in developing and implementing cost-effective approaches. AASHTO and FHWA have provided national leadership with work such as Model Minimum Inventory of Roadway Elements (MMIRE), the Digital Highway Measurement System, the Interactive Highway Safety Design Model, SafetyAnalyst, etc.; and towards critical upcoming milestone products such as the Highway Safety Manual and SHRP2 results (especially the crash causation database which will be created). NHTSA and FMCSA, working with AASHTO/FHWA and other partners, have advanced similar improvements focusing on behavioral and heavy vehicle issues.

While the range of current efforts is impressive, we are just on the cusp of creating a truly comprehensive analysis and decision-support system with the capability to compare the effectiveness of investment and policy opportunities across the 4 Es of safety (i.e., the contributions of engineering, education, enforcement, and emergency medical services). This project would create and sustain a nationally-coordinated, multi-year initiative to integrate efforts like those noted above into a Comprehensive Safety Analysis Framework. This Framework is envisioned as a ‘blue print’ which the full safety community will contribute to and which will provide for objective, data driven evaluation of safety programs, policies, and investments across Federal, state, and local levels.

Objectives and tasks to create and sustain the Safety Analysis Framework include: (1) develop, pilot test, evaluate, fine tune, and update the model framework for estimating the effectiveness of behavioral countermeasures; (2) in-depth evaluation of existing and soon-to-be-released tools; (3) assessment of critical deficiencies in data and tools to

support better comprehensive decision making; (4) development of a comprehensive, consensus strategic plan for further development and support of data systems and analytical tools to address critical deficiencies, coordination among ongoing activities, professional capacity needs, and support for investment decision making and policy analysis and development; and (5) implementation support for the multi-year program, to include tasks such as coordination of data needs across all elements, development of '4 E' policy analysis tools not currently available, quality assurance of analysis algorithms, software integration efforts as needed, communication, training, and technical assistance for at least the first several years.

The intended outputs are: (1) a strategic development and deployment program coordinated across partners in the 4 Es; and (2) an initial version of a next generation of tools that permits objective analysis of investment decisions across the 4 Es. The expected benefit/outcomes are significantly more effective investment decisions and, as a result, steeper reductions in motor vehicle fatalities and serious injuries.

◆ **Project 17-47**

Human Factors Guidelines for Road Systems-Phase IV

Research Field: Traffic
Source: AASHTO Standing Committee
on Highway Traffic Safety
Allocation: \$500,000
NCHRP Staff: Charles W. Niessner

The TRB Joint Subcommittee on "International Human Factors Guideline for Road Systems," AND10(2), was created to help plan the development of a human factors guideline for road systems that highway designers and traffic engineers could readily use in their work. NCHRP 17-18(8), *Comprehensive Human Factors Guidelines for Road Systems* was initiated in 2001 and provided the framework for the guideline and two chapters. The project was completed on January 31, 2005.

NCHRP Project 17-31 began in August 2005 to develop additional chapters and integrate them with the work completed under Project 17-18(8). The Project 17-31 contractor developed a style guide for the Guideline, refined Chapters 1 through 5 from NCHRP Project 17-8(8), and prepared four new chapters: signalized intersections, unsignalized intersections, work zones, and horizontal curves. Project 17-31 was completed in August 2008. The work completed under project 17-31 has been published as NCHRP Reports 600A and 600B.

NCHRP Project 17-41 started in March 2008 and is developing 5 additional chapters. The completion date for this project is March 2010. With the completion of Project 17-41 there are 7 chapters remaining to be completed.

The Human Factors Guide (HFG) is intended to be a resource document for highway designers, traffic engineers, and other practitioners. The purpose of the HFG is to provide the best factual information and insight on road users' characteristics, in a useful format, to facilitate safe roadway design and operational decisions. The impetus behind this effort was the recognition that current design references have limitations in providing the practitioner with adequate guidance for incorporating road user needs and capabilities when dealing with design and operational issues.

The work of this Joint Subcommittee is being coordinated with the development of the Highway Safety Manual being overseen by the TRB Task Force to Develop a Highway Safety Manual (HSM). The first edition of the HSM is expected to be produced after the completion of NCHRP Project 17-36 in January 2009. While the HSM includes one section of a chapter on human factors, it will provide only a broad scope and not include guidelines.

The objective of this project is to complete the development of the Human Factors Guide.

The following tasks would be conducted: (1) literature review, (2) develop a list of topics under each chapter, (3) prepare annotated outline for each guideline, (4) develop draft guidelines, and (5) develop final guidelines.

◆ **Project 17-48**

Development of a Strategic National Highway Infrastructure Safety Research Agenda

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

Reducing the number of fatalities and injuries from highway traffic crashes is a high-priority goal shared by AASHTO, FHWA, and the States. While fatality rates have steadily decreased over time, the number of fatalities has remained unacceptably high. While increased safety funding under SAFETEA-LU and States' development and implementation of strategic highway safety plans can be expected to significantly improve highway safety, research is needed to develop innovations that will be needed to achieve AASHTO's goal of halving fatalities in 20 years. Achieving the greatest benefits from research will require well-targeted and coordinated research investment.

At the request of FHWA and AASHTO, TRB convened an expert committee to provide an independent review of current processes for establishing research priorities and coordinating highway safety research activities. In TRB Special Report 292, the committee presented its findings and recommended that "an independent scientific advisory committee should be established and charged with (1) developing a transparent process for identifying and prioritizing research needs and opportunities in highway safety, with emphasis on infrastructure and operations; and (2) using the process developed to recommend a national research agenda focused on highway infrastructure and operations safety."

This problem statement proposes an NCHRP project to implement expert committee's recommendation. Development of a national research agenda would support the Safety Management Subcommittee of the AASHTO Standing Committee on Highway Traffic Safety in carrying out its highway safety research oversight and advocacy responsibilities.

The objectives of this project are to: (1) develop a transparent process for identifying and pri-

oritizing research needs and opportunities in highway safety; and (2) using the process developed to recommend a national research agenda focused on highway infrastructure and operations safety. Specific tasks necessary to achieve these objectives include:

1. Develop a process for identifying and prioritizing safety research needs that includes the following features: (a) a quantitative analytical approach that examines clearly defined criteria to determine the value of a research project or topic, and (b) the involvement of a mix of experts to formulate an agenda that is informed by the quantitative analysis results.
2. Develop research priorities by applying the process to identify critical safety problems, identify potential research issues, assess the status of data and methodologies to conduct research that addresses the problems, estimate the costs and timeframes for research, and assess the likely outcome of alternative research topics.

◆ **Project 20-83(06), FY 2010**

Effects of Socio-Demographics on Travel Demand

Research Field: Special Projects
Source: AASHTO Standing Committee on Research
Allocation: \$1,000,000
NCHRP Staff: Christopher J. Hedges

The transportation industry will face new and emerging challenges in the future that will dramatically reshape transportation priorities and needs. AASHTO recognizes that research can help ensure that transportation practitioners are equipped to deal with future challenges facing the industry over the next 30 to 50 years. For the fiscal year 2009/2010 programs, AASHTO allocated \$8,000,000 to examine longer term strategic issues, both global and domestic, that will likely affect state departments of transportation (DOTs). This is one of seven projects selected and deals with the effects of socio-demographics on travel demand.

The profile of America is expected to change substantially over the coming 40 years. According to the U.S. Census Bureau, the U.S. population is projected to increase to 438 million by 2050,

more than a 40% increase from the 2008 population of 304 million. This population will be more ethnically diverse; over 80% of the projected population increase is attributed to immigrants and their descendants. The population also will be substantially older; it is estimated that more than 20% of the U.S. population will be 65 years or older by 2050, compared to 12.6% currently. The sizeable increase in population will create the need for more housing, employment, and services, which may lead to substantial impacts on travel patterns and demands. It is estimated that majority of the U.S. population will live in mega-regions, with more than 80% of the population in urban/metro areas, including suburbs. Baby boomers are expected to choose a 'soft retirement' and continue to work part-time beyond retirement age. Young people coming out of full-time education may increasingly choose to enter what they consider temporary, short-term jobs, which they use to finance international travel, volunteering in nonprofit or arts-related careers, and/or continued education. These nontraditional workers are sometimes referred to as "Moofers" (Mobile Out of Office Workers). Potential changes in family structure, incomes, lifestyles, and social expectations also may occur.

Transportation demand is a function of the number and types of people in an area, their lifestyles, and economic structure and activity. Many issues over the next 30 to 40 years will change the population's transportation needs, travel patterns, and expectations regarding mobility. These include changes in demographics (e.g. population size, affluence, ethnicity, age, etc.) and technologies that substitute or alter travel behaviors (e.g. telecommuting opportunities or mode shifts). In addition to passenger travel, changes in global and national economic activity, fuel prices, and policy will influence freight travel demand. The interplay between these issues is important as well. The effects of some trends, such as population growth, may mitigate or amplify the effects of others, such as the aging population or migration. In 2050, the U.S. population will be significantly larger, older, and more ethnically diverse than today. Clearly, these trends may dramatically influence transportation demands and patterns. Some of these trends suggest a dramatic increase in mobility needs – the addition of over 130 million more Americans in the next 40 years, medical advances that enable older Ameri-

cans to have increasingly active lifestyles, and shifts in the growth areas within the U.S. suggest surging travel demands. At the same time, it is plausible that travel demands will not increase substantially, due to enhancements in information and communication technologies, changes in land use patterns (e.g., movement to urban, pedestrian-oriented areas that minimize vehicle travel demands), increases in fuel prices, and changes in attitudes toward transit and alternatives to driving. Furthermore, if a majority of the population increase is from immigrants, then their transportation habits may differ. The patterns of travel also could change substantially, with travel increasing for different types of trips, in different locations, and at different times than currently.

Long-range transportation planning being conducted by States and Metropolitan Planning Organizations takes an outlook of 20+ years into the future, but is largely based on the current relationships between demographics, land use patterns, and travel activities. A wide range of demographic, social, technological, and economic changes are likely to affect travel demands and patterns in the future. These changes, and their fundamental relationships to travel demand, are currently not well understood.

The objective of this project is to determine how socio-demographic factors are likely to affect travel demand over the next 50 years, and to identify strategies and actions that can be used by state DOTs to plan and prepare for plausible future scenarios.

The research should focus on understanding the fundamental relationships between social, demographic, and economic factors and travel demands. These include effects such as increasing diversity, aging and retirement patterns, personal wealth, increasing immigration and its impact, increasing mega-regions, changing regional migration patterns, and the decreasing size of households and changing family structures. It also would help to develop more accurate tools and approaches for forecasting travel demand and behavior.

Note: At its March 2009 meeting, the AASHTO Standing Committee on Research recommended continuing the series of projects under Project 20-83, *Long-Range Strategic Issues Facing the Transportation Industry*, and allocated \$3,000,000 for FY 2010. From this amount, they selected two addi-

tional projects from a list of previously suggested topics and allocated \$1,000,000 to each one: (1) Effects of Socio-Demographics on Travel Demand, and (2) Sustainable Transportation System and Sustainability as an Organizing Principle. These two projects are now being listed as “New Projects.”

◆ **Project 20-83(07), FY 2010**

Sustainable Transportation Systems and Sustainability as an Organizing Principle for Transportation Agencies

Research Field: Special Projects
Source: AASHTO Standing Committee
on Research
Allocation: \$1,000,000
NCHRP Staff: Lori L. Sundstrom

The transportation industry will face new and emerging challenges in the future that will dramatically reshape transportation priorities and needs. AASHTO recognizes that research can help ensure that transportation practitioners are equipped to deal with future challenges facing the industry over the next 30 to 50 years. For the fiscal year 2009/2010 programs, AASHTO allocated \$8,000,000 to examine longer term strategic issues, both global and domestic, that will likely affect state departments of transportation (DOTs). This is one of seven projects selected and deals with the integration of sustainability as a core principle in a DOT’s investment and operations decisionmaking processes.

Building on related ongoing and completed research, this research will refine the definition of what constitutes a sustainable transportation system and demonstrate how DOTs can integrate sustainability principles into their day-to-day operations and investment decision making, including long-range planning, scenario development, and forecasting activities. The research also should address internal processes and organizational schemes that would assist DOTs in institutionalizing sustainability.

Sustainability is likely to become a core focus for transportation agencies in the future, both because citizens and state legislatures are requiring it as a matter of public policy and because it has the

potential to produce more cost-effective transportation solutions over the life span of a transportation facility. DOTs are challenged, however, to identify what a sustainable transportation system is in a manner that they find useful for purposes of making decisions that will balance short-term cost effectiveness with long-term sustainability. Guidance is needed on how to achieve a sustainable transportation system that is economically feasible and sound, environmentally friendly or at least environmentally benign, and supports commerce and facilitates mobility. DOTs also are interested in how their internal operations can be made to operate in a sustainable manner and how they can monitor their progress and measure success.

This research should construct one or more scenarios in which DOTs will be asked to achieve sustainability goals that reflect likely conditions 30-50 years in the future. The research should place key DOT activities such as forecasting, planning, project development, maintenance, and operations, in that future context and should at a minimum also consider basic relationships between transportation, public health, environmental justice, and quality of life in developing a framework for sustainability that will serve DOTs. The research will identify key elements of a long-term sustainable transportation system and strategy.

Increasing societal awareness on the environmental affects of the surface transportation system has already led to new demands on DOTs to provide environmentally and socially responsive infrastructure and transportation services. To meet these expectations, DOTs may require data and models that can calculate marginal environmental, societal, and economic values of transportation system performance and compare with marginal costs. In addition, the role of federal agencies and federal regulation and how they help or hinder the DOTs pursuit of sustainability should be considered. Building on research currently under way in the Strategic Highway Research Program 2, this project also may project how different and more comprehensive approaches to environmental protection and enhancement will enable DOTs to achieve a sustainable transportation system.

Note: At its March 2009 meeting, the AASHTO Standing Committee on Research recommended

continuing the series of projects under Project 20-83, *Long-Range Strategic Issues Facing the Transportation Industry*, and allocated \$3,000,000 for FY 2010. From this amount, they selected two additional projects from a list of previously suggested topics and allocated \$1,000,000 to each one: (1) Effects of Socio-Demographics on Travel Demand, and (2) Sustainable Transportation System and Sustainability as an Organizing Principle. These two projects are now being listed as “New Projects.”

◆ **Project 20-84**

Streamline and Simplify Right-of-Way Procedures and Business Practice

Research Field: Special Projects
Source: Federal Highway Administration, California, Oklahoma, Washington
Allocation: \$500,000
NCHRP Staff: David A. Reynaud

Several State Departments of Transportation (DOTs) are considering revising their right-of-way business practices with the goal of simplifying and streamlining processes. Current right-of-way practice and procedure manuals are the products of 40 years of statutes, case law, regulations, management styles and best practices. The procedural manuals have chapters to cover elements such as: a) appraisal; b) appraisal review; c) relocation planning and assistance; d) relocation eligibility and supplemental payments; e) nonresidential relocations; f) acquisition and negotiations; g) legal settlements; h) eminent domain; i) titles and closing; j) property management; k) leasing; l) sale of excess property; m) mapping and geographic information systems (GIS); n) encroachments; o) contracting for services; and p) administrative costs.

Procedures and guidelines are often an accumulation of historical practice or those adopted from other agencies. State procedures vary widely because of differences in State laws. Local agencies are required to follow State DOT procedural manuals when they use State or Federal funding. Questions arise as new staff try to understand the reason or underlying basis for requirements. Contractors

and consultants face a wide array of requirements and forms among the various States.

This research is in support of the AASHTO Highway Subcommittee Right-of-Way and Utility strategic plan to provide leadership and support to member agency right-of-way staff. This research will provide new direction and lead to immediate cost savings by reducing the hours required to accomplish certain functions. This research will result in streamlined business practices that are easier to maintain, cost effective and result in delivery of projects sooner.

Research is needed to provide information to State DOTs and local agencies to rationally evaluate current right-of-way procedures and business practices; to determine what function is served by each procedure; to determine the need for each procedure, i.e. statute or practice; to document the benefits and operational logic for continuing a procedure, modifying, or eliminating it, evaluate the cost of maintaining current procedures and to quantify the benefits from them. This includes, but is not limited to, the current cost of agents, training new agents and administrative costs on a parcel or tract basis. Determine what processes are essential to providing a consistent product and comply with statutory requirements, such as the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Uniform Act), as well as the most common elements of State eminent domain laws, identify institutional, political, and economic barriers to the adoption of procedures that will be easier to maintain for the next 20 years, and examine and compare several common types of existing FHWA approved right-of-way manuals used by State DOTs and local agencies and common State regulations.

Agencies will be contacted and staff will be interviewed to ascertain what are the origins, purpose and authorities for the existing procedures; what criteria and procedures are needed, as a minimum, to protect owner and tenant rights; what procedures would work if the agency could start anew; how and/or whether procedures might be modified for local agency use, i.e., a stand alone manual for local agencies; what are the issues in administering procedures that need to be addressed to assure consistent application; and what are the institutional, political, and economic barriers to implementation?

A major objective of the research will be to develop a rationale or basis for a new or modified

approach. This will include an objective analysis of all key elements mentioned above, i.e., appraisal, appraisal review, relocation, etc.

This research would culminate by analyzing the typical right-of-way business model for the four major elements of appraisal, acquisition, relocation, and property management, and developing a revised model that is less costly to maintain.

It would outline a sample procedural manual with forms that could be used to administer a simplified and cost-effective right-of-way program that is responsive to national statutes and the Uniform Act. The resulting business model would be accompanied by a cost/benefit analysis and recommended roll-out implementation plan that could be readily adopted and applied by State DOTs and local agencies for national consistency.

One of the initial goals of the Uniform Act was to create a fair and consistent process for the acquisition of real property by public agencies. This research would help us assure the continued uniformity of the process.

This research will be a direct follow-on to the 2008 International Scan for ROW and Utilities called "Integrating & Streamlining Right of Way and Utility Processes with Planning, Environment, and Design." Ideas and strategies derived from the 2008 International Scan will feed directly into revised business practices. State DOTs who undertake pilot projects in 2009 will be able to use lessons learned and provide input to this research effort. The timing is beneficial for all parties in that this research product will bring about full implementation of the 2008 streamlining strategies.

This research will provide new direction and lead to immediate cost savings by reducing the hours required to accomplish certain functions. This research will result in streamlined business practices that are easier to maintain, cost effective and result in delivery of projects sooner. The effort devoted to training new right-of-way agents, who may or may not stay with the agency, is becoming cost prohibitive and is time consuming.

It is anticipated that there will be many institutional barriers to overcome. Many right-of-way agents have adapted to the current procedures and will be resistant to change. State DOT legal staff also may resist changes, thinking that revised procedures may affect property owner rights. In order to address these barriers, the final research report

should contain an outline of a revised procedural manual that would be sufficient to meet Federal regulations and laws, allowing each State to augment this information with specifics to address that particular State's laws.

◆ **Project 20-85**

Wind, Solar, and Ground-Source Energy for Maintenance Area Facilities

Research Field: Special Projects
Source: Minnesota
Allocation: \$500,000
NCHRP Staff: Edward T. Harrigan

In the face of rising energy costs, state DOTs are striving to reduce the energy requirements for heating, cooling, and maintaining their facilities. In addition to the customary options of oil, gas, and electrical energy, alternative sources of energy, including wind power, solar power, and ground-source heating and cooling, are being evaluated for their cost effectiveness and reliability. While none of these alternatives to conventional energy sources may be effective alone in all situations, together they may provide appreciable savings in energy use for some facilities. In the future, energy conservation guidance for state agency facilities may mandate increased efficiencies in facility energy consumption. This research will evaluate active energy options including wind power, solar power and ground-source heating and cooling, as well as passive building and site modifications to reduce energy use.

The objectives of this research are to identify and evaluate effective, implementable means of energy conservation for maintenance and other state DOT facilities.

The following tasks are anticipated to accomplish these objectives: (1) assess alternative energy options currently employed at DOT-managed facilities; (2) assess potential areas/sites where alternative sources of energy such as wind, solar, and ground-source heating/cooling may be effective; (3) assess maintenance area sites where passive site and building modifications have the most probability of reducing energy use; (4) prioritize a short list of sites where alternative energy sources and passive energy reduction measures would have the most

potential for being effectively employed in the near-term (within 10 years); (5) using currently available technology for the three alternative energy options and passive site and building measures, develop preliminary, detailed plans for installation of one option at each of four selected sites reflecting differing climatic and physiographic regions within one or more states; (6) develop cost performance measures for evaluation of reduced energy use and related cost effectiveness for each of the four options employed; and (7) in partnership with a DOT, construct and maintain applicable structures and measures for the four options and monitor effectiveness for two years in accordance with the established performance measures.

◆ **Project 20-86**

Skill Set Requirements and Career Opportunity Awareness for Transportation Systems Operation and Management Needs at High School and College Levels

Research Field: Special Projects
Source: California
Allocation: \$375,000
NCHRP Staff: Andrew C. Lemer

There is an accelerating shift in state Departments of Transportation (DOTs) away from the more traditional design and construction function of civil engineering to a systems operation and management (SOM) function. Fewer engineering students, coupled with the imminent departure of the over-represented older groups of engineers (over 40 years old) will soon deplete the ranks of qualified transportation professionals. A study done by the Texas Transportation Institute in 1998, for example, noted that the "...increased emphasis on transportation systems operation and management requires a skill set not available in traditionally trained students."

Research has confirmed the need to provide outreach to students at all educational levels, particularly middle school and high school, to positively influence students' interest in transportation-related engineering careers. Programs have been implemented in a number of regions with this goal. However, there is little information on how much emphasis is placed on highlighting career opportu-

nities for transportation engineering SOM functions. Research is needed to address the shift in emphasis from capital programs to operations and management and how to motivate students to be interested in this aspect of a career in transportation.

The objective of this research will be to define a set of knowledge, skill, and ability requirements needed by the DOTs for their current and future engineers relative to the increased emphasis on SOM responsibilities. The research will include proposals for high school and college curriculum enhancements that will better meet the future workforce needs of the DOT. The research also will propose outreach programs for grades 6-12 and undergraduate students that emphasize the expanded career opportunities of different engineering skills beyond those of design/build, to include SOM activities within the DOT.

◆ **Project 22-20(02)**

Design of TL-5 Roadside Barrier Systems Placed on MSE Retaining Walls

Research Field: Design
Source: Texas
Allocation: \$500,000
NCHRP Staff: Charles W. Niessner

NCHRP Report 350: Recommended Procedures for the Safety Performance Evaluation of Highway Features and its successor, the *AASHTO Manual for Assessing Safety Hardware (MASH)*, define impact performance criteria for roadside barrier systems. These documents define six different test levels of increasing impact severity that incorporate varying impact speeds and vehicle types. These test levels provide a basis for establishing warrants for the application of roadside barriers for roadway facilities with different levels of use (i.e., service levels).

The design test vehicle for Test Level 5 is an 80,000-lb tractor-van trailer. A TL-5 barrier may be warranted along high-speed roadway sections with a significant percentage of truck traffic. Several state departments of transportation require TL-5 barriers on certain highway facilities, and numerous other states use such barriers when site conditions warrant.

A situation that is commonly encountered throughout the country is the use of mechanically stabilized earth (MSE) retaining walls at bridge approaches. It is estimated that 10 million square feet of MSE retaining wall is constructed annually in the United States. Most MSE retaining walls used in highway fill applications are constructed with a roadside barrier system consisting of a traffic barrier connected to a below grade moment slab or foundation. The moment slab is intended to provide stability to the barrier system during an impact and reduce the influence of barrier impact loads on the underlying retaining wall system by distributing the load over a wide area. Current procedures and design details for roadside barriers placed on retaining walls vary widely among state highway agencies. Most designs currently used are overly conservative because of inadequate understanding of how barrier impact loads are distributed through the barrier and transferred to the moment slab and wall system.

Under NCHRP Project 22-20 "Design of Roadside Barrier Systems Placed on MSE Retaining Walls," guidelines were developed for designing the barrier moment slab and MSE wall to withstand vehicle impact loads. However, the scope of the project was limited to passenger vehicle impacts (i.e., Test Level 3) and did not include consideration of large trucks.

The interaction and impact loads associated with large truck impacts (e.g., Test Level 5) are substantially different than those associated with passenger vehicle impacts. The magnitude of the impact load for a TL-5 truck impact is 3 to 4 times greater than the load associated with the 5,000-lb pickup truck that is the design vehicle for TL-3. Further, the height of the applied load is much greater for a TL-5 impact, and the articulated nature of the tractor-van trailer results in three distinct impact events with the barrier.

Additional research is needed to enhance our understanding of the behavior of an MSE wall and barrier moment slab system when subjected to large truck impacts. Developing guidelines for the use of truck barriers on MSE walls will permit the development of more relevant and cost effective designs for the barrier moment slab and MSE wall. This project will build upon and extend the work accomplished and guidelines developed under Project 22-20, and eliminate the need to extrapolate knowledge

from a TL-3 impact to a TL-5 impact, which has more than four times the impact severity.

The objective of this research is to develop, in a format suitable for adoption by AASHTO, procedures and guidelines for designing roadside barrier systems placed on mechanically stabilized earth retaining structures to resist impacts from large trucks. The project will consist of engineering analyses, computer modeling, and full-scale testing of a tractor-van trailer into a barrier placed atop an instrumented MSE retaining wall.

The guidelines should address Test Level 5 (TL-5) impacts consisting of an 80,000-lb tractor-van trailer impacting the barrier at a speed of 50 mph and an angle of 15 degrees. Specific considerations include defining appropriate design loads for a TL-5 impact, and developing procedures for sizing the moment slab and designing the MSE wall when truck barriers are required.

◆ **Project 24-34**
Risk-Based Approach to Bridge Scour Prediction

Research Field: Soils and Geology
Source: AASHTO Highway Subcommittee on Design
Allocation: \$500,000
NCHRP Staff: Waseem Dekelbab

Current practice for the prediction of scour depth at bridge piers and abutments uses empirical equations developed primarily from laboratory-scale studies, supplemented by limited data from field measurements. Equations for contraction scour (both clear-water and live-bed conditions) are based on an approach that combines both empirical and deterministic relationships. Additionally, the statistical analysis that was performed on the data collected from the laboratory studies and was used to create these relationships employs various statistical approaches that possibly provide more conservative results than necessary. When you also take into account the uncertainty associated with the development of key parameters used in the empirical relationships, the room for error is significant. In contrast, because of numerous advantages, bridge structural engineers, and more recently geotechnical engineers, have adopted Load and Resistance Factor Design (LRFD) which is a probabilistic approach to

design. LRFD considers a probabilistic approach and allows for the possibility of assessing the level of risk associated with a given design. There is a need for the bridge scour engineer to have the option of performing scour calculations using probabilistic methods so that risk can be more appropriately assessed and the option of something other than the most conservative design considered.

Current practice for determining the total scour prism at a bridge crossing involves the calculation of various scour components (e.g., pier scour, abutment scour, contraction scour, and long-term channel changes). Using the principle of superposition, the components are considered additive and the scour prism then is drawn as a single line for each frequency flood event (e.g., 50-year, 100-year and 500-year flood events). This approach does not provide an indication of the uncertainty involved in the computation of any of the additive components. Uncertainties in hydrologic and hydraulic models and the resulting uncertainty of relevant inputs (e.g., design discharge, flow duration, velocity, depth, flow direction, etc.) to the scour calculations will have a significant influence on scour prediction.

To develop an overall estimate of confidence in the estimated scour magnitude, one must examine the level of confidence associated with the results of the hydrologic analysis (design discharges, flow duration, etc.), the level of confidence associated with the hydraulic analysis (depths, velocities, flow direction, etc.), and the level of confidence associated with the scour estimates (pier, abutment, contraction, long-term channel changes, etc.). Scour reliability analysis involves quantification of the uncertainties in each of these steps and then combines them in such a way that the overall estimate of confidence is known for the final prediction of scour.

For the hydrologic analysis component, the desired end product could result in a probability density function (PDF) of the peak discharge. This can be done by examination of the flood flow frequency curve developed from gage records. If no gage records are available and regional regression equations are used, levels of confidence based on the results of the statistical analysis used to develop the regression equations can be used. If a single or lumped-parameter hydrologic model is used, important parameters could be identified, a PDF developed for these parameters, and a Monte Carlo

simulation of these parameters could be performed to obtain the PDF of the peak discharge. The same can be performed for the hydraulic model except that the PDFs of the relevant hydraulic parameters would be developed using Monte Carlo simulations.

Current practice provides an estimate of scour based on the hydrologic and hydraulic conditions associated with a specified design event (a 100- or 500-year flood, for example). The scour equations are generally understood to be conservative in nature, and have been developed as “envelope” curves for use in design. The research objective is to develop a methodology that can be used in calculating bridge scour so that the scour estimate can be linked to a probability; for example, there is a 95.0% probability that the maximum scour will be 8.3 feet or less over the life of the bridge.

To achieve this objective, at a minimum the following tasks must be performed:

1. *Review of existing knowledge*: Some work along these lines has already been done in the area of hydrologic and hydraulic analysis. Relating the uncertainty associated with the hydrologic and hydraulic analysis to the uncertainty associated with the scour estimation techniques needs to be performed. Other disciplines where risk and reliability approaches are being integrated into engineering design also should be explored and documented by the research team.
2. *Identify uncertainties*: This task will consist of identifying and evaluating the parameters associated with each of the various components (hydrology, hydraulics, and scour).
3. *Formulate the methodology*: This task will consist of combining the uncertainty associated with each of the various components (hydrology, hydraulics, and scour) into a procedure to use for scour prediction. The results of this task will ultimately lead to a probabilistic method to compute and evaluate bridge scour that will be consistent with LRFD approaches used by structural and geotechnical engineers.
4. *Proof of concept*: This task will consist of validating the methodology against data sets where variability in measured scour has been quantified. The new methodology must be demonstrated to be consistent with probabilistic

approaches currently used by bridge structural and geotechnical engineers.

5. *Final Report*: The final report will be written in two parts. The first part will document the research performed to arrive at the methodology. The second part will be written in the form of a manual that provides design guidelines for practitioners in the field of bridge scour calculation.

Currently scour estimates at bridge foundations use the best available technology, but are still roundly criticized as being overly conservative. The most common complaint is that the equations that were developed under laboratory conditions don't fit conditions at the site. Often this results in deeper foundations than necessary which leads to more costly bridge designs, which can stress already overloaded state department of Transportation budgets for bridge replacement and repair. Bridge designers and engineers are in need of a tool to make cost versus reliability tradeoff decisions with respect to scour and foundation design. A reliability-based design procedure for estimating scour at bridges will provide a consistent methodology for making decisions on design scour depth based on calculated risk instead of estimates which can be overly conservative.

The pay-off is a scour estimate that will be more reliable in that it will be tied to a selected level of reliability that can be effectively communicated to the public. This type of approach will help alleviate over-conservatism in bridge design inconsistent with accepted target risk levels.

◆ Project 25-32

Enhanced Stormwater Treatment BMPs in Highly Urbanized Areas

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

Starting in the late 1980s, efforts to address polluted runoff have increased significantly, and the requirements for treating the runoff also have gotten more stringent. Not long ago, most highway runoff could be treated using a few simple treatment methods such as bioswales, wet ponds, or vegetated filter

strips. However, lately the treatment requirements have been shifting to include the removal of dissolved metals. In Washington State, besides oil and phosphorous control, there are two significant groups of Best Management Practices (BMP), these are basic treatment BMPs and enhanced treatment BMPs. The basic treatment BMPs target the total suspended solids (TSS), and enhanced treatment BMPs not only target the TSS, but also the removal of dissolved metals. While the specific requirements for removing metals may be different from one state to another, there is a trend nationwide that dissolved metals in stormwater is becoming more of a concern to the regulatory agencies, particularly in highly urbanized areas where traffic volumes are high and treatment options are limited.

The current available and approved enhanced treatment BMPs that are effective in removing dissolved metals include the following: media filter drains (previously known as ecology embankment), compost-amended vegetated filter strips (CAVFS), constructed stormwater treatment wetland, sand filtration treatment BMP (amended or large sand filter), two facility Treatment trains, and bioretention. In highly urbanized areas, the ability to utilize these current BMPs is limited significantly by the lack of available space.

The objective of this project is to develop one or more enhanced treatment BMPs that could be used in highly urbanized areas. Task would include the following:

1. Gather all available information and the facts about enhanced treatment BMPs through literature review and talking to other researchers, stormwater treatment vendors, and professors in universities and other public agencies such as department of transportation from other states. The gathered information could be the available technologies to remove dissolved metals in stormwater, BMPs that could be used in highly urbanized areas, the pros and cons for each BMPs, maintenance concerns, etc. The approving authority agencies would be involved during the developing process to get early buy-in. Timeframe: 3 months to 6 months.
2. Come up with one or more practical enhanced treatment BMPs potentially that could be used in highly urbanized areas. Various tests will be done in the labs to validate the conceptual de-

signs. Mini models would be built to test the conceptual designs. Seek conceptual approval from appropriate agencies such as Washington State Department of Ecology. Timeframe: 6 months to 12 months.

3. If the conceptual designs work and the lab tests validate the design theories, the full scale models would be tested in situ. Timeframe: 1 year to 3 years.

The proposed BMPs could have small footprints that could be easily installed under the sidewalks. Low impact development (LID) would be considered in the development process; in this regard, landscape areas in the median or between the curbs and the sidewalks would be considered to see if the landscape areas can be utilized as part of the treatment mechanism. The BMPs would likely remove the sediments and dissolved metals by using gravity feed, filter systems and uptake by plants. To achieve a small footprint, a highly effective filter will be essential. The more effective the filter, the greater the pollutant decrease, resulting in a smaller footprint requirement compared to other less effective filter systems. The targets for enhanced treatment BMPs are the removal of 80% or more of total suspended solids (TSS) and the ability to provide a significantly higher rate of removal of dissolved metals than basic treatment BMPs for influent concentrations ranging from 0.003 to 0.02 mg/L for dissolved copper and 0.02 to 0.3 mg/L for dissolved zinc. Long term operation and maintenance costs would be considered during the BMP's development.

◆ **Project 25-33**
Evaluation of the Methodologies for Visual Impact Assessments

Research Field: Transportation Planning
Source: California, Rhode Island

Allocation: \$100,000 (Additional \$100,000 from Federal Highway Administration)
NCHRP Staff: Nanda Srinivasan

National Environmental Protection Act (NEPA) requires that visual impacts be considered for highway improvement projects. To assist State Departments of Transportation (DOTs), the FHWA developed *Visual Impact Assessment for Highway Projects* in 1981 to provide guidance in analyzing and quantifying visual impacts for highway proposals. This is the standard methodology used throughout the country to identify visual impacts for highway improvements. The guidance is over 27 years old and has not been evaluated for effectiveness, nor have any substantial updates been made. As a result, some DOTs have modified this methodology to meet their needs. This implies that the FHWA methodology may no longer be effective in meeting NEPA requirements for the protection of scenic quality. To understand the value of the current FHWA guidance and to justify the substantial resources needed to prepare visual impact assessments, there is a critical need to understand the usefulness of the guidance as an effective environmental assessment tool for evaluating scenic impacts of highway design. Research on this topic could provide recommendations for updating the current FHWA visual analysis guidance, benefiting DOTs nationwide by streamlining the methodology.

Using accepted research methods, a consultant would survey DOTs to determine applicability and effectiveness of the FHWA visual analysis process in assessing visual impacts for highway projects. Research would determine if the FHWA methodology is still being used, has been modified, or if the DOTs have adopted their own approach. The project would include an examination of 50 to 75 highway projects of different sizes across the country to determine if the visual impact studies were instrumental in protecting scenic resources identified in the environmental reports.