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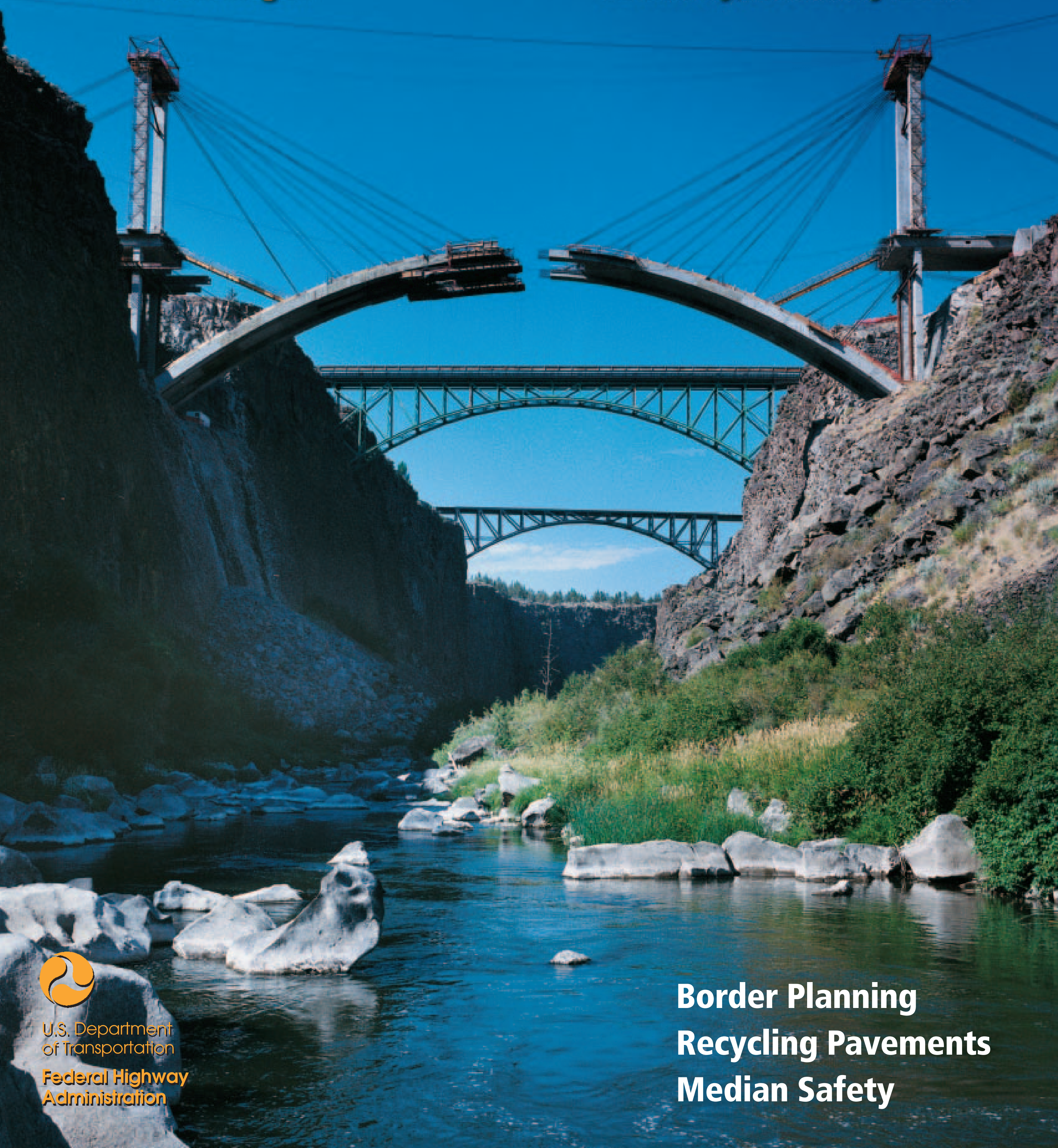
January/February 2005



Border Planning

Recycling Pavements

Median Safety

U.S. Department of Transportation

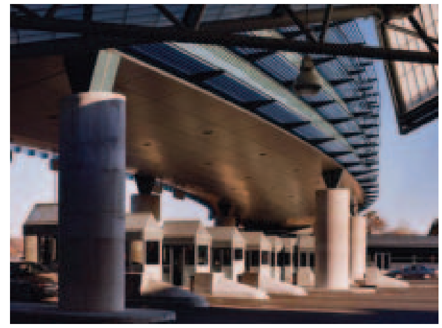
Federal Highway Administration

Public Roads

January/February 2005 www.tfhrc.gov Vol. 68, No.4

—featuring developments in Federal highway policies, programs, and research and technology—

Articles



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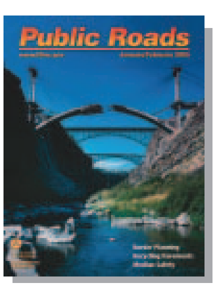

Front cover—In 2002, increasing traffic on U.S. Highway 97 prompted the Oregon Department of Transportation (ODOT) to build the new Rex T. Barber Veterans Memorial Bridge (foreground) as a replacement for the 79-year-old High Bridge. The new structure, built using cast-in-place segmental methods, has a slender profile to help preserve the dramatic view of the Crooked River Gorge 92 meters (300 feet) below. ODOT retained the older bridge as a pedestrian crossing, enabling visitors to enjoy the view of the gorge on foot. The third bridge (in the background) is a historic railroad bridge. *Photo: ODOT.*

Back cover—The Federal Highway Administration's Eastern Federal Lands Highway Division along with the Arkansas State Highway and Transportation Department upgraded this section of Forest Highway 65 in the Ozark-St. Francis National Forest in Arkansas to accommodate increased traffic while protecting the area's natural features. The stone retaining wall, shown here, was built using mechanically stabilized earth and faced with locally quarried stone. The natural materials enhance the view for canoeists paddling the Mulberry River. *Photo: Eastern Federal Lands Highway Division.*

Thanks to the Kentucky LTAP Center for providing the center photo used in the advertisement on the inside back cover.

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Guest Editorial

Vital Borders and Transportation Impacts

The United States' borders with Mexico and Canada are more than just lines on a map. The border regions represent dynamic links between the people of the United States and our neighbors in a strong and vibrant network of trade, and cultural, social, and institutional relationships. As a transportation official, I recognize the expected growth of these links as a result of the North American Free Trade Agreement. Yet I am amazed by the sheer size and impact these links have on personal lives and on business.

More than 12 million Mexicans and Americans live in the counties, towns, and cities adjacent to the border that stretches from the Pacific Ocean to the Gulf of Mexico. Every year, some 350 million people legally cross to and from the United States and Mexico, and more than 200 million people cross the U.S.-Canadian border to share knowledge and culture, to work and play, and to visit family and friends.

Every day, the United States and Canada trade more than $1 billion in goods and services ($394 billion total in 2003)—more than any other two nations in the world. In fact, trade between the United States and Canada is greater than that of the United States and all 15 European Union countries combined! The United States and Canada represent barely 5 percent of the world's population, yet more than a third of the world's gross domestic product.

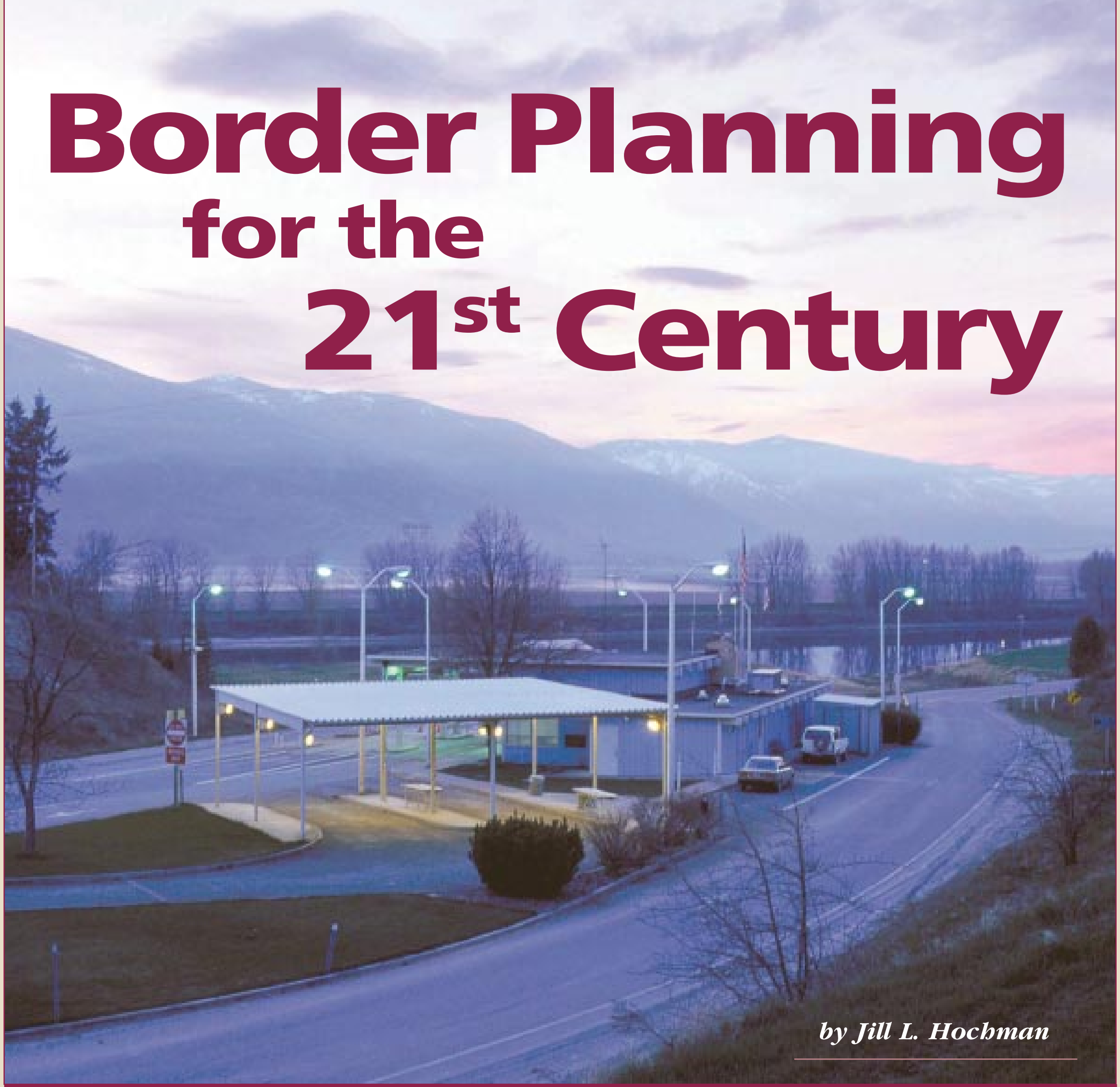
In 1999, the United States' other neighbor, Mexico, surpassed Japan as the United States' second-largest trading partner and has remained in this position ever since. The total U.S.-Mexico trade exceeded $235 billion in 2003—about $500,000 a minute.

When countries trade at the volumes that Mexico, Canada, and the United States do, when people travel across borders in the numbers that they do, and when goods and services cross borders with such frequency, the transportation and border inspection systems need to work well together, not only to maintain security but also to maximize the efficient flow of people and goods. The Federal Highway Administration (FHWA) works in close collaboration with the U.S. Departments of Homeland Security and State, the General Services Administration, the Government of Mexico and its States, the Federal Government of Canada and Canadian Provinces, U.S. border States, and many others to identify issues and implement solutions, including increased capacity, operational improvements, border intelligent transportation systems, innovative financing, and preclearance procedures, to highlight just a few.

The challenge is to meet transportation and security needs promptly before these matters can weaken the economy and U.S. security. With the heightened focus on U.S. land borders, FHWA has been working diligently with Federal, State, and local partners to maximize the efficiency, security, and safety of the Nation's transportation system. By recognizing that U.S. land ports of entry are not islands, but rather integral parts of America's transportation system, the transportation community can fully meet our national need to ensure a strong America.

Cynthia J. Burbank
Associate Administrator for Planning, Environment, and Realty
Federal Highway Administration

Border Planning for the 21st Century



by Jill L. Hochman

Multiagency partnerships, innovative strategies, and new technologies are improving the safety, efficiency, and security of overland ports of entry.

Growing travel and trade between the United States and its neighbors, Canada and Mexico, make border crossings a key contributor to the Nation's economic health. A snapshot of recent statistics tells the story: According to the North American Transportation Statistics database, the United States traded $629 billion in goods with Canada and Mexico in 2003, with trucks carrying 64 percent of that freight.

(Above) One of only two land ports of entry in Idaho, Porthill (shown here at dusk) is a permit port, which means that importations of cargo must be approved in advance by the service port at Great Falls. *Photo: General Services Administration.*

Truck crossings at the U.S.-Canada border reached 13.3 million, and truck crossings from Mexico into the United States reached 4.2 million in 2003. The value of freight shipments moving between the United Sates and Canada and Mexico has risen 170 percent since 1990, growing at an average rate of almost 8 percent a year.

In addition, data from the U.S. Department of Transportation's (USDOT) Bureau of Transportation Statistics show that about 80 percent of passenger vehicle trips across the borders with Canada and Mexico involve same-day travel to take part in everyday activities, such as commuting to jobs, shopping, visiting family and friends, and accessing health care.

Recognizing the value of cross-border travel and trade, the Federal Highway Administration (FHWA) is involved in a number of initiatives with its State, Federal, and international partners to address the challenges of improving mobility and security at overland border crossings.

"Canada and Mexico are the Nation's top two trading partners, so the U.S. borders with Canada and Mexico represent a vital aspect of the U.S. economy," says FHWA Associate Administrator for Planning, Environment, and Realty Cynthia Burbank. "Improving the way we communicate and plan for changes that will take place at the U.S. land ports of entry is one of the most important challenges FHWA and its transportation partners face."

With its counterparts in Mexico and Canada, FHWA created joint working groups that cooperate on planning and facilitating cross-border movements. In addition, FHWA is involved in initiatives with other agencies and organizations to share technologies, streamline the movement of cargo trucks across borders, adopt innovative tools to plan border-crossing improvements, create frameworks that enable key technologies to work together, and measure success in achieving objectives in global connectivity.

"As increasing traffic and new security protocols make it more expensive and complicated to move across borders, it's critical that we work closely with our partners to facilitate a more efficient transportation system," Burbank says. "We may each have different interests and points of view, but we share common goals. The jigsaw puzzle doesn't get completed unless everyone works together."

Cooperation on the Southern Border

The 1994 North American Free Trade Agreement (NAFTA) eliminated many trade barriers between the United States and its neighbors. Spurred by the ratification of NAFTA and increasing traffic at border crossings, USDOT identified the need for a mechanism to address binational transportation issues with Mexico's Secretariat of Communications and Transportation (SCT). A 1994 memorandum of understanding between the two countries established a Joint Working Committee (JWC) to coordinate planning and programming of intermodal projects along the U.S.-Mexico border.

The JWC's primary focus is to plan overland transportation and facilitate efficient, safe, and economical cross-border movement of people and goods. Its goals include promoting effective communication between the national governments and border States, developing coordinated plans for land transportation, and evaluating current and future impacts of traffic demand on transportation infrastructure.

The committee's members include FHWA, SCT, the U.S. Department of State, the Mexican Ministry of Foreign Affairs, and departments of transportation (DOTs) for the 10 U.S. and Mexican States on both sides of the border. The committee meets twice a year, once in each country.

One of the JWC's first major accomplishments was a jointly funded, binational study completed in 1998. The study looked at the two countries' border transportation infrastructure, trade flow processes for commercial vehicles, transportation planning processes, and ability to handle expanding trade flow across the border. A key product of the study is a databank, maintained by FHWA and the Mexican Transportation Institute, containing information on trade and traffic flows at ports of entry, socioeconomic data for border areas, and existing and planned border infrastructure improvements. The databank is available on the Web at www.fhwa.dot.gov/binational/databank/data.html.

A new memorandum of understanding signed in 2000 reinforced the importance of the JWC and identified key topics for the committee to work on. One project evaluated the infrastructure needs of the 42 major transportation corridors in the border region and identified 311 significant transportation projects, 258 in the United States and 53 in Mexico, to meet those needs. The project developed a systematic approach for assessing transportation infrastructure needs that can be used in future assessments, as well as an evaluation tool that States can use to prioritize transportation corridor needs.

In an ongoing effort, the committee is looking at financing tools available for transborder projects from USDOT, SCT, States, municipalities, binational agencies such as the North American Development Bank, and international agencies such as the World Bank. The group created an inventory of financing options and is developing workshops on border finance aimed at State and local transportation and finance officials. Another study is analyzing short-term, low-cost ways to solve road infrastructure and traffic management bottlenecks that slow the movement of people and goods at the U.S.-Mexico border. The objective is to develop a methodology for conducting consistent analyses of bottlenecks along the entire border.

Communicating on Northern Border Issues

Growing trade and traffic flows, the resulting border delays, and increasing interest in developing interoperable transportation systems also led U.S. officials to establish a formal agreement with their Canadian counterparts. In 2000, the United States and Canada signed a memorandum

California Department of Transportation

San Ysidro, CA, (shown here from above) is home to the world's busiest land border crossing, where U.S. Interstate 5 crosses into Mexico at Tijuana, Mexico. Each year, more than 14 million vehicles and 40 million people enter the United States at San Ysidro.

General Services Administration

Skagway Port of Entry, Skagway, AK.

of cooperation highlighting the importance of coordination between the two countries on transportation along their shared border. The memorandum cited a need for increasing the degree and speed of communication between USDOT and Transport Canada, as well as the need to exchange information on border transportation issues of mutual concern.

The U.S.-Canada Transportation Border Working Group (TBWG) was created to fill that need. When the group first met in Windsor, Ontario, in 2002, the first order of business was to establish a core membership of Federal, State, and Provincial entities from both sides of the border. The members then collaborated on an action plan identifying key priorities, including data collection, border technology programs, and information exchange.

The group meets twice annually, with meetings rotating between the United States and Canada. In addition, subcommittees on data, technology, and communications issues collaborate year-round on projects and initiatives.

"Canada and the United States share the largest bilateral trading relationship in the world. It is essential, therefore, that the United States and Canada collaborate closely on border issues to ensure the safe and efficient flow of people and goods between our two countries," says Paul Arvanitidis, senior policy advisor for Transport Canada. "The opportunity to meet regularly and work with a network of representatives from all border jurisdictions, including customs agencies and other federal players, is invaluable for advancing our border initiatives."

Although the membership includes primarily government entities, the TBWG works with other partners on border transportation issues, including metropolitan planning organizations, chambers of commerce, stakeholder coalitions, and the private sector. U.S. agencies participating include FHWA, State DOTs along the border, Customs and Border Protection (CBP), the U.S. Department of State, and the General Services Administration (GSA). Canadian participants include Transport Canada, Provincial and territorial governments, Foreign Affairs Canada, the Canada Border Services Agency, and the Canadian Food Inspection Agency.

In one TBWG effort, the New York State DOT led a committee to develop the report, *Border Infrastructure Compendium 2003 and Beyond*. The compendium includes descriptions of ownership, physical layout, and annual traffic and trade for the ports of entry, as well as detailed information on current or planned projects in support of border crossings.

The study showed that 224 projects have been proposed to improve infrastructure and inspection operations at or near the U.S.-Canada border at an estimated cost of $13.4 billion. The TBWG plans to update the compendium periodically and use it to facilitate interagency planning, coordination, and funding efforts.

FHWA spearheaded a TBWG effort to create a *Northern Border Noteworthy Practices Reference Guide*, a Web-based compilation of best practices for facilitating the movement of goods and people across the border. The guide describes approaches used by Federal, State, and local agencies in conducting day-to-day border activities.

The following are among the best practices included in the guide:

- Installing trailers that detect vehicle backups at border crossing locations. Upon detecting a queue, the system automatically activates portable variable message signs that display preprogrammed messages to alert motorists approaching border crossings to expect delays.
- Providing a booklet for commercial drivers explaining what they need in the way of forms and documents for crossing the U.S.-Canadian border. Many long-haul drivers cross the borders infrequently, and such a document enables drivers to familiarize themselves with the layout of a port and check their documentation before arrival.
- Holding classes once a month to familiarize truck drivers with policies and procedures at the border. In Alexandria Bay, NY, the training has decreased the timeframe for releasing cargo.

The guide is available on the Web

Blue Water Bridge Authority

Trucks cross the Blue Water Bridge over the St. Clair River, connecting the communities of Port Edward/Sarnia, Ontario, to Port Huron, MI.

A hand-operated ferry crosses the Rio Grande River at Los Ebanos, TX. The small facility, located in the southwestern corner of Hidalgo County, TX, about 5 kilometers (3 miles) south of Expressway 83, was an ancient ford used by American Indians and early Spanish colonists in the late 17th century. Today the facility processes noncommercial and pedestrian traffic, carrying around 3,350 cars and 8,500 pedestrians yearly.

John W. Mayes, General Services Administration

at www.fhwa.dot.gov/uscanada/studies/notewrthy_prac/index.htm.

Also through the TBWG, Transport Canada, together with Provincial and interested State partners, is pursuing a national roadside survey of heavy truck data. "The survey will be a critical source of information for deciding what future transportation infrastructure investments Canada will pursue at the border," adds Arvanitidis.

Sharing Technology Across Borders

A partnership that complements the work of the JWC and TBWG is the Border Technology Exchange Program (BTEP), which FHWA initiated to provide opportunities for sharing information and technology among the U.S. border States and their counterparts in Mexico and Canada. Its mission is to enhance the knowledge and skill of transportation personnel in the border regions through the exchange of technology, information, and technical training to facilitate the safe, efficient, and secure movement of people and goods.

"FHWA has worked for years with other countries on technology exchange, but the passage of NAFTA provided us with an opportunity to have an entire program devoted to this activity," says Ed Rodriguez, BTEP program manager for FHWA.

The technology exchange program with Mexico, launched in 1994 with FHWA seed money, includes the States of Arizona, California, New Mexico, and Texas. On the Mexican side of the border, the members are Baja California, Chihuahua, Coahuila, Nuevo Leon, Sonora, and Tamaulipas.

Over the past decade, the program has resulted in several technology exchange efforts between U.S. and Mexican States. Highway agencies in California and Baja California, for example, are conducting joint regional planning for transportation facilities. Arizona and Sonora have created a local area network to monitor motor carrier registration and prevent multiple entries. Chihuahua transportation officials have adopted pavement-marking standards from FHWA's *Manual on Uniform Traffic Control Devices* and are using a New Mexico laboratory to validate the content of asphalt additives being used in highway construction.

The program also was the catalyst for the creation of six technology transfer (T2) centers along the U.S.-Mexico border, including one T2 center at a university in each Mexican border State and one in San Diego, CA. The centers serve as hubs to disseminate information such as transportation standards and best practices as well as offer training to transportation professionals and technicians in the latest methods and technologies for highway planning, design, and infrastructure. Both FHWA and the universities provide instructors for the training programs.

"For us, the Border Technology Exchange Program provides access to a country with one of the most highly developed transportation technology systems in the world," says Juan Aviles, engineer on exchange from Mexico, with the Nuevo Leon Border Technology Exchange Program Center. "It also helps us to gain an understanding and develop an excellent working relationship between our countries. Plus, we are able to provide information to our local stakeholders in Mexico."

The BTEP has been so successful on the U.S.-Mexico border that it is now being expanded to include the U.S.-Canada border, where technology exchange programs are underway in Alaska and Washington. In the Alaskan program, transportation officials work closely with their counterparts in Yukon, Canada, on issues that include winter weather construction and rural road maintenance. A chief area of focus is construction and maintenance of the Alaska Highway, a major roadway linking Alaska and the Yukon Territory.

BTEP was designed to create an environment that fosters uniformity and consistency among border States that can improve U.S. motor carrier access and raise the confidence levels of U.S. shippers and other users. But a linchpin of BTEP is its flexibility, says Rodriguez, which enables the program to meet the unique technical needs of the States along the borders.

"The success of the program is evidenced by the fact that it has grown from initial seed money in 1994 to include six technology centers on the U.S.-Mexican border and is now expanding to Canada," says Rodriguez. "Ten years of growth is something to be proud of."

Freight in the FAST Lane

Customs clearance processes for cargo moving across country lines can create bottlenecks for truck traffic at border crossings. The Free and Secure Trade (FAST) program, a joint initiative involving CBP and agencies in Mexico and Canada, offers expedited processing for cross-border truck traffic for importers, carriers, and drivers who satisfy the program's security requirements.

Under the program, shipments for approved companies, transported by approved carriers using registered drivers, are cleared across borders with greater speed. The program also reduces the cost of compliance by minimizing the requirements for

U.S. Customs and Border Protection

Free and Secure Trade (FAST) lanes, such as this one at Port Huron, MI, reduce waiting times at designated border crossings for importers, carriers, and drivers cleared to participate in the program.

customs clearance, eliminating the need for importers to transmit data for each transaction, dedicating lanes for FAST clearances, and verifying trade compliance away from the border.

Dedicated FAST lanes have dramatically reduced processing time for truck shipments, according to Enrique Tamayo, CBP program manager. "Where we have dedicated FAST lanes, a process that used to take 3 to 4 hours now takes minutes," he says. "The program allows us to redirect resources to the trucks we need to be looking at instead of FAST trucks."

FAST participation is open to importers, carriers, and drivers who have a demonstrated history of compliance with all relevant legislation and regulations, and have acceptable books, records, and audit trails. Each application is put through extensive security review.

Border crossings with FAST lanes are equipped with advanced technology to improve efficiency in screening commercial traffic. Antennas, for example, read small transponders attached to the windshield of each truck identified by an importer as a participant in the program, enabling customs officials to access computerized information on the truck quickly.

CBP expanded the program recently by opening designated FAST lanes in San Diego, CA; Port Huron, MI; El Paso, Laredo, and Pharr, TX; and Blaine, WA. FAST lanes operate at additional border crossings in Michigan, Montana, New York, North Dakota, Vermont, and Washington State.

In addition, CBP coordinates with State DOTs and agencies in Mexico and Canada to develop exclusive routes to expedite trucks to FAST lanes at border crossings. "The California DOT helped us construct an additional lane for the new San Diego crossing," says Tamayo.

For more information on the FAST program, visit www.cbp.gov/xp/cgov/import/commercial_enforcement/ctpat/fast.

Modeling Movements With Border Wizard

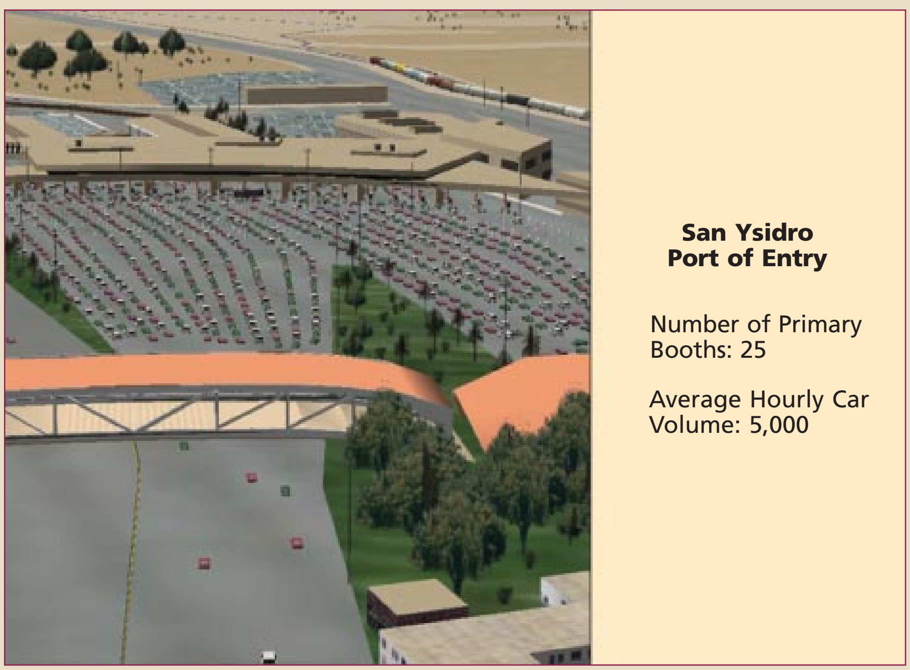
Increasing traffic volumes and delays in processing commercial vehicles have led to significant congestion at U.S. border crossings with Canada and Mexico. In addition, a new national emphasis on security calls for more efficient and secure border crossings.

Coordinating improvements to ports of entry can be a challenge for U.S. agencies involved in border activities. Therefore, FHWA, in conjunction with GSA, CBP, and Immigration and Customs Enforcement (ICE), developed a tool called Border Wizard to coordinate improvements to border crossings that increase security, traffic throughput, and trade efficiency. Border Wizard, available from GSA, is on FHWA's list of priority technologies and innovations that have proven benefits and are ready for deployment.

Border Wizard is a computer-based model that simulates cross-border movements of automobiles, buses, trucks, and pedestrians. It can simulate all Federal inspection activities—including customs, immigration, motor carrier, and security procedures—at any land border crossing to determine infrastructure, facility, and operational needs to ensure safe and secure operations.

"The primary benefit of Border Wizard is the ability for everybody to see the same picture, so improvements to border crossings are based on a model instead of a best guess," says Sylvia Grijalva, a community planner in the FHWA Office of Interstate and Border Planning.

The program also is designed to work with other traffic modeling and planning tools used by States



Regal Decision Systems, Inc.

Border Wizard is a computer-based tool that simulates cross-border movements. This screen grab from the program includes a computer-generated model showing the specific port of entry and summarizes the number of booths and average hourly car volume.

and metropolitan planning organizations. In fact, FHWA is sponsoring a series of case studies to assess the feasibility and effectiveness of Border Wizard as an integrated tool for transportation planning purposes.

The case studies involve organizations in four locations—El Paso, TX; San Diego, CA; Whatcom County, WA; and southeast Michigan—that are documenting their use of Border Wizard as part of their transportation planning processes. In coordination with the Border Station Partnership Council, which consists of the four agencies that developed Border Wizard, FHWA will use data from the studies to leverage the tool to enhance transportation planning.

CBP has used Border Wizard to evaluate proposed inspection methods and routing in commercial operations at both northern and southern border stations. In addition, ICE now collects data at all major border stations in preparation for using Border Wizard to evaluate inbound and outbound inspection operations and assess the impacts of security changes at U.S. borders.

In the future, FHWA expects that Border Wizard will enable users to run studies on multiple border stations simultaneously and compare their effects on each other. These studies will be useful in analyzing proposed border station development and in determining when an area will reach capacity and require a new border station to be built.

Creating an Information Architecture

Although installing new technologies offers the promise of improved efficiency, if the systems used by the various agencies are not compatible, the upgrades could prove counterproductive instead.

"Many agencies are planning or implementing technology and information systems to help them accomplish their work," says Crystal Jones, transportation specialist in the FHWA Office of Freight Management and Operations. "But lack of coordination and collaboration among these various agencies could result in the deployment of technology that is not interoperable, is redundant, or is an impediment to efficient operations."

To eliminate problems with interoperability, the United States and its neighbors are collaborating to develop information architectures that promote data sharing and coordination among the multiple agencies that operate at border crossings, as well as to increase the interoperability of technologies used to support their operations. An *architecture* is the communications and information backbone that supports and unites key technologies, enabling them to work together and communicate with each other. It describes the interaction among various physical components of the transportation system, such as travelers, vehicles, sensors, databases, and control centers.

The architecture does not dictate which technologies agencies must use, but it helps them ensure that the technologies they choose are interoperable with other systems, making them easier to upgrade and cheaper to produce and use. The architecture is not a strategy or plan, but a tool for planning the integration of systems at the border.

The Smart Border Declaration signed by the United States and Canada in December 2001 included a 30-point action plan to enhance the security of the U.S.-Canada border while facilitating the legitimate flow of people and goods. One action item called on the United States and Canada to ensure the interoperability of their technologies.

As part of the U.S.-Canada TBWG, FHWA and Transport Canada are spearheading a Border Flow Information Architecture initiative to support the deployment of interoperable technologies. A working group established in February 2004 and composed of representatives from agencies involved in processes at or near the border is coordinating the effort in the north. Since then, FHWA expanded the effort to include an initiative under the JWC aimed at developing an architecture for technologies used on the U.S.-Mexico border.

The initiatives are building frameworks for operations on both borders that depict the flow of information between government agencies and components of the transportation system as they relate to border processes, such as the flow of advanced traveler information from inspection and enforcement agencies to transportation organizations.

"The U.S.-Mexico and U.S.-Canada products will be similar, but they will focus on the specific operational needs of each border," Jones says.

Measuring Our Progress Toward Global Connectivity

One of FHWA's strategic objectives is global connectivity, which is aimed at facilitating a more efficient global transportation system that enables economic growth and development. As part of its efforts to meet that

Photo copyright: Robert Reck

The port of entry at Calexico, CA, is shown here at dusk. Located 200 kilometers (125 miles) east of San Diego, the building features glass-fiber tensile roof structures reminiscent of the tents and covered wagons that once characterized the region.

Photo copyright: Michael Moran

View of U.S. Customs and Border Protection Building and Inspection Booths, Niagara Falls, NY. Built in 1941, Rainbow Bridge is one of the busiest ports of entry into the United States. The bridge is operated by the Niagara Falls Bridge Commission and leased to the General Services Administration.

objective, FHWA identified travel time variability and border crossing delays as potential key indicators of performance for the transportation system.

Low variability in travel times enables freight carriers to get goods to market according to more predictable schedules, which is an important factor in determining how the carriers allocate resources. Delays result in economic, environmental, social, and governmental costs to border communities, passengers in automobiles and trains, importers and exporters, shippers, and public agencies.

FHWA is leading an initiative to establish performance measures for travel time reliability on freight-significant corridors, such as interstates, and delay times at border crossings. Performance measures tell public officials and citizens in a quantitative way how well services are meeting customer needs.

FHWA has begun collecting travel time data for freight-significant corridors, including Interstates 5, 70, 65, 45, and 10. The initiative uses private sector data collected from tracking and communications technologies, such as satellites, that a number of trucking firms already use to manage inventory.

"We are attempting to use technologies that commercial carriers already have in place to calculate average speeds and travel times that we can use in developing performance measures," Jones says.

Next steps will focus on developing performance measures for delay at four U.S.-Canadian border crossings. The technologies that will be used to gather data on crossing times have not yet been chosen, but one avenue under consideration is using commercial vehicles as probes.

Partnerships For Progress

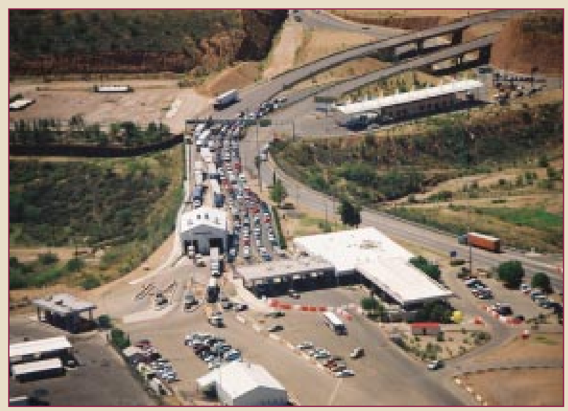
To meet the growing challenge of transportation issues on the Nation's borders, FHWA created a land border team that includes representatives from the FHWA Office of Planning, Environment, and Realty; Office of Interstate and Border Planning; Office of Freight Management and Operations, and division offices.

"Organizationally, we recognize how complex these issues are, so we've created a virtual team from throughout FHWA to work with our partners to address them," says Burbank. "Whether it's by enhancing operations, building infrastructure, or developing intelligent transportation systems and safety facilities, FHWA's role is to make sure we keep people and commerce moving efficiently across our borders."

By creating partnerships to deploy innovative technologies and strategies to expedite border crossings, transportation and other agencies involved in border operations are working to facilitate trade and travel throughout North America. Through innovative efforts such as the U.S.-Mexico JWC and the U.S.-Canada TBWG, government agencies and other partners are cooperating on binational transportation issues, evaluating current and future demands, and sharing the latest technologies. New technologies such as Border Wizard and initiatives to develop information flow architectures and performance measures are helping agencies plan and coordinate their efforts more efficiently and cost effectively.

"By working together on these issues, we're not focusing just on the needs of individual countries, but looking at how we can enhance the movement of people and goods throughout North America," says Burbank. "FHWA's commitment to this effort will continue to grow as NAFTA brings our countries even closer together."

Jill L. Hochman, director of the FHWA Office of Interstate and Border Planning, created and cochairs the TBWG with Transport Canada to address binational issues related to the northern U.S. border. Among her responsibilities include directing the FHWA borders and corridors programs, spearheading FHWA's safety conscious planning efforts (a proactive approach to considering safety in transportation planning), and directing improvements to travel demand forecasting and modeling, along with land border communication and coordination. A University of Maryland graduate and long-time employee of USDOT, Hochman worked for the Office of the Secretary of Transportation, Federal Railroad Administration, and U.S. Coast Guard before joining FHWA in 1987.



Arizona DOT

The Mariposa border crossing at Nogales, AZ, (shown in this aerial photo) is Arizona's largest commercial port of entry, with a 96-percent increase in exports and imports between 1994 and 2000.

For more information on transportation planning on the U.S.-Canada border, visit www.fhwa.dot.gov /uscanada/index.htm. For more information on U.S.-Mexico border planning, go to www.fhwa.dot.gov /binational/index.html.

Recycled Roadways

by Jason Harrington

FHWA and the agency's partners are engineering high-quality pavements using reclaimed materials.

Today more than ever before, demands are being placed on the transportation community to find high-quality materials to renew and restore America's highways. Finding available high-quality aggregates has become a significant challenge in many areas of the United States. Because aggregates and paving asphalt are nonrenewable materials, the supply is limited. The United States produces 1.8 billion metric tons (2 billion tons) of aggregate annually. In response to increased demand, aggregate production is expected to increase to 2.3 billion metric tons (2.5 billion tons) by the year 2020—a statistic that raises concerns about the pace at which virgin aggregate is being consumed.

(Above) Reclaimed asphalt pavement (RAP) is being processed at this crushing plant.

The Federal Highway Administration (FHWA), charged with stewardship of the Federal-aid highway program and environmental quality, has created a national policy on recycling and a team to assist the transportation community. In the March 2002 Administrator's Memo on FHWA Recycled Materials Policy, FHWA's Executive Director Frederick G. Wright, Jr., wrote, "The same materials used to build the original highway system can be reused to repair, reconstruct, and maintain [it]. Where appropriate, recycling of aggregates and other highway construction materials makes sound economic, environmental, and engineering sense. The economic benefits from the reuse of nonrenewable highway materials can provide a great boost to the highway industry. Recycling highway construction materials can be a cost-saving measure, freeing funds for additional highway construction, rehabilitation, preservation, or maintenance."

The memo continued, "Recycling presents environmental opportunities and challenges, which, when appropriately addressed, can maximize the benefits of reuse. The use of most recycled materials poses no threat or danger to the air, soil, or water. Furthermore, careful design, engineering, and application of recycled materials can reduce or eliminate the need to search for and extract new, virgin materials from the land."

Applying sound recycling principles that protect the environment, the FHWA Recycling Team is helping industry reclaim materials like asphalt and concrete pavement, foundry sand, scrap tires, and roofing shingles into new highway materials while conserving the Nation's natural resources.

The FHWA Recycling Team, working with the Recycled Materials Resource Center (RMRC) at the University of New Hampshire and others, finds appropriate highway

The Recycling Team

The University of New Hampshire's Recycled Materials Resource Center (RMRC)—a strong partner of FHWA's Recycling Team—was formed to provide leadership, direction, and technical guidance for appropriate and environmentally friendly use of recycled materials in the highway system. "RMRC is a partnership between FHWA and the University of New Hampshire to promote the wise use of recycled materials," says Dr. T. Taylor Eighmy, RMRC director and research professor of civil engineering. RMRC provides the research to determine the long-term physical and environmental performance of recycled materials.

The Recycling Team is guided by the five tenets of FHWA's policy on recycling:

1. Recycling and reuse can offer engineering, economic, and environmental benefits.
2. Recycled materials should receive first consideration in materials selection.
3. Selection of recycled materials should include an initial review of engineering and environmental suitability.
4. Assessment of economic benefits should follow next in the selection process.
5. Restrictions that prohibit the use of recycled materials without technical basis should be removed from specifications.

FHWA's longstanding position has been that any material used in highway or bridge construction, whether virgin or recycled, should not adversely affect the environment or the transportation system's performance and safety. Through technology transfer, information collection and synthesis, outreach, and training, the Recycling Team endeavors to remove barriers to recycling and acts as a catalyst for promoting the use of recycled materials.

RMRC's Web site (www.rmrc.unh.edu), plus workshops like the one held in September 2004 for 11 northeastern States and reports such as the comprehensive online *User Guidelines for Waste and Byproduct Materials in Pavement Construction* provide resource information for engineers and program managers interested in increasing recycling efforts in their areas.

"An opportunity exists to reclaim the inherent value in existing road materials and to use them again in road rehabilitation," says RMRC's Eighmy. "Such opportunities can make our Nation's highways much more sustainable."

applications for byproducts that are not used by the industry that produced them, thus keeping those materials out of the waste stream. Additionally, the team recognizes that some recyclable aggregates are already being used successfully in existing highways and bridges. "To derive all of the value from the original materials," says Dr. Constance M. Hill, FHWA environmental protection specialist, "why *not* use these best performing materials again? The more we recycle today, the fewer environmental impacts we will have in the future. Recycling is not only environmentally friendly but can be economically viable as well."

Cost Savings

In some cases, the addition of industrial byproducts may enable bridge decks and structures to last about 75 to 100 years, which is many years more than current lifespans. Penn State researchers credit byproducts with helping to lengthen bridge deck lifespans, for example, because the added material reduces the permeability of concrete, deters salts from entering the concrete, and increases electrical resistance. Pennsylvania is planning to construct 10 bridges along Interstate 99 using concrete mixtures containing industrial byproducts such as fly ash, silica fume, ground granulated blast furnace slag, and an alkaline earth mineral admixture. Because water and salt may not reach the steel reinforcement rods in the bridge deck for 40 or 50 years, corrosion could be slowed and lifespan lengthened. Costs for using the new mix designs are similar to those of conventional mixes, but the estimated lifespan increases could provide Pennsylvania with savings of more than $35 million annually.

Indirect cost savings from using recycled materials also add up. Recycling concrete pavement prevents the recycled concrete aggregate (RCA) from going into landfills, for example, and, if the recycled material is used locally, can lead to decreased energy consumption and other costs associated with hauling and producing aggregate. In cities like Houston, TX, where the demand for new concrete is high, RCA is providing a value engineering solution. According to a 2004 FHWA report, all concrete rubble generated in Houston is reused as RCA within the city. This recycling saves time and money when compared with transporting aggregates from distant quarries. Improved air quality due to reduced transportation emissions is a benefit as well.

Asphalt: One of the Top Two Recycled Materials

Sound engineering principles based on research and testing provide detailed information on mix design, performance, and construction specifications to make recycled materials function as required. One goal is the concept of "closing the materials cycle," or using 100 percent recycled materials in road construction.

"The single most recycled material in the world is asphalt," says Byron N. Lord, a program coordinator in FHWA's Office of Infrastructure. According to Lord, "The U.S.

A member of the FHWA Recycling Team examines a recycled concrete aggregate (RCA) sample.

Use of Recycled Materials in U.S. Highways

Byproduct Materials Produced	Production (million metric tons)	Recycled in Highway Applications (million metric tons)	Applications
Blast Furnace Slag	14	12.6	Concrete
Coal Bottom Ash	14.5	4.4	Asphalt, Base
Coal Fly Ash	53.5	14.6	Cement Production, Structural Fill
Foundry Sands	9 to 13.6	?	Flowable Fill, Asphalt
Cement Kiln Dust	12.9	8.3	Stabilizer
Bottom Ash	8	Small Amounts	Asphalt, Base
Nonferrous Slags	8.1	?	Base, Asphalt
Steel Slags	?	7.5	Base, Asphalt, Concrete
Recycled Asphalt Pavement	41	33	Asphalt, Base
Reclaimed Concrete	?	?	Base, Concrete

Note that the use of some recycled materials may not be tracked across the Nation. A question mark indicates that the information is not known.
Source: T. Taylor Eighmy.

highway community recycles more than 81 percent of all asphalt back into highway use."

In fact, reclaimed asphalt pavement (RAP) is most commonly reused as an aggregate for hot-mix asphalt (HMA). During this process, RAP is added as aggregate feedstock at the drum or batch plant, where it is combined with virgin aggregate and asphalt cement to produce new HMA paving mixtures.

In a 1996 report, *Pavement Recycling Executive Summary and Report* (FHWA-SA-95-060), FHWA researchers surveyed States that frequently use RAP in HMA. They found that over a 17-year period, the performance of recycled HMA designed and controlled during production is comparable to conventional HMA and actually can improve the materials properties of the existing pavement layer. Data from the Washington State Department of Transportation (WSDOT) supported this finding. In the late 1970s, WSDOT built two projects using more than 70 percent RAP (very high content, experimental) in the HMA. The two projects were monitored and did not show any unusual signs of mixture aging throughout their service life of 16 years. In comparison, the control sections, which included no RAP, lasted for only 10 years of service.

In the years since RAP first appeared in use, recycling techniques have evolved to create a more consistent and reliable product. In the past, RAP often was crushed but not screened or sized. The resulting recycled product may have been either fine or coarse and contained a varying amount of liquid asphalt.

"That's okay at 10 and 15 percent," says Dr. J. Don Brock, president of Astec Industries, Inc., a Chattanooga, TN, manufacturer of specialized equipment for building and restoring the highway infrastructure, "because it's such a small amount that you can stay within specifications." Adding more recycled material to the mix requires a more consistent recycled product. According to Brock, "When you get up over 20 percent, you need to treat it like any other aggregate. You need to crush it and size it to match whatever size of virgin material that the HMA plant is running."

Brock explains by offering an example of a contractor in Daytona Beach, FL, where rock cost $19 per ton and liquid asphalt was an additional $12 per ton. Staying within specifications enabled use of a maximum of 20 percent of unsized RAP in the mix. Mixes containing sized RAP enabled the contractor to increase the amount of recycled material to 45 percent and still stay within specifications. For this company, which sells 362,800 metric tons (400,000 tons) of product annually, the $7 difference per short ton resulted in $2.8 million in savings.

Today, RAP can be fractionated (separated) and screened. And, like its virgin counterpart, RAP comes in different gradations. "Since RAP usually comes from milling 0.50-inch maximum-sized aggregate surface mix, and by screening the recycle into 0.50 to 0.25 gradation and minus 0.25 gradation, black 78s gradation and black screening can be produced. The 0.50 to 0.25 size screen recycled aggregate contains approximately 3-percent asphalt while the minus 0.25 gradation will contain about 7.5-percent asphalt. If you do it right," says Brock, "recycled product makes an equal, if not better, mix than you would normally get with an all-virgin mix."

Brock points out an added benefit of RAP: In many cases, the liquid asphalt it contains is a better quality than that available today, which is made from a harder crude that contains more liquid oil than its predecessor did in order to soften enough for use. Additionally, if the aggregate is an absorptive material, RAP, which has already gone through the absorption process, produces a better asphalt. This is because old aggregate also might have been a higher quality aggregate than that which is used today.

Creating recycled materials that equal their virgin counterparts has meant making changes to processing, storage, and handling methods. For RAP, the changes include the redesign of plant technology for processing RAP into HMA and the use of drum plants that are capable of increasing the amount of RAP in the mix while staying within specification. Given that the amount of heat energy required during production increases with the proportion of RAP in the mix, some of today's plants use double-barrel mixers that retain more heat than traditional counterflow mixers. According to Brock, "As you superheat the virgin material up to 800 or 900 degrees, the drum shell gets up to 800 or 900 degrees." If the barrel is open, that heat dissipates and more fuel is required. In the double-barrel configuration, a mixer built around the dryer drum minimizes heat loss.

Astec Industries, Inc.

This equipment is used to fractionate (separate) RAP.

"The economics really work," says Brock, who points to the increasing price of aggregate and asphalt. "Recycle is really worth what it replaces," he concludes.

Three versatile methods for in-place recycling of asphalt pavement also have evolved: hot in-place recycling (HIR), cold in-place recycling (CIR), and full-depth recycling (FDR). When compared to the time needed for conventional rehabilitation methods of milling and overlaying with HMA, in-place asphalt recycling processes make it possible to return the roadway to service sooner. All three in-place recycling methods have different uses depending on the depth of repair required.

When shallow repairs are needed, hot in-place recycling can provide an appropriate choice. The HIR process renews a damaged asphalt pavement surface by using heat to soften the existing surface to an approximate depth of 5 centimeters (2 inches). After the pavement is heated, the surface is mixed with a rejuvenator that softens the asphalt, which in turn helps to bind the old paving materials back together to renew the riding surface. Cost figures from Florida, Mississippi, Oregon, and Texas indicate that in comparison to control pavements, HIR offers savings of 17 to 50 percent, depending on whether repaving or remixing is performed.

Deeper pavement recycling uses cold in-place recycling, a process in which the pavement is milled instead of heated and then is mixed with an asphalt binder like foamed asphalt (hot asphalt and cold water combined in a tank to make a foam), emulsion (a suspension of water, oil, and admixtures), or a combination of emulsion, hydrated lime, or portland cement, and laid down as a new pavement. After proper curing to reduce moisture content, a surface treatment or seal coat is applied. CIR can be used to a depth of 13 to 15 centimeters (5 to 6 inches) but is not intended to go into the aggregate subbase. CIR also can incorporate aggregate to change the final materials gradation, resulting in a renewed, stronger base pavement than what was initially in place.

The New Mexico DOT routinely uses CIR as its primary rehabilitation tool. Because CIR avoids the need for milling and hauling the material back as RAP to an asphalt plant, economic savings are realized. According to *Pavement Recycling Guidelines for State and Local Governments* (FHWA-SA-98-042), compared with conventional mill and overlay projects that need maintenance about every 4 years, CIR projects may only require maintenance every 8 years.

When reworking, rebuilding, or removing all of the existing pavement layers as well as some of the aggregate subbase to widen or change the roadway profile, full-depth recycling can provide the appropriate solution. In the FDR rehabilitation method, the full thickness of the asphalt pavement and some of the underlying base or subgrade material is pulverized and blended to provide an upgraded

Hot in-place recycling equipment, shown in these two photos, is frequently referred to as a "train" and typically consists of heaters, heater-millers, a mixing machine, and pavers for HIR or a milling machine, crusher, and paver for CIR.

base material. In Maine, FDR represented a savings of $8.87 per square meter when compared to full conventional reconstruction (excavate, place grade and compact, pave). The Maine DOT is just starting to use FDR with hot foamed asphalt as the primary process to rebuild low-volume road base, in preparation for adding an asphalt riding surface.

Concrete: The Other One Of the Top Two

The *Transportation Applications of Recycled Concrete Aggregate: FHWA State of the Practice National Review* indicates that building demolition in the United States generates an estimated 112 metric tons (123 million tons) of waste per year and helps to create the second most recycled material by weight worldwide: construction debris and recycled concrete. According to the review, recycled concrete can include old portland cement concrete (PCC) pavement, bridge structures/decks, sidewalks, and curbs that are being removed from service. Any steel in the pavement debris must be removed.

Similarly, commercial construction debris used to create recycled concrete aggregate as an aggregate base for highways and buildings construction must be cleaned of unwanted material such as bricks, wood, steel, ceramics, and glass. After the material is crushed, electromagnets remove any residual metal, and the remaining recycled product is used as fines or can be screened and washed to be used as RCA. States that are high producers and consumers of RCA include California, Illinois, Michigan, Minnesota, and Texas.

The proportion of RCA permitted in the specifications varies by State. Comparing specifications for RCA in Minnesota and California, Charles Luedders, P.E., contract management engineer for FHWA's Central Federal Lands Highway Division, explains, "The specifications in both States allow the contractor to remove a composite pavement, process it, and use it without separate operations. These specifications are providing a base aggregate with superior qualities while providing economic and environmental benefits." Luedders points out that "Minnesota allows 3-percent asphalt cement by dry weight of the aggregate. This allows the inclusion of about 50-percent recycled asphalt pavement." Although the California Department of Transportation (Caltrans) initially limited the amount of RCA to 50-percent by weight of the total aggregate, a special provision in 2003 enabled the use of 100 percent of recycled concrete aggregate, according to the Caltrans report, *Summary of California Recycled Concrete Aggregate Review*. According to Luedders, "By allowing a mixture of any percentage of recycled concrete aggregate and recycled asphalt pavement, California allows the contractor to use the most economical material in any percentage combination."

Prior to recycling, uncrushed portland cement concrete (PCC) with rebar and wire attached is visible in this supply stockpile.

Industrial Byproducts: Foundry Sand

When are industry discards not considered waste? Nearly always. "Recycling is not about waste," says FHWA's Lord. "It is about preserving and reusing the value of materials."

Some byproducts produced by industry have been found to be just the right ingredients when applied to highway use. Fly ash, a byproduct of coal-fired electric power production, is routinely used, for example, in the creation of PCC. Silica fume, slag, and sand represent other industrial products that have been recycled for highway applications with success.

Foundry Industry Recycling Starts Today (FIRST), a nonprofit consortium focused on the market development of beneficial reuse of foundry industry byproducts, estimates that approximately 91 million metric tons (100 million tons) of sand are used in production annually. Of that, 5 to 9 million metric tons (6 to 10 million tons) are discarded annually and are available to be recycled into other products. In Cleveland, OH, facilities like Ford Motor Company's motor assembly plant discard 295,000 metric tons (325,000 tons) of foundry sand annually. Used by the auto industry to make the molds used to cast engines, the sand's initial angularity is essential to this process. When worn down by repeated use, it is discarded by the auto industry.

Even after worn smooth, however, the chemical composition of discarded foundry sand makes it an appropriate additive to PCC and for cement production, which, among other components, requires the correct amount of silica. This good source of silica, although no longer useful to the auto industry, provides an essential ingredient for the production of cement and PCC. "Using recycled sand where the material's angularity is unnecessary also conserves virgin material for use by those processes like engine manufacturing that require it," points out FHWA's Hill.

Foundry sand also has been used as fill material in embankments and other similar highway applications. Again, the angularity of the sand is unimportant in this application.

In Ohio, when a major runway extension for the Cleveland Hopkins International Airport required enclosing Abrams Creek by routing a portion of the creek through four 3-meter (10-foot)-diameter concrete pipes, foundry sand was used as flowable fill between the pipes. With only a 305-millimeter (12-inch) gap between the concrete pipes, normal trench backfill material could not have been compacted sufficiently to create the pipe bedding, which needed to provide adequate pipe strength to resist an average of 20 meters (65 feet) of fill that would be placed over the pipes. "In this instance," Hill explains, "byproduct material that presents

An impact crusher is used to break concrete rubble.

no environmental problems was reused in another application for which it was just the right solution."

Recent Research: Asphalt Shingles And Scrap Tires

Two abundant materials that have been the subject of recent testing and use include asphalt shingles and scrap tires. Unless recycled, both materials generally are discarded in landfills.

Approximately 10 million metric tons (11 million tons) of asphalt shingles are sent to landfills every year. According to the U.S. Environmental Protection Agency, asphalt shingles are 19 to 36 percent asphalt cement and 20 to 38 percent aggregate—both common highway component materials.

Florida, Georgia, Indiana, Maryland, Michigan, New Jersey, North Carolina, and Pennsylvania specify the use of up to 5 percent of manufacturer's scrap asphalt shingles in HMA. States such as Georgia, Minnesota, North Carolina, Ohio, and Texas have performed laboratory studies on the use of manufactured recycled asphalt shingles (RAS). Field studies conducted in Minnesota, North Carolina, Pennsylvania, and Vermont in which portions of highways or trailways were paved with asphalt containing RAS and then monitored over time have shown the benefits of including RAS in HMA to be increased stiffness of the asphalt, decreased cracking, no effect on moisture sensitivity, decreased susceptibility to rutting, and decreased optimum content of virgin asphalt cement.

In a Vermont field study from July 1999 to April 2000, the State collected 357 metric tons (394 tons) of tab shingles (remnants from shingle manufacturing plants, not postconsumer goods) for processing into recycled road materials. In a demonstration project, about 3,628 metric tons (4,000 tons) of mixed RAS/RAP/gravel were manufactured and installed. Town officials reported that the driving surface was hard and durable, potholes and washboard

A magnetic belt removes the remaining metal from crushed concrete rubble.

effects were less evident than on a nonrecycled surface, grading was less frequent, and the material was not as dusty as natural aggregate.

Similarly, in Minnesota where 453,500 metric tons (500,000 tons) of postconsumer shingles are created annually, the Minnesota Department of Transportation (MNDOT) allowed 5-percent recycled shingle into HMA in 2003. MNDOT specifications further required that the shingles used must be scrap from manufacturing plants. Although it is possible to use postconsumer tear-offs, these materials often must be tested for asbestos, are of varying quality, and contain the added complication of nails that need to be removed before processing. RMRC concurs that although there are many opportunities for post-consumer asphalt shingles to come in contact with contaminants, scrap from manufacturing plants is unlikely to be contaminated. In Minnesota, although production of the material was slow at only about 18 metric tons (20 tons) per hour, the grinding equipment experienced difficulty grinding up the shingles, and the stockpile would clump up over time, but the low viscosity of RAS made a stiffer mix that resists rutting.

As for scrap tires, the New York Department of Environmental Conservation, for example, estimates that the State has 29 million tires in approximately 95 locations with an additional 18 to 20 million waste tires (approximately one tire per State resident) generated annually. States like New York are highly motivated to eliminate tire piles and the hazards they pose.

"When tire piles catch fire, they create noxious fumes and difficult-to-extinguish blazes that can smolder for extended periods of time," says Hill. "They also provide a fertile breeding ground for mosquitoes and increase the health risks of mosquito-borne diseases such as West Nile Virus." Not surprisingly, 38 States ban whole tires from landfills.

According to *U.S. Scrap Tire Markets 2003*, a report by the Rubber Manufacturers Association, expanding markets now consume four out of five scrap tires with 80 percent or about 233 million of the 290 million scrap tires generated in 2003 going to an end-use market, compared to just 11 percent in 1990. Scrap tires can be recycled as shredded tires or crumb rubber, depending on their origin. Due to concerns over contamination—dirt, rocks, and other road debris trapped in the tread or inside the tires from a discarded tire pile—this material is shredded. Recently removed tires that have never been in a tire pile—called new takeoffs—can be ground to make crumb rubber.

Since 2001, there has been a 41-percent increase growth in the use of tire shreds in civil engineering applications. Highway applications include using shredded tires as lightweight fill over weak soils in bridge embankments and subgrade, in retaining wall reinforcements, or in very cold climates as insulation of the road base to resist frost heaves and as a high-permeability medium for edge drains. Crumb rubber is used in rubberized asphalt concrete (RAC), which can be applied to the road surface and subsurface.

Arizona, California, Florida, and Texas have had success using RAC for highway resurfacing. According to California's Rubberized Asphalt Concrete Technology Center, rubberized asphalt was developed by Charles McDonald, a materials engineer for the City of Phoenix, AZ. In the mid-1960s, McDonald blended approximately 18-percent crumb rubber from scrap tires with asphalt cement. This material was applied to 140 test sections on a 0.8-kilometer (0.5-mile) segment of a busy Phoenix street. The results were so impressive that between 1967 and 1988 the city constructed more than 4,830 lane kilometers (3,000 lane miles) of rubberized asphalt chip seal. Over the years, modifications have resulted in increased durability and flexibility of the pavement, increased resistance to reflective cracking, and a reduction in the pavement's tendency to ravel.

By the end of 2004, the Arizona Department of Transportation (ADOT) Quiet Pavement Program will cover 105 kilometers (65 miles) of freeway with a 25-millimeter (1-inch) surface of rubberized

Foundry sand is used here to build a terraced embankment that later will be sealed with backfill material. The completed steps will have a high degree of compaction, and, if needed, drainage pipes can be placed in the steps to remove water and direct it to ditches or a settlement pond.

The Adams Creek, OH, project at Cleveland Hopkins International Airport, used recycled foundry sand mixed with 68 kilograms (150 pounds) per cubic yard of cement and 227 liters (60 gallons) per cubic yard of water to produce fill material with a strength of 57 to 136 kilograms (125 to 300 pounds) per square inch at a cost of $30 per cubic yard delivered to the site. The sand was used as flowable fill between the concrete pipes, shown here, which will carry the water from the creek.

asphalt and an additional 40 kilometers (25 miles) by the end of 2006. According to ADOT, paving with rubberized asphalt will recycle approximately 10,000 tires per mile. An additional and initially unintended benefit: Studies have shown that rubberized asphalt can reduce traffic noise levels by 3 to 5 decibels. A 3-decibel reduction in noise equates to reducing freeway traffic volume by half.

California, like New York, also must manage large quantities of scrap tires generated annually within the State. According to the Rubberized Asphalt Concrete Technology Center, California "is faced with the challenge of diverting or safely managing more than 33 million reusable and waste tires generated in the State each year." RAC is playing a considerable role in keeping new tires out of scrap piles in California. In 1985, the County of Los Angeles, CA, resurfaced a street with 38 millimeters (1.5 inches) of RAC over lightly alligatored, but mostly sound, pavement. Nineteen years later, the roadway shows no visible reflective cracking. Since 1993, the county's Department of Public Works installed 805 lane kilometers (500 lane miles) of RAC resurfacing that used more than 1.1 million scrap tires. The Department of Public Works specifies RAC for approximately 75 percent of all arterial highway resurfacing projects. An additional 50,000 tires have been used to create a rubberized asphalt slurry for more than 30 projects involving county streets, as well as major and secondary roads.

Similarly, California's Sacramento County Department of Public Works uses RAC on maintenance overlays and capitol improvement projects. Since 1989, the county has placed

A tanker truck is used to adjust the moisture content of fill materials on the Adams Creek project.

Scrap tires from piles such as this one can be shredded and used in highway applications as lightweight fill, retaining wall reinforcements, or insulation of the road base to resist frost heaves.

more than 150,000 tons of crumb rubber asphalt concrete, or the equivalent of 338 lane kilometers (210 lane miles) of RAC resurfacing projects that have used nearly 500,000 scrap tires. A key factor in the successful use of RAC was determining the correct overlay thickness. Recently, the county began a standard maintenance treatment in which 25-millimeter (1-inch)-thick asphalt overlays are placed on residential streets.

To improve upon traditional crumb rubber, the Rhode Island DOT is using chemically modified crumb rubber. The rubber is being modified to create a mixture that is homogeneous. Although 60 percent more expensive than conventional crumb rubber asphalt, longer pavement life and a lower separation range after heated storage are thought to have been worth the additional cost.

Getting the Word Out to States

There is no way to avoid the fact that, in the past, recycling has battled a bad image. The concept of adding material to the Nation's roads that otherwise would sit in a pile at a landfill *as garbage* is not appealing. Even when research shows that what the Nation throws away contains valuable material that can be processed to be as good or, according to some demonstration projects, *better* than new, some barriers still prevail between research and practice. In fact, Lord says, "One of recycling's greatest barriers has been the stigma of using waste products. If recycling is to become a standard practice across the industry, it must be approached with all the quality controls and sound management practices that virgin materials receive."

RMRC research and outreach aim to do the required convincing. "One of our experiences with barrier reduction," says Taylor Eighmy, "is simply getting the right specifications in place. If the specification for the use of a recycled material exists, that material has a better chance to be used."

On August 13, 2004, the American Association of State Highway and Transportation Officials (AASHTO) submitted a new resolution on recycling that states: "Resolved, that the AASHTO Subcommittee on Materials recommends that the AASHTO Strategic Plan include specific language promoting the use of recycled materials where technologically, environmentally, and economically appropriate."

Terry Mitchell, an FHWA materials research engineer who is secretary of the AASHTO Subcommittee on Materials, says, "The fact that AASHTO's Standing Committee on Highways and its Board of Directors endorsed the statement shows the high level support the use of recycled materials has in the State highway agencies. We're hoping it will further encourage the States to have their engineers consider the appropriate use of recycled materials on every project."

Environmental Stewardship

Recycling materials for use on the Nation's highways supports FHWA's strategic goal of environmental stewardship. "The bottom line," says Lord, "is that recycling is everybody's business. The DOTs are strong proponents. FHWA promotes, the DOTs promote, but the *industry* recycles."

Using recycled materials made available by industry is a balancing act, a series of tradeoffs. For example, with modified crumb rubber, costs are higher than for conventional crumb rubber asphalt, but service life is longer. With RCA, the recycled product is less expensive to produce than virgin material and may even be a better aggregate, but it requires a high level of quality control during production and construction. Foundry sand can be a superior fill material, but it is not always available when and where needed. Other examples are numerous and reveal recycling's biggest tradeoff: Using recycled means changing familiar methods in order to enhance the environment by conserving natural resources and supporting sustainability.

Jason Harrington is the team leader of the FHWA Recycling Team. He has devoted the last 9 of his 19 years with FHWA to recycling technology and recycled materials. A civil engineering graduate of the University of Alabama at Birmingham, he also is a member of the Transportation Research Board's committee on Waste Management in Transportation, TRB ADC60.

For more information, visit the Recycling Team's Web site at www.fhwa.dot.gov/Pavement/recycle.htm, or contact Jason Harrington at 202-366-1576 or jason.harrington@fhwa.dot.gov.

Improving Signalized Intersections

(Above) This intersection features lane-aligned signal heads (one signal head for each lane of traffic), with dual left-turn lanes, two through lanes, and a right-turn lane.

FHWA's new guide will help State and local agencies plan, design, and install appropriate facilities to improve safety and traffic operations for all users.

by Joe G. Bared

According to 2002 data compiled by the National Highway Traffic Safety Administration, 21 percent of crashes and 24 percent of all fatalities and injuries related to motor vehicle collisions occurred at signalized intersections. Research conducted by the Federal Highway Administration (FHWA), however, has shown that under the right circumstances installing traffic signals can reduce the number and severity of crashes. But signals that are not designed appropriately can have an adverse effect on safety, so traffic managers need to design, place, and operate them carefully.

Because traffic signals play a key role in enhancing safety, FHWA recently produced a comprehensive handbook that explains methods to evaluate the safety and operation of signalized intersections and that highlights tools to remedy deficiencies. *Signalized Intersections: Informational Guide* (FHWA-HRT-04-091) provides information and tools that can help traffic engineers, project managers, and other transportation professionals conduct insightful assessments of intersections and understand the tradeoffs from potential improvement measures.

"The state of the art of intersection engineering has been greatly enhanced over the past 10 years, and what the guide does is deploy this new knowledge," says Fred Ranck, a safety design engineer at the FHWA Resource Center, who has taught workshops on intersection design and operation.

The guide includes examples of innovative treatments and best practices used by jurisdictions across the United States. These examples include low-cost measures such as improving signal timing and signs, and more expensive measures such as reconstructing intersections or grade separations. Although some treatments apply only to high-volume intersections, the guide provides solutions relevant to the entire range of traffic volumes.

The guide takes a holistic approach to signalized intersections and considers the safety and operational implications of a particular treatment on all system users, including motorists, pedestrians, bicyclists, and transit users. Also covered are intersection fundamentals, analysis methods, and solutions to intersection deficiencies.

"None of us learns in school how it is in the real world—where the tire hits the road, so to speak—so the guide provides that information," says Thomas Hicks, director of the Maryland State Highway Administration's Office of Traffic and Safety and a member of the committee that

A well-designed signalized intersection can improve traffic safety and mobility. Pavement markings, like those shown in this overhead photo, can be used to delineate travel lanes within wide intersections.

reviewed the guide. "You can read in a textbook about reaction time and how wide a lane should be, but the guide puts all the pieces together in terms that reflect what drivers actually see as they drive through an intersection."

Intersection Basics

Designing signalized intersections begins with knowledge of the fundamentals of road user needs, geometric design, and traffic design and illumination, all covered in separate chapters of the guide.

Road users, such as motorists, bicyclists, and pedestrians, are the operative players in the road system, and their perceptions and decisions affect their performance. In the 1980s, FHWA's Human Factors team began applying human factors-based knowledge to the design of roadways and signage. Termed *positive guidance*, the concept focuses on understanding how road users—primarily motorists—acquire, interpret, and apply information while driving.

The concept of positive guidance is simple: If drivers are provided with the information they need in a format they can read, understand, and react to in a timely fashion, then the chances of driver error will be reduced and safety will be improved.

"The idea is to give motorists the information they need at the time they need it," says FHWA's Ranck. "Intersections are complex meetings of roads, so it is crucial for the driver to get the right information as to what lane to be in and where to go."

Traffic engineers apply knowledge of road user needs by designing and operating signalized intersections that inherently convey to various users what to expect. This information reinforces common expectations or communicates alternative information if uncommon elements are present, such as an emergency vehicle running a red light, allowing sufficient time for drivers to react.

Geometric Design

Geometric design of signalized intersections covers channelization principles, number of intersection approaches, intersection angles, horizontal and vertical alignments, corner radius and curb ramp designs, detectable warnings, access control, sight distance, pedestrian facilities, and bicycle facilities. Geometric design includes making evident points of potential conflict in an intersection, particularly those involving vulnerable road users such as pedestrians and bicyclists, and offering the approaching driver, bicyclist, and pedestrian a clear view of one another. For instance, is the intersection free of obstructions such as vegetation, newspaper boxes, and street furniture, such as benches, water fountains, kiosks, clocks, planters, and trash containers?

In addition, the layout of travel lanes, curb ramps, crosswalks, bicycle lanes, and transit stops are all part of the geometric design of a roadway. The design influences roadway safety, shapes the expectations of road users, and defines how to proceed through an intersection. For example, the design can facilitate desired vehicle and pedestrian actions by discouraging undesirable movements, defining appropriate paths for vehicles, encouraging safe speeds, helping separate points of conflict, facilitating the movement of high-priority traffic flows, providing safe refuge, and offering wayfinding clues for bicyclists and pedestrians.

A primary goal of intersection design is to limit the severity of potential conflicts among road users. Intersection channelization, a geometric design concept used to reduce conflicts, employs such techniques as raised medians or traffic islands to discourage wrong-way turns or other undesirable movements. Channelization also uses techniques such as pavement markings to delineate desirable vehicle paths.

Engineers also separate conflict points by adding turn lanes and reducing the number of approaches to the intersection. In addition, intersection approaches that cross as close to 90 degrees as practical can minimize the exposure of road users to potential conflicts.

Pedestrian and bicycle facilities are an important component of geometric design. Pedestrian facilities should be provided at all intersections in urban and suburban areas, and should be designed with the most challenged users—those with mobility or

The green sign on the right reads "Madison Next Signal," providing motorists advance notification of the name of the cross street at an upcoming intersection.

Intersection channelization includes techniques such as the raised medians shown here, which restrict left turns from a driveway between two signalized intersections.

visual impairments—in mind. Among other things, effective curb ramp designs facilitate access to intersections for people with disabilities by enabling access for wheelchairs, scooters, and other wheel-based equipment. Curb ramps also should provide detectable warnings for people with visual impairments, enable boundary identification between the bottom of the curb ramp and the street, and provide a usable grade for equipment accessibility.

Intersections with bicycle lanes or offstreet bicycle paths entering the intersection should be designed to help cyclists navigate the intersection safely. Offroad bicycle facilities (trails) separate bicyclists from other vehicles but are problematic at intersections where trails and roads meet, and drivers may encounter the bicyclists unexpectedly. Onstreet bicycle lanes are better for cyclists at intersections because drivers can expect to encounter them as they navigate through the intersection, but, on the other hand, onstreet lanes can lead to more onroad conflicts.

Understanding Signalization

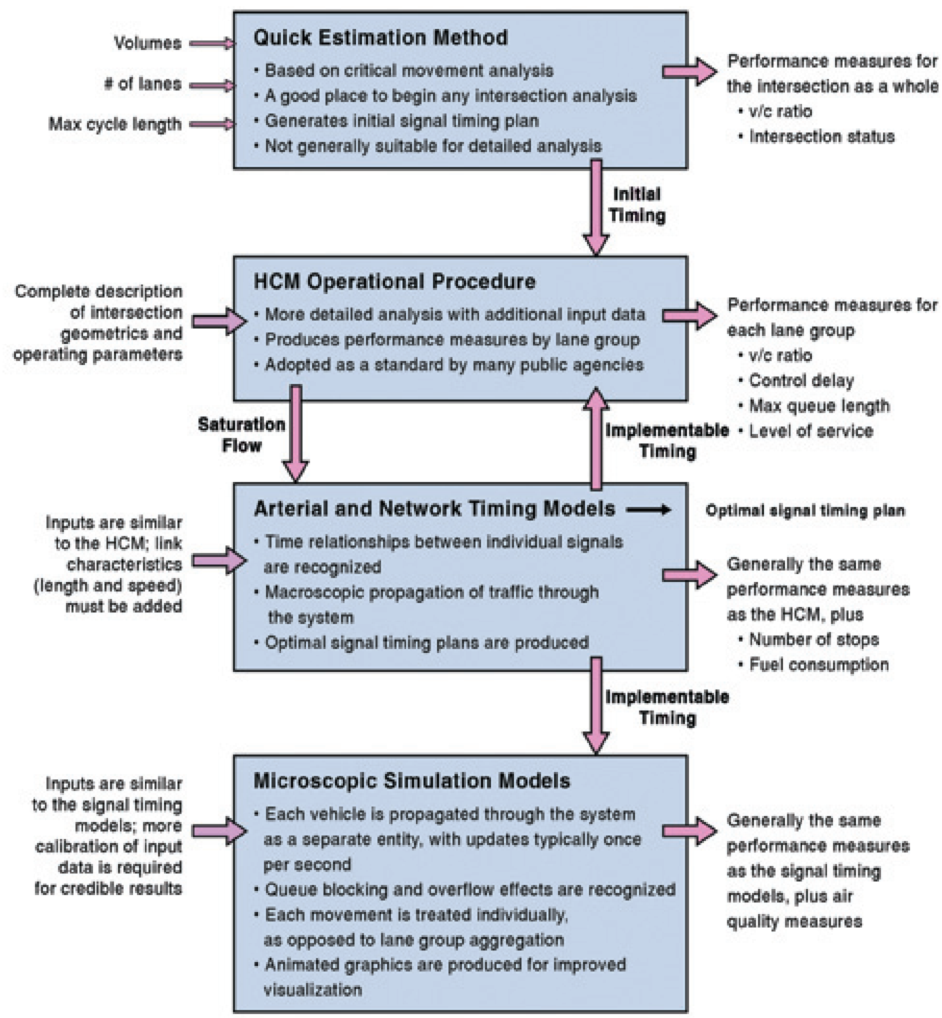
Proper signalization is a key component in improving the safety and efficiency of intersections. Traffic engineers need to consider a variety of elements when designing a system for signalization at an intersection. One factor is the type of control, either a pretimed signal that operates with a fixed cycle length or an actuated signal that varies the length of the green light based on traffic demand.

Development of a signal timing plan should address all user needs at a particular location, including pedestrians, bicyclists, transit vehicles, emergency vehicles, automobiles, and trucks. In general, the guidebook recommends that the cycle lengths for conventional, four-legged intersections not exceed 120 seconds.

Another design element is signal phasing. A signal phase is the interval of time allotted for green, yellow, and red in a traffic movement cycle. Signal phasing is the sequence of individual phases in a cycle that defines the order in which pedestrians and vehicles have the right-of-way to move through the intersection.

In split phasing, for example, two opposing approaches move consecutively rather than at the same time (that is, all traffic movements origi-

Overview of Intersection Traffic Analysis Models



Project managers use a variety of models, such as those listed in this flow chart, to analyze intersection traffic operations and identify potential countermeasures. *Source: FHWA.*

nating from the west followed by all movements from the east). Split phasing can be used in cases where a shared through/left lane is needed, or the geometry of the intersection is such that it is difficult for motorists to make opposing left turns at the same time.

Another important consideration is the layout for the signal poles. Each of the three primary types has advantages and disadvantages:

- *Pedestal* or *post-mounted signals* cost less to buy and maintain than other types of signals but do not always meet visibility requirements, particularly at large, high-volume intersections.
- *Span wire signals* provide flexibility in signal head placement and can accommodate large intersections, but they can suffer wind and ice damage and have higher maintenance costs. In addition, according to FHWA research, some people consider span wire signals aesthetically unpleasing.
- *Mast arm signals* provide good signal head placement but are more costly than span wire signals, particularly for large intersections.

Analyzing Projects

During the initial stages of signalizing an intersection, project managers determine the scope of analysis needed and collect the appropriate level of data. With this information, they develop a problem statement and identify potential countermeasures or treatments for the intersection. While evaluating the alternatives, they assess possible treatments for feasibility and effectiveness. Once they choose a treatment, they implement and monitor the chosen solution over time.

An important step early in the process is identifying stakeholders and their concerns. Stakeholders include everyone affected by a project, including intersection users, adjacent property owners and residents, and intersection owners and managers.

"Intersection design is complex because it involves much more than just vehicular traffic," says Ranck. "A specific feature such as a large turning radius for heavy trucks, for example, may pose a problem for pedestrians by creating a wide crossing distance."

The following are common concerns raised by stakeholders:

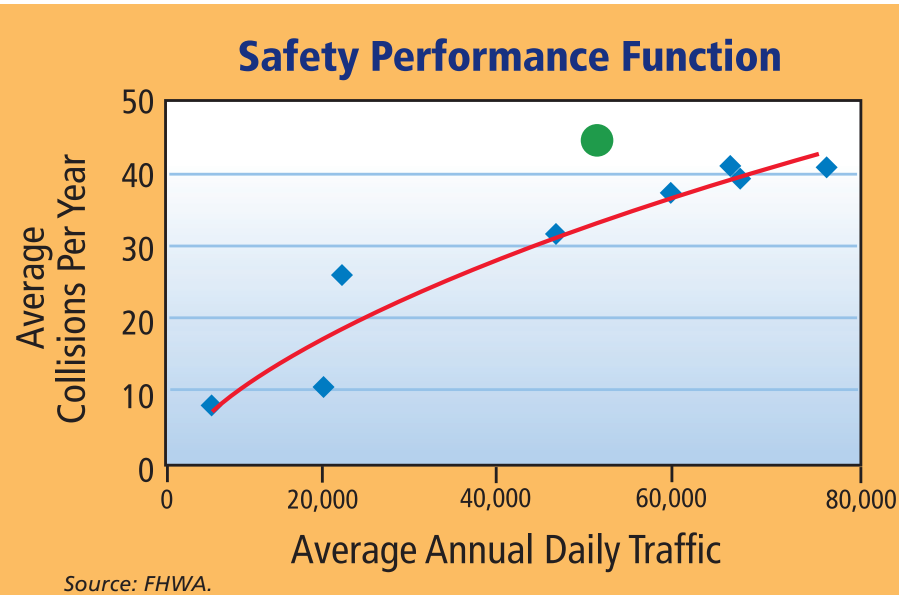
- Motorists—long delays, inefficient signal timing, numerous crashes, poor sight distance, and confusing signs
- Pedestrians—long wait times, wide crossing distance, poorly designed and/or located ramps or push buttons, and confusion about when to begin crossing
- Transit riders—inaccessible or poorly located bus stops, impeded vehicle movement, and difficult traffic stream merges
- Bicyclists—inadequate facilities, ineffective lane striping, and numerous conflicts with vehicles
- Facility managers—meeting of local or State policies, maintaining of traffic flow during construction, and fiscal and right-of-way constraints

The selected performance measures should address the concerns raised by stakeholders as well as the issues identified during the office review and field investigation. Sample performance measures include quantitative measures, such as motorist and pedestrian delays, vehicle queues, approach speeds, and crash severity, and more qualitative measures like multimodal impacts or way-finding success.

Planning for Safety

Safety is a prime consideration for traffic planners when designing, operating, managing, and rehabilitating intersections. Planners have several methods of using collision data to assess intersection safety. Traditionally, engineers have used collision frequency to evaluate the safety of an intersection. Many jurisdictions produce a "Top 10" list of intersections with the highest collision frequency and concentrate their improvement efforts at those sites. Collision frequency, however, does not take traffic volume or collision severity into consideration. By measuring collision rates, which take into account exposure to traffic volumes, engineers can assess the risk that road users face.

By looking at both collision frequency and rates, planners can select



The mathematical relationship between collision frequency and traffic volume is based on a group of intersections with similar characteristics. The blue diamonds represent individual intersections, while the green circle represents an intersection with worse-than-expected performance.

those intersections with both high collision frequencies and high collision rates for more detailed safety diagnoses. In addition, they can look at collision severity through use of an index that gives greater weight to collisions resulting in serious injury or fatality than to those resulting in property damage only.

Planners analyzing intersections also use safety performance functions, equations that present the mathematical relationship between collision frequency and volume based on a group of intersections with similar characteristics (that is, signalized, same number of legs, and similar average annual daily traffic). This method can be complex, but it helps planners calculate the potential for safety improvement more accurately than other methods.

The ability to measure, evaluate, and forecast traffic operations is a basic element of effectively diagnosing problems and selecting appropriate treatments for signalized intersections. An analysis of traffic operations describes how well an intersection accommodates demand for all user groups. Planners can use operations analyses at a broader level to determine the size of intersection needed, and at a more refined level to develop signal timing plans.

Planners commonly use three measures of effectiveness to evaluate signalized intersection operations: volume-to-capacity ratio (how well an intersection can accommodate traffic volumes), delay (additional travel time experienced by motorists moving through the intersection), and queue (lines of traffic in areas such as turn lanes).

Remedies for Intersection Problems

Once project planners have analyzed a signalized intersection, they can apply a variety of remedies to minimize safety or operational deficiencies, including systemwide, intersection-wide, alternative, approach, and individual movement treatments.

"The guide describes and illustrates the strengths and weaknesses of various alternatives, and why one would be more appropriate to meet certain needs than another," Ranck says.

Systemwide treatments apply to roadway segments located within the influence of signalized intersections and to intersections affected by traffic flow along a corridor. These treatments primarily address safety concerns associated with rear-end collisions, turbulence related to vehicles turning in the middle of the block from driveways or nonsignalized intersections, and coordination problems associated with how traffic progresses from one location to another.

An example of a systemwide treatment is construction of a directional median opening to create a midblock opportunity for drivers to make an unsignalized U-turn. A Florida study on this treatment found a reduction in the crash rate of 26.4 percent, compared with direct left turns at the intersection.

Studies have shown that conventional methods of increasing intersection capacity—such as adding left-turn, through, and right-turn lanes—can have diminishing returns. Larger intersections increase traveler delays because of longer clearance times for vehicles and pedestrians, greater imbalances in lane use, and potential queue blockages caused by longer cycle lengths.

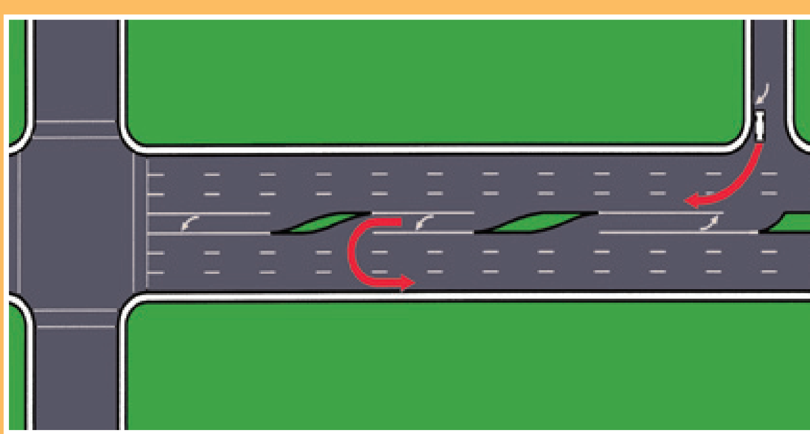
Alternative intersection treatments increase capacity and reduce delay by diverting left-turn flows from the main intersection and reducing potential conflicts. An example is the median U-turn crossover, used on some Michigan arterial roads, which eliminates left turns at intersections and moves them to median crossovers beyond the intersection.

For median U-turn crossovers located on a major road, drivers turn left off the major road by passing through the intersection, make a U-turn at the crossover, and turn right at the crossroad. Drivers wishing to turn left onto the major road turn right onto the major road and make a U-turn at the crossover.

Another alternative treatment is the continuous flow intersection, which has been built at a few locations in the United States. Continuous flow intersections eliminate potential conflicts between left-turning vehicles and oncoming traffic by adding a left-turn bay to the left of oncoming traffic. Vehicles access the left-turn bay upstream of the main signalized intersection and cross over the median and the opposing through segment.

Construction of a continuous flow intersection at the junction of

Access Management Requiring U-turns at an Unsignalized, Directional Median Opening



A Florida study found that constructing a median opening that allows drivers to make midblock U-turns reduced crashes more than 26 percent. The diagram shows a right-in/right-out/left-in (RIROLI) intersection and a median U-turn opening located before a signalized intersection. Drivers that desire to turn left out of the RIROLI intersection instead turn right and make a U-turn at the midblock U-turn intersection. *Source: FHWA.*

Maryland Routes 210 and 228 near Washington, DC, has reduced waiting time at the busy intersection while maximizing its capacity, says Hicks.

"What we didn't want was the southern Maryland traffic not going to Washington stopped at the intersection, so they take a left turn in advance of the intersection," he says. "Because of that, we're able to use two-phase rather than multiphase signals, which reduces the time it takes to get through the intersection."

An FHWA study of a continuous flow intersection with displaced left turns on all approaches found that average delay was reduced 48 to 85 percent and queue lengths were reduced 62 to 88 percent, compared to a conventional intersection. The effect of this design on intersection operations and safety is still being evaluated, but continuous flow intersections are gaining in popularity.

Approach treatments include sight distance, signing, and pavement markings; grading and intersection angles; and lack of clutter. These treatments ensure that approaching motorists, bicyclists, and pedestrians can see that an intersection is ahead and that a traffic signal is controlling the traffic flow. Adequate signs and pavement markings, for example, help drivers choose an appropriate lane and travel direction. The pavement on the approaches gives drivers a smooth, skid-resistant surface. Sight distance for all approaches should be adequate for drivers proceeding through the intersection, particularly those making left turns.

Francisco Mier, 1999

Continuous flow intersections, such as this one in Mexico, divert left-turning vehicles to a left-turn bay in the middle of the block.

Individual movement treatments influence how vehicles travel through signalized intersections and how they make left-, right-, and U-turns at those intersections. They help reduce rear-end collisions under congested conditions, collisions involving left-turning vehicles, and bicycle and pedestrian crashes. Examples include adding turn lanes and providing reversible lanes along a roadway section to increase capacity during peak traffic periods without widening the road.

Safer, More Efficient Intersections

Beginning in the spring of 2005, the National Highway Institute will offer a workshop on using *Signalized Intersections: Informational Guide* to develop intersection projects. The workshop will focus on a case study in which participants assess problems at an intersection and identify alternatives to improve it. To register, visit www.nhi.fhwa.dot.gov.

"By using the guide in the workshop, participants will become familiar with what's in it and how to use it for their own projects," says Ranck.

Assuring the safe and efficient operation of signalized intersections is becoming an increasingly important issue as agencies attempt to maximize vehicle roadway capacity to serve the growing demand for travel. Enhancing safety and reducing crashes are key objectives whenever the design or operational characteristics of a signalized intersection are modified.

"Safety is our number-one goal in Maryland, and mobility is right up there with safety," says Hicks. "We know that good intersection design will improve mobility, and with improved mobility comes enhanced safety."

Joe G. Bared is a highway research engineer in FHWA's Office of Safety Research and Development. He is heading the program area on intersection safety, and manages contracts and conducts staff research in the areas of safety and the operational effects of design. He has a Ph.D. in transportation engineering from the University of Maryland, and he is a registered professional engineer.

Signalized Intersections: Informational Guide *will be available from the FHWA Report Center by e-mailing report.center@fhwa.dot.gov, faxing 301-577-1421, or calling 301-577-0818. The guide also is available online at www.tfhrc.gov/safety/pubs/04091/index.htm.*

Using a variable lane sign (as shown here) to add a second right-turn lane during peak traffic periods can increase intersection capacity without widening the road.

RUMS—Right-of-Way

by Sande Snead

Software from Virginia helps manage this complicated process from start to finish and provides real-time customer service.

The Virginia Department of Transportation (VDOT) expects to complete more than 150 construction projects in fiscal year 2005. The agency acquires about 3,500 land parcels annually and is the largest right-of-way owner in the Commonwealth of Virginia. Relocation of homeowners must be done uniformly, according to guidelines established by the Federal Highway Administration (FHWA). How the relocation is handled at the State level is extremely important from a customer service perspective.

Say that "John Smith" had a simple request. He wanted to know the status of a parcel of his land being considered for acquisition by VDOT. He couldn't remember the name of the field agent to whom he had spoken, but nevertheless he needed information.

Enter VDOT's Right of Way and Utilities Management System (RUMS). Not a tropical drink, nor an abbreviated name for a card game, the RUMS software program cost the agency $2.5 million to develop and helps VDOT's Right of Way and Utilities Division effectively manage the complicated and sometimes lengthy right-of-way process from start to finish. And VDOT believes that one of the system's best features is the ability to communicate up-to-the-minute information, meaning better customer service during the process.

(Above) VDOT right-of-way agent Joanne K. Wilmans talks with homeowners Irene and William Newsome. *Photo: Tom Saunders, VDOT.*

Customer Service And More

RUMS provides right-of-way managers with a single, comprehensive view of project and land parcel status and lets them track deadlines more efficiently. When citizens like Smith call about the status of their properties, anyone from VDOT with access to the Web-based RUMS system can answer their questions.

"Anyone in our division can provide status information simply by typing in the landowner's name," says C.L. "Les" Griggs, Jr., information technology section manager with VDOT's Right of Way and Utilities Division. "With this system they can get an immediate answer even if their right-of-way agent is out in the field or on vacation. I could say, 'Let's see, Mr. Smith. I see that Mr. Jones was out there just last week, and you discussed . . .' "

Stuart Waymack, director of VDOT's Right of Way and Utilities Division, says that the RUMS "lookup" feature was tops on his wish list when the system was in the design phase. In fact, it is known in-house as the "Stuart Waymack requirement."

"If a phone call came to me from an irate landowner, he had probably already gone through his congressman or contacted the governor's office," Waymack says. "I wanted to be able to immediately give him the status of his property with no information other than his first and last name."

But being able to give a landowner an instant status report on a parcel of land is only one benefit of this sophisticated software program. Additional benefits relate to the other responsibilities of VDOT's Right of Way and

Tracking

Tom Saunders, VDOT

In addition to tracking right-of-way purchases, RUMS tracks the status of electric, telephone, and cable utilities. A lightbulb icon is used by the software to show the status of clearing utilities. If the lightbulb is lit, that utility has been cleared; if it is dimmed, it has not been cleared. Shown here is a photograph of utility wires in Virginia.

Utilities Division. Besides appraising and acquiring rights of way and easements for road construction and expansion projects, this VDOT division is responsible for removing building structures and other improvements; relocating utilities, businesses, and residences; and tracking residue parcels and surplus rights of way for public sale or lease. RUMS tracks all these activities as well.

Old Software System

"Road projects are planned years in advance so the homeowner knows that their property will be affected, but not exactly how or when," says Linda Franks, right-of-way agent specialist with VDOT. "That unknown time period is very stressful. RUMS helps us stay on track and make the scheduled advertisement without further delay for the homeowner."

The agency's former computer software program, the legacy system, was hampering rather than helping right-of-way activities. The legacy system tracked and displayed some project dates, but not others. And the project information that *was* available was difficult to find. Management, staff members, and contractors often had to drill down through multiple layers of screens, resulting in delays and mistakes.

"With the old system, you had to search and dig for information," says Walter E. Daniel, right-of-way agent specialist senior with VDOT. "RUMS presents data in a more concise format, and you can see the status of a project at a quick glance. The color-coded icons for each project and the triangles by each parcel allow you to determine the exact status without having to open each individual file."

According to Brian J. Pierce, a senior manager with BearingPoint, the company that helped VDOT develop RUMS, "Another problem with the old system is that it didn't focus users on critical dates," says "With RUMS, the system has the ability to allow right-of-way agents to pace the work so that enough time is allowed for negotiations with homeowners for successful property acquisitions."

Jack Beilbart, VDOT

Brian Pierce (standing), BearingPoint senior manager; C.L. "Les" Griggs, Jr., VDOT IT section manager (left); and Derek Thompson, VDOT consultant, demonstrate RUMS at a Southeastern Association of State Highway and Transportation Officials (SASHTO) conference in August 2004.

Developing RUMS

Along with needing an improved software system, VDOT managers were in urgent need of data that simply were not available. To come up with a solution, VDOT Right of Way and Utilities staff formed a steering committee to help identify tracking software and data that the system needed to include.

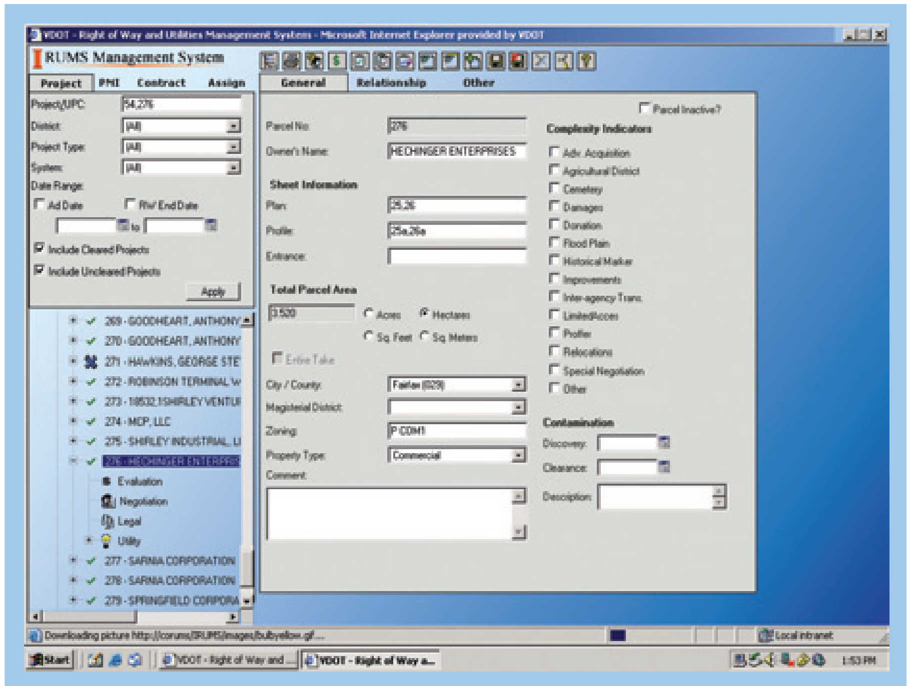
"We got together and said, 'Let's see what is on the shelf that we can modify," Griggs says. "We contacted DOT right-of-way managers in all 50 States." However, nothing was available in the transportation community that was right for VDOT use.

The steering committee, made up mostly of field agents who would use the system, met for several months before presenting their ideas to VDOT management. Based on the committee's deliberations, VDOT issued a request for proposal in August 1997 and 4 months later awarded a contract to help with the technical aspects of the software development.

While working with VDOT to develop a system, the contractor asked the agency, "In a perfect world, if you could have anything you wished for, what would you want?" Griggs says the process "was like having new crayons and white paper to work with."

According to Pierce, an important component of the development process was analyses of the as-is (the existing system) and the to-be (the desired system) work flow. "Our as-is analysis detailed all data tracked by the Right of Way and Utilities Division's existing system," says Pierce, "including how it was tracked and the type of system that tracked it. The analysis also provided a detailed examination of the manner in which VDOT conducted its right-of-way and utilities business."

Following this analytical process, the contractor developed the software specifications, incorporating critical procedures that employees previously had performed using spreadsheets and other manual processes. RUMS went live in September 1999, and since then the software has helped VDOT managers improve their record of staying on track to meet critical deadlines. "With RUMS, before a project is advertised for construction bids," says Pierce, "there is a checklist that shows what needs to be done, and a manager can see that at a glance."



Tom Saunders, VDOT

A screen capture of VDOT's iRUMS shows the owner of the parcel, size, location, and projects that were cleared.

The New System

Taking the system a step further in 2003, VDOT migrated the RUMS solution from a client-server environment to the VDOT intranet (iRUMS). The Web version is based on Microsoft® .NET technology, and its data are in an Oracle® 9i database. Plans are to make the system Internet accessible in 2005 to authorized users.

The new iRUMS integrates easily with document management and is user-friendly. One of its most popular features is its ability to populate forms automatically, including plugging in names, dates, and other critical information. "By having a feature that automatically populates forms, it discourages users from accessing outdated forms they've saved on their hard drives," Griggs says.

Daniel adds: "The form-populating feature is a true blessing for those of us who are 'keyboard challenged.' From a legal standpoint, this data populating has significantly reduced errors in our deeds, options, and other legal documents."

The iRUMS system uses color coding to alert managers about a project's status. In RUMS, the icon colors are blue, yellow, and red, with a green checkmark to indicate that the project is ready for advertisement. As a project moves closer to the advertisement date, the icon colors change. When the project moves to within 120 days of the advertisement date, the colors change from blue to yellow, and the project has higher priority than projects "in the blue." When the project is within 90 days, the icon turns red.

"At this point, it's time to reassess your resource mix and move more manpower and attention to that project while there is still time to make the advertisement schedule," Pierce says.

iRUMS is not available for viewing by the public, because it serves as a storehouse of information on citizens and the location and value of their land parcels. Legal information available on iRUMS includes title orders, deeds, condemnations, condemnation orders, multiple owners on a property (if applicable), relocations, appeals, and payments made for a property.

One RUMS function, however, has been made available online for public viewing. The agency posts surplus properties for sale (obtained during right-of-way acquisition) on VDOT's external Web site, www.virginiadot.org/business/row-pmi.asp. This feature has increased exposure for VDOT properties and improved sales.

The intranet RUMS version, however, that is open only to authorized users is set up with tabs at the top of the page similar to typical Web sites. On the left-hand side of the screen, iRUMS has a "TreeView" with a series of folders and subfolders for various functions. For example, under utilities, there might be three subfolders for various utility companies that serve Virginia such as telephone, cable, and power. A lightbulb icon is used to show the status of clearance—utility lines have been relocated, and the land is ready for construction—for each utility affected by a given project. If the lightbulb is lit, that utility has been cleared; if it is dimmed, it has not been cleared.

Another benefit of iRUMS is its ability to store the estimate information on a project. The software enables anyone with VDOT's Right of Way and Utilities Division to see the history of the parcel from the earliest entry to final distribution. Once the parcel is acquired, a checkmark indicates completion.

Furthermore, data in the database can be exported to a Microsoft Excel spreadsheet and manipulated with the click of a button. Likewise, with a click on the Microsoft Word template icon on the toolbar, the user can generate letters, certificates, and forms with name, address, route numbers, and other fields populated.

Other DOTs Interested

Although VDOT is not in the business of marketing RUMS, the agency has spent years and millions developing and upgrading the software and hopes to recoup some of the investment by licensing the source code. Pierce notes that there are differences in the ways that States handle rights-of-way acquisitions. Maine, for example, is a blanket condemnation State, whereas Virginia looks at each parcel and tries to acquire property deed by deed. Maine's William Leet, MaineDOT senior property officer says that the State anticipates building in a tremendous amount of customization to make the system work for the agency.

Two State DOTs to date have licensed the right to use RUMS. In February 2004, the Minnesota transportation agency was the first DOT to sign a software licensing agreement for RUMS, and Minnesota DOT's 11-month implementation will go live in February 2005. Maine signed a licensing agreement with VDOT in June 2004.

Les Griggs holds a user manual for the agency's Right of Way and Utilities Management System (RUMS). The screen capture shows parcel information for land owned by Hechinger Enterprises. A single project can involve as many as 200 property owners.

Tom Saunders, VDOT

Maine settled on RUMS after thorough research and information sharing, including 2002, 2003, and 2004 AASHTO Highway Subcommittee on Right of Way and Utilities full subcommittee meetings; the "FHWA Right-of-Way and Planning Innovation Domestic Scan," San Francisco, CA; and FHWA's 2004 geographic information systems in right-of-way conference in Florida. MaineDOT's right-of-way staff looked at other systems throughout the country, but they were looking for a production tool. All they found were tracking systems.

"We wanted a system for our frontline people," says Leet, "something that could manage information collected from the beginning to the end of a project."

MaineDOT's staff also was looking for a database that would populate forms, as RUMS does. "Some projects have 200 property owners, and there might be 10 to 20 documents for each parcel," Leet says. "We were typing the same information in over and over."

An unanticipated byproduct is that other State agency divisions have found additional ways to use RUMS as well. Leet hopes that MaineDOT's Environmental, Utility, Legal, and Planning Divisions, for example, will use the system. "The Planning Division does a lot of upfront work with projects, so if we could interface with their database, it would be useful," Leet says. "There is a tremendous amount of information available through the RUMS system that a lot of departments [might be able to use]."

Closer to home, VDOT's Environmental Division looked to RUMS for guidance in developing a software program that would help track asbestos removal. Although the division's Comprehensive Environmental Data and Reporting (CEDAR) system tracks environmental projects, the CEDAR program is designed to be project-specific, whereas RUMS is parcel-specific. Therefore, RUMS works better for tracking asbestos, including costs for abatement.

"When VDOT purchases a building with asbestos for demolition, the Environmental Division has to track the asbestos until the building is gone, so a piece of RUMS belongs to environmental," Griggs says. "If [RUMS] works for another division, that is money even better spent."

Sande Snead is a public affairs officer with VDOT, a position she has held since 2002. Prior to joining VDOT, she was a freelance writer for more than a decade. Snead has won numerous State and national writing awards, including a national award in 2004 for a series called "How Virginians Move" for the VDOT Web site.

For more information, contact Sande Snead at 804-225-4491 or Sande.Snead@VDOT.Virginia.gov or C.L. Les Griggs Jr., from VDOT's Right of Way and Utilities Division at 804-786-2917 or Les.Griggs@VDOT.Virginia.gov. Or see www.virginiadot.org/business/row-rums.asp.

Pushing the Boundaries

by Samuel S. Tyson and David K. Merritt

Demonstration projects around the country continue to explore the feasibility of using precast prestressed concrete in pavement applications.

Already a staple in the bridge designer's toolbox, precast prestressed concrete is finding new applications in the paving world. For years engineers have designed bridges, buildings, and other vertically oriented infrastructure using precast concrete, but only recently have researchers begun exploring the feasibility and potential benefits of applying this technology ongrade in pavement construction.

The July/August 2002 issue of PUBLIC ROADS showcased a demonstration constructed by the Texas Department of Transportation (TxDOT) that investigated the feasibility of using precast concrete for a paving project ("Texas Tests Precast for Speed and Usability," page 30). The article recounts an earlier feasibility study conducted by the Center for Transportation Research at The University of Texas at Austin for the Federal Highway Administration's (FHWA) Office of Infrastructure, Research, and Development (R&D), which showed that precast prestressed concrete panels *could* be a viable option for reconstructing pavements quickly. The TxDOT demonstration, which was completed in March 2002 on a frontage road near Georgetown, TX, *proved* that precast works and opened the door to future research and implementation.

Since that time, the California DOT (Caltrans) took the concept of precast construction a few steps forward by modifying some of the design features and requiring nighttime construction.

Both the Texas and California projects are part of the Federal Highway Administration's (FHWA) ongoing Concrete Pavement Technology Program (CPTP) Task 58, "The Use of Precast Concrete Panels to Expedite Highway Pavement Construction." The CPTP consists of research, development, and technology-delivery activities to foster innovation, improve the performance and cost-effectiveness of concrete pavements, and ultimately reduce user delays.

Following the success of the pilot projects in Texas and California, Missouri, Texas, and Indiana are planning new demonstrations within the scope of Task 58, which will continue to add layers of complexity and push the boundaries of precast pavement.

Center for Transportation Research

(Right) TxDOT had nearly 340 precast panels fabricated and installed on the frontage road near I–35 in Georgetown, TX, as part of a demonstration project in 2002. Here, workers guide a partial-width precast panel into place.

Anatomy of a Precast Prestressed Concrete Pavement

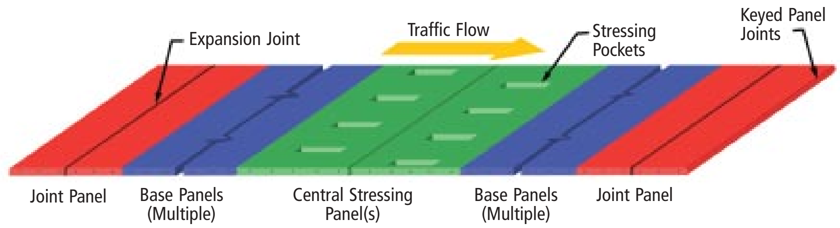
Three specific types of panels make up a precast prestressed concrete pavement: joint panels, central stressing panels, and base panels.

Joint panels are located at the ends of each posttensioned section and contain dowelled expansion joints to absorb horizontal slab movements.

The central stressing panels are placed at the middle of each posttensioned section and contain large pockets or blockouts where the posttensioning strands are fed into the ducts and stressed.

The base panels make up the majority of the pavement, placed between the joint panels and stressing panels. During a single construction operation, workers must place at least one complete section of panels from joint panel to joint panel.

The range of panel types requires special attention when transporting the precast panels to the construction site, as each type is needed for a complete section. Because the panels are not match-cast, however, they are interchangeable if problems are encountered during shipment. As a result of the logistics involved in the prestressing, this technology is more suited to large-scale replacement projects rather than small, isolated patches.



Source: FHWA.

Why Precast *Prestressed* Concrete?

The obvious benefit of using precast concrete is that agencies can reopen a pavement to traffic almost immediately after placing the panels, rather than having to wait for a cast-in-place concrete to reach sufficient strength in the onsite curing environment. Precast pavement, therefore, permits overnight and weekend reconstruction projects.

Less obvious, but equally important, is the benefit of improved durability. Conventional concrete paving is prone to certain quality problems, such as built-in curl and warp (due to moisture and temperature gradients, respectively), strength loss (due to insufficient curing), and inadequate air entrainment. Precast panels, on the other hand, are cast in a controlled environment using high-quality concrete mixes and optimal curing conditions, thereby reducing the probability of encountering such problems. The result is a more durable pavement that will meet the design-life requirements placed upon it.

Agencies can realize further benefits by incorporating prestress (in the form of pretensioning or posttensioning) into the precast panels. Prestress not only benefits durability by reducing tensile stresses that lead to cracking, but it also reduces the required slab thickness. Because prestressing induces a compressive stress in the pavement, tensile stresses caused by wheel loads in a thinner slab can be reduced to that which would be expected in a much thicker pavement slab. Engineers can therefore design precast panels that are only 200 millimeters (8 inches) thick but are essentially equivalent to a 355-millimeter (14-inch)-thick nonprestressed pavement, thereby reducing the concrete volumes and the probability of overhead clearance conflicts, which typically occur at bridge structures with the construction of thicker pavements.

Prestress also allows the precast panels to span small voids in the base layer, thereby accommodating placement on a base material that may not be perfectly flat. And with prestress, the pavement stays in compression, which prevents cracks from opening up, minimizing the potential for corrosion.

The Texas Pilot

Completed in 2002, the earliest project, near Georgetown, TX, demonstrated the viability of constructing a pavement using precast prestressed concrete. TxDOT placed approximately 700 meters (2,300 feet) of two-lane pavement (plus shoulders) on the frontage road along Interstate 35.

The precast, pretensioned panels were placed over a hot-mix asphalt leveling course and then posttensioned together in the longitudinal direction in 76-meter (250-foot) sections. Shear keys along the edges of the panels (similar to "tongue and groove" joints) ensured satisfactory vertical alignment during installation and good ride quality of the finished surface by interlocking the panels, preventing differential vertical movement between panels.

The precast panels were 200 millimeters (8 inches) thick, but because they were prestressed, TxDOT expects them to have a design life equivalent to that of a 355-millimeter (14-inch)-thick continuously reinforced concrete

Center for Transportation Research

Cars travel on the newly completed frontage road of I–35 in Georgetown, TX, paved with precast prestressed concrete.

pavement. As the contractor became more familiar with the construction process, approximately 25 panels—equaling 76 meters (250 feet) of pavement—were installed in a 6-hour period. TxDOT found that posttensioning, completed after the panels were installed, generally took just a few hours for each section of pavement.

Aside from demonstrating the efficacy of placing the slabs on grade, the Georgetown project demonstrated the viability of posttensioning the panels together in place. The project also showed that match-casting, which is commonly used for precast segmental bridge construction, was not required to ensure a tight fit between panels and to align the posttensioning ducts. Because match-casting is not necessary, the manufacturer can fabricate the panels faster, and shipment and installation are simplified.

TxDOT officials report that after nearly 3 years in service, the pavement shows no signs of distress. In fact, the agency expects the panels to last up to 40 years before any rehabilitation is required.

"Precast concrete pavement will be an excellent solution to provide long-term, high-quality pavement replacement and repairs with minimal impact on the traveling public," says Mark Herber, P.E., transportation engineer from the Georgetown Area Office of TxDOT. "[The material] could be especially useful when the pavement on urban freeways in downtown areas needs replacing, and the existing facility cannot be rebuilt due to adjacent development."

California's Project Adds Complexity

More recently, in April 2004, Caltrans upped the ante by constructing a precast prestressed concrete pavement at night on an interstate with a low tolerance for lane closure. The agency placed approximately 76 meters (250 feet) of two-lane (plus shoulder) pavement on Interstate 10 in El Monte, CA. The precast panels were placed over a lean concrete base and posttensioned together in the longitudinal direction in 38-meter (124-foot) sections.

In addition to conducting the operation overnight, another innovative feature is that Caltrans specified that the top surface of the precast panels vary in cross-slope from 2 percent on the main lanes to 5 percent on the shoulders. This requirement varied the panel thickness from 330 millimeters (13 inches) at the point of cross-slope change to 250 millimeters (10 inches) at the ends of the panels. Incorporating the crowned design, which will facilitate drainage to the outside edge of the pavement, demonstrated the viability of casting panels with more complicated shapes and features.

Sixteen, or just over half, of the precast panels were placed in approximately 5 hours during the first night of construction (between the hours of 12 midnight and 5 a.m.), while the remaining 15 panels were placed in just over 3 hours during the second night. The contractor completed posttensioning in a few hours the morning following installation of the panels.

Although the project was not constructed under the more stringent time constraints anticipated for future projects, it further demonstrates the viability of this technology for fast-track projects.

"Because the durable concrete panels are placed overnight or on weekends, construction is expedited, costs are reduced, and the freeway remains open to the motoring public during peak commute periods," says Douglas R. Failing, P.E., director of Caltrans District 7, which includes Los Angeles and Ventura Counties.

Furthermore, Caltrans officials expect the installation to last more than 50 years, under extremely high traffic volumes in one of the most heavily-trafficked corridors in the United States.

"Being on the cutting edge of new technology and techniques for freeway pavement reconstruction and rehabilitation is exciting," Failing adds. "This is a perfect example of a public-private partnership working as a team for the public benefit—a win-win situation all around."

Future Demonstration Projects

The success of the first two demonstrations generated significant interest within the highway industry, spawning additional projects and new applications for the technology. Whereas the Texas and California projects demonstrated the viability of the concept of precast pre-

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Workers place concrete for one of the panels used in the California demonstration project.

The Transtec Group, Inc.

This photo of a precast panel shows the crown shape used for the California project. The panel tapers from 330 millimeters at the high point down to 250 millimeters at the ends.

stressed pavements, three new projects will focus on constructing these pavements under more complex conditions and under even more demanding time constraints.

On a rural section of Interstate 57 near Sikeston, the Missouri Department of Transportation (MoDOT) will use precast prestressed concrete to replace a vintage jointed reinforced concrete pavement. Although the existing pavement lasted an impressive 45 years, increasingly heavy truck traffic has taken its toll on the roadway over the past 8 to 10 years. Pumping and joint faulting have led to severe pavement distresses, requiring patching and now full-depth replacement. The goal of the project is to test precast on a rural section of interstate that carries heavy traffic loads to determine whether similar applications could be implemented in more heavily congested areas like downtown St. Louis.

MoDOT, with assistance from FHWA and its contractor, will replace approximately 0.4 kilometer (0.25 mile) of pavement with about five posttensioned sections. The project will replace the existing pavement with 200 millimeters (8 inches) of precast prestressed pavement, which will be approximately 100 millimeters (4 inches) thinner than the jointed plain concrete pavement that will be used for the majority of the Missouri rehabilitation project. Because the elevation of the finished pavement surface will not be increased by the new precast pavement, MoDOT will avoid the need to excavate base material for vertical clearance at bridges or to taper down to the existing pavement surfaces at either end of the project.

The "rooftop crown" slope of the existing pavement surface will be cast into the surface of the precast panels, with each panel spanning the full width of the roadway (two lanes plus shoulders). The panels will be placed over a stabilized base and posttensioned together in 76-meter (250-foot) sections. To minimize disruption to traffic, construction will take place during weekend operations, ensuring that the project will not impede heavier weekday traffic.

"MoDOT anticipates gaining an alternate treatment option for high-density urban arterials like those in St. Louis that require an absolute minimum of traffic disruption during construction and virtually no maintenance through a long design life," says John P. Donahue, P.E., research and development engineer with MoDOT in Jefferson City. "The field experience gained on an interstate setting and the performance data acquired through an instrumentation investigation conducted by the University of Missouri at Columbia will combine to shape the State's expectations for this technology."

Construction is tentatively scheduled for the spring of 2005.

Weigh-in-Motion Sites

Adding to its track record of innovative applications for precast concrete in the pavement environment, TxDOT, along with FHWA and its contractor, is developing plans for a second demonstration project. This time, TxDOT will use precast panels that can accommodate weigh-in-motion (WIM) scales, which Texas and other States use to gather weight data for traffic.

TxDOT plans to construct several WIM sites around the State, and precast offers a way to minimize traffic disruptions associated with construction. Because the standard practice in Texas is to install the scales in a section of concrete pavement, the department selected a future WIM site on U.S. 175 southeast of Dallas as the location for its latest demonstration.

A 152-meter (500-foot) section of the existing asphalt pavement will be removed and replaced with precast concrete panels that have blockouts (or pits) for the WIM scales cast into them. Preforming the blockouts into the pavement panels during the casting operation will eliminate the usual field operations of sawcutting and jackhammering the pits for the scales, facilitating faster installation.

Because of the high volume of truck traffic on these pavements, TxDOT aims to minimize disruptions during construction. The original design called for a 355-millimeter (14-inch) continuously reinforced concrete pavement, which would have required several weeks of lane closures to construct. However, using a precast prestressed pavement will permit TxDOT to complete construction during a weekend closure.

"Our goal is to 'get in, get out, and stay out' of the traveling public's way," says Pavement Engineer Abbas Mehdibeigi, P.E., with the Dallas District of TxDOT. "We envision minimizing the construction time, and thus the closing time of the roadway. By utilizing precast panels, part of the construction can be undertaken offsite, as opposed to the

Precast panels delivered by truck to the California site could be lifted by crane over a construction barrier and lowered into place, as shown here.

The Transtec Group, Inc.

conventional method where everything is done onsite."

Also, because the new pavement will be prestressed, the panel thickness will be only 250 millimeters (10 inches), minimizing the amount of excavation required during removal of the existing pavement. Similar to the panels used in the first Texas project, these precast panels will be placed over a thin hot-mix asphalt leveling course. The panels for both the east- and westbound pavement sections will be posttensioned together in 152-meter (500-foot) lengths, and the panels will span the full width of each roadway (two lanes plus shoulders).

Mehdibeigi notes, "We expect to come up with a working design and specification that might be used for other sites across the State, with minor modifications." Construction is planned for the spring of 2005.

Depending on the success of casting the WIM blockouts into the panels, other unique applications may be possible down the road. Pavements in urban areas, for example, could feature drainage inlets or manholes cast into the panels.

Bridge Underpasses In Indiana

A third demonstration currently in development in Indiana will focus on applying precast prestressed concrete at bridge underpasses. With a number of bridges that have been hit in the last few years by trucks that exceed the maximum clearance height, the Indiana DOT (INDOT) sees the need to be able to construct thinner pavement sections beneath these structures.

Although a new conventional cast-in-place pavement may increase the existing pavement thickness (and decrease overhead clearance) by several inches, precast prestressed concrete pavement will permit INDOT to place a much thinner pavement section, thereby preserving precious overhead clearance. Precast pavement also will permit INDOT to construct these pavements under strict time constraints (overnight or weekend) in urban areas, minimizing disruptions to traffic.

"Our expectation is that the use of precast pavement sections will help minimize traffic impacts as we eliminate these low bridge safety hazards and provide increased levels of service and safety," says Victor (Lee) Gallivan, pavement and materials engineer with FHWA in Indiana.

Moving Forward

As pavements constructed during the interstate era reach their serviceability limits, highway agencies will need new technologies and strategies to repair and rehabilitate them. In urban areas, especially, the need to replace distressed pavements with minimal disruption to traffic will continue to drive decisionmaking.

"Traffic constraints will drive the market for this technology," says Failing from Caltrans. "The window for construction in places like California is getting smaller—maybe 4 hours per night. Precast is a known quantity, having proven its durability over the years."

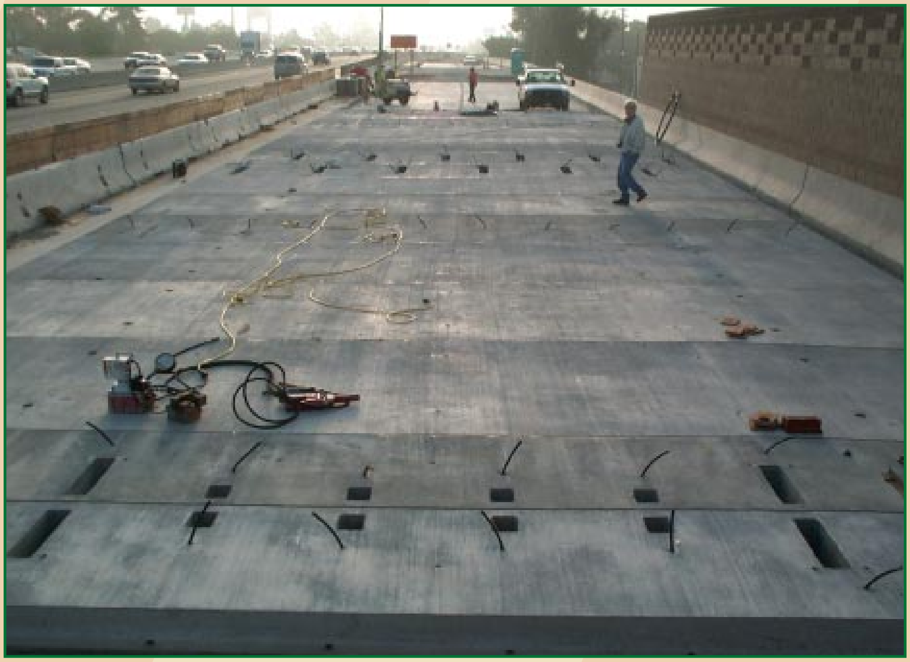
The Transtec Group, Inc.

The speed of placement of the precast panels used in the California demonstration improved significantly over the 2 nights of construction. Here, a crane lowers another panel into place.

Researchers expect to see continued growth and greater momentum for precast pavement. Future research is necessary to determine the feasibility of casting horizontal curves or pavement sections with significant changes in superelevation. Another area for further study is the variety of base conditions upon which precast panels can be placed. For example, what is the minimum threshold for acceptable base conditions to ensure long-term performance of the finished pavement? Speed of construction is still an issue as well. Although the California project demonstrated the feasibility of overnight construction, the actual precast pavement section was not opened to traffic the next morning. Future demonstrations might involve shutting down a segment of road after rush hour and reopening it the next morning.

Although precast prestressed concrete is currently more expensive than conventional cast in place, proponents argue that the reduction in user costs—such as traffic congestion, fuel consumption, and lost work time—will validate this technology for certain situations. New, competitively bid demonstration projects, such as that in Missouri, should provide a more realistic estimate of the costs involved.

"This technology has tremendous potential as one of the many tools that highway agencies can use to achieve the Highways for LIFE goals of improved safety, reduced construction-related congestion, and improved quality," says FHWA Deputy Administrator J. Richard Capka.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A worker surveys a 38-meter (124-foot) posttensioned section of precast pavement on the California jobsite.

Samuel S. Tyson is a concrete pavement engineer with FHWA in Washington, DC. He provides technical oversight and guidance for CPTP Task 65, a highly focused technology transfer activity for the numerous products resulting from some 30 projects within FHWA's CPTP. His areas of technical involvement for both jointed plain concrete pavements and continuously reinforced concrete pavements include all aspects of design, construction, repair, and rehabilitation. He earned his B.S. and M.S. degrees in civil engineering from the University of Virginia and is an active member of American Concrete Institute and Transportation Research Board (TRB) committees on concrete pavements. He is a registered professional engineer in the District of Columbia.

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The California demonstration project progressed smoothly. Shown here is the completed pavement.

Keeping Traffic on the Right Side of the Road

by Gary Strasburg and Lisa Crist Crawley

North Carolina saved lives by installing cable barriers on freeways where the median width is less than 21 meters (70 feet).

Cross-median crashes pose a significant hazard for motorists across the country, claiming numerous lives and causing millions of dollars of damage each year. To help combat this risk, the North Carolina Department of Transportation (NCDOT) implemented an aggressive and successful strategy to prevent vehicles from crossing medians, establishing the State as a national leader in the ongoing challenge to keep traffic on the right side of the road.

According to *Saving Lives by Preventing Across Median Crashes in North Carolina*, a document outlining a 1998 study conducted by NCDOT, more than 38 people lose their lives and nearly 300 others are injured in cross-median crashes on North Carolina freeways each year. Furthermore, those crashes are found to be three times more severe than other crashes, making their prevention a high priority for officials throughout the State.

However, through research studies by NCDOT and the subsequent installation of protective median barriers, the State has reduced its cross-median crashes dramatically, cutting the number of fatalities from these crashes nearly in half during installation of the median barriers from January 1999 through December 2003, and saving hundreds of millions of dollars in fatal crash costs alone. Many of the cross-median crashes that were still occurring during this time were on stretches of highway that were slated to receive median barriers but had not yet had them installed.

(Above) The cable median barrier stopped this semitrailer truck, preventing a potentially deadly cross-median crash. *Photo: NCDOT.*

The Unique Challenge of Cross-Median Crashes

A number of factors make the problem of cross-median crashes difficult to solve. First, there is no identified pattern for when and where the crashes occur. NCDOT research has demonstrated that they do not occur during a specific time of the day or day of the week, and there does not appear to be a well-defined season of the year for these crashes. Cross-median crashes take place on both horizontally and vertically curved sections of highways, as well as along straight and flat sections. In addition, there is no single cause of these crashes; the events that lead to a cross-median crash include everything from fatigue and improper lane changes to inattention and medical emergencies.

Compounding the problem, hundreds of miles of North Carolina freeways were constructed with medians between 11 and 15 meters (36 and

NCDOT

The North Carolina Department of Transportation installed this cable guardrail along Interstate 540 in Wake County, NC.

50 feet) due to right-of-way costs and environmental constraints. With such a short distance between the opposing lanes of these highways, in about the time it takes to yawn, change a radio station, or answer a cellular phone call, a vehicle traveling at posted freeway speeds can cross a median and strike opposing traffic head-on. Traffic volumes on the State's highways also are increasing at a rapid rate, making the risk of devastating cross-median crashes even greater.

The good news is, regardless of the circumstances of cross-median crashes, research has shown that most of them can be prevented through the installation of a protective median barrier. This reduction in crashes was evident from the outset of North Carolina's median barrier program, when in 1997 NCDOT tested an initial section of cable barrier in the Raleigh-Durham area and found that it significantly lessened the severity of cross-median crashes. "Prior to installation of a median barrier in the Raleigh-Durham area, there had been an average of one fatal crash every year," says Shawn Troy, NCDOT traffic engineer. "Afterwards there were none, and the seriousness of the injuries from crashes in the area also had decreased significantly."

The Median Barrier Story Begins

This success story actually begins 4 years prior to the first installation, with a 1993 cross-median research study by NCDOT.

"The department was concerned about the unusually high severity of cross-median crashes," says Kevin Lacy, State traffic engineer for NCDOT. "We decided it was time to look for ways to minimize this safety hazard."

The 1993 study used available crash history to identify 24 interstate locations totaling 148 kilometers (92 miles) that had an unusually high number of cross-median incidents. The researchers recommended prioritized safety improvements, primarily placement of median barriers, at these locations. These safety improvements were either constructed at the time or programmed into the NCDOT Transportation Improvement Program (TIP).

NCDOT also planned to use the study data to develop a model that would aid in identification of potentially dangerous locations on North Carolina interstates based on relevant variables such as median width, traffic volume, and other geometric and operational characteristics. This final objective of the research proved to be difficult to attain, however, leading to additional examination of cross-median crashes in the State.

In 1997, NCDOT revised the 1993 cross-median study to include 48 kilometers (30 miles) of additional interstate locations prioritized for placement of median barriers. Despite these additional data, NCDOT researchers still needed a more comprehensive study to help identify where cross-median crashes were likely to occur.

A Closer Look

In 1998, NCDOT conducted a second cross-median study that examined all such crashes on North Carolina freeways from 1994 through 1997. The primary objective was to reduce the number and severity of cross-median crashes on the State's high-speed highways by establishing a warrant for median barrier placement and by identifying divided freeways (both interstate and noninterstate) that have cross-median crash histories.

The study investigated more than 800 cross-median crashes along approximately 2,214 kilometers (1,375 miles) over a 3.5-year study period. Area staff investigated each identified section of divided freeway and also identified additional candidate locations. The study concluded that there were more than 1,932 kilometers (1,200 miles) of candidate freeway in North Carolina, the majority of which had median widths of less than 21 meters (70 feet).

"The study was finished in 1998," says Lacy. "Its findings provided a great deal of momentum to convince upper management of the need for more barriers, and the Board of Transportation subsequently approved $120 million for barrier installation.

Sample Installations of Median Guardrails in North Carolina

Location	Miles (Length)	Cross-median Crashes Per Year Before Installation	Cross-median Crashes Per Year After Installation	Fatal Cross-median Crashes Per Year Before Installation	Fatal Cross-median Crashes Per Year After Installation
I–26 from Buncombe County Line to MM 23.8 and Green River to Polk County Line	16.48	7.54	0.32	0.56	0.00
I–40 from S.R. 1138 to 0.201 miles west of U.S. 64	6.809	3.96	0.00	0.55	0.00
I–40 from U.S. 70 to 1.0 mile east of U.S. 221	13.94	5.58	0.00	0.56	0.00
I–95 Bus from 250 feet south of Cross Creek Bridge to 1,060 feet north of U.S. 301	5.00	3.15	0.00	0.30	0.00
I–40 from Johnston County Line to Pender County Line	20.19	5.18	0.67	0.14	0.00

Source: NCDOT.

NCDOT

Another cable guardrail installation on Interstate 540 in Wake County, NC, showing an extremely narrow median.

As a result, nearly 1,610 kilometers (1,000 miles) of barrier were placed across the State." This series of 62 projects to place median barriers on North Carolina freeways began in 1999 and was completed in 2004.

The Federal Highway Administration (FHWA) also played a significant role in ensuring that median barriers would become a reality across the State. Nicholas Graf, the FHWA division administrator in North Carolina at the time, sent correspondence to the NCDOT leadership and appeared before the Board of Transportation to identify reduced highway fatalities from cross-median crashes as a FHWA focus area.

"The division office has been very supportive of NCDOT's efforts to reduce highway fatalities," says Division Administrator John F. Sullivan III. "NCDOT's median barrier program has truly brought a new level of safety to the State's highways and has proved to be a valuable model for other States." FHWA also provided needed data concerning median barriers, including examples of cross-median crash studies and the median policy from California, as well as other information necessary for NCDOT to complete its 1998 report.

Implementation of the Study Results

The results of the two studies became a three-pronged proactive strategy to save lives by preventing cross-median crashes. The first phase was to install protective median barriers on freeways with cross-median crash histories. The second phase was to systematically protect all freeway sections with median widths of 21 meters (70 feet) or less. The third phase consisted of revising policies to prevent the construction of additional freeway sections with unprotected narrow medians.

Phase 1—Installing Median Barriers. When the process of installing barriers began, NCDOT used a number of different types. For a 14.5-kilometer (9-mile) stretch of interstate in the Raleigh-Durham area that carries some 90,000 vehicles per day and has the worst crash rate in the State, the agency decided to use cable guardrail. In other cases, NCDOT left it up to the construction teams as to the type of barrier to use. The type installed depended on a number of site conditions, namely median width and slope. However, the agency typically recommended installing cable barrier where design constraints were met because it is less expensive, causes less damage to vehicles, and is easiest to replace.

Phase 2—Protecting Freeways with Narrow Medians. To ensure that freeway sections with median widths of 21 meters (70 feet) or less would be protected by median barriers, it was suggested that the American Association of State Highway and Transportation Officials' (AASHTO) *Roadside Design Guide* be changed to present a stricter standard for the installation of median barriers. "NCDOT's research and the results that the agency has achieved in terms of saving lives indicate the need to revisit the AASHTO design guide," says Lacy.

Chapter 6 of the guide states that a barrier traditionally is not warranted in medians wider than 10 meters (30 feet). AASHTO further recommends that installing barriers on medians from 10 to 15 meters (30 to 50 feet) should be optional. Agencies typically do not install barriers for those optional situations because of the need for cost savings. Based on research in their own States, California and North Carolina suggested that any medians with widths up to 23 meters (75 feet) could warrant barriers, depending on specific crash histories. Because of initiatives taken by California, North Carolina, and several other State DOTs, the AASHTO Technical Committee for Roadside Safety currently is revising the *Roadside Design Guide* warrants and plans to have more conservative warrants in place in 2005.

Most recently, AASHTO named the median barrier a Technology Implementation Group Focus Technology. As a focus technology, the median

Cable Barrier Systems at a Glance

Cable barriers have been used on the Nation's highways since at least the 1930s. The modern system, which uses three cables supported by weak steel posts, was developed in the 1960s and has been used successfully by several States. Since 1989, AASHTO's *Roadside Design Guide* has contained information on a cable median barrier design that mounts the middle cable on the opposite side of the posts from the other two cables, allowing the barrier to contain and redirect vehicles that strike the system from either side.

Cable median barrier designs have been tested in accordance with the National Cooperative Highway Research Program's *NCHRP Report 350* Test Level 3. Only a few studies, however, have been published about the inservice performance of this system.

The cable barrier system used by North Carolina consists of three steel 19-millimeter (0.74-inch)-diameter cables with steel supporting posts a maximum of 5 meters (16.4 feet) apart. The bottom cable height is 540 millimeters (21 inches) from the ground; the top cable height is 840 millimeters (33 inches) from the ground. Anchor post brackets and breakaway anchor angles secure each end of the cable run. The maximum distance between anchors is 600 meters (1,968 feet). The cable tension is controlled by spring turnbuckles located near each end of the cable run.

In addition to the "generic" cable barrier system described above, there are now several proprietary designs that have also successfully met Report 350 evaluation criteria. These are characterized by the use of prestretched cables that are then installed with significantly greater cable tension than in the original design. These modifications are intended to reduce deflection in a crash and to require less repair afterwards in many instances.


NCDOT


NCDOT

U.S. 64 in Franklin County, NC, before (inset) and after installation of a cable barrier. The guardrail was installed as part of a repaving and shoulder rehabilitation project.

barrier will be promoted to AASHTO member departments and the highway community, aiding in the expansion of the technology to other areas of the country. Efforts to promote the technology will likely include speaker presentations, demonstration workshops, and the development of instructional brochures and CD-ROMS, among other methods of building awareness within the transportation community. North Carolina will also most likely serve as the lead State for the focus technology team, which may include representatives from several State DOTs, FHWA, private sector companies, and academia.

Phase 3—Preventing the Future Construction of Highways with Unprotected Narrow Medians. NCDOT adopted a new design policy in 1998 to prevent the construction of highways with unprotected median width of less than 21 meters (70 feet). Highways with narrow medians can still be constructed as long as median barriers are included as part of their design.

Results in Dollars Spent And Lives Saved

Median barriers clearly have achieved their objective of reducing cross-median crashes and saving lives. Although property damage cost has increased as a result of the barrier placement, NCDOT estimates that 96 lives were saved from January 1999 to December 2003 alone, resulting in an estimated crash cost savings of more than $290 million.

The department's cost-benefit analysis indicates that the program already has paid for itself in lives saved. Installation of cable barriers costs approximately $55,000 per mile in materials and labor, and New Jersey concrete barriers cost between $900,000 and $1.4 million per mile, depending on median width. There have been a few fatal cross-median crashes since installation of the barriers, but the number is significantly lower than it was prior to installation of the barriers. As one may expect, there have been many reported hits on the barriers and an increase in single vehicle crashes.

To date, the installation of median barriers has resulted in:

1. An estimated 90-percent reduction in freeway cross-median crashes
2. Approximately 25 to 30 lives saved each year
3. Hundreds of injuries prevented or reduced in severity
4. Savings of millions of dollars in crash costs annually

"As we build and maintain the State's network of highways, safety is the department's number one priority," says North Carolina Transportation Secretary Lyndo Tippett. "We're very pleased by these findings, and that's why we will continue to place a high priority on installing these life-saving devices along the State's highways."

Median barriers have saved lives in North Carolina, and they offer a promising solution for other States across the Nation. After seeing the success of the program pioneered in North Carolina, several other States currently are implementing the same median barrier technology. As more States realize the important role that median barriers play in preventing crashes, this life-saving device will undoubtedly become a mainstay in highway systems throughout the Nation.

For the future, NCDOT plans to continue seeking innovative solutions to address highway safety. To this end, the department has formed an Executive Committee for Highway Safety to research and develop solutions to other pressing safety issues such as lane departures and motorist behaviors that contribute to crashes on the highways. This diverse, multiagency committee includes membership from FHWA, the University of North Carolina Highway Safety Research Center, and the State Highway Patrol as well as NCDOT. In addition to the implementation of the median barrier program, NCDOT is expanding the use of other roadside technologies, such as rumble strips along the highways, to ensure that citizens are protected and traffic stays on the right side of the road.

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Evaluating the Field Performance of Asphalt Mixtures in The Lab

by Leslie Ann Myers and John D'Angelo

FHWA is assessing the Simple Performance Tester to determine its effectiveness for use in the field.

The National Cooperative Highway Research Program (NCHRP) is developing advanced pavement technology that supports the Federal Highway Administration's (FHWA) mission to achieve long-lived asphalt pavements. One of these advanced technologies is the Simple Performance Tester (SPT), which evaluates asphalt mixtures to determine their response to permanent deformation (rutting) and fatigue cracking. FHWA is supporting NCHRP's research by evaluating how well the SPT works in a field laboratory environment.

Highway engineers have been looking for a simple, inexpensive, and accurate performance test for hot-mix asphalt (HMA) since HMA first came into use in the late 19th century. One of the first tests was the Hubbard-Field method, developed in the 1920s, which measured the strength of the asphalt by using a punching shear load to test for failure.

In the 1930s and 1940s, the industry developed new tools, including the Marshall Stability test to determine the maximum load resistance that an asphalt test specimen will develop at 60 degrees Celsius (140 degrees Fahrenheit) and the Hveem Stabilometer test, which applies vertical loads to compacted specimens to measure the resulting lateral pressures and thus the internal friction within a mixture. During the 1970s and 1980s, a new approach used a loaded wheel tester to apply a load over a compacted slab of specimen mix.

"All of these tests had shortcomings," says John Bukowski, senior engineer, FHWA. "The tests provided only relative rankings of the performance of the mixtures, and they were unable to indicate how each of the variables in the pavement mixture affected performance."

(Above right) This section of asphalt roadway exhibits high levels of rutting.

SPT and Superpave™ Mix Design

From 1987 through 1993, the Strategic Highway Research Program

(SHRP) conducted a $50 million research effort to develop new ways to specify, test, and design asphalt materials. The final product of the SHRP asphalt research program was a new system referred to as Superpave, which stands for Superior Performing Asphalt Pavements. The Superpave method specified how asphalt could be mixed, designed, and analyzed.

"Superpave included a suite of tests and equipment to characterize the performance of mix designs," says Dr. Ed Harrigan, senior program officer for NCHRP, "and the Superpave mix design method has been adopted almost exclusively around the country by State departments of transportation. But the equipment, which is very good, has been found to be too sophisticated and too complex for routine day-to-day operations."

In 2000, the Transportation Research Board's Superpave Mixture and Aggregate Expert Task Group surveyed materials engineers with State agencies and found that they need a simple performance test during mix design, and possibly for field quality control, to evaluate how well the HMA resists permanent deformation and fatigue cracking.

In response to this need, NCHRP developed and evaluated a Simple Performance Tester to complement the Superpave mix design method by providing a test to evaluate the asphalt mix design quickly. "The goal was to come up with equipment that was reliable but inexpensive enough to be placed in all State and contractors' labs," says Harrigan. "It was designed to be small enough to be used either in a fixed or mobile lab and also to be available at a practical cost."

Why Conduct Performance Testing?

Materials engineers use Superpave mix designs that are appropriate for their region. In Florida, for example, the asphalt binder must be stiffer at higher temperatures than would be required in a State such as Maine with its cooler climate. The SPT can be used to test HMA mixtures in any region to determine how the mixture will perform in the field.

The tester is used to help design both the pavement structure and the HMA material used in the pavement. "The Simple Performance Tester helps us get engineering strength values for hot-mix asphalt and mechanistic input values for pavement design modeling," says Dr. Murari Pradhan, bituminous engineer with the Utah Department of Transportation (UDOT), "which is really helpful because it is not only good for materials design, but also it is going to be an integral part of pavement design."

A technician runs the Simple Performance Tester to evaluate an asphalt mixture for its response to permanent deformation (rutting) and fatigue cracking.

The tester will be useful in designing the pavement structure (for example, determining the appropriate thickness of each layer of pavement), because it outputs a stiffness, or E*, value. As described in "Three Tests Included in the Superpave Performance Tester" on this page, this value is used as an input in the overall design of the pavement structure in NCHRP's *Mechanistic-Empirical Pavement Design Guide*. (For more information about the mechanistic-empirical guide, see "Designing Tomorrow's Pavements" in the September/October 2004 issue of PUBLIC ROADS.)

The SPT also is used to design the pavement material based on the desired pavement performance. For example, a materials engineer who wants to achieve less than 12.7 millimeters (0.5 inch) of rutting can use the SPT to test the asphalt pavement mixture and determine how stiff the mixture should be to meet that criterion.

SPT Facilitates Flexibility In Designs

The SPT offers unprecedented flexibility when designing asphalt pavement materials. "Right now we have specified parameters for controlling volumetrics and mix design, which is kind of like a recipe," says Judie Ryan, asphalt mixtures specialist at the Wisconsin DOT (WisDOT). "And the recipe calls for 1 cup of sugar and 2 teaspoons of salt, and so forth, and it makes something called an

Three Tests Included in the Superpave Performance Tester

The SPT conducts the following three tests:

- *Dynamic Modulus Test.* This test, also known as the E* test, outputs a stiffness value for the asphalt pavement mixture. This stiffness value can then be used as an input in the *Mechanistic-Empirical Pavement Design Guide*. This test is run at appropriate temperatures for each location based on data from the Long Term Pavement Performance Bind program (LTPPBind) and the National Oceanic Atmospheric Administration (NOAA) weather database. One advantage of this test is that it is nondestructive, so the analyst can test a single specimen at multiple temperatures and multiple load frequencies.
- *Repeated Load Test.* This test simulates driving a heavy vehicle repeatedly over a sample of pavement. The output for this test is the number of load cycles the pavement can tolerate until it flows. Because the test is destructive, an asphalt specimen can be tested only once.
- *Static Creep Test.* This test simulates a heavy vehicle standing on a pavement specimen, much as a truck might apply steady pressure to pavement while waiting at a red light. The output for this test is flow time, which is the length of time the pavement can withstand the steady pressure until flow occurs.

FHWA's Mobile Asphalt Laboratory working onsite near U.S. 218 in Charles City, IA.

'apple pie.' As you start to develop your own taste, you may change what's in the recipe, say by adding less sugar, but it's still called an apple pie. But with our current parameters, we can only keep asking for apple pies. If I want something else, say a pie with blueberries, I'm out of luck; our current requirements never allow us to get to any new type of pie. We have a finite set of ingredients and combinations, and while other performance testers can measure symptoms that define poor product, the SPT may be that additional tool that helps prevent it."

Ryan continues: "The SPT probably isn't as simple as we all had hoped, but the new technology provides more information than we've ever had before. It's very specific to application and use, where that's been a weakness in our specifications up to this point. So with the SPT, the opportunity is there to find that next best way to design mixtures since we can relate it to actual performance parameters."

Performance testing is also of interest to contractors. "Wisconsin was one of the first States to develop a warranty specification for HMA," says Ryan. The current warranty period is 5 to 7 years and requires the contractor to perform remedial or corrective work whenever a distress threshold is exceeded. "The intention of the warranty is to give the contractors as much freedom as possible while assuring a quality product," says Ryan, "so the warranty specification allows contractors to select their own materials, mix design, construction techniques, and so forth. What this means for the SPT is that if contractors have that next great idea, they can use the SPT as a tool to test and evaluate [the mix] prior to producing it. The risk has shifted to them as they provide that product. In the event that there are some failures, then they have the liability to maintain the roadway for at least the length of the warranty period."

Mobile Asphalt Lab Brings The SPT to the States

At the invitation of State highway agencies, FHWA's experienced technicians and engineers have been traveling with the agency's Mobile Asphalt Lab to project sites across the country. To date, the Mobile Asphalt Lab has visited about 15 States to help them implement new pavement technologies, including the SPT.

Utah is one of the States visited. "The FHWA Mobile Asphalt Lab was here for 2 weeks," says UDOT's Pradhan. "During those 2 weeks, FHWA conducted a presentation to about 30 to 40 people, including all of our pavement and materials engineers from both regional and central offices, as well as contractors and consultants. It was a good opportunity to educate everyone on pavement design and volumetrics design. Now all our engineers, including consulting and contracting engineers, are familiar with the SPT and how it can improve our material mixes, and also how it is going to be part of the new mechanistic-empirical pavement design procedures."

A masonry tile saw is used to cut the end off a cored pavement mixture specimen for the Simple Performance Tester.

Fabrication of Test Specimens

A rigorous evaluation of the SPT in the field, using data from several of the States visited by the Mobile Asphalt Lab, provided promising results that demonstrate SPT's applicability in a field laboratory environment. FHWA analyzed both laboratory-blended and plant-produced materials. For laboratory-blended samples, the researchers brought the samples to testing temperatures with approximately 1 hour of oven heating. After measuring the mixture properties, they compacted specimens in the Superpave gyratory compactor according to the target air void content in the field, as indicated in construction specifications. Specimens typically were compacted to 180 to 185 millimeters (mm) in height, and the average air void content was typically 1.5 to 2 percent higher than the target for the final specimen.

The technicians measured the height and average diameter (at the

Range of Stiffness Data at Effective Pavement Temperatures for Various Mixtures

Project ID	Mix ID	Eff Temperature for Fatigue (°C)	Dynamic Modulus, E* (MPa) Min	Dynamic Modulus, E* (MPa) Max	Eff Temperature for Rutting (°C)	Dynamic Modulus, E* (MPa) Min	Dynamic Modulus, E* (MPa) Max
Coarse 19 mm PG 76-16	Laboratory-Blended	22.0	1594	7298	44.0	169	2061
	Plant-Produced	22.0	1316	8499		203	2694
Fine 19 mm PG 64-22	Laboratory-Blended	15.6	1744	13050	31.2	183	6501
	Plant-Produced	15.6	1126	11885			
	Laboratory-Blended	19.6	1679	11920			
	Plant-Produced	19.6	823	10863		224	6644
	Laboratory-Blended	23.6	874	9784			
	Plant-Produced	23.6	437	8555			
12.5 mm PG 76-22 & PG 67-22	Coarse 76-22	20.1	2663	10313	53.4	272	2530
	Fine 76-22		2782	10063		190	2466
	Coarse 67-22 Top Lift		2675	11100		118	2742
	Coarse 67-22 Bottom Lift		2080	11696		110	2523
Coarse 19 mm PG 58-28	Laboratory-Blended	17.0	1017	9576	40.0	92	2315
	Plant-Produced	17.0	1424	10106			
	Laboratory-Blended	23.0	882	7226	40.0	114.3	2453
	Plant-Produced	23.0	582	6697			

Source: FHWA.

mid and third points of the specimens along two perpendicular axes) using a digital caliper ruler. They calculated the standard deviation of the resulting six measurements, recording to the nearest 1.0 mm. Specimens were required to have a standard deviation less than 1.0 mm. For the ends of the specimens, the technicians recorded parallelism, using a machinist's square and feeler gauges, and flatness, using the feeler gauges and a straight edge. The technicians then cored specimens using a conventional core drill to obtain a sample 100 mm in diameter. Finally, the specimen ends were trimmed with a masonry tile saw to obtain a height of 150 mm.

Tests Conducted in Field Lab

The FHWA engineers analyzed the asphalt mixtures in the SPT using two performance tests, dynamic modulus and repeated load test, as described in "Three Tests Included in the Superpave Performance Tester" on page 39. The FHWA technicians conducted the tests in accordance with protocols currently being established through NCHRP research projects 9–19 and 9–29. In the dynamic modulus test, the technicians applied a continuous haversine axial compressive load and used the resulting stresses and strains to calculate the dynamic modulus and phase angle. The testing protocols included running the dynamic modulus test at six different frequencies to represent traffic loads traveling at low to high speeds.

For the repeated load test, the technicians applied a pulsating load for 0.1 second, followed by a 0.9-second rest period and contact stress of 30 kilopascals (kPa). They applied an axial stress of 600 kPa to simulate an average tire contact stress of a mixed traffic loading.

They ran the dynamic modulus tests to obtain stiffness values for a pavement at the two temperatures—the effective pavement temperatures for fatigue damage and for rutting, respectively. Effective pavement temperatures were calculated using equations developed in NCHRP and SHRP research programs, and were based on climatic data from the NOAA and LTPP weather databases.

Dynamic Modulus Database

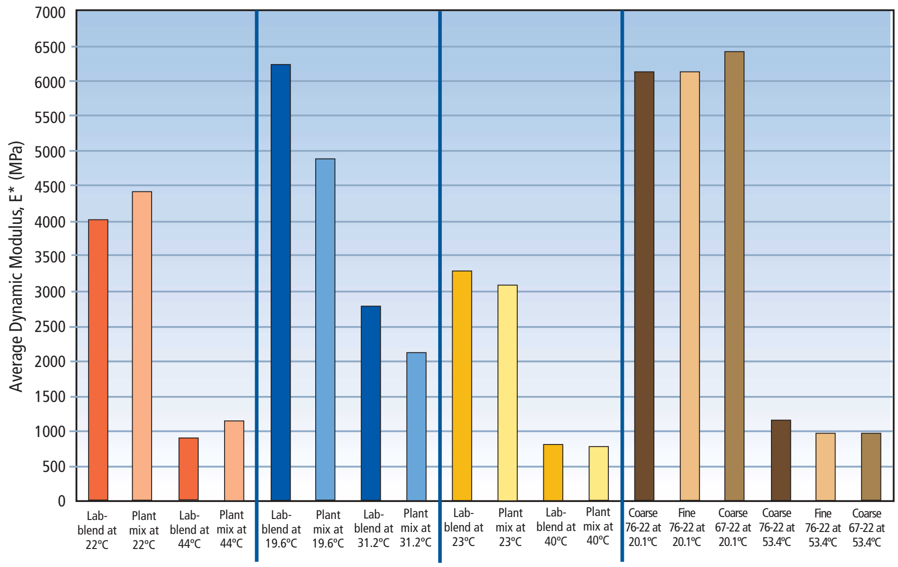
The FHWA engineers developed a database to present the range of stiffness values for the different mixtures investigated in the Mobile Asphalt Lab. The findings, shown in the table above, provide the minimum and maximum stiffness values for the laboratory-blended and plant-produced specimens at the various temperatures for fatigue cracking and rutting.

The engineers assessed the volumetric data to help explain differences in stiffness values that were observed. Note that for all data from one State, the 12.5-mm PG 76–22 and PG 67–22 mixes are based on plant-produced specimens only. The differences in stiffness between lab-blended and plant-produced mixes are consistent, although slightly less pronounced for rutting. This result implies that using stiffness values from lab-blended specimens in a mechanistic pavement design or asphalt mix design procedure could possibly under- or overestimate the material stiffness.

Evaluation of Data from Repeated Load Test

The repeated load test conducted in the SPT is also used for predicting the rutting performance of the HMA pavement. Technicians ran the test at the effective pavement temperature for rutting for each mix. A mixture with a low value of microstrains, which represents strain (deformation) expressed as parts per million, can be expected to exhibit better rutting performance than a mixture with a high amount of strain. That is, a low number of microstrains means that the asphalt mix does not flow as easily under a heavy pulsing load and could be expected to perform well in the field under the axle loads applied by traffic. Typical flow numbers result in 4,000 to 25,000 microstrains. The flow number is the number of load repetitions when shear deformation occurs under

Average Stiffness Values for Mix Design Lab-Blend and Plant-Produced Mix over Range of Frequencies



This figure shows that the differences in stiffness between lab-blended and plant-produced mixes are consistent, although slightly less pronounced at the effective pavement temperature for rutting. *Source: FHWA.*

constant volume. The total accumulated microstrains is the amount of deformation in the specimen at the end of the repeated load test.

The importance of capturing the total accumulated microstrains was even more pronounced in data derived exclusively from plant-produced specimens, as seen in the figure above. If only the microstrains at flow number are captured, both fine- and coarse-graded mixtures, regardless of the binder type and applied stress level, appear to behave similarly. The general trend is that if the test is stopped at microstrains at flow number, there is no discernable difference between the four mixes. A review of the total accumulated flow (microstrains) for these specimens, however, tells a very different story. Once the test is carried out to the total accumulated microstrains, the data clearly demonstrate the difference in rutting performance between the modified and unmodified coarse and fine mixtures. In doing so, results make engineering sense in that the modified (PG 67) mixes are more resistant to rutting than the unmodified neat (PG 76) mixes. Therefore, although the current test protocol in NCHRP 9-19 recommends flow number as the determining criterion, the investigation indicated that important trends will be missed; and the behavior of the mix in the field may be miscalculated if flow number is used to define mixture rutting performance. These data suggest that the more appropriate parameter may be the total accumulated microstrains, and this parameter should be used to evaluate mixtures in the repeated load test for rutting.

Key Findings from Investigation

The most important finding of the overall investigation is that the SPT can be used routinely and can be used in a field laboratory. FHWA has used the SPT for more than 2 years on construction sites and has successfully tested field mixes in a field laboratory, facilitating a quick and easy prediction of the asphalt performance.

A second finding is that any of the tests included in the SPT (such as the dynamic modulus test, repeated load test, or static creep test) appear to verify a clear relationship between the volumetric properties (the makeup of the mix) and composition, and the predicted performance in the field.

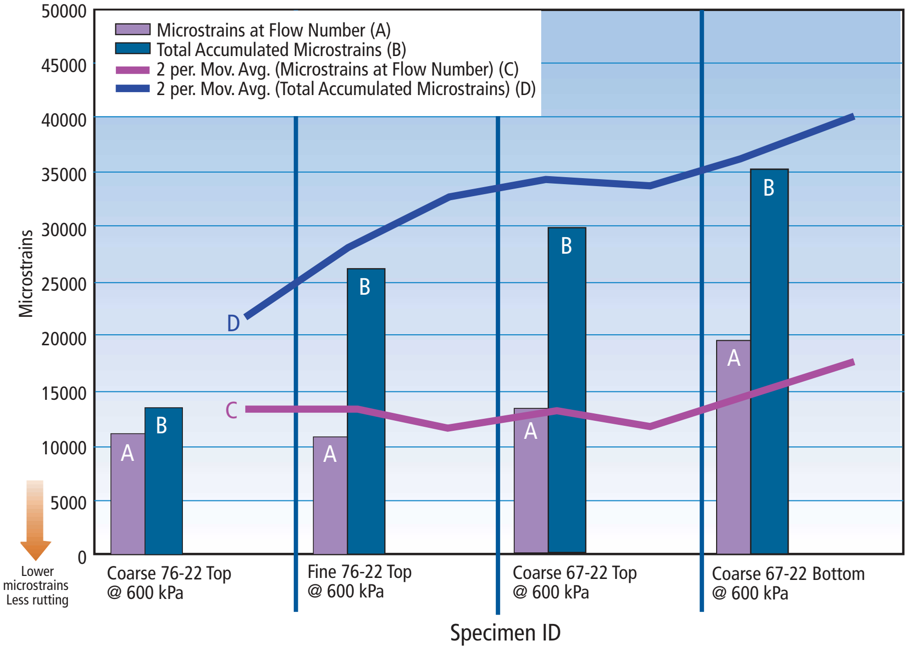
A third study finding is that, for the repeated load test, analysts should review not only the flow number but also the total accumulated microstrain, which will provide a more accurate indication of the flow characteristics of the asphalt mix.

Range of Flow Number and Accumulated Microstrain Data (Total Damage) for Various Mixtures

Project ID	Mix ID	Temperature °C	Microstrains at Flow Number		Total Accumulated Microstrains		Flow Number (Cycles)		Total Number of Cycles	
			Min	Max	Min	Max	Min	Max	Min	Max
Coarse 19 mm PG 76-16	Laboratory-Blended	44.0	13228	26466	17818	26466	1591	6251	3485	9990
	Plant-Produced		12752	24798	13003	24798	971	9411	1415	9990
Fine 19 mm PG 64-22	Laboratory-Blended	31.2	4231	13520	4414	35431	3111	16331	6000	18000
	Plant-Produced		6259	22015	6539	50000	1511	15951	3700	20000
12.5 mm PG 76-22 & PG 67-22	Coarse 76-22	53.4	6393	19116	13310	19318	2531	11711	8173	12180
	Fine 76-22		8473	18095	12325	50000	1231	6411	3835	17031
	Coarse 67-22 Top Lift		16752	18917	26432	37120	1091	1971	2596	3451
	Coarse 67-22 Bottom Lift		17867	21364	25245	49423	730	2451	1316	5294
Coarse 19 mm PG 58-28	Laboratory-Blended	40.0	11941	20918	50000	50000	131	671	341	2231
	Plant-Produced		13838	17155	50000	50000	151	551	463	1787

Source: FHWA.

Characterizing Flow Behavior of Coarse and Fine Plant Mixtures Using Repeated Load Test



This figure shows that if only the microstrains at flow number are captured, both fine- and coarse-graded mixtures, regardless of the binder type and applied stress level, appear to behave similarly. However, a review of the total accumulated microstrains (total damage) demonstrates the difference in rutting performance among the modified and unmodified, coarse and fine mixtures. *Source: FHWA.*

States Look Forward to Using the SPT

To date, only one State, Maryland, owns the latest model of the SPT. But other States plan to purchase it once testing and refinement of the SPT is complete and it is available commercially, which is expected within a year.

"From a State point of view, there's a real need for the equipment," says Larry Michael, regional engineer and asphalt team leader for the Maryland State Highway Administration. "We need a quick strength test for HMA mixes, and the equipment will work well with the new *Mechanistic-Empirical Pavement Design Guide*, which is of interest to Maryland. The equipment itself is user friendly and performs well. We've all been surprised at how good the early tests have been."

Utah also was pleased. "FHWA demonstrated that [the] SPT can be used in the field," says UDOT's Pradhan. "We ran two performance testers, and we found that the results were consistent, and they can be reproduced. We're going to use the SPT for our [mixture] design, and as we get comfortable with the design, we may be using it on the field mixtures too."

According to UDOT, the SPT may be particularly helpful in the field when there's a dispute between the agency and the contractor. "When the contractor lays down the pavement, we take a sample and test for the volumetrics," says Pradhan. "Sometimes this does not match up with what is required, which can lead to a dispute. So in this situation the SPT will be helpful since we can quickly conduct the tests to provide some objective data."

Wisconsin also plans to use the SPT. "In Wisconsin, up until the early 1990s, the department would just go out and kind of kick the tires and, if we thought the pavement mixture needed something else, we kind of guessed, turned some dials, and that's what it was," says WisDOT's Ryan. "So we're very excited that, in this last decade, we've learned more about the materials that are going into the mixture and what the end-product is coming out. And the SPT should allow us now to define what it is that we actually want to come out, in terms of an expected performance."

Next Steps

FHWA plans to continue evaluating the SPT throughout the country, visiting as many locations in the Mobile Asphalt Lab as possible. Because only two mixes at each location will be tested, State transportation agencies eventually will need to have their own SPTs.

To further assist States, FHWA will post data on the agency's pavement technology Web site showing the range of stiffness values found at given temperatures for various types of asphalt mixes around the country. So as States begin to purchase SPTs and conduct tests, they can compare their test results to the posted data. FHWA expects that States will find data from a region comparable to their own to confirm that their tests are functioning properly.

Leslie Ann Myers, Ph.D., is program director for the Mobile Asphalt Laboratory, which evaluates new and research-grade asphalt testing technology in the field by visiting States throughout the United States. She is a member of the Asphalt Team in FHWA's Office of Pavement Technology. She is also a member of the Design Guide Implementation Team and has worked on pavement design and analysis for the last 10 years. She holds a doctorate in civil engineering from the University of Florida; her research focused on top-down cracking in asphalt pavements.

John D'Angelo is an asphalt materials engineer in the Office of Pavement Technology at FHWA. He has been with FHWA for 27 years. For the past 12 years, he has been involved with the implementation of Superpave. He has published numerous papers on material testing and quality control.

For more information, visit FHWA's Asphalt Technology Team Web site at www.fhwa.dot.gov/pavement/ashome.htm, and FHWA's Mobile Asphalt Pavement Mixtures Laboratory Web site at www.fhwa.dot.gov/pavement/asmixlab.htm.

Signs Show The Way to Cost-Effective Rural Safety

by Gib Peaslee

A county in California recently showcased a low-cost and successful program for saving lives on secondary roads.

More crashes occur on rural roads, like this one through Potter Valley in eastern Mendocino County, CA, than on any other roadways in the Nation. *Photo: MCDOT.*

According to the National Highway Traffic Safety Administration, rural roads—though often scenic—are actually the most dangerous roads in the Nation. In 2001, rural roads accounted for approximately 60 percent of all fatal crashes.

Many small secondary roads were constructed originally to follow property lines, so the curves often are not up to code in terms of the degree of turn. Some secondary roads on these old systems have no shoulders, no centerline stripes, and no road edge markings. Some have curves that start with one radius and end with another. Given these conditions, plus local economic realities that limit reconstruction to change alignments, correctly placed and consistently employed signs may be the most effective strategy to save lives at a cost that almost any county can afford.

Mendocino County, CA, has demonstrated just how effective signs are as a low-cost safety measure. In a landmark, low-tech program, the Mendocino County Department of Transportation (MCDOT) reduced its crashes by a startling 42.1 percent from 1992 to 1998 at a cost of $79,260 over the 6-year period. The benefit-cost ratio works out to $299 in savings for every $1 spent, using California Department of Transportation (Caltrans) formulas.

"Although this cost-benefit ratio may not be achievable on all projects, even a tenth of the cost-benefit ratio may

Mendocino County has miles of rural roads in the valleys and along the coast. This scenic road curves around Mendocino Bay with the town of Mendocino in the background.

Stephen Ford, MCDOT

justify the investment," says Federal Highway Administration's (FHWA) Road Departure Team Leader Harry W. Taylor.

MCDOT refers to its program for evaluating and improving the safety of the county's road signs as Road System Traffic Safety Reviews. The scope is similar to road safety audits and the evaluation process used by many State DOTs, but the focus is primarily on highway signs.

"We believe that the most cost-effective method for enhancing safety on rural roads is to make the driver more aware of road conditions through consistent signing and markings," says Eugene C. Calvert, P.E., former director of transportation with MCDOT and now principal project manager for the Collier County Transportation Services Division in Florida.

A Typical County

Mendocino County is similar to many rural counties, parishes, townships, and reservations across the Nation. Located about 161 kilometers (100 miles) north of San Francisco, Mendocino has a largely agricultural economy and a slowly growing population approaching 90,000 people. The terrain is mountainous, and many of the county's crashes involve vehicles running off the roads at curves.

In size, the county is 9,091 square kilometers (3,510 square miles), and MCDOT is responsible for maintaining and improving 1,639 kilometers (1,018 miles) of secondary roads. Among them are paved and unpaved local roads, major and minor collectors, and one four-lane arterial carrying about 18,000 cars per day. Some of the local roads see an average daily traffic (ADT) of only 20 cars per day. Most of the collectors and paved local roads carry more than 500 ADT.

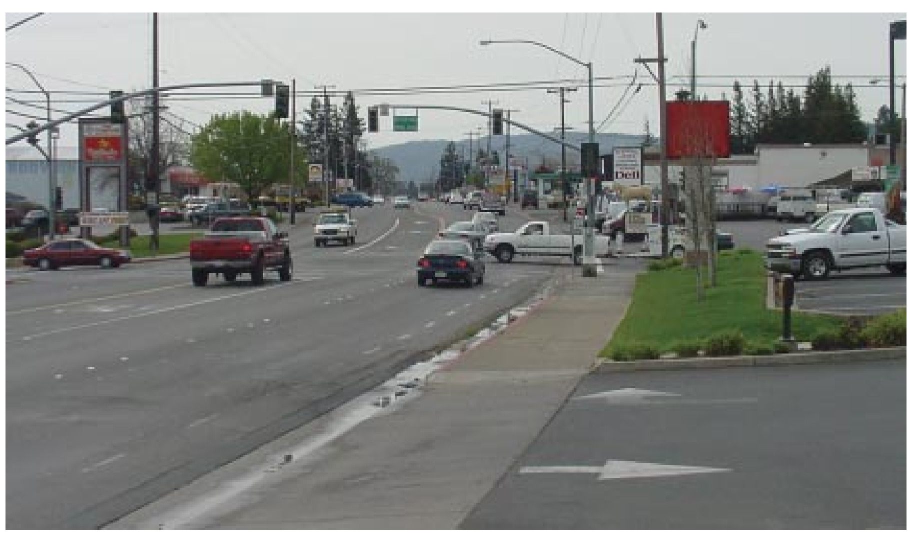
The county transportation agency operates with limited funds and has to maximize the use of every highway dollar. "The local government highway agencies that are responsible for the majority of the two-lane roads in the United States do not typically have large resources or the professional staff to complete exhaustive safety studies," says Calvert. "They need to get the most bang for their buck for any safety improvements that are implemented."

Mendocino County focused on improving signage because installing signs is cheaper than improving the road geometry by widening or flattening curves. Installation of each sign costs Mendocino County about $107 for labor and materials. Quite a few signs can be installed for an amount that would pay for very little in construction realignment.

A Practical Program

"One of the most impressive things about the program is its practicality," says Susanna Hughes-Reck, a technology deployment specialist with the FHWA Resource Center in Denver, CO. "Almost any county can replicate Mendocino's strategy as long as the program is adapted to local conditions."

In the late 1980s, long before safety became a priority for local agencies, Mendocino County



Stephen Ford, MCDOT

North State Street in Ukiah, the county seat and center of population, is the only four-lane arterial in Mendocino County, carrying 18,000 vehicles in average daily traffic.

Sign Color Studies

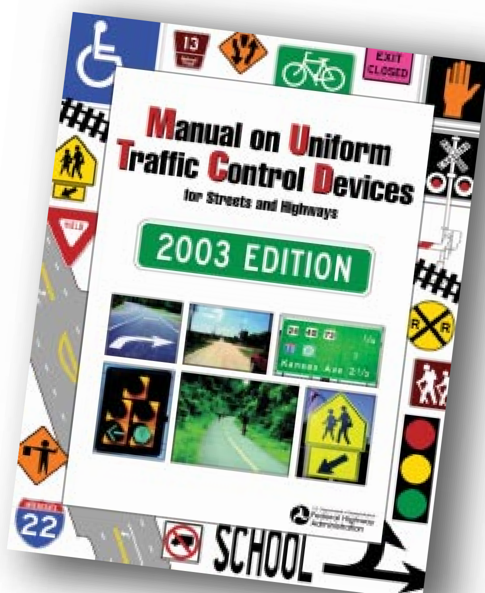
FHWA has had sign programs over the decades, and sign technology has changed and is continually evolving. For example, FHWA has extended the regulations for sign retroflectivity to all signs, not just regulatory and warning signs, to improve safety and visibility during adverse ambient conditions. Other changes are afoot as well.

In 1998 and 2001, Vicki Neale, director of the Center for Human Factors Research at the Virginia Tech Transportation Institute (VTTI), conducted research that led to adoption of black text on fluorescent pink (originally an orangish coral) backgrounds for signs targeted at incident management. Such signs might include notification of a temporary exit closure or detour, as described in Section 6–1 of the current *Manual on Uniform Traffic Control Devices* (MUTCD). See http://mutcd.fhwa.dot.gov/pdfs/2003r1/Ch6I.pdf.

The studies, funded by the Virginia Transportation Research Council (VTRC), first evaluated existing reserved MUTCD traffic sign colors that had not yet been assigned for a specific use. Shortly thereafter, VTTI and VTRC determined that additional research was warranted on the fluorescent counterparts of those colors. The 2001 study compared black on fluorescent pink, fluorescent yellow on fluorescent purple, black on fluorescent yellow-green, and nonfluorescent yellow on nonfluorescent purple.

Overall results indicated that black on fluorescent yellow-green was the most visible color, but this combination was already reserved by FHWA for pedestrian crosswalk and school zone signs. "The next best performer," says Carl K. Andersen, manager of FHWA's Arens Photometric and Visibility Laboratory at the Turner-Fairbank Highway Research Center in McLean, VA, "was black on fluorescent pink—thus the selection of this highly visible color combination for these critical signs."

For more information, see www.ctr.vt.edu/index.cfm?fuseaction =DisplayResearchProjects& ProjectID=49 and www.ctr.vt.edu /index.cfm?fuseaction=DisplayResearchProjects&ProjectID=135. Or contact Carl K. Andersen at 202–493–3366 or carl.andersen@fhwa.dot.gov.



The 2003 edition of FHWA's *Manual on Uniform Traffic Control Devices.* The MUTCD served as Mendocino County's guidebook for selecting and placing signs.

recognized that something needed to be done. Selecting a handful of roads, the agency looked at the previous year's collision records for each road. At that point, the county was choosing the roads by a trial-and-error method in which the roads reviewed were the hotspots that had the greatest number of crashes.

Then in 1992, Mendocino named Stephen Ford, a civil engineer, as the county's traffic engineer, although he had no background in that field at the time. What he found surprised him. "When I first started," says Ford, "I saw that our previous traffic engineers had been submitting reports, but no signing changes had been made. I also realized that we had been reviewing the same few roads over and over again."

He decided to do the reviews in a systematic way instead of spot checks. So he divided the county into three major geographical areas—the coast, southern inland, and northern inland—and then instituted a rotation system, so that each road would be reviewed on a recurring 3-year cycle to identify signing and marking deficiencies.

Starting small, Ford reviewed 25 miles of road in 1992, covering the engineering costs with $7,200 secured from the Regional Transportation Planning Agency using Statewide Transportation Improvement Program (STIP) funds. Every year after that, the county expanded the program, until 226 miles of road were reviewed in 1998 at a cost of $10,500.

For each review, the reviewer studies all of the crashes reported in the subject area during the preceding 3 years. This review requires reading each individual collision report, not just statistical summaries, to understand what the investigating officer saw and why the crash may have occurred at that particular location. Early efforts concentrated on improving curve and turn signing and on eliminating nonstandard signing. Later efforts focused on object markers for bridges, culverts, roadside trees, and other hazards, plus the installation of delineators to outline curves, a measure that is particularly useful for motorists driving at night or during inclement weather.

Reviewing in 3-year cycles tends to even out the erratic annual variations in collision numbers common on low-volume or rural roads. The cycles allow some regression to the mean and improve the reviewer's chances of spotting truly meaningful trends in collision patterns. Cyclical reviews allow the message, location, or physical dimensions of the sign installations to evolve in response to experience. In addition, maintenance crews tend to focus on potholes and ditches, failing to notice that a sign may have been damaged or fallen down. The ongoing reviews ensure that conditions do not deteriorate and that the crash rates do not rise again. Also, after the first couple of reviews, situations requiring attention beyond just signing and marking improvements become apparent. Information developed for Traffic Safety Reviews lends support to requests for project funding of safety improvements such as turn lanes and removal of obstacles.

The review program is affordable and low-tech. The only essential equipment is a vehicle equipped with an accurate distance measuring instrument and a ball bank indicator to locate and evaluate crash sites. An accurate milepost system is desirable, though not necessary, as are a computerized sign inventory, collision databases, and a laptop computer. In 1992 MCDOT had only a computerized sign inventory. A laptop computer, which increased productivity significantly, was acquired a couple of years later. The county is just now obtaining a geographic information system (GIS)-compatible collision database and is still working on installing an accurate milepost system.

Funding from the Hazard Elimination Safety (HES) Program paid for Mendocino County's sign installations in 1992. Much of the county's sign inventory was old, so about one-quarter of the signs were changed that first year. "After that," says Ford, "we included something in the budget so that signs would get replaced within a few months after each review."

To provide guidance in selecting potential corrective measures and to ensure standardization of signing, the county used the policies in the Caltrans *Traffic Manual*. This was superseded in 2004 when California adopted the FHWA MUTCD. Ford believes that the rational placement of standard signs is critical to the program's success.

In June 2003, Ford and Calvert presented a technical paper on Mendocino County's program at the Transportation Review Board's 8th International Conference on Low-Volume Roads. In that paper, they noted amazingly successful results on the original 19 roads in the program for the period from 1992 to 1998: Total crashes had declined from 601 to 348, or 42.1 percent. Fatalities were down from 13 to 5, and injuries had decreased from 266 to 155.

Unfortunately, Ford is not aware of any other counties or States that have developed a signage program similar to Mendocino's. "Every time I take a driving trip around the country," says Ford, "I see a lot of nonstandard signing out there on small roads in rural areas, where people are in the same boat we are—not a lot of money and a small staff."

Mendocino County has many scenic byways, such as this postcard-worthy coastal road near the Point Arena lighthouse (left), a Comptche Ukiah Road passing through young redwoods (above), and a rustic road in the village of Comptche (below).
Photos: Stephen Ford, MCDOT.

Cost-Benefit Ratio

When Calvert joined the county as director of transportation, he asked Ford to research the benefits of the program and to calculate the cost-benefit ratio. Ford totaled up the costs, finding that the engineering reviews in 1992 and 1995 added up to $14,760. Sign replacement in 1992 cost $46,300 and $18,200 in 1995. The program's grand total was $79,260.

He then compared crash records for two sets of control roads: the county roads that had not yet been reviewed and the State highways within the county, also not reviewed. In most cases, both sets of control roads had the same characteristics as the reviewed roads: the same driver demographics, same driving habits and patterns, same crash reporting and investigation standards, same weather and climatic conditions, and same funding levels and maintenance practices.

The unreviewed county roads showed a 26.5-percent increase in total crashes over the 6-year period. Without the program, if crashes on the reviewed roads had increased at the same rate, the county would have had 696 additional crashes.

Therefore, using Caltrans' 1998 estimate of $34,100 for the average total cost of a crash on rural two-lane mountainous roads (emergency response, medical costs, time lost

David Page, Florida LTAP

During the showcase's field visits, Mendocino County closed off the road except for local traffic and stationed flaggers at both ends. Note the small "2" and "5" signs attached to the curve signs. Number 2 (the sign farthest from the camera) represents the signing condition as of 1992. Number 5 (the sign closest to the camera) represents the 1995 upgrade.

from work, and the like), Ford determined that this would have resulted in a greater number of additional crashes (696) and a savings of $23.7 million, a cost-benefit ratio of 1/299. The State highways did show a 3.3-percent decrease in crashes, perhaps due to the State's history of standardized signing and marking. Still, even at that rate of decrease, the county would have had 369 additional crashes. Using the Caltrans estimate, this would have resulted in a savings fo $12.5 million, or $159 saved for every $1 spent.

In either case, the benefits are above normal. Although all projects may not have the same cost-benefit ratio, the ratio does indicate a large benefit for this specific project.

Showcasing Mendocino's Success

To highlight Mendocino's strategy for reducing crash rates on rural roads, FHWA's Local Technical Assistance Program (LTAP) sponsored a showcase on September 28–29, 2004. The event was part of a series of LTAP showcases for local highway agencies featuring hands-on demonstrations of proven, new technologies and practices.

Nationwide, rural transportation agencies are responsible for constructing and maintaining nearly 4.8 million kilometers (3 million miles) of roadways and more than 29,000 bridges. But at the local level, technology buy-in is complicated by the financial, professional, and political risks that public agencies face when committing limited funding to the implementation of technologies with which they themselves have not had field experience. In the 1980s, FHWA introduced LTAP to facilitate information exchange to support local road and bridge agencies. In 1995, the LTAP center in Florida launched an innovative Product Demonstration Showcase program with the goal of speeding up the implementation of new technologies at the local level.

Showcases target decisionmakers such as crew chiefs, road supervisors, city and county engineers, public works directors, and elected officials. Travel stipends help participants cover the cost of attending. After the showcase, based on their newly acquired experience with a technology, local personnel have more confidence about putting their professional reputations on the line when they go to their city commissioners and say, "We've got to have this technology." (For more on the showcase program, see "Technology Goes Local" in PUBLIC ROADS, March/April 2003.)

The 188 participants in the Mendocino showcase attended presentations by county and LTAP staff on the importance of highway safety, the collection of data to evaluate safety problems, the causes of crashes and what to look for in crash hotspots, and the importance of consistent signage and how to establish safe and consistent advisory speeds on curves. The participants gained a basic understanding of the MUTCD, including various types of signs, such as regulatory stop signs, warnings for curves, guide signs for route numbers, service signs, and markers for recreational and cultural attractions.

They also visited field sites to observe roadway conditions and the corrective measures that Mendocino County had applied. The participants discussed whether the right signs were used in the right places or should be relocated, whether the signs were large enough, where the road should have object markers (bridge abutments, culverts, roadside trees) and curve delineators, whether the road had enough signs or too many, whether advance warning signs and street signs were adequate, and whether the posted

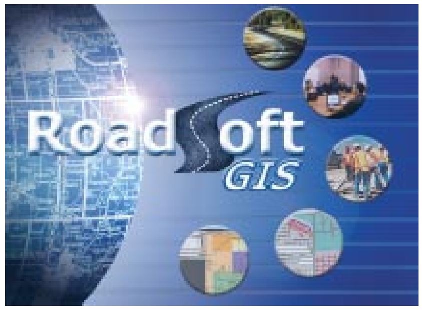
David Page, Florida LTAP

Ben Colucci, codirector of the Puerto Rico LTAP, inspects a sign that was placed temporarily during the showcase to illustrate a former signing condition.

Software Assistance

Three special presentations during the Mendocino event showcased software applications that can help local agencies develop their sign review programs.

Local Agency Crash Analysis Using RoadSoft GIS: Over the past 11 years, the Michigan LTAP, with support from the Michigan DOT and FHWA, developed RoadSoft GIS as a transportation management tool for local agencies in Michigan. RoadSoft GIS is an integrated roadway management system designed specifically for counties and cities. It enables agencies to manage their roadways and roadside assets (signs, pavement markings, guardrails, culverts, pavements, and crash data) within one GIS-based software application.

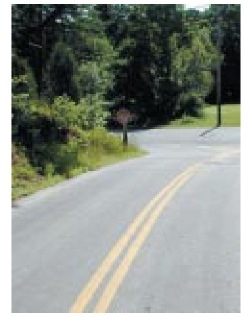


The RoadSoft startup screen.
Source: Michigan Technological University, 2004.

During the showcase, Tim Colling, P.E., assistant director of the Michigan LTAP, demonstrated how local agencies and law enforcement units in Michigan use the features of RoadSoft's Safety Management Module. Counties and cities, using the supplied jurisdictional crash data, can perform a wide range of reporting and analysis on intersections and road segments. Agencies can determine potential safety hazards or crash trends by running any of the numerous standardized reports, such as intersection and road segment reports, which use traffic volumes and a cost model to rank hazardous locations. Users also can generate GIS map outputs or create customized reports that integrate additional management data, such as traffic counts, pavement type, and pavement condition. Users can export the entire data set to a shape file for use in other GIS systems. A downloadable demo of RoadSoft GIS is available at www.roadsoft.org.

Sign Inventory Management System (SIMS): Charlie Goodspeed, professor in the College of Engineering at the University of New Hampshire, demonstrated SIMS, which provides effective sign management in an easy-to-understand format with easy-to-use software. Initially designed for small- to medium-sized county highway agencies, SIMS has helped large agencies provide adequate signing as well. It enables local agencies to identify unsafe traffic signs, repair or replace them, and to remove obstructions.

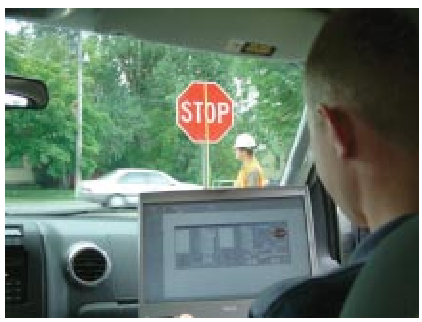
The New Hampshire LTAP developed SIMS with three guiding principles. First, the most important responsibility of a government entity that maintains roads is to ensure that motorists can travel on its roadways safely. Second, effective management of traffic signs is essential to ensure motorist safety. Finally, effective maintenance is the best defense against civil liability claims involving traffic signs.



SIMS identifies traffic signs like this one that are unsafe due to age, damage, or obstructions.
Photo: UNH Technology Transfer Center.

The management system and its supporting software contain the following components to help highway agencies manage their traffic signs effectively: sign inventory including condition assessment, priority analysis of the most serious threats to motorist safety, scheduling of repairs and maintenance, documentation of actions through SIMS work orders to facilitate the preparation of sign maintenance budgets, and parts management.

With the SIMS software, users can organize and access the data by index, query software tools, and generate customized reports. The New Hampshire LTAP and similar centers in certain other States provide technical support.



Employee Brian Birch of the Utah LTAP Center takes an outside measurement while his colleague Dan Jones records it in the sign management module of the Transportation Asset Management Software (TAMS).

Transportation Asset Management Software (Utah LTAP TAMS): Doyt Bolling, director of the Utah LTAP Center, has developed an asset management package that helps cities and towns implement a GIS-based system enabling local agencies to assess their total needs, develop appropriate preservation programs, and evaluate and predict the likely outcomes for the transportation system in terms of service life for a period of up to 10 years. Stuart Thompson, assistant director with the Utah LTAP, demonstrated the sign management module added by the Utah LTAP to TAMS.

advisory speed limits at curves were consistent from one location to another. They were driven to the sites where actual crashes occurred and asked to consider why crashes happened in given locations by looking at damaged guardrails, skid marks, and the like.

During the site visits and question-and-answer sessions, the showcase participants raised a number of issues. They pointed out, for example, that most of their agencies—like the MCDOT itself—have neither the technical staff nor the financial resources to develop crash analysis and asset management systems. Jurisdictions without engineers on staff were advised that they can seek engineering assistance from their State DOT, a nearby city, or a traffic engineering consultant.

To further respond to these technical needs, representatives from the Michigan LTAP center presented a crash analysis and reporting system that is integrated with agencies' management systems for road surfaces, signs, guardrails, and pavement markings. Showcase participants received handouts on the Michigan crash analysis system plus free copies of software packages for sign and asset management developed by the New Hampshire and Utah LTAP centers. The software packages are user-friendly, even for a relative computer novice, especially since postshowcase technical support is available to assist participants with implementation of their own sign programs. (See "Software Assistance" this page.)

To address the need for financial resources, the showcase included two grants resource specialists who discussed potential grant sources, such as the HES Sign Replacement

Stephen Ford, MCDOT

A ball bank indicator and distance measuring instrument are mounted on a car dash in the line of sight.

Programs, State safety programs, governors' offices of traffic safety, regional rural transportation planning agencies, and metropolitan planning organizations. Participants asked so many questions of the grants specialists that their sessions had to be extended.

Some equipment is needed to get started: a distance measuring instrument that attaches to the dashboard of a vehicle and has a digital readout, an inclinometer or hand level for measuring down grades, a ball bank indicator for measuring curves, safety vests, flashing beacons, an audio recorder, and a laptop (optional). Crash reports can be logged on a computer or in a binder, recording the date, road, and milepost location. A computerized and searchable crash database will help with identifying trends and patterns, as well as analyzing the effects of the program. Most States require a mileage inventory for arterials and collectors, so that inventory can be a viable place to start a safety review program.

Typical fields on a sign inventory database include the road number and name, installation number, milepost, side of road, facing direction, size, face material, MUTCD sign code, mounting type, installation date, and maintenance date.

"You can start small," says Calvert. "You don't have to do every road the first year. Start with one or two, find out what works for you, and slowly add more roads to the system." A given county's schedule of reviews will depend on the personnel and time available, geographic extent, and number of road miles.

Further, in cooperation with the Idaho Technology Transfer (T2) Center, FHWA has funded the development of a short course on sign safety reviews, and the course is available on CD-ROM. "A road superintendent with proper training through the course can make a difference at the local level," says Calvert. "He may not be able to make a 42-percent difference, but every little bit helps."

Finally, representatives of the National LTAP Association's Product Demonstration Program at the Florida LTAP Center will contact all participants over the coming year to track local implementation of sign review programs throughout the United States and to document the success of those programs. "We want to ensure that we weren't just a fluke," says Calvert. "Maybe our signs were so bad that we got big results. Right now, we don't have the statistics."

He adds that if Mendocino County's results prove to be typical, then ensuring that safety program funds get to local agencies could "really make a dent in fatalities. Like many throughout the United States," says Calvert, "I too have had family and friends die on our Nation's rural highway system. If we can save a life, this effort will be worth it."

Gib Peaslee is codirector of the Florida T2 Center and director of the Florida LTAP. He has been involved in the development of the Product Demonstration Showcase program, a national LTAP initiative to encourage implementation of field-tested new products and processes among local, State, and Federal road and bridge professionals.

For more information on the Mendocino County program, visit www.pdshowcase.org/default.asp?view=mendovideo, or contact Eugene Calvert at 239-213-5833 or EugeneCalvert@colliergov.net, and Stephen Ford, RCE, at 707-463-4351 or fords@co.mendocino.ca.us. For information on the short course, contact Jim Smith, 352-392-2371, ext. 270, or jim@ce.ufl.edu to request the training. To learn more about the showcase program, visit www.pdshowcase.org or contact Gib Peaslee at 352-392-2371, ext. 245, gib@ce.ufl.edu.

Road Safety Audits

A road safety audit is a formal safety performance examination of an existing or future road or intersection by an independent team. The American Association of State Highway and Transportation Officials' Technology Implementation Group (TIG) recently approved road safety audits as a focus technology. In partnership with TIG, FHWA included road safety audits on its list of priority technologies and innovations. Visit www.fhwa.dot.gov/rnt4u.

Along the Road

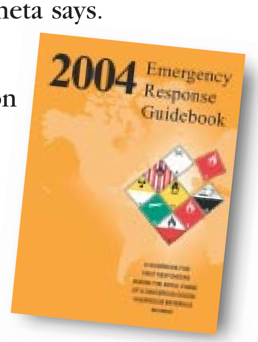
Along the Road is the place to look for information about current and upcoming activities, developments, trends, and items of general interest to the highway community. This information comes from U.S. Department of Transportation (USDOT) sources unless otherwise indicated. Your suggestions and input are welcome. Let's meet along the road.

Management and Administration

USDOT Distributes Hazmat Guidebooks To Emergency Organizations

U.S. Transportation Secretary Norman Y. Mineta recently announced that USDOT is distributing 1.73 million copies of a new safety manual on hazardous materials (hazmat) to police, fire, and other emergency response organizations. *Emergency Response Guidebook 2004* is designed to assist emergency response personnel who may be the first to arrive at the scene of a transportation incident involving hazardous materials.

"This book is the safety gold standard for first responders who must know what they are dealing with before responding to an incident," Mineta says.



A joint project between USDOT, Transport Canada, and the Secretariat of Communications and Transportation of Mexico, the guidebook helps first responders identify the types of materials that may be involved in an incident and the threats those materials might pose to emergency crews and the public.

Free copies are available to public emergency responders through State coordinators, whose contact information is accessible on the Hazardous Materials Safety Web site at http://hazmat .dot.gov or by calling 202–366–4900. Others may purchase copies through the U.S. Government Online Bookstore (http://bookstore.gpo.gov) or commercial vendors.

For more information, access the guidebook online at http://hazmat.dot.gov/erg2004/erg2004.pdf.

NHTSA Announces Historically Low Highway Fatality Rate in 2003

According to recent findings from the National Highway Traffic Safety Administration (NHTSA), the fatality rate on the Nation's highways in 2003 was the lowest since recordkeeping began in 1974. The number of crash-related injuries also dropped to a historic low in 2003.

U.S. Transportation Secretary Norman Y. Mineta cited NHTSA efforts as instrumental in reducing the fatal crash rate. The agency not only collected crash statistics from each State to produce its annual report on trends in traffic fatalities, but it also led campaigns to encourage safety belt use and discourage impaired driving, worked with State legislatures to pass tougher safety belt and drunken driving laws, and pursued rulemaking efforts to improve vehicle safety standards.

The statistics show that 42,643 people died, and 2.89 million were injured in 2003. The fatality rate per 100 million vehicle miles traveled was 1.48 in 2003, down from 1.51 in 2002. It was the first time that the rate dropped below 1.5. In 2002, 43,005 were killed, and 2.93 million were injured. Alcohol-related fatalities also dropped significantly in 2003, the first such decline since 1999, as more States adopted laws enabling them to prosecute drivers at levels of 0.08 blood alcohol content (BAC) and above. In addition, 2004 marks the first year that 0.08 BAC laws have been enacted in all 50 States, the District of Columbia, and Puerto Rico.

NHTSA's Fatality Analysis Reporting System (FARS) also shows that the following happened between 2002 and 2003:

- Rollovers declined 7.5 percent for passenger cars (from 4,794 to 4,433) and 6.8 percent for pickup trucks (from 2,755 to 2,569).
- Twenty-seven States reported decreases in the total number of fatalities. The highest percentage decreases were in Colorado (15 percent), Vermont (12 percent), Connecticut (10 percent), Ohio (10 percent), Oklahoma (10 percent), and West Virginia (10 percent).
- Passenger vehicle occupant fatalities dropped to 31,904—the largest decrease since 1992. Declining fatalities in passenger vehicles are consistent with increases in safety belt use and more crashworthy vehicles.

In 2003, the number of unbelted fatalities declined, reflecting an increase in safety belt use. Still, 56 percent of those killed in passenger vehicles were not wearing safety belts.

"The lower totals and the trend that started is good news, but this is still clearly far too many deaths on our highways," FHWA Administrator Mary E. Peters said to FHWA employees in a recent memorandum. "These new data show that the hard work that we have focused on under the vital few [priorities: safety, congestion mitigation, and environmental streamlining] over the past several years is paying off in the best way possible—lives saved."

A summary of the 2003 report is available on the NHTSA Web site at www-nrd.nhtsa.dot.gov/pdf/nrd-30 /NCSA/PPT/2003AARelease.pdf.

Public Information and Information Exchange

Summit Helps Advance Regional Transit System in Texas

Elected and appointed officials from throughout Texas recently convened in Irving, TX, to analyze and act on transportation strategies for improved mobility, taking steps to approve a unified transit plan for northern Texas. During the 7th Annual Texas Transportation Summit in Irving, TX, community leaders unanimously approved a 10-point resolution, along with a local financing plan and governance structure, that balances competing interests from across the region. Hundreds of local leaders began discussing the plan during last year's summit and then met more than 70 times over the past year to create a transit plan that will unite six Texas counties and three existing transit authorities under a $3.5 billion, 419-kilometer (260-mile) regional transit system.

The plan is just one of several initiatives and resolutions introduced during the annual summits over the last 7 years. Initially created as a 2-day, regional event drawing about 150 attendees, the summit has evolved into one of the most comprehensive multimodal transportation events in the Nation. This year's 4-day conference, hosted by the city of Irving and 50 additional cities and counties in Texas, drew a record 1,200 participants.

Speakers included U.S. Senator Kay Bailey Hutchison and U.S. House Majority Leader Tom DeLay. In addition, high-ranking transportation officials spoke on roads and highways, freight and passenger rail, high speed rail, transit, safety, air quality, and financing.

A variety of businesses and other event sponsors from the transportation industry hosted booths during the summit to promote some of the latest developments in transportation technology. One of the featured devices was a 16-meter (53-foot) truck-driving simulator showcased by the Texas Motor Transportation Association. The simulator, which offers a virtual trip behind the wheel of an 18-wheeler, serves as a classroom to train truck drivers on how to react to obstacles or hazards in the road and changes in weather.

For more information on the summit, contact Jane Card at 972–721–4978 or jcard@ci.irving.tx.us.

City of Irving, TX

City of Irving, TX

House Majority Leader Tom DeLay addressed an audience of transportation leaders and panel of elected officials, which included (from left to right) Harris County, TX, Judge Robert Eckels and Irving Deputy Mayor Pro Tem Sam Smith, during the 7th Annual Texas Transportation Summit in Irving, TX.

North Carolina Launches 511 Traffic Information Service

Federal Highway Administrator Mary E. Peters and State highway officials recently announced that North Carolina drivers now can access up-to-the minute information about local road and traffic conditions by calling 511, the three-digit number designated nationwide for traveler information.

The new system enables callers to find the latest information about traffic jams, road construction, and alternative routes across the State. An innovative feature of North Carolina's system is that it also includes information regarding trains and ferries, which are integral to transportation in the eastern part of the State.

USDOT provided a $100,000 grant to help North Carolina develop its 511 service. Twenty-one 511 systems currently are up and running in other parts of the country. In some of those areas, up to 97 percent of drivers who use 511 say they have changed their travel routes because of the information provided.

"The service will help North Carolina drivers get to where they need to go and get there on time," Peters said during a speech at the J. Douglas Galyon Depot in Greensboro, NC. "Folks will be making the call before setting out for Asheville, Charlotte, Wilmington, or just across town."

With 511 service now available in North Carolina, almost 25 percent of the total U.S. population lives in areas covered by a 511 system. By the end of 2005, half the population is expected to have access to the travel information service.

For more information, visit http://ops.fhwa.dot.gov/TravelInfo/index.htm or www.fhwa.dot.gov/trafficinfo/index.htm.

TTI Annual Mobility Report Finds Congestion Worsening

Despite efforts to control traffic congestion, U.S. cities are falling further behind with each passing year, according to 20-year trends recently announced by the Texas Transportation Institute (TTI). The *2004 Urban Mobility Report* published by TTI shows traffic congestion across the Nation is growing in cities of all sizes, consuming more hours of the day, and affecting more travelers and shipments of goods than ever before.

"We can see pretty clearly what 20 years of almost continuous economic growth can do to us," says Tim Lomax, one of the study's authors. "If we're lucky enough to sustain this growth and the funding levels and options do not increase from current trends, we shouldn't be surprised if we see even more congestion."

The TTI study ranks congestion in urban areas according to several measurements, including annual delay per peak period (rush hour) traveler, which has grown from 16 hours to 46 hours since 1982; the annual financial cost of traffic congestion, which has ballooned from $14 billion to more than $63 billion since 1982 (as expressed in 2002 dollars); and fuel wasted by engines idling in traffic jams, totaling 21.2 billion liters (5.6 billion gallons).

This year's installment of the report increases the number of urban areas studied from 75 to 85 and includes all urban areas with a population exceeding 500,000. The report also measures the degree to which contributions from public transportation services and techniques for improving roadway operating efficiency have reduced congestion. Although the techniques discussed can be used both nationally and locally to help reverse the trend of worsening traffic problems, researchers say that the problem has grown too rapidly and is too complex to be addressed by a single solution. The report recommends that in addition to new road and public transportation projects, the United States needs to use its roadways more efficiently, improve demand management, and diversify its land use options.

"We're facing an increasingly urgent situation," Lomax says. "To make real progress, it's critical that we pursue all transportation solutions—short-range, small-scale projects and policies, midrange efficiency programs, and longer term, more significant projects and programs that require more planning and design time."

FHWA Administrator Mary E. Peters agrees. "Today's report validates what we've known all along," she says, "the solution to road congestion isn't just pouring new concrete and paving new roads."

Short-term solutions include using toll-based high-occupancy vehicle lanes to encourage carpooling, congestion-based toll charges to discourage highway use at the busiest times of day, and ramp-metering technologies that improve the flow of traffic onto and off of highways. Additional measures include improving the timing of traffic signals to match traffic patterns and avoid gridlock, and investing in new telephone and Internet-based information systems to help drivers avoid traffic and construction.

For more information, contact Tim Lomax at 979-845-9960, t-lomax@tamu.edu or David Schrank at 979-845-7323, d-schrank@tamu.edu. To view the report, visit http://mobility.tamu.edu/ums/report.

Texas Transportation Institute

WSDOT Wins Awards for Excellence in Communication

The Washington State Department of Transportation (WSDOT) recently won two national communications awards from the National Transportation Public Affairs Workshop (NTPAW), a subcommittee of the American Association of State Highway and Transportation Officials (AASHTO).

The first award recognized the "Tacoma Narrows Bridge" Web site (www.wsdot.wa.gov/TNBhistory) for excellence in online communications. The site spans the history of the bridge from "Galloping Gertie"—the first structure that collapsed in a 1940 windstorm only 4 months after construction—through the new Tacoma Narrows Bridge, currently under construction.

The second award, in the category of "Issue Management," honored WSDOT for its communications plan for the construction site of the Hood Canal Bridge Graving Dock. WSDOT issued the plan after Native American artifacts and remains were discovered in the construction area. The plan called for an active outreach strategy, including community meetings to discuss the findings, project status, and long-term impacts the discovery could have on construction.

Gig Harbor Peninsula Historical Society and WSDOT

WSDOT's new Web site featuring the history of the Tacoma Narrows Bridge takes the viewer from the construction of the original bridge, shown here, to current plans for a replacement bridge.

Details about the project and the accompanying communication plan are available at www.wsdot.wa.gov/projects/sr104hoodcanalbridgeeast.

For more information on the Tacoma Narrows Bridge, contact DawnMarie Moe at 360-705-7898 or moed@wsdot.wa.gov. For more information on the communication plan or the Hood Canal Bridge Graving Dock communications plan, contact Lloyd Brown at 360-357-2789 or brownl@wsdot.wa.gov.

Expo Highlights Practices for Managing Winter Weather

Following the "Blizzard of 1996," which nearly paralyzed transportation in the eastern United States by dropping between 46 centimeters (18 inches) and 0.92 meter (3 feet) of snow, FHWA set out to develop a forum that would expedite the exchange of information and technologies available to manage winter weather. The result was the Eastern Winter Road Maintenance Symposium and Equipment Expo—now held annually in September—for winter maintenance managers and other public works practitioners from cities, townships, counties, and States (as well as other public agencies and private sector partners) east of the Mississippi River.

FHWA and the Tennessee DOT recently sponsored the 9th annual symposium in Knoxville, TN, drawing an audience of 1,000 winter maintenance professionals. Participants learned about the latest developments in road maintenance during the winter season and viewed the newest equipment and technology available to battle snow and ice, gaining insights into best practices and materials, while comparing notes with peers from other States.

The topics discussed included state-of-the-practice anti-icing techniques and technologies, such as salt-brine pretreatment and automated bridge deck deicing systems. Also highlighted were Weather Information Systems, which use meteorological measurement stations strategically positioned to collect data on local pavement and atmospheric conditions. In addition, this year's symposium focused on environmental concerns, such as how to store chemicals safely and how to clean and fuel maintenance equipment.

For more information, contact Mark Sandifer at 708-283-3528 or mark.sandifer@fhwa.dot.gov.

Personnel

Arkansas's Dan Flowers Receives MacDonald Award from AASHTO

Dan Flowers, P.E., director of the Arkansas State Highway and Transportation Department, recently received the Thomas H. MacDonald Memorial Award for service to the State transportation community. He accepted the award at the AASHTO annual meeting in Philadelphia, PA. Presented since 1957, the MacDonald Award recognizes outstanding achievement in the fields of highway administration, engineering, and research. Nominees are judged by a panel of their peers in the State highway and transportation community.

In addition to serving as a senior member of AASHTO's Board of Directors, Flowers was especially instrumental in developing Arkansas's $1-billion Interstate Rehabilitation Program. He started with the department as a summer employee in the Resident Engineer's Office in Batesville, AR, before becoming a full-time employee in 1969, after graduating from the University of Arkansas, Fayetteville with a bachelor's degree in civil engineering.

Flowers was president of AASHTO in 1999 and chairman of the Standing Committee on Highways, Subcommittee on Design, and Special Committee on International Activity Coordination. In addition, he served as vice president and president of the Southeastern Association of State Highway and Transportation Officials, and on the board of directors of the Mississippi River Trail Corporation.

To view an application form for the award, visit http://downloads.transportation.org/MacDonaldAward.pdf

Maryland's Thomas Hicks Honored for Engineering Achievements

Thomas Hicks, P.E., director of the Office of Traffic and Safety at the Maryland State Highway Administration, was named the 2004 recipient of the Alfred E. Johnson Achievement Award. The 21-year-old award honors contributions to management in the field of highway engineering. Hicks received his award during the recent AASHTO annual meeting in Philadelphia, PA.

During almost five decades in the transportation field, Hicks held posts in the transportation departments of the District of Columbia, New Jersey, Oklahoma, and Maryland. Hicks also served a number of professional organizations, including 42 years with the AASHTO Subcommittee on Traffic Engineering, where he currently is vice chair.

Committed to the development of transportation in academia, Hicks served on the faculty of a mentoring program on transportation management systems at Texas A&M University and helped develop Maryland's Traffic Engineering Skills Training program with the University of Maryland and private business.

In 1991, Hicks received the AASHTO President's Transportation Award in the category of "Highway Traffic Safety" and the Institute of Transportation Engineers' Theodore M. Matson Memorial Award in 1999. Hicks resides in Towson, MD, and holds degrees from the University of Maryland and Yale University.

Training Update

New Course Explores Geotechnical Aspects Of Pavement Design

NHI's new course on the geotechnical aspects of pavement design will help transportation specialists avoid road collapses like this one caused by problems in the subgrade.

Within each State department of transportation (DOT), engineering professionals are involved in the process of defining, designing, and verifying the geomaterials used in pavement construction. Specification writers, pavement designers, and roadway, geotechnical, and construction engineers need to understand the geotechnical aspects of pavements and work closely to build and maintain cost-effective roadways. In addition to being familiar with sophisticated design models that rely on skillful characterizations of geotechnical variables, these professionals also need to be familiar with the latest advanced techniques, such as new procedures for conducting subsurface explorations and real-time evaluations of pavement layers as they are constructed.

To help engineers, specification writers, and others learn about these tools, and to facilitate interaction among the various disciplines involved in pavement design, the Federal Highway Administration's (FHWA) National Highway Institute (NHI) is offering a course titled Geotechnical Aspects of Pavements (#132040A). The course is the first offered by NHI that focuses on geotechnical variables and their influence on pavement design and performance.

FHWA-approved instructors will present the 3-day interactive course using a number of visual aids, including computer-generated slides, overhead transparencies, flip charts, and whiteboards. Each attendee will receive a copy of the course's first-of-its-kind reference manual, which serves as a comprehensive source of information on the geotechnical aspects of pavements. The class also provides a training environment in which professionals with the responsibility for designing pavements can learn and share experiences in a common setting.

After completing the course, participants will have a better understanding of the geotechnical parameters related to pavement design and construction and the impacts of unsuitable subgrades, climate, moisture, and drainage on performance. In addition, they will know how to determine the geotechnical inputs for pavement design and construction and how to evaluate and select appropriate remediation measures for unsuitable subgrades. Participants also will learn how to apply geotechnical considerations to pavement specifications and inspection requirements.

"This course will help State DOTs apply state-of-the-art tools for assessing the geotechnical aspects of pavements in the planning, design, construction, repair, and maintenance phases of highway projects," says Sam Mansukhani, a geotechnical engineer with the FHWA Resource Center at Olympia Fields, IL. "It will improve design and construction quality, increase safety, and reduce the cost of highway projects."

Although the course has no prerequisites, an undergraduate degree in civil engineering, geology, or equivalent engineering experience in the field of highway transportation is desirable.

For more information, contact Sam Mansukhani at 708-283-3550, sam.mansukhani@fhwa.dot.gov or Jerry DiMaggio, P.E., at 202-366-1569, jerry.dimaggio@fhwa.dot.gov. To schedule a course, contact Danielle Mathis-Lee at 703-235-0527 or e-mail danielle.mathis-lee@fhwa.dot.gov. To obtain information about NHI courses, access the course catalog at www.nhi.fhwa.dot.gov or contact NHI at 4600 N. Fairfax Drive, Suite 800, Arlington, VA, 22203; 703-235-0500 (phone); or 703-235-0593 (fax).

by Keri A. Funderburg

Staying Informed: Training without Travel

According to a 2003 study by the U.S. Department of Transportation's Bureau of Transportation Statistics, Americans make more than 405 million long-distance business trips per year. A recent study by the Texas Transportation Institute found that in addition to all that travel, U.S. drivers sit in traffic for an average of 46 hours per year. This is 30 hours more per year than just a few decades ago. With so much time spent on business trips and commuting to and from work, busy professionals are looking for ways to reduce their travel requirements so they can lead more balanced lives. In addition, many agencies and organizations face limited travel budgets that require managers to reduce spending.

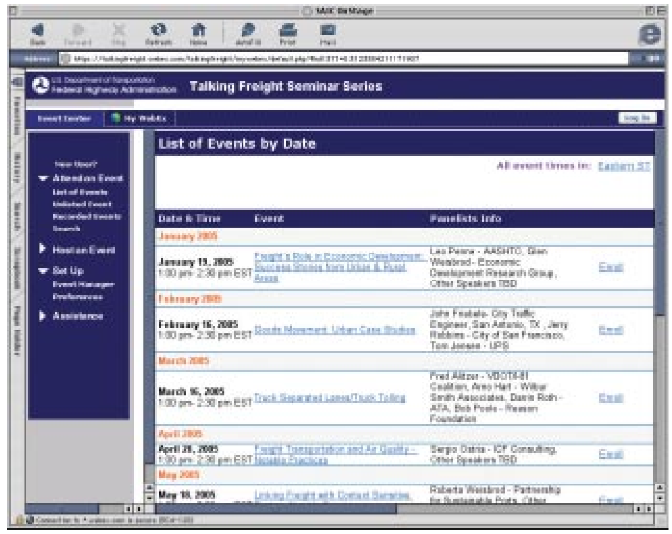
To help transportation professionals spend less time on the road and help agencies reduce their expenses for business travel, the Federal Highway Administration (FHWA) and many other organizations are turning to Web broadcasts to conduct meetings, conferences, and training sessions. These Web-based events enable personnel located across the country to access video and audio broadcasts, share documents, e-mail comments, and interact with other participants online by logging onto specialized Web sites.

Web meetings and conferences offer numerous benefits. In situations where face-to-face communication is not vital to the outcome of an event, a Web meeting can save participants and agencies time and money, in addition to increasing participation of people who otherwise might not have attended because of the longer time commitment due to travel. Such events also can potentially boost productivity by giving employees more time to attend to pressing matters in the office. And Web events may be a step in the right direction toward helping to reduce congestion. These benefits help explain why Web events are becoming increasingly popular alternatives to conventional meetings.

Teaching Lessons Through Talking Freight

For more than a year, FHWA's Office of Freight Management and Operations, in partnership with the Office of Planning, Environment, and Realty, have jointly hosted a monthly seminar series via internet and telephone called "Talking Freight," led by a variety of government and industry experts. A component of FHWA's Freight Professional Development and Transportation Planning Capacity Building programs, the Talking Freight seminars provide current information, new training opportunities, and noteworthy practices on various freight planning topics, targeting those in the public and private sectors who are responsible for planning, designing, building, managing, and operating the transportation system. FHWA held the first seminar on July 23, 2003.

Each seminar lasts 90 minutes, with 60 minutes allocated for presentations by transportation planning experts and 30 minutes for questions from participants. FHWA provides instructions to registered participants on how to view the speakers' slide presentations using Web-conferencing tools. Participants can listen to the audio portion of the seminar by calling a designated teleconference number. Recent seminar topics have included freight security and urban goods movement and planning.



FHWA's "Talking Freight" Web site.

"The feedback from participants has been overwhelmingly positive," says Scott Johnson with FHWA's Office of Freight Management and Operations. "Our partners have told us repeatedly that training resources are becoming more and more constrained, so they appreciate that we listened and responded to their concerns with this free and flexible delivery approach."

According to Eloise Freeman-Powell with FHWA's Office of Planning, customers also can access archived Talking Freight presentations at any time after the seminar. "This is one of the great advantages to using webconferencing technology for training purposes—it accommodates our customers' busy work schedules," she says. "In fact, about one-third of our total audience has accessed the archived Talking Freight presentations from our joint FHWA Freight Planning Web site, which demonstrates the value of this feature."

Due to the positive feedback, the planning and freight offices are exploring even more opportunities to deliver freight planning training via webconferencing technology during 2005.

For more information on the Talking Freight series, visit http://talkingfreight.webex.com

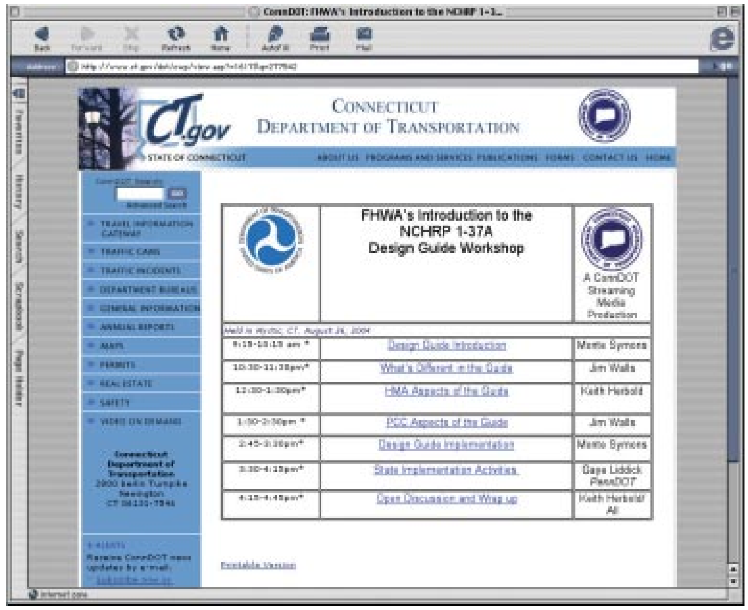
Real-Time Web Courses Generate Real-World Success

FHWA's National Highway Institute (NHI) offers several courses that rely on Web capabilities. For example, NHI soon will offer the Web-based course Statistical Resources and Performance Measurement. Targeted at research directors and managers from State transportation agencies, the course will instruct participants on where to find relevant materials and how to use various statistical techniques to measure roadway performance. Instructors will teach the course via the Web and connect in real time to participants across the Nation.

Although NHI offers both real-time (synchronous) and self-paced (asynchronous) courses, the reviews of the asynchronous courses have been mixed. "Research and experience have shown that having a synchronous component increases the completion rate for the course," explains Debbie Gwaltney, with FHWA's Office of Professional Development.

NHI and FHWA's Office of Planning, Environment, and Realty are developing an asynchronous course to serve as a prerequisite to the existing course, NEPA Transportation Decision Making (#142005A). The advantage of an online prerequisite course is that instructors can be certain that all participants will have the same baseline knowledge because each will either have taken the course or tested out of it.

According to Gwaltney, "This asynchronous course will enable the instructor-led course to delve deeper into the subject than currently is possible without covering material that some participants already may know." For more information on NHI's e-learning opportunities, visit www.nhi.fhwa.dot.gov.



This Web page from a course hosted by Connecticut DOT features links to a course agenda and streaming video from the event.

Connecticut DOT Hosts Web-based Meetings

Aside from FHWA, State departments of transportation (DOTs) also are broadcasting meetings and training via the Internet. The Connecticut Department of Transportation (ConnDOT) hosted a live Webcast of the American Association of State Highway and Transportation Officials' (AASHTO) recent National Research Advisory Committee meeting. While researchers from 40 States and staff from AASHTO and FHWA attended the meeting in person in Mystic, CT, many others participated online. During the 4.5-day meeting, remote users were able to upload live video and pose questions and comments by sending faxes or e-mails. Meeting officials estimate that an average of 25 simultaneous connections was typical throughout the event.

In addition to the AASHTO meeting, ConnDOT has held several other Web events. In July 2004, the department hosted a 1-day workshop on modified asphalts for the Association of Modified Asphalt Producers. ConnDOT held the workshop at its materials testing facility for a live audience of about 35 people and for an online audience of 14 viewers. To access the agenda and on-demand streaming video, visit www.ct.gov/dot/AMAP.

Embedded videos like the one shown here are used during some Web-based training events.

In August 2004, ConnDOT hosted a 1-day Webcast of an FHWA-led conference entitled "Introduction to NCHRP 1-37A (Mechanistic-Empirical) Pavement Design Guide." This well-publicized event resulted in more than 110 users simultaneously connecting to the Webcast throughout the day. According to Drew Coleman of ConnDOT, user feedback was overwhelmingly positive. To view streaming video from the event, visit www.ct.gov/dot/pavement101.

Web-based learning quickly is becoming a valuable way to provide transportation professionals with a wealth of knowledge. For agencies and individuals, the Web can save time and money, and reduce the hassle of travel.

Keri A. Funderburg is a contributing editor for PUBLIC ROADS.

Communication Product Updates

Compiled by Zac Ellis of FHWA's Office of Research and Technology Services

Below are brief descriptions of products recently published online by the Federal Highway Administration's (FHWA) Office of Research, Development, and Technology. Some of the publications also may be available from the National Technical Information Service (NTIS). In some cases, limited copies are available from the Research and Technology (R&T) Product Distribution Center.

When ordering from NTIS, include the NTIS publication number (PB number) and the publication title. You also may visit the NTIS Web site at www.ntis.gov to order publications online. Call NTIS for current prices. For customers outside the United States, Canada, and Mexico, the cost is usually double the listed price. Address requests to:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703–605–6000
Toll-free number: 800–553–NTIS (6847)

Address requests for items available from the R&T Product Distribution Center to:

R&T Product Distribution Center, HRTS-03
Federal Highway Administration
9701 Philadelphia Court, Unit Q
Lanham, MD 20706
Telephone: 301–577–0818
Fax: 301–577–1421

For more information on research and technology publications from FHWA, visit the Turner-Fairbank Highway Research Center's (TFHRC) Web site at www.tfhrc.gov, FHWA's Web site at www.fhwa.dot.gov, the National Transportation Library's Web site at http://ntl.bts.gov, or the OneDOT information network at http://dotlibrary.dot.gov.

A Critical Literature Review of High-Performance Corrosion Reinforcements in Concrete Bridge Applications
Publication No. FHWA-HRT-04-093

This publication is the result of an extensive literature review of the corrosion process and high-performance reinforcement options for concrete bridge applications. The review is divided into five areas of analysis, comprising (1) the corrosion-induced deterioration process, (2) corrosion-control alternatives, (3) utility of corrosion (pitting)-resistant alloys for applications in environments containing chloride, (4) the pitting mechanism, and (5) performance of various metallic reinforcement types in aqueous solutions, cementitious embedments, test yard exposures, and actual structures. In addition, the review focuses on the properties and uses of several specific alloys, including black steel, MMFX-II (a microcomposite steel), and various grades of ferritic (containing ferric oxide compounds), austenitic (containing carbon and other solutes in solid solution with iron), and duplex (ferrite plus austenite) types of stainless steels. Both solid and clad bars in as-received and pickled conditions are being evaluated.

The review determines that from a corrosion-resistance standpoint the high-performance alloys outperform black steel. Unlike black steel, however, a relatively wide range of corrosion performance—depending upon the alloy and surface conditions—is apparent for their high-performance steel alloys. The typical approach is to identify the reinforcement option that will achieve the target design life at the least life-cycle cost. This approach, however, requires that engineers should know the long-term performance characteristics of each reinforcement option with respect to the anticipated design life (as long as 75–100 years). Since knowledge of the service history for reinforcement options is limited, the necessary data may be obtained through accelerated, short-term tests, in addition to longer term data in salt-contaminated reinforced concrete slabs.

To view the report, visit www.tfhrc.gov/structur/pubs/04093.

Long-Term Performance of Epoxy-Coated Reinforcing Steel in Heavy Salt-Contaminated Concrete
Publication No. FHWA-HRT-04-090

This report describes the long-term, natural weathering of 31 post-Southern Exposure (SE) steel test slabs that were not autopsied during FHWA's original exposure testing research conducted between 1993 and 1998. The remaining samples were exposed from September 1998 to December 2002 at an outdoor test yard in Northbrook, IL.

Between 1993 and 1998, researchers tested more than 52 bar materials, leading to the selection of 12 bar types for use in the long-term durability tests described in this report. The tests used concrete exposed to an aggressive SE test that alternated wetting (with 15 weight-percent sodium chloride solution) and drying cycles for 96 weeks. During the test, researchers collected samples of macrocell current corrosion occurring between top and bottom mats, as well as data on the potential for short circuiting. Later, the researchers performed autopsies and subsequent laboratory analyses on the test slabs.

According to the report, the results confirmed that black steel bars produced the highest mean macrocell current density—indicating the least resistance to corrosion—among the bar types, regardless of slab configuration. In contrast, stainless steel bars exhibited negligible mean macrocell current density. Compared with the black bar, the epoxy-coated reinforcing bars (ECRs) used in just the top mat reduced corrosion susceptibility by at least 50 percent, even when they contained coating damage and were connected to the black bar on the bottom mat. Overall, bent ECRs in the top mat, coupled with black bars in the bottom mat, performed the worst among all ECR cases. Straight top-mat ECRs, however, showed a macrocell current density varying from just 7 to 40 percent of the highest black bar case, depending on the size of initial coating damage and the type of bar in the bottom mat. In cases where straight ECRs in the top mat were connected to ECRs in the bottom mat, the mean macrocell current density was no greater than 2 percent of the worst black bar case—even when rebar coatings had defects—and approached the corrosion resistance levels of stainless steel reinforcement. Researchers attributed the improved corrosion resistance in this scenario to (1) reduction in cathodic area, (2) higher electrical resistance, and (3) reduced cathodic reaction.

In cases where the researchers autopsied an ECR slab with negligible macrocell current density, the appearance of the extracted ECR and concrete-bar interface was excellent, with no sign of corrosion. ECR specimens with high macrocell current densities, however, revealed coating deterioration caused by corrosion and exhibited numerous hairline cracks and blisters, along with reduced adhesion, coating disbondment (permanent adhesion loss), and underlying steel corrosion. Researchers found no consistent relationship between the level of macrocell current density and the extent of coating adhesion loss. These results and earlier FHWA studies indicate that adhesion appears to be a poor indicator of long-term performance of coated bars in chloride-contaminated concrete, as no direct relationship exists between loss of adhesion and the effectiveness of ECR to mitigate corrosion.

To view the report, visit www.tfhrc.gov/structur/pubs/04090.

Guidelines for Ultrasonic Inspection of Hanger Pins
Publication No. FHWA-HRT-04-042

A failed hanger pin initiated the tragic collapse of one span of the Mianus River Bridge in Greenwich, CT, on June 28, 1983, resulting in the deaths of three motorists. Following the collapse, there was an immediate increase of interest in inspecting and evaluating the condition of bridge hanger pins. Ultrasonic inspection has since become the primary method of performing detailed inspections of inservice hanger pins.

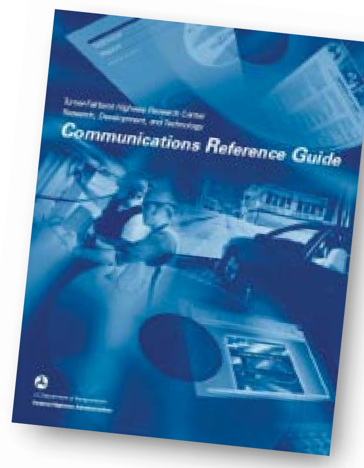
This document describes the fundamentals of ultrasonic testing and general requirements that State transportation agencies and others can use to perform inspections of hanger pins. In addition, the report reviews the inspection of five hanger pins with known defects to emphasize and explain important aspects of the process more completely.

The report describes the techniques that the researchers used in their review, including the pulse-echo technique, pitch-catch technique, decibel scale, piezoelectric effect (electric polarity due to pressure), beam diffraction, beam absorption, beam spread (or divergence), beam centerline location, and distance amplitude correction. Topics included in the section on general inspection requirements are cleaning and coupling requirements, interpretation of signals, defect sizing techniques, effect of wear grooves, phenomena of acoustic coupling, inspection documentation, data collection, and inspector qualifications and certifications.

Results from the experimental program include beam diffraction graphs, distance amplitude correction curves, sensitivity analysis of straight and angled beams, defect sizing analysis, and verification of the acoustic coupling phenomena.

Communications Reference Guide
Publication No. FHWA-RD-03-074

The new *Communications Reference Guide* (CRG) created by FHWA's Office of Research, Development, and Technology (RD&T) provides users with tools, techniques, and timelines for planning, scheduling, and producing communications products, which include print materials, electronic information and technology, outreach materials, and events. It also links users with communications and marketing resources in the Office of Research and Technology Services (HRTS). This document replaces all previous versions of the *Quick Reference Guide.*



The CRG will be especially useful to FHWA Contracting Officer's Technical Representatives (COTRs) and their contractors and support staff who develop research and technology communication products according to the FHWA standards and regulations referenced in this publication. The document is available on the Turner-Fairbank Highway Research Center's Web site and is offered as a complement to the *FHWA Publications and Printing Handbook*. Although the guide is available in printed form upon request, the most recent and up-to-date version is posted on the Web.

To view the guide, visit www.tfhrc.gov/qkref/qrgmain.htm.

Conferences/Special Events Calendar

Date	Conference	Sponsor	Location	Contact
March 15-19 2005	CONEXPO-CON/AGG 2005	Association of Equipment Manufacturers, National Stone, Sand & Gravel Association, National Ready Mixed Concrete Association, and Associated General Contractors of America	Las Vegas, NV	Caroline Roberts 800-867-6060 croberts @conexpoconagg.com www.conexpoconagg.com
March 16-18 2005	Integral Abutments and Jointless Bridges Conference	Federal Highway Administration (FHWA), U.S. Department of Transportation, West Virginia University, and West Virginia Department of Transportation	Baltimore, MD	Samer H. Petro 304-293-7608 samer.petro@mail.wvu.edu www.cemr.wvu.edu/cfc /conference/IAJB.pdf
April 11-13 2005	5th International Conference on Bridge Management	Composite Bridge Alliance Europe	Surrey, UK	Janina Disney j.disney@surrey.ac.uk +44 (0) 1483 689251 www.surrey.ac.uk/eng/BM5
April 24-28 2005	Tenth TRB Transportation Planning Applications Conference	Transportation Research Board (TRB)	Portland, OR	Rick Donnelly 505-881-5357 rdonnelly@pbtfsc.com Richard Walker 503-797-1765 walkerd@metro.dst.or.us www.trb-portland-05.com /index.html
May 10-13 2005	65th Annual New York State Association of Transportation Engineers (NYSATE) Conference	NYSATE	Alexandria Bay, NY	Martin C. Percy 315-785-2322 mpercy@dot.state.ny.us www.nysate.org
June 25-July 1 2005	2005 AASHTO Subcommittee on Bridges and Structures Annual Meeting	American Association of State Highway and Transportation Officials (AASHTO)	Newport, RI	Tamara Reid 202-624-3635 treid@aashto.org Dan DiBiasio 401-222-1362 ext. 4013 ddibiasio@dot.state.ri.us www.aashto.org
July 17-20 2005	6th International Bridge Engineering Conference	FHWA, TRB	Boston, MA	Lou Triandafilou 410-962-3648 lou.triandafilou @fhwa.dot.gov http://gulliver.trb.org /conferences/TRB_IBEC-6th-Announcement-Preliminary.pdf
August 13-18 2005	8th International Conference on Concrete Pavements	International Society for Concrete Pavements	Colorado Springs, CO	Dan Zollinger 979-845-9918 d-zollinger@tamu.edu www.concretepavements .org/Meetings/ ConcreteCallForPapers.pdf
Sept 15-20 2005	AASHTO 2005 Annual Meeting	AASHTO	Nashville, TN	Hannah Whitney 202-624-5800 hwhitney@aashto.org www.aashto.org

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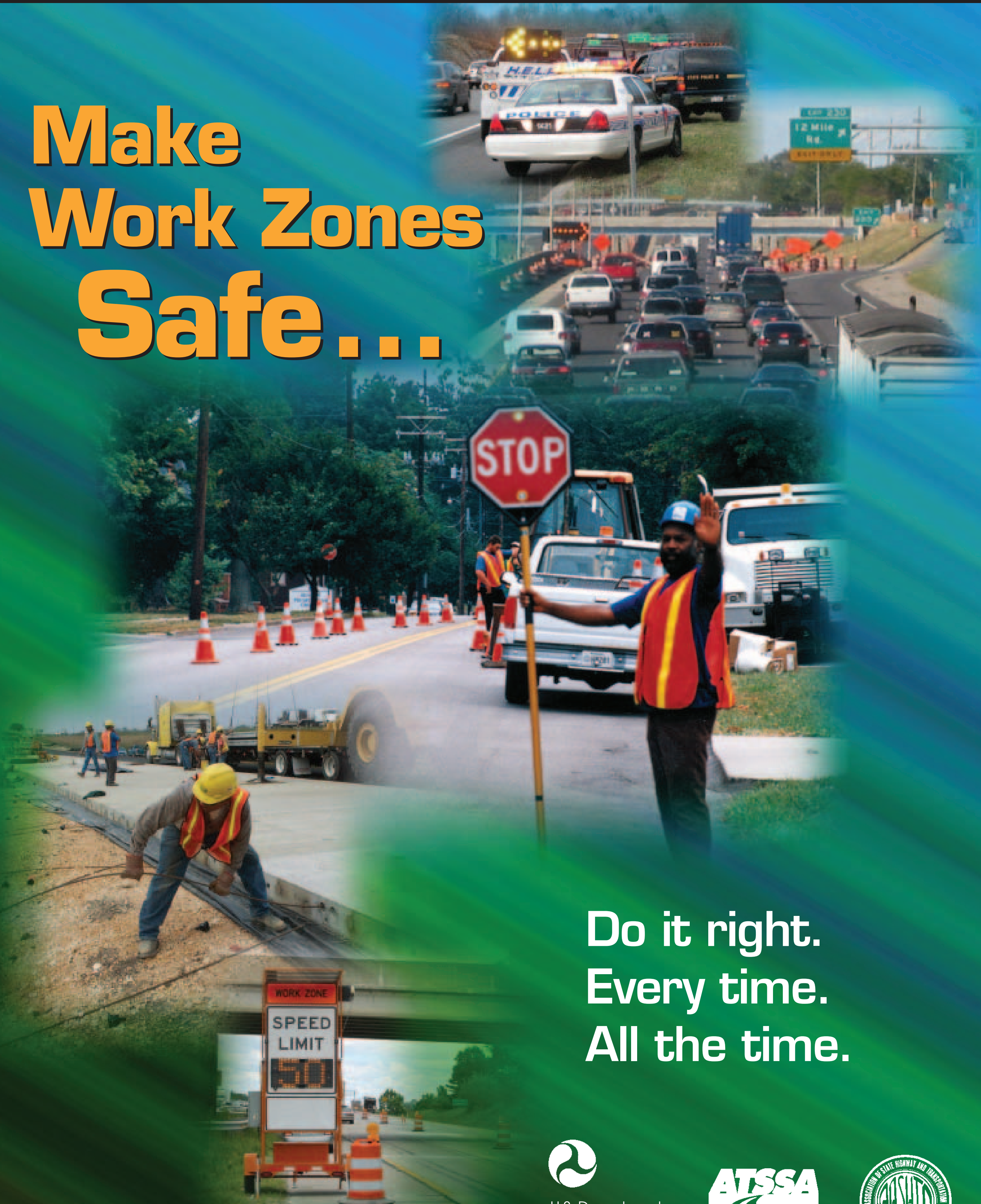

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