

Public Roads

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Women in the Workforce
Climate and Transportation
Asphalt Recycling



U.S. Department
of Transportation
Federal Highway
Administration

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Front cover—Rhode Island's new Intermodal Facility will include an enclosed skywalk bridge, shown here under construction. The transportation facility will connect an existing interstate and airport with a new train station and a new parking garage with intercity bus service. The skywalk spans a major thoroughfare, with the airport parking lot and connection to the terminal in the background. For more information, see "Small State, Big Vision," on page 2 in this issue of PUBLIC ROADS. *Photo by Don Pillsbury Photography.*

Back cover—Scheduled for completion in fall 2010, the Intermodal Facility will include this six-story parking garage for rental cars and commuters' vehicles. Here, a crane is visible in the background and rail line in the foreground. This historic transportation hub will include extension of commuter rail service from Boston and Providence to Warwick and North Kingstown, RI. *Photo by Don Pillsbury Photography.*



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Guest Editorial

Recycling and Reuse in the Highway Industry

Keeping highways and associated structures in a state of good repair is critical to the Nation's ability to provide the safest, most efficient roadway system possible, while simultaneously ensuring the greatest level of protection to the human and natural environments. In many cases, the same materials used to build the original highway system can be reused to repair, reconstruct, and maintain it. For the most part, the use of recycled materials poses no threat to the air, soil, or water. What's more, careful design, engineering, and application of recycled materials can reduce or eliminate the need to search for and extract virgin materials. Therefore, where appropriate, recycling of aggregates and other highway construction materials makes sound economic, environmental, and engineering sense.

Over the past decade, the Federal Highway Administration (FHWA) has worked to increase the use of recycled materials in highway construction and to optimize the beneficial reuse of industrial byproducts. FHWA is collaborating with a number of agencies, committees, and industry groups to promote recycling technology by providing needed specifications, best practices, design guidance, and materials testing.

For example, FHWA is partnering with the University of New Hampshire and the University of Wisconsin-Madison to operate the Recycled Materials Resource Center, which is charged with being the national point of contact for information on the uses of industrial byproduct materials. The center already has conducted more than 50 research projects and produced several specifications for recycled materials that have been adopted by the American Association of State Highway and Transportation Officials (AASHTO). The center also hosted four regional workshops on the proper reuse of industrial materials, delivered presentations to several thousand highway professionals, and began planning a major conference with ASTM International.

In addition, FHWA is working with AASHTO, the National Asphalt Pavement Association, and others in the industry to test and verify the performance of new technology to produce hot-mix asphalt at a lower temperature. By lowering the heating temperature required during the blending process, warm-mix asphalt offers the



Gloria Shepherd



King W. Gee

promise of fuel cost savings and reduced greenhouse gas emissions. In partnership with the American Concrete Pavement Association, FHWA and States are looking at ways to make cement and concrete production more environmentally friendly too.

Also, FHWA is a leading partner on the Green Highways Partnership's Reuse and Recycling Team, which facilitates information sharing among States in the mid-Atlantic through the hosting of workshops and support for pilot efforts. Through a partnership with the Industrial Resources Council, which represents industries that are large generators of byproduct materials, FHWA is providing technical information on best practices for reuse of industrial byproducts in the highway industry.

And in the realm of research and technology delivery, FHWA is spearheading a number of activities related to recycling and beneficial reuse of industrial byproducts, such as recycled asphalt shingles, fly ash, spent foundry sand, taconite mine material, and steel slag. Through these and other partnerships with resource agencies and industry groups, FHWA will continue to lead and coordinate recycling activities and initiatives that will help State departments of transportation do more with less while conserving energy and natural resources.

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Infrastructure
Federal Highway Administration

Small State, Big Vision



by Corey Bobba, Ann L. Clarke,
Stephen Devine, and Norah Davis

Rhode Island is constructing an intermodal transportation facility to connect an existing interstate and airport with a new train station and rental car garage.

Rhode Island is leading the way in intermodal transportation. Aided by a number of strong partnerships, the Rhode Island Department of Transportation (RIDOT) and the Rhode Island Airport Corporation (RIAC) are developing an intermodal transportation facility that centralizes transportation access by connecting trains, planes, buses, and rental car operations.

According to the Federal Highway Administration (FHWA), intermodal transportation enhances mobility by shifting traffic from

congested highways to rail and other modes. Improving system performance and capacity through intermodal operations is critical for the Northeast Corridor, where the ability to add new highway capacity is limited. By reducing highway congestion, seamless connections among travel modes also help improve air quality, economic productivity, and quality of life.

(Above) The new Intermodal Facility includes a skywalk, shown here under construction. Photo: RIAC.

In constructing the \$267 million Intermodal Facility, RIDOT is taking advantage of the contiguous locations of Interstate 95 (I-95), U.S. Route 1, an airport, and commuter rail. T.F. Green Airport, a medium-size commercial-service hub, is located about 1 mile (1.6 kilometers) off I-95 in Warwick, RI. The airport is a 10-minute drive from Providence, RI, and an hour from Boston, MA.

When the project is finished, the Massachusetts Bay Transportation Authority (MBTA) will extend commuter rail service from Boston and Providence to Warwick and North Kingstown, RI. In addition, Amtrak® already offers long-distance train service to nearby Providence.

This complex and high-profile model of intermodalism has several components: a train platform for commuter rail service, a six-story garage for rental cars and public parking that straddles the train tracks, a three-story building containing services for rental car customers, and an intercity bus stop. In addition, a 1,250-foot (381-meter) elevated and glass-enclosed skywalk with moving walkways will transport travelers between the train platform and the airport terminal, spanning U.S. Route 1. Escalators and elevators will convey passengers down from the skywalk to the terminal.

At an August 2009 press conference, Kevin A. Dillon, president and chief executive officer of RIAC, said that he soon will be able to “market Green Airport’s link to commuter rail. This is considered an attractive option by our current carriers, as it will provide an additional and convenient way for our customers to access the airport. It is also of interest to international carriers and passengers, who depend on this type of connectivity. This facility will be a true transportation gateway for the region.”

Nearly 20 years in the making, this historic transportation hub has not been without critics and cost increases. Nevertheless, the facility is on track for completion on schedule by fall 2010. In addition to major public-private partnerships, the Intermodal Facility features innovative financing and a number of “green” elements. Here is the tale of the development of this remarkable facility.

The Back Story

In 1989, RIDOT began identifying potential locations for transit facilities and 2 years later began evaluating this location for a rail-to-airport connection. An article in *The Providence Journal* by Peter B. Lord summarized the subsequent events as follows:

In 1992, Warwick’s local elected officials proposed a train station next to the airport, and environmental leaders flocked to support this forward-looking intermodal concept. In addition, U.S. Senator John H. Chafee had cosponsored a national highway bill that would enable States to use a percentage of highway funds for transit projects.

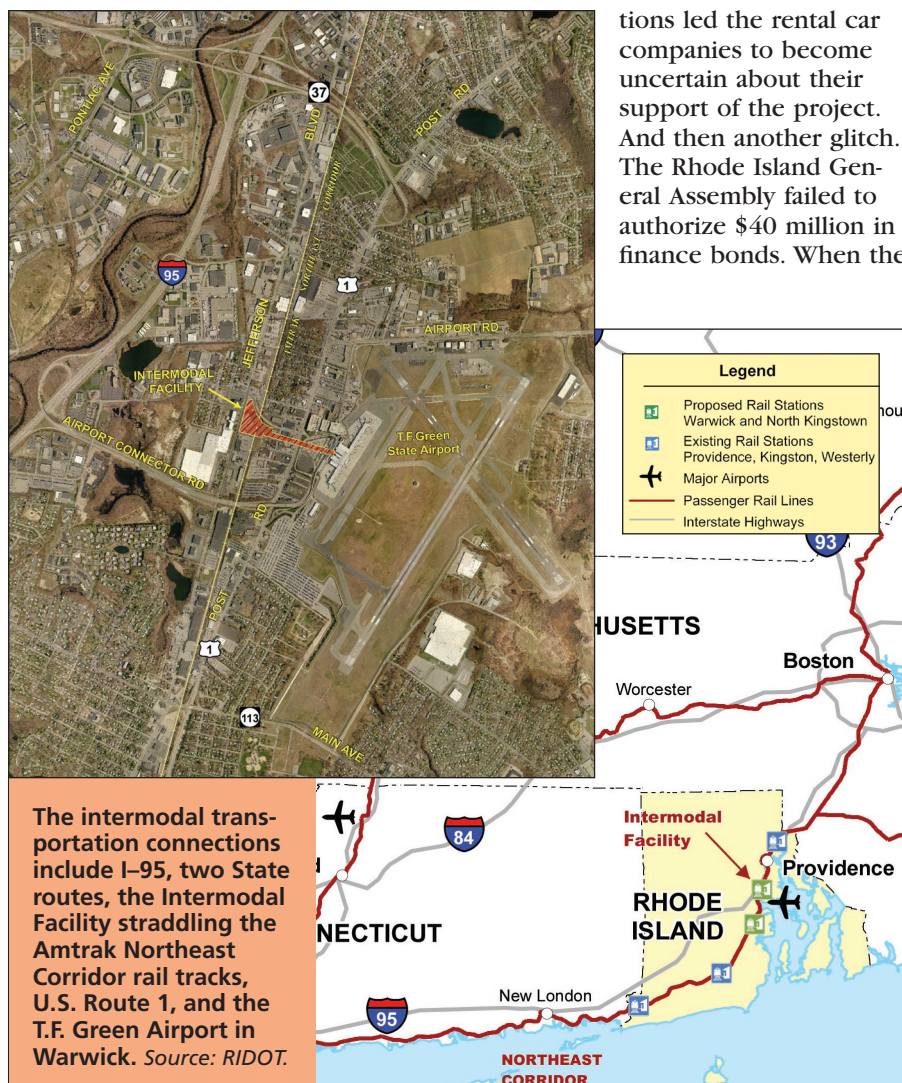
Five years later, in 1997, former Governor Lincoln Almond and Warwick then-Mayor Lincoln Chafee (the Senator’s son) revived the train station idea and quoted a price tag of \$15 million. The following year Senator Chafee, Mayor Chafee, and

Governor Almond announced plans for a \$15 million train station connected to the airport by a \$10 million “people mover” (a self-propelled horizontal elevator or elevated tram).

The State gradually began to develop partnerships and acquire land for the project. Federal funds were slated to be used to finance the construction, but suddenly RIDOT discovered a monkey wrench. Then-Director William D. Ankner pointed to a RIDOT study indicating that the people mover alone would cost \$23.5 million; thus private investors would be needed to help build it in exchange for the right to develop retail space.

By 2001, RIAC had agreed to invest \$130 million in the people mover and a garage that would consolidate rental car facilities and solve parking limitations at the airport. Then came the attacks on 9/11. The potential for declining airline ridership and corresponding reduction in rental car transactions led the rental car companies to become uncertain about their support of the project. And then another glitch. The Rhode Island General Assembly failed to authorize \$40 million in finance bonds. When the

tion in rental car transactions led the rental car companies to become uncertain about their support of the project. And then another glitch. The Rhode Island General Assembly failed to authorize \$40 million in finance bonds. When the





This crane lifted the 160-ton (145-metric ton) skywalk above the arrival, departure, and commercial roadways and set it into place at night, limiting disruption to travelers by beginning work after the airport's last flight of the evening had landed.

governor tried to bypass the assembly by asking the State Supreme Court to approve the bond sale, the court turned him down.

Governor Donald L. Carcieri took office in 2003 and renewed negotiations with the various stakeholders. Also in 2003, RIDOT proposed the skywalk in place of the people mover to gain operational and maintenance benefits. By then, RIDOT had made all land purchases for the project.

In 2005 the new U.S. transportation law, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), authorized RIDOT to proceed with negotiations with Amtrak to extend the MBTA commuter rail service south of Providence to Warwick and North Kingstown.

Finally, with the pieces in place and the General Assembly and rental car companies back on board, the governor broke ground for the new train station in July 2006. In late 2007, RIDOT then-Director Jerome F. Williams directed design to be finalized and construction to begin.

Many Parts to the Puzzle

Without strong public-private partnerships across multiple jurisdictions, the Intermodal Facility never would have seen the light of day. According to RIDOT Director Michael P. Lewis, construction is proving to be the easy part. Quoted in *The Providence Journal* July 17, 2009, he said, "What people can't see is the jigsaw puzzle of Federal and State agencies, agreements, financing bun-

dles, and engineering logistics that had to be pieced together. The \$267 million burden is being shared by RIAC, the Federal Government, and the State through a combination of bonds, grants, and revenue streams."

Public partners include RIDOT, Economic Development Corporation (EDC), RIAC, the Rhode Island Division Office of FHWA, Amtrak, MBTA, the Federal Transit Administration, Federal Railroad Administration, and the city of Warwick.

Private partners include the rental car companies, Gilbane Building Company (the construction manager), and a host of other engineering, construction, and architectural firms. The breakthrough with the rental car companies came when they agreed to relocate their operations from the airport into the new facility and to collect customer facility charges to subsidize operations and debt repayment for the project.

In addition, the partnerships cross State jurisdictions—Rhode Island and Massachusetts—and also encompass several municipalities—North Kingstown, Providence, and Warwick. Complicating matters is that RIDOT owns the land where the airport and Intermodal Facility are situated, and RIAC is in charge of operations. RIDOT managed the project during the planning, programming, environmental, and design phases, while RIAC handled the contract, construction, and overall project management and delivery. What's more, Amtrak owns the tracks where MBTA transit runs the commuter service. The difficulty of obtaining agreements among these entities challenged the project from the beginning.

A Showpiece of Transportation Benefits

Among the Rhode Island project's anticipated benefits are tangible performance improvements to the transportation system: expanded commuter service and more convenient air and highway travel.

Transportation and elected officials expect a reduction in traffic congestion and overall improvement of the performance of the local and regional transportation system. They project an 8 percent reduction in traffic volumes on U.S. Route 1 and the airport connector road alone. The consolidated rental car facility will improve traffic flow by eliminating rental car shuttle buses and shuttled private vehicles from local roadways.

Also among the transportation benefits are gains from improvements to the airport. Currently, it serves more than 4.5 million passengers per year, with 200 daily operations (that is, takeoffs and landings). Projected growth is 7.5 million passengers and 325 daily operations by 2020. To accommodate the anticipated growth, Green developed a master plan in 2001 and supplemented it in 2004.

Then in 2008 the airport completed a massive terminal improvement project to streamline travel by minimizing congestion, improving security, and enhancing concessions. The airport now is studying parking and roadway improvements. In addition, the Federal Aviation Administration is conducting an environmental impact study on the projected demand and need for an airport expansion. Currently under evaluation are safety and efficiency upgrades to a secondary runway and an extension of a main runway. A longer runway would enable the airport to accommodate nonstop coast-to-coast and international flights, plus to attract additional airlines to T.F. Green.

"We are at an important crossroads," says Laurie White, president of the Greater Providence Chamber of Commerce. "Extending the runway and much needed infrastructure improvements will put us in a position to meet the needs of airlines and air travel consumers

The skywalk stretches across U.S. Route 1 (Post Road), as shown in this construction photo.

Primary Funding Sources for the Intermodal Facility

Funding Source	Dollars (Millions)	Percent of Total
FHWA	\$124.6	46.7%
State Matching Grants	\$31.1	11.7%
TIFIA	\$42.0	15.7%
First-Lien Bonds	\$39.6	14.8%
Customer Facility Charges	\$29.6	11.1%
Total	\$267.0	100%

Source: RIAC.

while at the same time positively impacting our economic future."

RIAC's Dillon believes the Intermodal Facility will give T.F. Green an edge over the competition. "We're looking forward to [completion of the Intermodal Facility] because that becomes a major marketing enhancement for us," he says. "International carriers are looking for that rail and airport connectivity."

An Economic and Environmental Home Run

Direct benefits to the local and regional economy are anticipated, both during and after construction. At its peak, the construction alone is employing 300 workers onsite and is expected to take about 530,000 direct man-hours to complete. The

project is creating jobs in three categories: direct (for example, construction and trade), indirect (materials suppliers), and induced (local sandwich shops and gas stations). Rhode Island residents make up two-thirds of the workforce, with the balance from Massachusetts and Connecticut. Eighty companies, many from Rhode Island, are serving as subcontractors. These statistics are in addition to the jobs supported in engineering, architectural, and other disciplines.

Warwick's redevelopment agency is finalizing plans to enable the city and private developers to capitalize on the new Intermodal Facility by building an adjacent downtown district that will have a greater land use density than what is there today. Draft drawings show hotels,





This view of the T.F. Green Airport terminal was taken before construction of the Intermodal Facility began. In addition to commercial air and cargo service, the airport offers taxi, limousine, and local and intercity bus service, plus rental cars from nine companies.

conference centers, offices, and retail space. A grant from the FHWA Transportation, Community, and System Preservation Program to RIDOT is helping with this planning.

"In the decade since the Intermodal Facility was first proposed, local and out-of-state developers, lured by the promise of the train station, have invested tens of millions of dollars in new development and redevelopment projects," says Warwick Mayor Scott Avedisian.

One of the project's overall goals was to create a showplace for employing small businesses. To attract disadvantaged business enterprises (DBEs), the construction manager and airport are striving to meet a DBE participation goal of 10.9 percent. To help meet that target, the two partners hosted two open houses for approximately 140 individuals, who received information on the contracts, upcoming bids, schedules, subcontractors, and guidance on becoming certified as minority or woman-owned business enterprises.

The economic gains are not all. The intermodal project carries green benefits as well: improvement in air quality through reduced traffic congestion and remediation of a brownfield site (an area contaminated by former manufacturing activities) to create the site for the parking garage. In addition, various project components incorporate Leadership in Energy and Environmental Design (LEED) features and offer climate change benefits from decreasing the carbon emissions produced by vehicles.

Other environmental benefits include green features engineered into the new buildings, as reported on the airport's Web site: recycled and regionally manufactured construction materials, including steel, aluminum, and concrete fly ash, plus 17,500 square feet of flooring; energy-efficient elevators and moving walkways; high-efficiency, noncondensing boilers; lighting controls using photocells, occupancy sensors, and time switches; and water-conserving restrooms.

One-of-a-Kind Package of Innovative Approaches

"Innovation is critical at this time of enormous resource constraints, increasing demand for services, aging infrastructure, and increasing maintenance costs," says Division Administrator Peter Osborn, head of the FHWA Rhode Island Division Office. "The Intermodal Facility exemplifies innovative solutions and involves a number of innovative approaches in contracting, financing, insurance, safety, and construction features," adds Osborn.

Instead of the conventional design-bid-build approach, RIAC selected a construction manager-at-risk contract. Under a traditional method, the contracting agency or its engineering consultant designs a project and prepares the construction contract, which then is awarded to the lowest bidder. Under the construction manager-at-risk approach, on the other hand, the contracting agency hires a construction management firm as an advisory consultant dur-

ing the preconstruction phase. The construction manager provides the contracting agency with a guaranteed maximum price and acts as the general contractor during the construction phase, just as a prime contractor would under the traditional design-bid-build method. The construction manager-at-risk alternative allows construction to begin while the design is proceeding, thus potentially reducing the total project cost and duration. (See "Megaproject Procurement: Breaking from Tradition," PUBLIC ROADS, July/August 2004.)

In another innovative approach, the project drew on a Federal loan under the Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA), which established a Federal credit program for projects of national or regional significance. RIAC received a \$42 million TIFIA loan and passed along \$12 million of that to the private sector, specifically to the rental car companies to help them pay the cost of moving into the facility and fitting it with quick-turnaround fueling systems, car washes, and vacuuming systems.

In a third innovative funding approach, RIAC began collecting customer facility charges on rental car transactions in 2001 to help repay the TIFIA loan and the facility's operational expenses. These customer facility charges help leverage the available Federal and State dollars.

The partners are enhancing safety and reducing the project's costs by using an owner controlled insurance program (OCIP), which is centrally procured insurance. The OCIP, also



The skywalk shown here sheathed in orange netting extends over U.S. Route 1 (Post Road), a local access to the airport.

referred to as wrap-up insurance, replaces the approach in which each contractor and subcontractor purchases its own insurance—typically a large line item in a contract—and passes that cost on to the project owner. The owner purchases liability insurance and workers compensation that covers most of the contractors and subcontractors on the jobsite. Rolling the insurance under a single umbrella policy reduces costs because of volume discounts and increases safety because the owner has a financial incentive to implement aggressive risk management and consolidation of claims.

To further reduce insurance costs and improve safety, the project supplements the construction manager's safety philosophy with a project-specific safety plan. In addition, a private health-care company, Medcor®, provides an onsite aid station with an emergency medical technician for every hour that the jobsite is open. This specialized workplace health management enables treatment to be provided the moment an injury occurs. According to the company's Web site, "With this approach, unneces-

sary treatments, claims, and costs are avoided, while required treatments are obtained right away." Safety statistics provided by RIAC indicate the project had only one lost time claim due to injury during the first year of construction.

In another innovation, the parking garage incorporates elevated fueling, washing, and vacuum facilities. RIAC had to obtain special permission from the State fire marshal for the fueling platforms and was required to add multiple safety features. When the facility opens in fall 2010, it will be the first elevated vehicle fueling facility in the country.

A precast concrete plant in Connecticut prefabricated the garage in roughly 3,500 pieces and then shipped them to the project site, where they were assembled over active rail lines. This approach provided considerable benefits in schedule and product quality.

This aerial view shows the parking garage under construction on the east side of Jefferson Boulevard, west of the Amtrak tracks.

A Gateway to Lessons Learned

Achieving multimodal connections was no small task for Rhode Island. A key obstacle is continuing operation of the airport during construction. Lanes cannot be closed as in highway construction. To help reduce impacts on air travelers, RIAC and the project management company reach out to the local community, speaking with residents and





Construction crews are placing concrete forms (foreground) for skywalk piers along the road leading to the new customer service building. Recently completed piers are visible leading up to the terminal in the background.

collectively developed a document, *Vision for the New England High-Speed and Intercity Rail Network*, pledging to promote rail.

This collaborative approach is embodied by the I-95 Coalition as well. Dubbed “the granddaddy of

business owners, and updating them on the project’s progress. In addition, monthly construction updates are emailed to local hoteliers, rental car operators, public transit operators, news media, elected officials, and airport tenants. The emails help ease concerns over parking lot changes, roadway closures, and nighttime work, and have generated a stream of positive press coverage on the project’s progress.

Another obstacle is the number of modal, operating, and administrative entities involved in the project. With so many partners and jurisdictions, the project involves major differences among the agencies in procurement, funding, and institutional systems, including how to conduct the work (as in DBE requirements). The project’s partners recommend getting together early at the Federal, State, and local levels to iron out differences. They insist that a dedicated team environment and structure are vital to make intermodal projects run smoother, faster, and more economically.

For elected officials, the challenge is how to fund intermodal projects more efficiently, given the potential involvement of numerous entities with varying funding sources. For multijurisdictional projects, rather than collecting funds piecemeal, a mechanism is needed to line up the sources of funding and coordinate

the process. The interdependency of transportation systems must be considered when identifying and considering funding and project priorities.

Looking to the Future

Intermodal transportation connectivity is imperative for economic development, commerce, and livable communities. Opportunities exist for Federal and State leaders, as well as private sector partners, to collaborate on intermodal solutions from the regional, corridor, and national perspectives.

In 2009, for example, the six States of the New England region

the multistate transportation organizations” by the American Association of State Highway and Transportation Officials, the coalition represents States from Maine to Florida. In a recent report, *A 2040 Vision for the I-95 Coalition Region*, the coalition departs from its historic role of focusing on short-term operational improvements to recognition of the importance of intermodal operations: “Today...it is increasingly recognized that there are a range of issues at a larger scale, the most obvious being the movement of people and freight within the north-south transportation corridor along the east

Sampling of Intermodal Projects

As reported in a 2009 article in *USA Today*, airport-to-rail links “have long been popular in Europe and Asia. But only eight of the 20 *largest* [emphasis added] U.S. airports . . . have rail service that drops passengers off within walking distance of the terminals: Atlanta, Chicago O’Hare, New York John F. Kennedy, San Francisco, Newark, Minneapolis, Boston, and Philadelphia.”

Other airports, not among the top 20, also have connections to their downtowns. Portland, OR, is one example of a rail airport-to-downtown connector that is already up and running. So is Reagan National Airport near Washington, DC, where a heavily used regional metro system links to the airport. Cleveland and St. Louis also have airport-to-rail connections.

Others are under construction, and some are in the planning stages, including Seattle/Tacoma, WA; Dallas/Forth Worth, TX; Miami, FL; Washington Dulles, VA; and Los Angeles, CA.

Among these, the new Miami Intermodal Center is similar to the Rhode Island project in that it will feature safe and efficient transfers for users of rail systems, buses, taxis, rental cars, privately owned automobiles, pedestrians, and bicyclists. Miami’s airport-to-rail connector is expected to be completed in 2012 (See “From Highways to Skyways to Seaways—the Intermodal Challenge,” *PUBLIC ROADS*, July/August 2004.)



Installation of paneling and sheathing is shown at the building that will house rental car counters and offices.

Ann L. Clarke is senior vice president of planning, environment, and engineering at RIAC and project manager for the Intermodal Facility. Clarke has more than 30 years of experience in environmental and land use planning, and oversight of engineering design and construction management. She has a degree in urban planning from The State University of New York.

Stephen Devine is chief of intermodal planning at RIDOT, which includes overseeing the Intermodal Facility project. Devine's planning positions at RIDOT include a particular emphasis on rail transit planning and design. He holds a B.A. in urban studies from the University of Rhode Island.

Norah Davis is the editor of PUBLIC ROADS.

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coast, involving common concerns ranging from real-time operations to improved *modal integration* [emphasis added] and the long-term viability of the system in light of energy and climate concerns."

And nationally, a December 2008 agreement between the I-95 Coalition and U.S. Department of Transportation further strengthened the partnership by committing to "a seamless integrated intermodal passenger and freight network to link the major metropolitan regions."

At an August 13, 2009, press conference to update the public on the Intermodal Facility's progress, Governor Carcieri said, "With the completion of the intermodal project, T.F. Green will stand out as one of the Nation's finest transportation hubs and will offer one of the most efficient infrastructure corridors in the Northeast, with central and easy access to air, rail, and auto travel."

Corey Bobba, P.E., PMP, is the senior operations engineer and leads the program delivery team at FHWA's Rhode Island Division Office. Bobba has served in FHWA as a program analyst and geotechnical and pavement engineer. He holds bachelor and master of science degrees in civil and environmental engineering from the University of Rhode Island.



This view shows the skywalk with the glass exterior in progress.

Women in Transportation

by Susan Hanson and Elaine Murakami

Improving the current gender imbalance will require strategies on a number of fronts, from education to industry organizations and the workplace.



Dramatic lighting highlights the curves of the 70-foot (21-meter)-tall piers of the new I-35W bridge in Minneapolis, MN, which was designed by a woman-owned bridge engineering firm. Photo: FIGG.

The proportion of women aged 16 and older in the U.S. workforce has grown steadily from 30 percent in 1950 to about 46.5 percent in 2008. Despite this increasing presence in the workforce in general, women remain underrepresented in engineering and the transportation industry. In 2008, only 10.4 percent of *all* civil engineers in the United States were women. In the category of transportation and material-moving occupations, which includes various jobs ranging from airline pilot and bus driver to stock handler and bagger, the percentage of full-time employed female workers totaled only 13 percent in 2008.

With women making up 46.5 percent of the U.S. labor force, even this larger occupational grouping of 13 percent does not approach gender equity in transportation. Whether white collar or blue collar—engineer, planner, or skilled construction worker—jobs in transportation are still disproportionately held by men.

Why should these figures concern the transportation community? Statistics like these are troubling for two main reasons. At the individual level, they might reflect a lack of equality between women and men in access to employment opportunities or a lack of interest by women—related perhaps to a gap in education or a lack of role models. At the industry level, they indicate unnecessary limitations on the talent pool tapped by transportation firms and agencies. Not only does this gender imbalance limit women's opportunities for interesting and well-remunerated work, it deprives the transportation field of a vital source of talent.

To address this gender underrepresentation, eight women leaders in transportation interviewed individually for this article offered the following major suggestions for attracting women to the field and retaining them. Their recommendations target both the industry and women themselves: (1) Connect with children and young people through schools, existing programs to attract women and minorities to science and engineering, and directly through YouTube™ and other social media. (2) Build relationships through networking. (3) Participate in industry organizations and take leadership positions in those organizations.

Women in Selected Occupations, 2008

Occupation	Employed, Both Sexes (in thousands)	Employed, Female (in thousands)	Percentage Female
Supervisors, transportation and material-moving workers	208	43	20.5
Civil engineers	346	36	10.4
Construction and building inspectors	93	9	9.5
Industrial truck and tractor operators	568	51	8.9
Construction managers	1,244	102	8.2
Engineering managers	109	7	6.3
Motor vehicle operators, all others	74	4	5.5
Driver/sales workers and truck drivers	3,388	167	4.9
Heavy vehicle and mobile equipment service technicians and mechanics	217	2	1.1
Bus and truck mechanics and diesel engine specialists	358	3	0.9
Highway maintenance workers	103	2	1.9

Source: U.S. Department of Labor Women's Bureau.

(4) Be mentors. (5) Recognize that workers have lives outside their jobs by ensuring flexibility in the workplace, creating part-time positions, facilitating telework, and avoiding the equation of long work hours with productivity. The women interviewed also suggested ways to improve opportunities for women-owned transportation businesses.

Wage Inequality

According to the U.S. Bureau of Labor Statistics (BLS), median weekly earnings by women working full-time in 2008 were about 80 percent of men's, representing an increase from 62 percent in 1979. The BLS also reported that women's wages as a proportion of men's generally increased from 1979 to 2005 with only slight declines in the mid-1990s.

Women working in gender-typical occupations such as kindergarten teacher and dental assistant generally earn less than women working in gender-atypical occupations such as firefighter and drywall installer. As noted by the Women's Bureau of the U.S. Department of Labor, women can increase their wages and their opportunities for advancement by working in male-dominated occupations. The tendency for women to be underrepresented in certain lines of work is a major reason for the gender pay gap.

But data on gender imbalances among occupations and on gender wage disparities are extremely sensitive to how narrowly or broadly the occupations in question are defined. For example, according to the BLS



This woman, a researcher at Rutgers University, is conducting half-cell corrosion potential testing on a bridge deck in northern Virginia. Half-cell testing provides information about the likelihood of active corrosion.

Photo: Dr. Nenad Gucunski, Center for Advanced Infrastructure and Transportation, Rutgers, The State University of New Jersey.

Current Population Survey, women made up 46 percent of bus drivers in 2008, up from 30.5 percent in 1990. But the occupation of bus driver includes those who operate schoolbuses, transit vehicles, and intercity buses, and the wages for driving these different kinds of vehicles differ (median weekly wage of \$594 for schoolbus drivers versus \$617 for transit and intercity bus drivers). Although the gender composition of these categories (schoolbus drivers, intercity bus drivers) is not available from the BLS, it is possible, perhaps even likely, that the gender difference in median weekly wage for "bus driver" (\$605 for men and \$507 for women, or 83.8 percent of men's earnings) reflects women's overrepresentation, relative to men, as schoolbus drivers and underrepresentation as intercity bus drivers.

Similar gender wage disparities are evident in other transportation-related occupations. BLS data for 2008 show, for example, that the median weekly earnings for full-time wage and salary workers in architecture and engineering for men were \$1,286 and for women were \$1,001 (or 77.8 percent of men's earnings). In transportation and material-moving occupations, women fared somewhat worse, as their earnings were only 74 percent of men's (\$615 for men; \$455 for women). In addition to bus drivers, this category includes crane and tower operators, packers, and packagers.

Many specific occupational categories, however, do not have enough female workers for the relevant wage data to be reported, a situation that is telling in itself. The BLS requires a minimum of 50,000 workers in an occupational category for the reporting of wage data. As a result, wage data are available for general groupings of occupations, but not for detailed occupational categories that have few women in them, such as construction managers; transportation, storage, and distribution managers; engineering managers; civil engineers; surveying and mapping technicians; materials engineers; and environmental engineers.

In terms of the gender wage gap, the question in all these cases is the extent to which the gap reflects different job types and job titles within a particular occupational category or different pay for the same work.

Limited Talent Pool

The second cause for concern about the relatively small numbers of women in transportation—the limitation of needed talent—points to the need for strategies to recruit and retain women in transportation jobs. Over the past 20 years, many occupations that formerly were dominated by men have attracted enough women that these occupations are no longer considered nontraditional for women (for example, lawyers, physicians, chemists, and mail carriers). The Women's Bureau defines a nontraditional occupation as one in which women make up 25 percent or less of the workforce.

Although the proportion of women in engineering has increased substantially over the past quarter century, engineering, like other transportation-related occupations, remains distinctly male-dominated. If medicine, law, and the United States Postal Service® can attract women's talents, why not transportation?

Learning From Women Transportation Executives

To help determine answers to this question and others, eight senior-level women discussed their experiences working in transportation. Members of the planning committee for a Transportation Research Board conference on women's issues held in Irvine, CA, in October 2009 recommended the following women leaders in transportation:

- Brenda M. Bohlke, president, Myers Bohlke Enterprise, Great Falls, VA



Street Smarts

Marsha Anderson Bomar, one of the eight women transportation leaders, is shown here on construction equipment during the groundbreaking of her company's new office building in Duluth, GA.

Employed Civil Engineers By Gender, 1972–2008

Year	Total Employed Civil Engineers	Percent Women
1972	154,000	0.6
1980	180,000	3.3
1989	249,000	5.4
2000	288,000	9.7
2008	346,000	10.4

Source: U.S. Census Bureau, *Statistic Abstracts of the United States*, www.census.gov/prod/www/abs/statabs.html. Numbers may vary from other reports that use only full-time workers.

- Marsha Anderson Bomar, AICP, president, Street Smarts, Duluth, GA
- Linda Figg, president, FIGG Engineering Group, Tallahassee, FL
- Carla W. Holmes, P.E., PTOE, founder and principal, Carla Holmes Engineering, Ellenwood, GA
- Linea Laird, P.E., project manager, Washington State Department of Transportation, Seattle, WA
- Wendy Lopez, P.E., vice president, URS Corporation, Dallas, TX
- Kim Thatcher, owner, KT Contracting Company, Inc., Salem, OR
- Doris Willmer, P.E., LEED AP BD+C, president and principal consultant, Willmer Engineering, Atlanta, GA

Seven of the eight own or have owned transportation-related firms, and all have worked for decades in a wide variety of positions at transportation agencies and companies. All are pioneers; whether earning a Ph.D. in geotechnical engineering (Bohlke) or a B.S. or M.S. in engineering (Figg, Lopez), they had few or no female classmates.

Topics of discussion included their work experiences and ideas

for attracting and retaining women in transportation. The suggestions they provided pertain equally well to members of other underrepresented groups in the transportation industry, such as minorities or people with disabilities.

Attracting More Women

The women interviewed offered three primary suggestions for attracting more women to transportation: connect with young people, network, and participate in professional organizations.

Connect with young people.

To educate students about career choices and demonstrate that gender does not limit career possibilities, companies and agencies need to connect with educational institutions, especially middle schools but also high schools and colleges. The aim should be to demonstrate how mathematics, science, and engineering help to solve real-world problems and improve lives.

School projects and field trips can be transformative. During the interview, Doris Willmer described how her interest in engineering began with a fifth grade assignment to interview someone about his or her work. When the chemical engineer she interviewed likened the field to baking a cake, Willmer thought, "I can do that." She later shifted to civil engineering after realizing that she was more interested in a discipline where she could see more immediate benefits from her work.

In another school-related project, Linda Figg's bridge engineering firm involved 1,800 schoolchildren in the design of the I-35W bridge in Minneapolis, MN. The children attended a class that included an introduction to bridge engineering and construction, the making of mosaic



Carla Holmes



Wendy Lopez



Doris Willmer



Linda Figg

tiles, and a site tour. The Minnesota Department of Transportation incorporated the children's tiles into the bridge.

Brenda Bohlke, Figg, and Willmer provided two more recommendations. In addition to sponsoring field trips, another way for companies and agencies to connect with young people is through educating school counselors about engineering and opportunities for women. Still another is to sponsor summer internships and semester-long apprenticeships for high school and college students.

Also effective is establishing cooperative programs between industry and academia, whereby young women employed in the transportation industry work simultaneously on a degree. During the discussion, Bohlke pointed out that once these employed students complete their degrees, they will have acquired a broad familiarity with job choices. (See "Selected Programs to Attract Women and Minorities to Science and Engineering" below.)

Still another suggestion, from Linea Laird, was to connect directly with young students via YouTube, Facebook, and other social networking Web sites, as many youths seem to prefer these media to more conventional publication outlets.

The last recommendation for connecting with young people was to work with one or more of the existing programs that help draw women to engineering.

Build relationships through networking. During the discussion, Marsha Bomar pointed out that the relationships women develop as business owners or managers help with recruiting. She organizes a "power lunch" for women at the annual conference of the Institute of Transportation Engineers, an opportunity to build relationships that are useful when looking for new staff or creating project teams.

"I network with a lot of engineering organizations and with their women members, so I've probably met more highly qualified women than your average person who is looking for potential employees," Bomar said. "As a result, I have more women in a pool of candidates than an average company does." By offering opportunities for networking, engineering organizations serve as a pool for recruiting women engineers into transportation.



KT Contracting Company, Inc.

Kim Thatcher is shown here with one of her employees during a traffic control training exercise.

Participate in professional and industry groups and take leadership roles in those groups. Taking on leadership roles in transportation organizations is not only an effective form of networking, it also elevates the visibility of women as leaders and demonstrates that women are making significant con-

Selected Programs to Attract Women and Minorities to Science and Engineering

Garrett A. Morgan Technology and Transportation Education Program at the Federal Highway Administration (www.fhwa.dot.gov/opd/universitygrants.htm#GAMTTEP)

The program focuses on improving K–12 students' skills in science, technology, engineering, and mathematics, with particular attention to women and minority students.

U.S. Department of Labor Women's Bureau (www.dol.gov/wb)

The Women's Bureau offers programs that encourage women to pursue nontraditional occupations.

Women in Science, Technology, Engineering, and Mathematics On The Air! (womeninscience.org/about.php) This program funded by the National Science Foundation includes a radio program and Web site.

American Society of Civil Engineers (www.engineeryourlife.org). This program is called "Introduce a Girl to Engineering."

tributions in the fields of transportation engineering, road construction, bridge design and construction, and highway construction. Bomar was president of the international Institute of Transportation Engineers (1994) and currently is president of the American Society of Civil Engineers' Transportation & Development Institute. Bohlke was chair of the Underground Construction Association of the Society for Mining, Metallurgy, and Exploration (2007–2009). Wendy Lopez currently is chair of the board of directors of the National Association of Women Business Owners. By taking on leadership positions in their professional organizations, these women raise the visibility of all women, not just themselves, which in itself can attract other women to the field.

Retaining Women in Transportation

If women employees leave the transportation field, then any gains made through the above strategies were only temporary. The eight senior executives addressed this issue by offering two primary suggestions.

Be a mentor. Make a priority of mentoring women and men early in their careers. Carla Holmes credits her mentor, Marion Waters, now retired from the Georgia Department of Transportation, for helping Holmes advance in her career. In turn, many people have sought advice from Holmes. She adds that it is not useful to assume you will be passed over for a promotion because you are a

woman or a minority. Instead, show your interest in advancement by taking courses and improving your skills.

Thus, mentors need to encourage staff training. At her former company, Lopez initiated a program called Pathway to Principal, in which employees work together in teams that differ from work project teams. This training program provides a venue for learning about the varied skills and strengths of their colleagues.

The Federal Highway Administration (FHWA) and U.S. Department of Transportation (USDOT) provide a number of opportunities for women to advance in construction and engineering. These opportunities include programs aimed at college-level students, such as the Summer Transportation Internship Program for Diverse Groups (STIPDG), the Dwight David Eisenhower Transportation Fellowship Program, and the Professional Development Program. In 2009, USDOT established a new program, Pilot Entrepreneurial Training and Technical Assistance Women and Girls Program, that provides internships, mentoring, and training. In 2008, women represented 38 percent of the FHWA workforce, an increase of 9 percent since 1990.

Recognize that workers are whole people. When Bomar started her company, she said, “I wanted to create a place where we could be professionally excellent but also be comfortable being whole people, that is, recognize that we have family, friends, and interests outside of work.”

Holmes added, “Workplace [managers] should not make employees choose family or work; work and family are both important. Employers cannot expect work to infiltrate *all* hours of someone’s life.” Specific suggestions culled from the discussion include the following four points:

Create a flexible workplace that helps attract and retain both women and men. Bomar says, “This approach is not just for women, and it’s not just for families. Someone who likes to go mountain biking might need to leave early on Fridays. The same flexibility should apply whether it’s for a school event or a personal hobby. Staff should feel comfortable that as long as they are acting like professionals, they will be treated like professionals.”



FHWA Nevada Division Administrator Susan Klekar, shown here on a street in Carson City, NV, worked part-time for 7 years “to keep all parts of my life in balance.” She credits FHWA with helping her maintain her career with a flexible schedule that allowed considerable family time.

Kim Thatcher points out: “Women have more understanding about the need for flexibility around family issues because responsibilities for child care and family still mostly fall to women. They need the flexibility to take care of these life matters. Things like a child’s recital or soccer game can happen before 5 p.m. when scheduled work time ends.”

Create part-time positions in a wide range of jobs. Many jobs in transportation, such as project design and surveying, can be made part time for people who do not want to work full time while raising families or going to school.

Facilitate teleworking, including working from home but other forms as well. At Figg’s company, employees can choose where to live, and project teams include people from a number of different offices, who communicate via Web conferencing and other tools.

Avoid equating long work hours with productivity. Thatcher encourages flexibility in the work process by avoiding micromanagement: “We tell staff, ‘Here is what we want to do, here’s the goal, and here are the parameters.’ Everyone is helping everyone else reach the goal—project completion. Workers love having the latitude to ‘go forth’ and get the job done.”

Bomar’s company operates on a similar philosophy. “You have a proj-

ect, a schedule, and a deadline,” she says. “There are core hours where most days you should be present, but as long as you meet your schedules, meet the quality of work we’re looking for, and keep your colleagues and your supervisors informed, you can [change] your schedule around to accommodate all kinds of things.”

Improving Opportunities For Women-Owned Businesses

The discussion with women who own their own businesses made it clear that many seek to create a different kind of workplace, one that does not replicate the way things were done in their previous workplaces. Bomar observes, “A lot of the rules that I created when I first started the business were a reaction to bad experiences I had at other places. One of the areas that I thought a lot about was how to have the kind of environment that I wanted as a single mother with three children, and I wanted time with my kids. How could I make sure that other folks had the same opportunity and yet still have a high-functioning, professional business. I wanted to create something better...by doing things differently.”

That these women have succeeded in doing things differently is clear from the fact that women constitute higher-than-average proportions of

their professional staffs—typically more than 25 percent. Compare this with the much lower proportion of female engineers in transportation; for example, the Institute of Transportation Engineers has 3,054 female members, only 16.2 percent of a total membership of 18,824.

At Lopez's company, people of color represent a higher percentage than at her former firm. Women-owned businesses appear to be an important medium for improving the participation of women and other underrepresented groups in transportation.

The business owners offered these suggestions for increasing opportunities for women-owned businesses in transportation:

Find enhanced ways to finance women-owned businesses in transportation. According to Megan Blake's 2006 article, "Gendered Lending: Gender, Context and the Rules of Business Lending," in the journal *Venture Capital*, women who are attempting to finance a business in a sector such as transportation that is nontraditional for women often encounter difficulty obtaining loans. In such cases, banks have denied loans on the grounds that customers will not want to do business with a woman-owned engineering or design firm.

Some *disadvantaged business enterprises (DBEs)* are concerned that the size standards used in the DBE program are too low, making it difficult for firms to grow enough to compete for larger contracts while still remaining eligible for the program. By statute, DBE firms must meet U.S. Small Business Administration size standards (usually expressed in gross receipts or, in some cases, number of employees). Another concern frequently expressed by subcontractors, including DBEs, is that slow payments by prime contractors hurt subcontractors' cash flow. Some have suggested requiring a specific schedule for payments, such as bimonthly. While not mandating a specific schedule, USDOT's DBE rule does require prompt payment of DBEs.

What Now?

Managers, business owners, and employees themselves can do much to alter the shortage of women in transportation. Many professions in the transportation industry are

Tips for Women in Transportation

1. Be a mentor to young women who are interested in transportation careers. Take the time to advise others on how they can succeed and advance their careers.
2. Early in your career, find a mentor, whether a woman or a man. A mentor can help you learn skills to advance and help build your network.
3. Find out what your aptitudes are. Don't let your peers or families limit your career choices.
4. Learn from your failures. Ask what you could have done differently. Don't dwell on the negative; create something positive such as a new work environment and produce high-quality work.
5. Demonstrate your interest in learning new skills. Take advantage of any management and leadership training opportunities that arise.
6. Learn to be a good manager if you want to advance. Over a long career in transportation, management skills will help you advance.
7. Effective communication skills will help you be a better project manager or team leader. Be a good listener, hearing the problems that people are having, and work cooperatively to come up with solutions.
8. Recognize that sometimes you might have to move to another location to take advantage of opportunities.
9. Be willing to put on a hard hat and work in the field, take on physically demanding work.
10. Pay it back. Get involved at the local level in school and community programs so others can learn about what you do.
11. Be an ambassador. Seek opportunities to represent the profession. Be visible, be accessible. Inspire someone.

well paid and offer opportunities for advancement. Some jobs that previously might have required physical strength now rely more on the ability to operate heavy equipment using fine motor skills. As women advance to become team leaders and project managers, their strengths in communications and building cooperative relationships become especially valued.

Women as business owners can make significant improvements to gender balance in the transportation industry. They are more likely to hire other women (based on the pool of female candidates they are exposed to through their networking experiences), establish scholarships, work with educational programs at all levels to encourage women to join the field, and create working environments that maintain work-life balance.

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Elaine Murakami is a community planner with the FHWA Office of Planning. Her education includes a B.A. from the University of California, Santa Cruz, and M.A. degrees in urban planning and gerontology from the University of Southern California. She has a longstanding interest in the role of women in the transportation industry.

The authors thank Katie Caudle for her valuable research assistance and thank each of the eight women who shared their experiences. Marsha Anderson Bomar also participated in developing this article with the authors. For more information, contact Susan Hanson at 802-388-9977, shanson@clarku.edu or Elaine Murakami at 206-220-4460, elaine.murakami@dot.gov.

Recruiting Effort Is a Sweet Success

by Carey Shepherd



Promising careers—and brownies—entice a diverse pool of young people to consider the transportation construction field in Florida.

(Above) At South Florida Construction Career Days, representatives of an engineering firm (left) show students how to purify water with peppermint, one of many innovative approaches to pique young peoples' interest in science and engineering.

Most places, the smell of warm brownies would signal a nearby bakery or at least lunch. But that was not the case in Davie, FL, for 2 days in October 2009. The rich brownie smell was wafting from one of the activities during the South Florida Construction Career Days.

Now in its ninth year, Construction Career Days featured dozens of hands-on transportation construction and consulting activities, including a "chocolate asphalt" tutorial. Students discovered the cohesive properties of road asphalt by mixing nuts, coconut, and crackers into a warm brownie batter, then rolling it into a sweet, messy chocolate miniature road that filled the air with an aroma arguably much more appealing than any petroleum product.

The Florida Department of Transportation (FDOT) sponsors the annual event, one of many transportation career days held across the Nation. As elsewhere, the South Florida Construction Career Days were a labor of love involving hundreds of volunteers. At this event, the volunteers represented more than 50 contractors, consultants, colleges, and government agencies. They worked together to bring high school students a glimpse of the myriad career opportunities in transportation construction and engineering, plus professional services.

About 1,500 area high school students received hands-on introductions to highway surveying,



Students roll out brownie mix into "chocolate asphalt."

you can't help but benefit," he said. "Everyone talks about the numbers—how many kids [attend], how to track them, et cetera. But look at these kids. They are listening and learning. What if they slow down in a construction zone? What if they are a little less impatient when sitting in construction traffic? Then we all benefit. What's more, he

added, some of them will tell their parents that "there are exciting and good-paying jobs in our industry."

According to Marty Anderson, a contract compliance manager at FDOT District 4 who specializes in equal employment opportunities and is one of the founders of the event in Florida, most attendees at the Career Days event were African-Americans, Hispanics, and/or females, bucking the stereotype that the transportation industry is unwelcoming to women and minorities. "Look around. You'll see that it isn't the girls who are hanging back and watching," Anderson says. "They are the ones on the equipment, working the simulators, asking questions, and getting the most out of the program."

design, construction equipment, grading, filling, earthmoving, traffic maintenance, signalization, water testing, media relations, intelligent transportation systems, and more. Area colleges and technical schools teamed with industry representatives to provide career counseling and share information about their curricula. The Florida Highway Patrol was on hand to impart life-saving traffic safety tips, one of which was to not drive drunk. Attendees had the opportunity to try on a pair of special glasses that give the wearer the illusion of drunkenness.

Bob Bursleson, president of the Florida Transportation Builders' Association, conducted the formalities that opened the event, assisted by Judy Paul, mayor of Davie; Jennifer Olson, chief operating officer of Florida's Turnpike Enterprise; Jim Wolfe, secretary of FDOT District 4; and Ellen Navarro, standing in for State Senator Nan H. Rich.

Dan Weekley, president of a paving company, received the 2009 Outstanding Prime Contractor/Consultant award from the Southern Transportation Civil Rights Executive Council. During his acceptance speech, Weekley pointed out the benefits of the Construction Career Days: "When you expose this many young people to something,

Students had the chance to operate various pieces of construction equipment, such as this backhoe.



Paul Kynerd, a teacher at the Miami Lakes Educational Center, notes that, of his top five students, four were minority females in 2009. However, he adds, that proportion does not carry over into the transportation construction industry. "There is a sexist culture in this country that females can't do math," Kynerd says. "Events like this dispel that idea and help improve female representation in all the sciences."

Measuring Career Days' success is an ongoing task, gauging the extent to which these events strengthen the transportation industry with a pool of fresh applicants and increase parity in a field not traditionally populated by women and minorities. However, one thing is clear: Career Days is a hit among South Florida teachers, volunteers, students, and construction industry representatives.

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Applying Lessons From a Bridge Collapse



*by Roger Surdahl,
Donald Miller, and Vicki Glenn*

The ripple effect of a 1989 bridge failure is still felt today as engineers and safety experts continue to update specifications for the construction of temporary shoring.

On the sunny summer morning of August 31, 1989, Stephen Brown was driving his regular rush-hour commute from his home in Maryland to Washington, DC, where he worked in the White House Communications Agency. While his eyes watched the road, his mind was reviewing the tasks to be tackled in the day ahead.

As Brown drove the Baltimore-Washington Parkway, he saw movement ahead on the Maryland Route 198 bridge, which crosses over the parkway. Construction had been occurring on the bridge for months, and seeing workers moving around overhead was nothing new. But on that morning, workers suddenly were moving fast, trying to get off the bridge.

With his attention riveted on the scene he was approaching at 55 miles (88 kilometers) per hour, Brown witnessed a slow-motion collapse as the structure fell, with still-liquid concrete literally flowing onto the parkway. Standing on his brakes, the 23-year-old stopped his car and maneuvered to the left shoulder fewer than 100 yards (91 meters) from the collapse. The car in front of Brown was not so fortunate, and he heard and watched the vehicle plow into the falling debris.

Brown also saw workers hanging onto rebar, trying to keep from falling onto the roadway below. With the help of another traveler, Brown extricated the driver of the car that had crashed into the debris. The driver had severe head injuries, and they moved her to the side of the road to await help. Fortunately, there were no deaths. Other than the driver in front of Brown, there were only several minor injuries, even though tons of concrete and steel had fallen onto a heavily traveled roadway.

In response to the collapse and to prevent future bridge failures, the Federal Highway Administration

(Left) Following the 1989 collapse of Bridge No. 4 carrying Maryland Route 198 over the Baltimore-Washington Parkway, FHWA and others initiated updating of specifications for the construction of temporary shoring. This aerial view looking north shows the collapsed bridge. Photo: United States Park Police.

Relevant Definitions

Shoring or Temporary Works: Temporary construction that supports the permanent structure until it becomes self-supporting. Shoring can include steel or timber beams, girders, columns, piles and foundations, and any proprietary equipment including modular shoring frames, post shores, and horizontal shoring. Shoring is also known as falsework.

Formwork: A temporary structure or mold that retains the plastic or fluid concrete in its designed shape until it hardens. Formwork must have enough strength to resist the fluid pressure exerted by plastic concrete and any additional fluid pressure effects generated by vibration.

Source: Guide Design Specifications for Bridge Temporary Works (FHWA-RD-93-032), November 1993.

(FHWA) launched a series of initiatives, and soon the American Association of State Highway and Transportation Officials (AASHTO), American Society of Civil Engineers (ASCE), and others joined the effort to learn as much as they could about the cause of the collapse. The agencies set out to develop procedures and specifications to improve construction of shoring and other temporary works, which were discovered to be the cause of the MD Route 198 bridge collapse.

In fact, the U.S. bridge construction industry is still addressing the effects of the collapse, two decades later. Spurred by another collapse—the 2007 failure of the I-35W bridge in Minneapolis, MN—AASHTO published interim revisions in 2008 to its specifications for temporary bridge works. ASCE plans to publish revisions in 2010 to its guidance. And the National Cooperative Highway Research Program (NCHRP) will reevaluate standards for designing, building, and inspecting temporary works, also for release in 2010.

Over the years, the purpose of such publications—whether by FHWA, AASHTO, ASCE, or NCHRP—has been to increase national awareness of the importance of building temporary structures that ensure the safety of bridges, the workers who build them, and the traveling public. Specifically, as a result of the bridge collapse on the Baltimore-Washington Parkway, the goal was to develop guidelines and standards, improve specifications, and publish a shoring handbook, where previously none existed.

Scenic Highway to the Nation's Capital

In the early 1920s, planners envisioned an access-controlled scenic

byway between the Nation's capital and Baltimore, MD, which became the Baltimore-Washington Parkway. Construction of the road became possible in the mid-1930s with the New Deal response to the Great Depression, but World War II intervened, delaying construction. The Maryland State Highway Administration owns and operates the northern 12-mile (19-kilometer) section, for which construction began in 1947. The National Park Service (NPS) owns and operates the southern 19-mile (30-kilometer) scenic section, for which construction began in 1950. The parkway opened to the public in October 1954.

Over the years, commuters increased traffic congestion, and the parkway was showing its age. There had been piecemeal upgrades to the facility, but in 1983, NPS began planning to upgrade the parkway. One component of the NPS portion of the parkway upgrade was in response to a 1983 inspection recommending that the two existing bridges carrying MD Route 198 traffic over the parkway be replaced with four new bridges: two each over the north- and south-

bound lanes of the parkway. These bridges were used heavily, as the MD Route 198 bridge is a main exit from the parkway to Fort Meade and the National Security Agency.

FHWA's Eastern Federal Lands Highway Division (EFLHD) designed the four new bridges and managed construction for NPS. The designers of the NPS structure also had to ensure the use of specific aesthetic features and materials.

Construction began in May 1987. The plan was to construct the two westbound bridges across the north- and southbound parkway lanes, then demolish the existing MD Route 198 spans and build the other two new spans at the site of the original eastbound lane of MD Route 198.

EFLHD designed the bridges as cast-in-place, posttensioned, concrete box girder structures with the eastern abutment bearings fixed and the western abutment bearing areas allowing for expansion. For Bridge No. 4, the simple span between abutments measured 95 feet (29 meters). Posttensioning in each girder web that provided the longitudinal strength for the box girder would occur at completion of the girder and as soon as the design concrete strength was reached. The final construction plans showed each bridge with a 30-foot (9-meter) horizontal width and 14.5-foot (4.4-meter) vertical clearance. The construction specifications required complete support by shoring until posttensioning could occur.

Bridge Nos. 2 and 4 were adjacent over the parkway's southbound lanes. The structure's design of concrete box girders and masonry-faced abutments met the aesthetic requirements of NPS.

After the collapse, FHWA, NPS, and construction contract officials began the meticulous process of combing through the debris to determine the cause of the failure and clearing the site to reopen it to traffic.





Workers are dismantling the collapsed bridge elements from Bridge No. 4. Shot from Bridge No. 2, this photo shows a portion of the bridge surface with set concrete (left) and the point of collapse, with the rebar part of the section that collapsed (right).

A Bridge Fails

If there ever is a “good” time for a bridge collapse, it is late August in the Washington, DC, metropolitan area—many employees are on vacation, so fewer commuters are using the roads. A United States Park Police officer told *The Washington Post* shortly after the collapse that on the day the bridge failed, “[traffic] was probably 20 percent lighter than usual. It is common for cars to be stopped bumper-to-bumper during rush hour. There must have been a slight break in the traffic. It’s a coincidence; a minute later or a minute earlier, and things could have been a lot different.”

The bridge collapsed at 6:50 a.m. At 2:00 a.m., workers had begun placing concrete for the deck slab. Accounts by workers and inspectors confirmed the placement was going well, and shortly before 6:00 a.m. workers had placed about 120 cubic yards (92 cubic meters) of concrete, out of a total 160 cubic yards (122 cubic meters). The crews had finished more than half the 100-foot (31-meter)-long overpass deck.

About 15 to 20 workers were on the bridge at the time. Several reported hearing a breaking sound or feeling the bridge vibrate. Others said the sound was like a trailer being pulled under the bridge, and they looked to see whether a truck was passing underneath (commercial vehicles are prohibited on the parkway). Five to 10 seconds later, the center of the span abruptly collapsed, dropping fresh con-

crete, steel beams, wood, rubble, and workers onto the road more than 20 feet (6 meters) below.

“The bridge just vibrated for a second, settled back to normal, and all of a sudden it collapsed and people started falling,” a 34-year-old worker told *The Washington Post*. He had plunged backward into a pile of wet concrete. “Fortunately, concrete, when it’s wet, makes a good cushion,” he said. “If it had been hard, it would have been a different story.”

Another worker told how he landed on his knees in the rubble on the parkway and looked up to see the 1-ton (0.9-metric-ton) concrete smoothing machine looming above his and others’ heads. “I just kept hoping that it didn’t fall down on us,” he said. (It didn’t.)

As Stephen Brown’s testimony confirms, drivers also had narrow escapes. Incident reports from the U.S. Park Police and followup interviews recount harrowing tales. A driver traveling south on the parkway saw the bridge begin to collapse. Debris struck the front windshield of his vehicle, but he was able to drive to safety. Another driver was in the last car to emerge from under the bridge. She saw the bridge collapse in her mirror. She reported having driven with a “pack” of other vehicles, all of which cleared the bridge and continued their commute, apparently oblivious to what was happening behind them.

U.S. Park Police and NPS personnel arrived within 10 minutes of the collapse, secured the scene, and redirect-

ed traffic as construction personnel, law enforcement, and fire and rescue units responded. Remarkably, the bridge collapse injured just 9 construction workers and 14 commuters.

By shortly after 7:00 a.m., area radio and television newscasts were broadcasting special reports to alert listeners and viewers of the situation.

Counting Heads

Immediately, construction personnel and others involved in monitoring the concrete placement began to account for construction workers and motorists. The bridge had collapsed in the middle, forming a “V” as the crumpled structure hung from the abutments at either end.

Tense hours passed as inspectors and rescue personnel surveyed the scene and carefully began to remove debris and other material to determine that no people or vehicles were buried under the mountain of rubble. One worker had fallen onto the parkway during the collapse but immediately began to search the area beneath the bridge for vehicles or other workers. Ironically, he was the only person “lost,” but the searchers soon accounted for him.

In late June 1989, Scott Wallace had become the FHWA project engineer overseeing the construction project. On August 31—the day of the collapse—Wallace arrived onsite early to monitor the day’s activities, including the concrete placement that began at 2:00 a.m. After hours of dividing his time between his office trailer and the bridge, he received a radio call that Bridge No. 4 had collapsed. He hurried to the site, which he would later describe as “bedlam.”

For 3 days Wallace worked around the clock to ensure the cleanup went smoothly and that nothing prevented investigators from securing samples of intact shoring components and other construction material that might help identify the cause of the collapse. He later participated in tests on screw

FHWA Conducts Loading Tests on Bridge Shoring Components

In late September 1989, FHWA staff with what was then the Office of Engineering Research and Development (R&D) began a series of tests on screw jacks and shoring tower components to duplicate the mechanism that led to the failure of the shoring towers and tower elements that resulted in the collapse of the MD Route 198 bridge. All the materials to be tested were undamaged and moved from the bridge site to TFHRC. Researchers inspected all elements for wear and corrosion and found none. The researchers conducted experimental evaluations on individual screw jacks and on shoring tower assemblies. The components tested were randomly selected from the recovered materials. Witnesses to the experiments included representatives of the Office of Engineering and Highway Operations R&D (now the Office of Operations Research and Development), EFLHD, Central Federal Lands Highway Division (CFLHD), and several private sector consultants.

Screw jack tests. Investigators initially attributed the failure of the screw jacks to the use of undersized components. For the screw jack tests, researchers used two test fixtures, Type A and Type B, both of which examined the performance of the screw jack and shoring frame tube assembly used to adjust the height of the framework above the shoring. For Type A tests, the researchers applied increasing vertical loads to a series of jacks while increasing the angle of rotation of the base plate to verify the angle of rotation that could cause the jack assembly to fail. The Type B tests also applied increasing vertical loads, but with no rotation. Instead, researchers tested a range of extended jack heights from 4 to 14 inches (10.2 to 35.6 centimeters), which duplicated various jack heights used in the bridge shoring, and load eccentricities to determine combinations that might result in failure.

Test results indicated that the screw jacks failed at load and configuration combinations that were unlikely to have occurred prior to the collapse. This led investigators to conclude that the screw jack

failures discovered in the debris likely occurred during the bridge collapse and did not cause it.

Shoring tests. The researchers also conducted tests on fully assembled shoring towers set up at TFHRC. The tests focused on establishing the failure modes of the shoring tower members. The researchers applied vertical loads that simulated those estimated to have been applied on the shoring towers adjacent to the parkway during construction. These towers had to resist the heaviest loading during construction and were believed to be involved in initiating the collapse.

Researchers conducted tests on shoring tower assemblies representing a variety of configurations that were used at the site. For the towers that failed, the researchers found that the cross-bracing members between shoring tower legs bowed out of plane, making them incapable of providing the bracing needed to support the shoring tower legs. This loss of bracing resulted in buckling and fracture of the shoring tower legs, similar to that found in the collapsed debris.

Researchers made additional observations related to the performance of the bracing. For example, the bracing walked off the pins connecting it to the lower legs. Gravity clips, which secure the cross-bracing onto the pins, could bend, allowing the cross-bracing to come loose. Pin connections broke off the tower legs and cross-bracing bent where it was connected to the frame. Once the cross-bracing failed, the top screw jacks rolled in the direction of the more heavily loaded tower section, which was the section carrying the roadway part of the falsework loads, resulting in the buckling and fracture of the tower legs.

Test results. Although FHWA researchers conducted all tests, other headquarters staff and private industry consultants determined the parameters investigated, such as loads, dimensions, and configurations tested. The results of the testing served as one of the primary bases of the final report.

Donald Miller

jacks and scaffolding conducted by FHWA at the Turner-Fairbank Highway Research Center (TFHRC).

“There were so many rumors—most wrong—circulating about the collapse and its cause,” Wallace says. “There were also investigators looking into every aspect of the project. Essentially, I worked to make certain that events or processes [that were] questioned were correct and accurately conveyed, which they sometimes weren’t.”

FHWA Responds to Bridge Collapse

FHWA moved quickly to determine the cause of the bridge collapse and identify appropriate responses to improve bridge safety during construction. The agency established an investigation with three elements: It assigned responsibility to EFLHD to investigate the failure and report to the FHWA Administrator; hired T.Y. Lin International, a private consultant, to conduct an independent investigation and report the cause of the collapse to the Administrator; and established a Board of Review to evaluate all aspects of the investigations. The review board thus evaluated the EFLHD and consultant

reports regarding the basic cause of the failure and recommended actions to prevent future collapses.

The result was the Board of Review’s December 1989 *Report of the Investigation into the Collapse of the Route 198 Baltimore-Washington Parkway Bridge* (FHWA-PR-90-001), which includes findings from the EFLHD investigation, the independent consultant’s investigation, and results of screw jack and scaffolding tests conducted at TFHRC. The report evaluated nine possible causes: severe ground vibrations, failure of stay-in-place deck forms, the concrete placement sequence, vehicle damage to shoring, movement of the shoring system from Bridge No. 2 to

Bridge No. 4, failure of shoring foundation slabs, use of hardwood blocking, dynamic loading by the concrete finishing machine, and shoring failure.

During construction, but prior to the collapse, Tom McFadden, then NPS superintendent of Catoctin Mountain Park, Greenbelt Park, and the Baltimore-Washington Parkway, had voiced concern about ground vibration. “I recall sitting on the Bridge No. 4 headwall and watching two heavy trucks stop on Bridge No. 2,” McFadden says. “Then as both trucks’ engines revved and they began to inch forward, I felt the ground and headwall vibrate. It was a fluid feeling, like jelly.”

This aerial photo taken during the bridge cleanup shows the point of the collapse between the dried concrete section and rebar, chunks of cement, and other structural elements—the “V” of the collapse.



NPS

This closeup shows that the yellow-colored shoring tower on the south-east corner has rotated. As the bridge deck rotated during the collapse, the left leg of the shoring tower slid at the top, turning at its base. Twisted and broken cross braces are visible between tower legs.

Early in the inquiry, however, investigators focused on the shoring system. Timber framework on steel longitudinal support beams, which were supported by metal shoring towers, supported the superstructure construction on Bridge No. 4. The shoring consisted of three simple span sections: one 35-foot (11-meter) roadway span and two 28-foot (8.5-meter) abutment spans.

The shoring system had several changes from the original shop drawings. (1) The positions of the longitudinal support beams differed in relation to the concrete girder webs. (2) The leveling beams needed additional hardwood blocking underneath. As noted, workers feared a truck had hit the bridge; the original 12-foot (3.7-meter) clearance height was raised to 14.5 feet (4.4-meter) after an illegal oversize and over-height truck struck the shoring during construction of Bridge No. 1. The additional hardwood blocking was used to gain the needed clearance. With EFLHD's approval, the contractor (3) redesigned the deck overhang support system, (4) made changes to the reinforced concrete foundation slabs, and (5) changed the type of hanger rod assembly.

The Failure

Following the collapse of Bridge No. 4, inspectors examining debris noted that many hanger beams were still intact even after sustaining the impact load from the collapse. They verified that the deck framework did not fail, and the positioning of the longitudinal support beams did not cause the collapse.

Inspectors examined the metal shoring system and confirmed it did not match the approved shoring drawings. After reviewing literature with the letterhead of the company supplying the shoring equipment, investigators asked representatives to visit the collapse site and confirm that their company



Steve Eisen

had manufactured the shoring system components. Following that inspection, the representatives determined their equipment had *not* been used in the shoring system.

Further investigation revealed that two elements of the system did not conform to what EFLHD engineers had approved for use: The top screw jacks were not of the approved bearing capacity, and the cross-bracing was made of 1-inch (2.5-centimeter)-diameter

tubing rather than 1.25-inch (3.2-centimeter)-diameter tubing. Most of the metal shoring elements did not bear a manufacturer's identification.

EFLHD designated screw jacks for a 25-kip (25,000-pound, or 11,375-kilogram) top and bottom shoring frame. But the screw jacks found at the collapse site were for a 10- to 11-kip shoring or heavy-duty scaffolding system. The top screw jacks also did not have the proper adapters to maintain vertical alignment



Shown here is a closeup of the northeast tower of the collapsed deck of Bridge No. 4. The screw jacks atop the shoring tower that hold the metal transverse cross-beams appear to be slightly bent. The hardwood blocking used to increase the deck elevation is above and to the left of the screw jacks.

in the structural tubing. The screw jacks were from different manufacturers and were 1.5 inches (3.8 centimeters) and 1.4 inches (3.6 centimeters) in diameter, while the opening in the shoring frame tubing was 2 square inches (12.9 square centimeters). Without the appropriate adapters, this created an unstable pin connection at the top screw jack-shoring interface.

In addition, investigators found that the top screw jacks were rusty, and many of the cross-bracing units had considerable rust and were heavily pitted. One cross-bracing member used a nail rather than the required bolt to connect the two cross-brace elements.

Investigations onsite and at TFHRC concluded that using improperly sized and poor-quality screw jacks and cross-bracing designed to be loaded at approximately 11 kips in the metal shoring elements—but loaded to approximately 25 kips—probably contributed to the Bridge No. 4 collapse.

After reviewing all findings and the position of the bridge following the collapse, investigators developed a probable failure sequence. The inadequate shoring system could not support the structure while workers were placing the deck slab. When the placement reached shoring tower 6 or 7, the bridge began to fail. Several eyewitnesses reported hearing a metal rattling noise just before the collapse, probably resulting from the cross-bracing as it failed and hit the metal shoring frame.

This failure redistributed the loads in the shoring system, and the re-

maining shoring towers in the first interior row of falsework beams on Bridge No. 4 (looking north on the parkway) failed almost instantaneously. The bridge failed at its midpoint because, before posttensioning, that is the weakest portion of a concrete girder section. As the bridge fell, it pulled its bottom flange off its bearing area, allowing the structure to fall to the ground. The bridge fell slowly, as evinced by drivers passing under the bridge as it began to fall and avoiding debris and emerging safely on the south side.

Board of Review Findings

The FHWA-appointed Board of Review concluded that it was reasonably certain the bridge collapse resulted from shoring failure at the second or third shoring tower (from the south) on the east side of the parkway. The board cited construction of the shoring towers out of compliance with plans approved by FHWA. Specifically, the contractor used 10-kip top screw jacks for the shoring towers rather than the specified 25-kip screw jacks shown on the plans. Moreover, the jacks used were in poor condition.

The board observed, “Other contributing factors included inadequate longitudinal strength in the overall falsework system, which was attributed to the smaller than required cross-bracing, a skewed shoring tower arrangement, excess blocking, a general lack of longitudinal cross support between the shoring tower members.”

The Board of Review recommended measures to improve methods of

shoring construction and approval to reduce the possibility of future shoring-related bridge problems. First, highway agencies should review and strengthen their specifications and construction procedures to better define the responsibilities of the material suppliers, contractors, and engineers. Second, agencies should provide a separate shoring design analysis for every bridge project. Moving shoring between bridges is an acceptable construction practice, but only when bridges are identical (which was not the case with the MD Route 198 bridges) and the shoring is thoroughly inspected for structural damage and plumbness when relocated, the board said. The inspection is to ensure that all members are in place and properly aligned and connected.

Contractors typically accept certificates for specification compliance from equipment manufacturers or providers. In the case of the MD Route 198 bridge, the contractor rented equipment and provided EFLHD the appropriate certification for elements of the approved shoring towers, but provided undersized jacks from various manufacturers. As its third recommendation, the board said highway agencies should—to ensure shoring systems are designed and constructed within manufacturers’ design criteria, specifications, and load test data—require all shoring design submittals to be formally signed and sealed by the contractor’s registered professional engineer, who will certify prior to placing loads that the shoring system has been assembled in conformity with approved drawings.

Fourth, the review board recommended that highway agencies design each shoring system to handle all vertical and horizontal loading, and to have enough redundancy to prevent failure of the entire system. The agencies should consider vertical loading and differential

settlement forces, plus lateral and longitudinal forces. They also should consider unbalanced temporary loading caused by the placement sequence, the board said.

Fifth, for shoring installations placed adjacent to open public roads, highway agencies should include special design considerations to ensure the shoring systems are not disturbed by errant highway vehicles or vibration forces caused by passing vehicles.

Sixth, agencies should move quickly to preserve and document in-place failure and assign investigation responsibilities to qualified, impartial parties.

Finally, FHWA should research manufactured shoring assemblies with the intent to improve current specifications and create new guidelines for design review and field inspection, the board said. The agency also should collect technical information on the various horizontal and vertical forces that interact in shoring tower arrangements.

The recommendations formed the basis of the 1990-1991 work of the Scaffolding, Shoring, and Forming Task Group, convened by FHWA, and the 1993 publication of a technical advisory (T 5140.24) encompassing four FHWA publications. (See "1989 Bridge Collapse Fosters 1991 Temporary Works Research Program" on page 26.)

The Difference One Bridge Collapse Can Make

Following the MD Route 198 bridge collapse, FHWA determined there was a need to reassess specifications used to design, construct, and inspect temporary shoring systems used in highway bridge construction. The agency created the scaffolding task group to coordinate this effort. One of the group's first actions was to form the FHWA Bridge Temporary Works Research Program.

The point of the bridge superstructure's failure is indicated here by the stiffened concrete in the foreground and a lack of concrete in the background. Concrete, plastic at the time of collapse, still clings to rebar in the background, indicating how far the deck placement had progressed at the time of the collapse.

John F. Duntemann of Wiss, Janney, Elstner Associates of Northbrook, IL, was principal investigator for the task group's contract in 1991 to research and develop design specifications for temporary works and a construction handbook for temporary works. He recalls that many States had very little guidance in their standard specifications regarding design, construction, and inspection of temporary works used in bridge construction. About two-thirds of States had some kind

of submittal requirement for the temporary works, while about half had more specific requirements for designing the temporary structures.

AASHTO adopted the results of the task group's effort and published its own *Guide Design Specification for Bridge Temporary Works and Construction Handbook for Bridge Temporary Works* in 1995. As a result, many States updated their standard specifications, including the requirement that any significant plan revisions



Steve Eisen

1989 Bridge Collapse Fosters 1991 Temporary Works Research Program

The independent advisory board of Federal and State government officials and private industry representatives that reviewed the findings on the MD Route 198 bridge collapse soon realized that although there were proprietary manufacturer's guidelines, no national standard codes or specifications were available for bridge temporary works. The panel's recommendations focused on the need to develop specifications on the responsibilities of material suppliers, engineers, and contractors.

Given that MD Route 198 spans a major route into the Nation's capital, the U.S. Congress was eager to ensure the prevention of such collapses. The appropriations committees incorporated the Board of Review's recommendations into the spending bill for the U.S. Department of Transportation for fiscal year 1991. The legislation directed FHWA to undertake the research project recommended in *Investigation of Construction Failure Maryland Route No. 198 Bridge Over the Baltimore-Washington Parkway*. The bill specified that the research should foster guidelines, improve specifications, and develop a shoring construction handbook that would apply to projects using Federal-aid highway funds.

FHWA established the Bridge Temporary Works Research Program and the Scaffolding, Shoring, and Forming Task Group. The task group included representatives of FHWA, AASHTO, Associated General Contractors of America, Transportation Research Board, American Road & Transportation Builders Association, and Scaffolding, Shoring & Forming Institute. During its first meeting in April 1990, the group identified five priority actions. Over the course of 2 years, the group changed how bridge owners, managers, and contractors perform bridge construction and reconstruction projects.

- First, the task group recommended surveying existing specifications on bridge temporary works, synthesizing them, and identifying gaps. An FHWA study, *Synthesis of Falsework, Formwork, and Scaffolding of Highway Bridge Structures* (FHWA-RD-91-062), became the basis for the task group's other research program activities.

- Second, the task group recommended establishing standard construction specifications to manage bridge temporary works. FHWA developed the *Guide Standard Specification for Bridge Temporary Works* (FHWA-RD-93-031), which established contractual requirements at the bid-preparation stage that apply to all bridge construction projects. The guide placed ultimate responsibility for ensuring that requirements are met on the contractor's registered professional engineer.
- Third, the task group recommended development of a comprehensive design manual on temporary works for bridges. The *Guide Design Specification for Bridge Temporary Works* (FHWA-RD-93-032) covers falsework, formwork, foundations, and temporary retaining structures. In 1995 the AASHTO Subcommittee on Bridges and Structures adopted the guide design as its specification.
- Fourth, the task group called for development of a certification program for manufactured proprietary shoring systems supplied to bridge construction projects. This resulted in the *Certification Program for Bridge Temporary Works* (FHWA-RD-93-033).
- Fifth, the group recommended development of a construction manual. The *Construction Handbook for Bridge Temporary Works* (FHWA-RD-93-034) is intended for use by field engineers responsible for bridge construction projects. The handbook provides guidance on using shoring systems supplied to bridge construction projects. In 1995 AASHTO adopted this publication as its own.

The task group published its results in November 1993. In October 1993 the FHWA Office of Engineering issued a Technical Advisory—Bridge Temporary Works (T 5140/24).

must be designed and sealed by a registered professional engineer.

A parallel effort to improve the design of temporary works was also active at ASCE. In 1987, a group of ASCE member design and construction engineers formed an ad hoc advisory committee to develop design standards for temporary structures

used in construction operations. ASCE formalized the committee in 1989. Private sector contractors did not support the effort at first, fearing further codification of construction processes could affect a company's competitive edge.

After 15 years of work, ASCE published *Design Loads on Structures*

During Construction (SEI/ASCE 37-02), which was embraced by private contractors. The publication applies to buildings and bridges, and the purpose is to provide minimum design load requirements for partially completed structures and temporary structures during construction. The standard does not specify the responsible party for design of temporary structures. Industry practice, however, is that the methods of construction are the responsibility of the contractor. The ASCE standard includes provisions beyond those in the AASHTO publications.

A Catalyst for Improving Bridge Construction Safety

The safety initiative continues, much of it in response to improved



Steve Eisen

This shot looks north at the collapsed southeast corner of the abutment on Bridge No. 4. The force of the collapse pulled the bridge deck away from the abutment.

Twenty years after the collapse and subsequent efforts to improve its safety, the completed Bridge No. 4 now gracefully spans the southbound segment of the Baltimore-Washington Parkway.



Roger Surdahl, FHWA

practices and materials. ASCE will issue its revised standards for publication in 2010. At AASHTO, the T-4 Technical Committee of the Subcommittee on Bridges and Structures published interim revisions to the *Guide Design Specifications for Bridge Temporary Works* in 2008.

“The 1995 guide design specifications helped define falsework and framework—the States may have used the terms but defined or interpreted them differently,” says Malcolm T. Kerley, chairman of the subcommittee and chief engineer for the Virginia Department of Transportation. “The subcommittee revised the specifications in response to the I-35W bridge collapse in Minneapolis in 2007. The revision reflects updates [primarily from ASCE and AASHTO] from the last publication.”

Ken Hurst, State bridge engineer for the Kansas Department of Transportation, chairs the T-4 Technical Committee, which approved the update. “We realized how out-of-date the 1995 specifications references had become, and in this first round they were updated. In addition, there are minor updates to the specification and commentary. But this was truly an interim step, and we need to look to the future.”

The interim step anticipates the proposed NCHRP project to reevaluate the current state of the practice for designing, constructing, and inspecting temporary works, according to Hurst. This project also will revise other AASHTO specification and guideline publications, as necessary. “Stability is a concern,” Hurst notes. “Shoring usually doesn’t fall down; it falls over. With the exception of Load and Resistance Factor Design [LRFD], which most State agencies have adopted, there has been no major reevaluation of current practices in almost 15 years. It’s overdue.”

State transportation agency compliance with the AASHTO and ASCE provisions, plus adoption of the LRFD standards, have improved how

projects are conceived and administered by agencies and their contractors, according to Duntemann, who was principal investigator for the 1993 publications resulting from the work of the FHWA Scaffolding, Shoring, and Forming Task Group. Duntemann now is principal investigator on NCHRP Project 20-07, Task 245, *Updating AASHTO Design and Construction Specifications for Temporary Works Used in Bridge Construction*. The literature review and research related to bridge construction practices for bridge temporary works is complete. Task 2, preparing an updated version of the *AASHTO Guide Design Specifications for Bridge Temporary Works*, should be published late 2010.

Duntemann notes that information gained from the initial part of the current project underscores the need to continue to evaluate and reevaluate the standards. He cites the collapse of the bridge over the Baltimore-Washington Parkway 20 years ago as the original catalyst, but the continued occurrences of these collapses reinforce the need for further development. “There is no question that FHWA, AASHTO, and ASCE initiatives improved standards that translate to better design and construction of these systems,” he says, “but we anticipate that the updated guides and specifications will further reduce bridge failures in the future.”

Stephen Brown, now 43 years old and an electronics technician in

Washington, DC, is also grateful for progress in bridge design and construction. “It’s been 20 years, but I still pay attention with my eyes every time I drive under a highway bridge.”

Roger Surdahl joined FHWA in 1987 after receiving a master’s degree in civil engineering from Montana State University. He is a registered professional engineer in Colorado. As the technology delivery engineer for CFLHD, he brings a wide range of experience in highway materials, contract administration, and innovative solutions to transportation problems.

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An overview of current activities, mitigation technologies, and adaptation strategies, including a sample greenhouse gas inventory by a State DOT.

Taking Stock:

Climate Change and Transportation

by Diane Turchetta

Certain facts about climate change are indisputable. During the 20th century, the Earth's surface warmed by about 1.4 degrees Fahrenheit, F (0.74 degrees Celsius, C). January 2000 to December 2009 was the warmest decade on record. Snow cover in the Northern Hemisphere and floating ice in the Arctic Ocean have decreased, while sea level

(Above) More intense storms are one impact of climate change, leading to flooded roads like this one and inundated bridges and other transportation infrastructure. Photo: www.shutterstock.com /Cheryl A. Meyer.

has risen globally by 4–10 inches (10–25 centimeters) over the past century. Worldwide precipitation over land has increased by about 1 percent. The frequency of extreme rainfall has increased throughout much of the United States.

Scientists have linked these recent changes in climate to increased concentrations of greenhouse gases (GHGs) in the atmosphere. Further increases in carbon dioxide (CO₂) and other GHGs are likely to accelerate the rate of climate change.

According to the U.S. Environmental Protection Agency (EPA), transportation activities in 2007 accounted for 28 percent of GHG emissions in the United States. Be-

tween 1990 and 2007, emissions from the transportation sector rose by 29 percent. This growth was due, in large part, to increased demand for travel and stagnation of fuel efficiency across the U.S. vehicle fleet. The U.S. Department of Energy (DOE) expects transportation energy consumption to grow by 10.8 percent between 2007 and 2030. The increase is expected to occur mainly due to rising energy consumption by freight trucks and commercial aircraft. According to DOE's Energy Information Administration, energy consumption by light-duty vehicles is expected to remain roughly constant over this timeframe, as continued growth in vehicle miles traveled

(VMT) is offset by improvements in vehicle fuel economy.

In addition to being a source of GHGs, the transportation sector is affected by climate change in a variety of ways and differently in each region. Sea level rise due to climate change could inundate and damage coastal infrastructure in low-lying areas and make coastal highways and bridges more vulnerable to storm surges. Increases in storm intensity could have serious impacts on transportation operations and infrastructure. Predicting when and where these impacts might occur is essential for protecting the current infrastructure and planning for future transportation systems.

In December 2009, representatives from around the world convened in Copenhagen, Denmark, at the United Nations Climate Change Conference (COP15) to create a new global agreement to reduce GHG emissions. The Copenhagen Accord emerged as the primary achievement of the conference. The nonbinding agreement calls for deep cuts in global emissions of GHGs so as to hold the increase in global temperature below 2°C, and it calls for industrialized countries to determine their economywide emissions targets for 2020 and submit them to the United Nations by the end of January 2010.

As decisions are being made on the global scale, U.S. Federal, State, and local transportation, environmental, and energy agencies already are taking action to reduce emissions and prepare for the impacts of climate change. The following offers an overview of Federal transportation mitigation activities, technologies for reducing impacts, and State and local strategies for adaptation, plus a sample State inventory of GHG emissions.

USDOT's Center for Climate Change

In 1999, the U.S. Department of Transportation (USDOT) established the Center for Climate Change and Environmental Forecasting as the focal point for information, research, technical expertise, policies, actions, and partnerships on the transportation-climate issue. The center promotes comprehensive approaches to reduce GHG emissions and prepare for the impacts of climate change

on the transportation system, while advancing USDOT's core goals of safety, economic competitiveness, livability, environmental sustainability, and state of good repair.

The center functions as a virtual USDOT-wide organization, with a membership of nine of the department's operating administrations, plus the Office of the Secretary of Transportation. The operating administrations contribute funds, staff, and technical expertise. In January 2009, the center launched the Transportation and Climate Change Clearinghouse, which serves as a one-stop source of climate information within USDOT. (See www.climate.dot.gov/index.html.) Beth Osborne, deputy assistant secretary for transportation policy and director of the Center for Climate Change says, "The center coordinates a multimodal response to this important issue."

Federal Activity on Climate Change

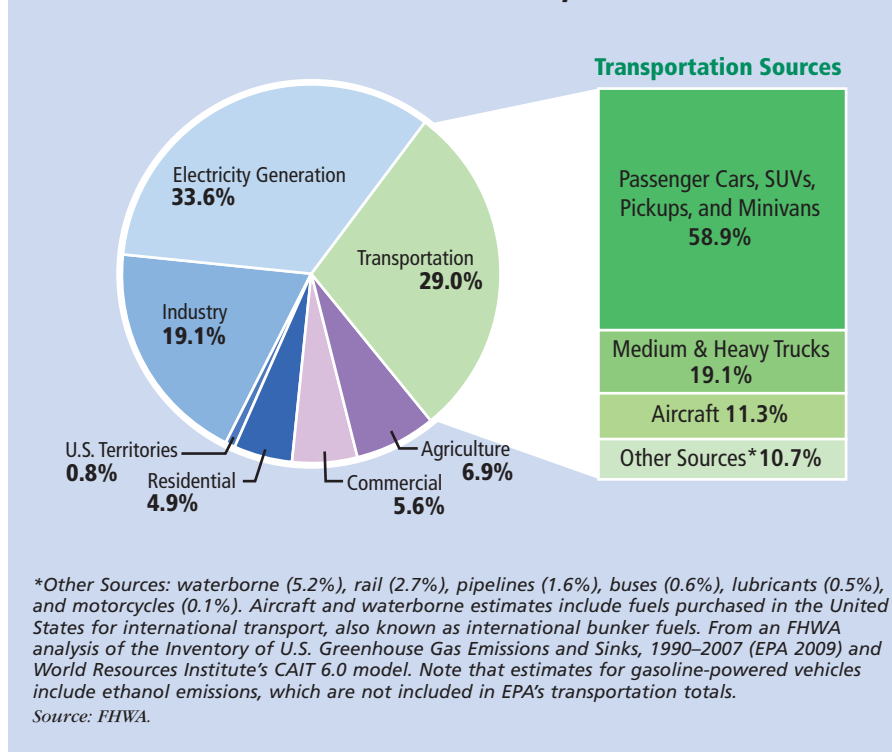
To date, members of the U.S. Congress have drafted a number of bills to address climate change. Some of this legislation, if passed, would affect the transportation community. In June 2009, the House of Representatives passed the first compre-

hensive climate change bill, which included a proposal to establish a cap on GHG emissions and to create a market-based trading system to achieve that cap. The Senate currently is debating climate change and energy legislation, including alternatives to a cap-and-trade program.

In addition, Congress could address climate change in the next surface transportation reauthorization bill. For example, the draft bill released by Congressman Jim Oberstar, the Surface Transportation Authorization Act of 2009, includes provisions that encourage integrated planning by linking land use, transportation planning, and GHG reduction strategies.

On the executive side, the Obama Administration has set an aggressive target of an 83 percent reduction in GHG emissions below 2005 levels by 2050, and the climate change legislation under consideration by Congress proposes similar targets. To achieve reductions of this magnitude, all sectors of the economy—including transportation—would need to reduce their GHG emissions. A wide range of strategies are available to effect reductions in the transportation sector. Transportation agencies can implement

U.S. GHG Emissions, 2007



some, while others involve action by industry (auto manufacturers, freight shippers, airlines, railroads) and the motoring public.

Cap-and-Trade Emissions Reductions

In the legislative cap-and-trade program proposed by the House of Representatives, the Federal Government would determine which GHG-emitting sources are covered by the program and would set an overall emissions target, or “cap,” for each of those sources. Once the caps are set and the covered entities specified, EPA or another Federal agency would distribute tradable emissions allowances equal to the level of the emissions cap. Each allowance would authorize the release of 1 metric ton of GHG emissions. At the end of each compliance period, covered entities must submit allowances equivalent to their level of emissions.

One point of regulation for the transportation sector might be “upstream” where fuels enter the economy, such as with crude oil producers, refiners, suppliers, or distributors. A second point of regulation might be “downstream” where emissions are released into the atmosphere—the consumer level. GHGs also could be regulated at a “midstream” level, in other words, with vehicle manufacturers.

Recent analyses by EPA determined that refiners’ obligations under the proposed cap would raise gasoline prices by \$0.25 in 2030 and \$0.69 in 2050—increases smaller than the fluctuations in gasoline prices seen in recent years. This indirect price signal on transportation fuel from the cap alone, however, cannot achieve a long-term transformation in transportation emissions. Complementary policies, such as the proposed GHG emissions and Corporate Average Fuel Economy (CAFE) standards regulation for passenger vehicles, are needed to ensure ongoing technological innovations for vehicles, lower carbon fuels, improvements to the existing fleet, and reductions in VMT.

Integrating transportation into a broad cap-and-trade program al-

Transportation and Climate Change Clearinghouse



This logo is a visual representation of the modes of transportation for which resources are available from the Transportation and Climate Change Clearinghouse: aviation, bicycle and pedestrian mobility, marine transportation, rail, freight trucks, automobiles/light-duty vehicles, and transit (buses and rail transit). *Source: USDOT Transportation and Climate Change Clearinghouse Modal Wheel. Developed by ICF International.*

lows for cost-effective reductions across sectors through allowance trading between transportation-related entities and other industries. However, the main concern with including the transportation sector in a cap-and-trade program is that reducing emissions from transportation is expected to be more costly, in the short term, than from other sectors. Initial reductions therefore are more likely to come from sectors other than transportation.

Because most legislation starts with a modest initial GHG cap, the price signal on transportation fuel is likely to be too small, at least in the short run, to drive a change in the types and amounts of fuel used. The success of an economywide cap-and-trade program to reduce transportation-related GHG emissions will depend on a number of factors, including where the cap is set or the

proportion of GHG-emitting sources covered, the level of the cap and the resulting cost of allowances, and the point of regulation.

Improving Vehicle Efficiency and Technologies

The majority of transportation-related reductions in the long term will come from improving vehicle efficiency and technologies. Success is highly dependent on the rate of vehicle fleet turnover and the market penetration and cost competitiveness of more efficient vehicles on a large scale.

In reality, other strategies beyond vehicles will be needed for reducing emissions from the transportation sector. The most promising are reducing the carbon content of fuels, improving the efficiency and operations of the transportation system, reducing growth in VMT, and reducing GHG emissions and energy use in highway construction, maintenance, and operations.

In January 2009, the Obama Administration directed USDOT to establish higher fuel efficiency standards for the 2011 vehicle model year. USDOT’s National Highway Traffic Safety Administration (NHTSA) is responsible for establishing CAFE standards. NHTSA estimates that the model year 2011 standards will raise the industrywide combined average to 27.3 miles per gallon (mpg), save 887 million gallons of fuel over the lifetime of 2011 cars and light trucks, and reduce CO₂ emissions by 8.3 million metric tons during that lifetime.

In September 2009, EPA and NHTSA began the process of conducting a joint rulemaking to establish vehicle GHG emissions and CAFE standards. If finalized, these standards would apply to passenger cars, sport utility vehicles, minivans, and pickup trucks built in model years 2012 through 2016. Together, these vehicle categories are responsible for almost 60 percent of all U.S. transportation-related GHG emissions. According to the *Federal Register*, “If ultimately adopted, these standards would represent a harmonized and consistent national policy pursuant to the separate statutory frameworks under which EPA and [USDOT] operate.”

Examples of vehicle technologies that could reduce GHG emissions

include improvements to internal combustion engines, hybrid-electric and plug-in hybrid-electric vehicles, low-weight materials, and low rolling resistance tires. In the longer term, new propulsion systems and fuel cell technology for vehicles could be developed.

Improvements in vehicle technologies could play a significant role in reducing GHG emissions. However, emissions reductions are dependent on the rate at which these new technologies penetrate the current vehicle fleet, and the implementation timeframe is estimated to be long term—most likely two decades or more. Federal incentives such as subsidies or tax credits could accelerate the marketplace's adoption of new technologies and vehicles.

Carbon Content of Fuels

Another policy option is to introduce alternative fuels with lower carbon content per unit of energy than the current petroleum-based fuels (gasoline and diesel), which account for 97 percent of U.S. transportation energy use. Examples of alternative fuels for vehicles include biodiesel, ethanol, electricity, propane, compressed natural gas, and hydrogen.

The emissions impact and energy output provided by alternative fuels varies. The impact of emissions reductions from low-carbon fuels depends on a number of factors, including price and availability of infrastructure and vehicle technology. Many fuels require some degree of power train modification, while others such as electricity require completely different power trains.

System Efficiency And Operations

Examples of strategies to improve the efficiency of transportation operations include incident management, signalization improvements, traveler information, speed management, intelligent transportation systems, and congestion pricing. Compared to vehicle efficiency and technology strategies, system efficiency

and operations improvements are expected to yield relatively modest GHG emissions reductions.

However, these strategies have co-benefits, such as congestion relief, that translate into time savings to travelers and reduced costs to shippers. In addition, for the most part, these strategies are directly under the control and jurisdiction of Federal, State, and local transportation agencies and therefore can be integrated into the planning, design, operations, and management of the transportation system. Transportation agencies have used most of these strategies to reduce congestion and provide bottleneck relief. The associated GHG emissions reductions and general air quality benefits, however, have not been thoroughly measured and documented, in part due to a lack of tools and models to quantify the reductions.

Reducing Growth in VMT

Strategies to reduce the growth in VMT seek to influence travelers' activity patterns and shift travel to more efficient modes, increase vehicle occupancy, and adopt actions that reduce the need for personal travel in single occupant vehicles. Pricing strategies such as pay-as-you-drive insurance and congestion and parking pricing provide incentives to drive less or at less congested times of day. Other travel demand strategies include carpooling and vanpooling, improvements that encourage nonmotorized travel such as

walking and bicycling, teleworking, and improved integration of transportation and land use planning.

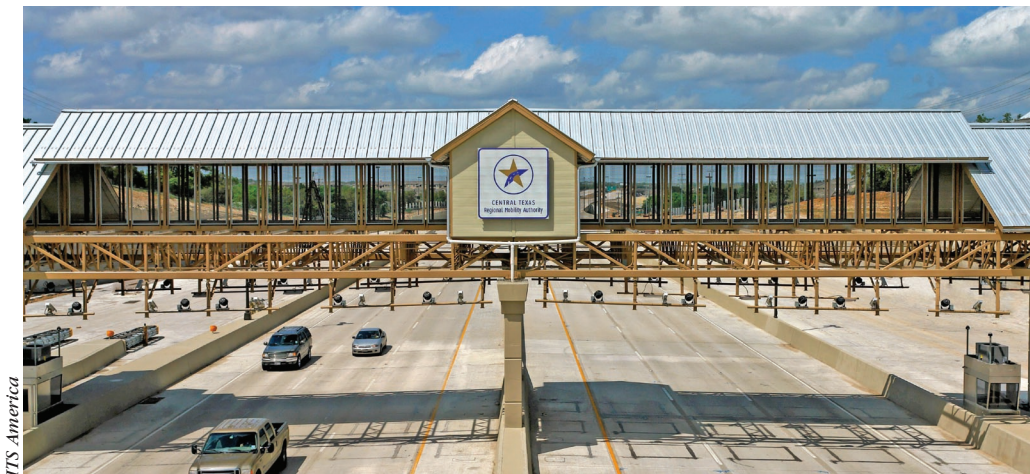
In 2008, the Urban Land Institute published *Growing Cooler: The Evidence on Urban Development and Climate Change*. The researchers concluded that urban development is both a key contributor to climate change and an essential factor in combating it. Meeting the growing demand for conveniently located homes in walkable neighborhoods could reduce growth in the number of miles Americans drive, shrinking the Nation's carbon footprint while providing more housing choices. The range in VMT reductions as a result of land use strategies will depend on the implementation of complementary strategies such as transit investments, pedestrian and bicycle infrastructure, and residential parking permits.

States such as California have taken a proactive role in the legislative arena to help curb sprawl and encourage more compact development. In 2008, the State passed a law that authorizes the California Environmental Protection Agency's Air Resources Board to establish targets for GHG emissions reductions for all 18 of the State's metropolitan planning organizations (MPOs). The MPOs then are required to develop sustainable communities strategies to demonstrate how they will meet the targets. The California law does not supersede local planning authority,

Next-generation cars like these two, which appeared on the "Today" show on NBC, could help reduce GHG emissions.



Progressive Automotive X PRIZE Foundation



This toll plaza in Austin, TX, offers open road tolling, a strategy that relieves congestion resulting from stopping to pay tolls. Reduced congestion means fewer GHG emissions.

but it encourages local governments to align their regional transportation, housing, and land use plans to reduce VMT. The law also provides incentives for creating attractive, walkable communities and revitalizing existing communities.

Federal action to integrate planning for transportation, land use, the environment, and housing includes the 2009 establishment of the Interagency Partnership for Sustainable Communities. The partnership, which includes USDOT, EPA, and the U.S. Department of Housing and Urban Development (HUD), is focused on developing policies that support livable communities. USDOT, EPA, and HUD agreed to align their resources to help improve access to affordable housing, transportation options, and lower transportation costs in rural, suburban, and urban communities. At the same time, the partnership aims to protect the environment in communities nationwide, promote equitable development, and help address the challenges of climate change.

Highway Construction, Maintenance, and Operations

A final strategy to reduce transportation-related GHG emissions involves activities that State departments of transportation (DOTs) can take to control energy use in construction, maintenance, and operations. Currently, methodologies and techniques for estimating GHG emissions from these activities are outdated. In January 2009 the National Cooperative Highway Research Program (NCHRP) initiated a project to help fill this information gap.

The NCHRP goal is to develop a spreadsheet tool that DOTs could use to quantify their GHG emissions as part of their day-to-day activities, while providing information to the public and other stakeholders. The project also will identify gaps in current research and produce studies on the cost-effectiveness of various strategies to reduce GHG emissions in construction, maintenance, and operations.

Opportunities to reduce GHG emissions and energy use include technological changes to existing maintenance vehicles and fuels, and the use of light-emitting diode (LED) traffic signals, lower carbon pavements, and reduced roadside mowing, plus alternative uses of interstate rights-of-way to sequester carbon and alternative energy sources for highway operations.

One example is Oregon's Solar Highway project, where 594 solar panels provide electricity to light an interchange at night, producing nearly 128,000 kilowatt-hours annually.

Completed in December 2008, the prototype project cost \$1.28 million, but because of an innovative public-private partnership with Oregon's largest utility, the Oregon Department of Transportation (ODOT) invested no capital and receives solar power at no greater cost than it would pay for power from the grid.

Allison Hamilton, project director of Oregon's Solar Highway program, says, "Through this partnership, the public gets multiple values out of its right-of-way asset. Using State and Federal tax credits, the renewable energy projects are developed at least possible cost, which benefits the utility rate payers including ODOT and the State of Oregon; ODOT gets green energy at grid rate instead of the higher green energy rate; the solar energy project is owned, operated, and maintained by the utility, which also assumes all the risk and is responsible for maintenance of the right-of-way for the term of the contract (25 years); and the utility gets to count

This bicyclist in Chicago, IL, and the pedestrian she is stopped for are doing their part to reduce growth in VMT and thus GHG emissions.



This aerial photo shows some of the 594 solar panels that are helping light an interchange. Oregon's Solar Highway Project installed the panels.

the project toward its renewable energy portfolio requirements. It's a win-win-win business model."

In 2008, the Federal Highway Administration (FHWA) initiated pilot projects with New Mexico and Minnesota on carbon sequestration. The goals are to sequester carbon on interstate rights-of-way and other lands managed by State DOTs by planting native vegetation, while determining whether revenue can be generated from the sale of carbon credits from these projects and whether FHWA should pursue a national effort to support DOTs in these activities. Several analytical and decision support tools are in development, most of which will be available in spring 2010.

Adapting Transportation Infrastructure

Rebuilding existing infrastructure and planning and designing new projects are opportunities to include adaptations to the effects of climate change. The magnitude of the impact of climate change is difficult to predict with certainty, but the scientific consensus is that impacts are occurring now and will continue during the rest of this century and beyond. These impacts have potential implications for where the Nation locates and builds transportation infrastructure and how the system is operated.

Potential climate change effects that could impact highways and bridges include sea level rise, which could lead to permanent inundation of infrastructure in some locations or loss of land where development could otherwise occur; more extreme weather, including more severe precipitation, which could impact operations; more icing in some areas, which could also impact operations; more frequent freeze/thaw cycles, which could damage pavements, bridges, and other structures; and more intense hurricanes with potentially higher storm surges and wave heights, which could damage infrastructure, cause temporary

flooding, and destroy natural and manmade protections.

Three major reports on adapting transportation infrastructure appeared in 2008. USDOT's Center for Climate Change and the U.S. Climate Change Science Program, which is sponsored by 13 Federal agencies, published the first report, *The Impacts of Climate Variability and Change on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I*. This publication discusses how changes in climate over the next 50 to 100 years could affect transportation systems in the central Gulf Coast region and how to account for potential impacts in transportation planning. The report generated research methodologies that could be applied in other locations. It also found that 24 percent of interstate miles and 28 percent of arterial miles in the regions—roughly 2,400 miles (3,862 kilometers) of major highways—and three-quarters of port facilities could be impacted by a 4-foot (1.2-meter) increase in relative sea level rise in the region. For the Gulf Coast, this is a realistic number because sea level rise in this region is exacerbated by land subsidence due to declining groundwater and natural factors.

The Transportation Research Board (TRB) published the second report, *Special Report 290: Potential Impacts of Climate Change on U.S. Transportation*. The report provides an overview of climate change effects faced by the United States and identifies potential adap-

tation strategies, including actions by the transportation community.

And the Center for Climate Change published the third report, *The Potential Impacts of Global Sea Level Rise on Transportation Infrastructure*, which employed multiple data sources to identify potential impacts on land and transportation infrastructure from Florida to New York. Maps indicate land and transportation infrastructure that, without protection, could be inundated regularly or be at risk of periodic inundation due to storm surges under a range of sea level rise scenarios.

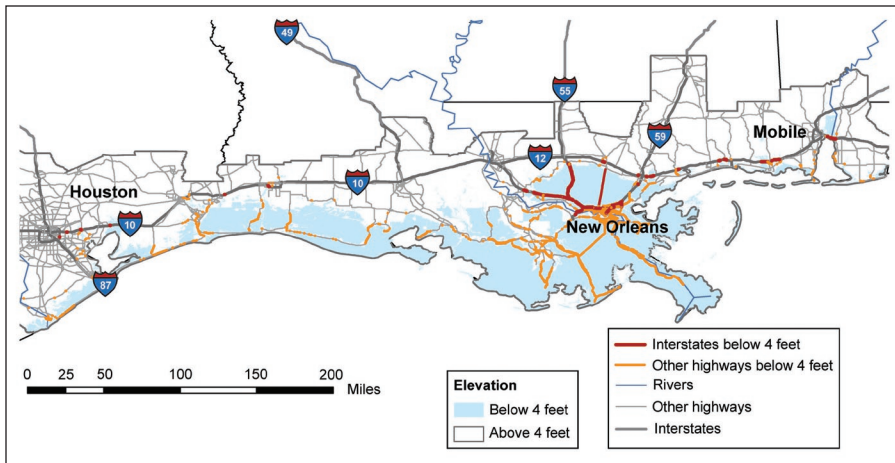
The Center for Climate Change's *Phase II Study* of the Gulf Coast, initiated in the fall of 2009, will focus on a detailed analysis of the Mobile, AL, area in that region. The second phase also will provide the knowledge and tools to better understand the risks, adaptation strategies, and tradeoffs involved in planning, investment, design, and operational decisions for all modes of transportation. The objective is to develop more definitive information about multimodal impacts at the local level and to serve as a template for other regions wishing to assess how climate change will affect their transportation systems.

Adaptation Actions By DOTs and MPOs

State DOTs and MPOs are beginning to look at adaptation activities within the context of their long-term transportation planning and investments. In 2008 and 2009, FHWA and the American Association of



Gary Weber/ODOT Photo and Video Services



This map shows major roads at risk in the Gulf Coast region in the event of a relative sea level rise of 4 feet (1.2 meters). Source: The Impacts of Climate Variability and Change on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I; Cambridge Systematics Analysis of USDOT Data.

State Highway and Transportation Officials (AASHTO) convened two peer exchanges on current adaptation practices and strategic needs. Participants included senior officials from DOTs, AASHTO, and FHWA headquarters and division offices. Reports summarizing the results are posted at www.fhwa.dot.gov/planning/statewide/pwsacci.htm.

One State that has been proactive on the adaptation front is Alaska. Documented impacts in that State include melting permafrost, increased storm frequency and intensity, coastal erosion due to sea level rise and a decrease in protective sea ice, river-bank erosion caused by increased precipitation, rising temperatures, and loss of the subsistence way of life for native populations.

Roads and bridges in many of Alaska's regions are underlain by ice-rich permafrost, a permanently frozen layer of soil. Increasingly, this soil is experiencing melting cycles that cause severe structural damage to roads and buildings. The Alaska Department of Transportation & Public Facilities (DOT&PF) spends about \$10 million annually to repair and smooth out its highways and airports from permafrost degradation, yet this is only a fraction of the need, and costs are expected to increase as warming trends continue. In addition, increasing storm frequency is causing more severe and frequent avalanches, floods, erosion, and debris flows that all significantly increase highway maintenance and operations costs.

Alaska is adapting to these extreme impacts with shoreline protection programs, planned evacuation routes, relocation of infrastructure and communities at risk, drainage

improvements, and placement of additional fill and insulation over ice-rich areas or relocation around those areas. Frank Richards, deputy commissioner, Alaska DOT&PF, says there is a need to increase the collection and density of data on stream flow and precipitation and to investigate alternative design, construction, and maintenance techniques to address the changing environment.

Proactive Strategies During Planning

The planning process should address climate change from both a mitigation and an adaptation perspective. Because climate change is an issue relevant to a broad geographic scope and time scale, the planning process is a more appropriate place to consider it than the project development process. GHG emissions are not a project-level issue since all emissions have similar effects on the global climate. At the least, they are a regional, if not a State or national issue. Addressing mitigation and adaptation upfront facilitates decisionmaking and improves efficiency at the program level, providing a sound basis for implementation strategies.

Many DOTs and MPOs already are exploring ways to integrate climate change and energy efficiency into their planning processes. To assist these efforts, FHWA funded a 2008 study, *Integrating Climate Change into the Transportation Planning Process*, which demonstrates how planning and regulations can support transportation decisions that reduce GHG emissions and adapt transportation systems to withstand the impacts of climate change.

In the 2009 report, *Integration of Climate Change Considerations in Statewide and Regional Transportation Planning*, the USDOT Center for Climate Change and FHWA provided analyses, observations, and lessons learned from three case studies and summarized the proceedings from two panels of State and regional experts. The case studies and panel summaries focus on how DOTs and MPOs are considering climate change in the following aspects of their transportation planning: visions and long-range planning; forecasts, data, and performance measures; public involvement; collaboration with partners; and project selection.

To help identify key themes and areas of concern, FHWA held three peer exchange workshops in 2008. Participants included representatives from MPOs and DOTs across the country. The objectives were to share information and experiences among DOT and MPO planning and executive staff, learn the state of the practice in the field, build peer networks, and advise FHWA and others about the challenges faced by DOTs and MPOs as they integrate climate change considerations into the planning process. The workshops also produced recommendations on how FHWA could help support this effort, including developing national guidelines to assist in reaching GHG reduction goals; promoting technology that will reduce GHG emissions and help transportation agencies better measure, assess, and mitigate GHG emissions; and providing resources for programming and planning activities related to climate change issues.

Several DOTs and MPOs have integrated climate change mitigation into their long-range transportation planning, and a few are beginning to consider adaptation strategies as well. Charlie Howard, transportation planning director with the Puget Sound Regional Council in Seattle, WA, says, "In our Transportation

2040, climate change figures prominently, with a four-part mitigation strategy and a discussion of the importance of adaptation, especially in our coastal region. It is clear that the transportation plans of the future will play a key role in addressing climate change.”

Adaptation strategies for coastal areas might include rerouting to send traffic around the problem situation and damage repairs (low capital cost), relocation of the in-

frastructure away from the threat (potentially high capital cost), abandonment and disinvestment, and reconstruction using higher design standards to reinforce a structure such as a bridge.

Greg Stuart, executive director of the MPO in Broward County, FL, adds that mitigation strategies are important for his county “because of the threat that climate change represents for our densely urbanized land area, which is mostly at

sea level. The strategies include the reduction of GHG emissions by increasing transit usage, improving transit service with an alternative fuel-powered fleet, enhancing land use density in areas that will not be immediately inundated, making regulatory changes to discourage higher density in potential inundated areas, and ultimately adopting a refocused long-range transportation plan [adopted in 2009] that can address these areas.”

GHG Inventory: Washington Shows the Way

The Washington State Department of Transportation (WSDOT) recently inventoried its 2007 greenhouse gas (GHG) emissions. The inventory included only emissions released by the agency, not those emitted by the public traveling on the State highways. Although WSDOT is working to reduce emissions from the transportation sector, it also is looking for strategies to reduce its own operational emissions.

A 2008 Washington State law mandated emissions reporting by State agencies and reductions to take effect in 2009. While preparing its inventory, WSDOT noted challenges and data gaps, and the agency now is working on solutions. By going through the emissions inventory process 2 years before reporting requirements take effect, the agency was able to identify challenges early and will be better able to meet the new requirements.

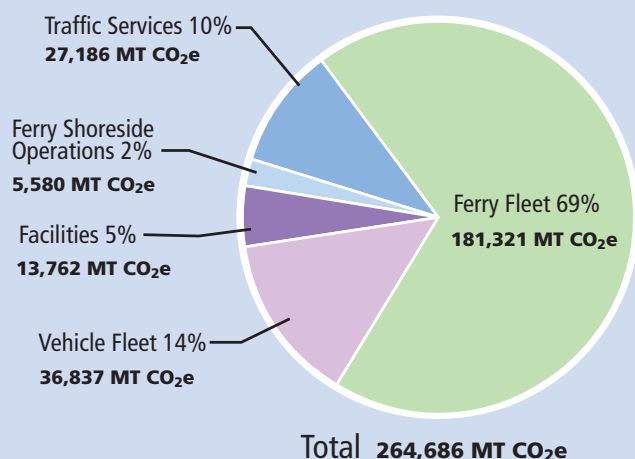
Similar to financial accounting, GHG reporting follows specific rules and guidelines. Washington’s guidelines were based on the *General Reporting Protocol* developed by The Climate Registry. The registry’s Web site describes it as “a nonprofit collaboration among North American States, provinces, territories, and Native Sovereign Nations that sets consistent and transparent standards to calculate, verify, and publicly report” GHG emissions.

GHG reporting typically includes the six gases regulated under the Kyoto Protocol.

1. Carbon dioxide (CO₂)
2. Nitrous oxide (N₂O), also known as laughing gas
3. Methane (CH₄), the principal component of natural gas
4. Hydrofluorocarbons (HFCs), coolant, flame retardant, and extinguishant
5. Perfluorocarbons (PFCs), medical and industrial uses because of their nonre-active nature
6. Sulfur hexafluoride (SF₆), used primarily as an insulator in electrical equipment

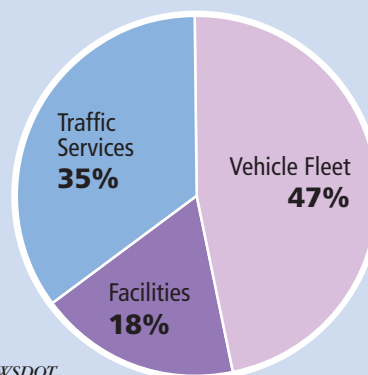
The WSDOT inventory reported the first three gases. In addition, the agency emits small quantities of hydrofluorocarbons, slated to be included in future inventories.

WSDOT’s GHG Emissions by Category (2007)



Source: WSDOT.

WSDOT’s GHG Emissions by Category Excluding the Ferry System (2007)



Source: WSDOT.

To clearly identify ownership of emissions and reduce complications from double counting, the protocol divides emissions into three scopes:

1. All direct emissions, such as those released from a tailpipe or smokestack.
2. The indirect emissions from purchased energy (primarily electricity).
3. All other indirect emissions—those released by someone else in the production of goods (such as paper used in offices or concrete used to build roads) or services (for example, airline flights or consultant services) used by the reporter. Emissions from employee commutes also can be considered under scope 3.

As required by the protocol, WSDOT reported on scopes 1 and 2.

Ferries. WSDOT based its estimates of CO₂, CH₄, and N₂O emissions from ferry vessels on the quantity of fuel used. The ferry terminal collects this information.

Vehicle fleet fuel. WSDOT tracks vehicle use by data gathered at the fuel pump. For all vehicles and equipment, the agency calculated CO₂ emissions based on the quantity of fuel used. It quantified CH₄ and N₂O emissions for passenger vehicles based on vehicle miles traveled (VMT), fuel type, and model year. For all other vehicles and equipment, the agency based CH₄ and N₂O emissions on the quantity of fuel used and emissions factors (provided in the protocol) for construction equipment.

Facilities and traffic services—electricity, natural gas, propane, and heating oil. Due to the large number of accounts and difficulty consolidating the data, WSDOT estimated utility use from payment information. Also, only utilities directly paid by WSDOT were included; utilities included in rent payments for leased space were not included in the inventory.

Utility data were the primary challenge encountered in preparing the inventory. In 2007, WSDOT made about 50,000 utility payments on more than 5,000 accounts. Although the utility providers bill WSDOT for its power consumption, the quantities consumed are not recorded in a comprehensive manner. To collect the needed data in the future, WSDOT plans to implement an electronic system to manage utility data.

Results. In 2007, WSDOT emitted approximately 265,000 metric tons of carbon dioxide equivalents (MTCO₂e). WSDOT’s emissions primarily came from the ferry fleet, vehicle fleet, highway system, and buildings. If emissions from the ferry system are excluded, WSDOT’s estimated releases might more closely represent the emissions profiles of other State DOTs.

—Karin Landsberg, WSDOT



On the Alaska Highway, thaw subsidence of the permafrost resulted in rapid collapse of the roadbed and surface. The driver of this pickup truck attempted to cross, but the asphalt gave way completely. Later rebuilding included mechanical air drains to prevent heat transfer from the road surface to the underlying permafrost.

Next Steps

Many State and local governments already have developed individual GHG emissions reduction plans and programs, and a few State DOTs, such as Washington State, have developed inventories of their own GHG emissions. A key first step in developing strategies for reducing emissions is to develop an inventory of baseline emissions by identifying and quantifying the sources within a region.

The Delaware Valley Regional Planning Commission recently completed a regional GHG emissions inventory, using 2005 as a baseline. The inventory will help regional policymakers and citizens understand the sources of GHG emissions in order to make well-informed decisions for regional and local policies to reduce those emissions. In addition, the commission provides estimated emissions for each county and municipality in the region. The initiative also will evaluate options for reducing GHGs, develop a regional action plan through stakeholder engagement, and assist member governments with emissions inventories and forecasts.

The commission found that more than 91 percent of the region's emissions come from energy consumption, including stationary consumption by residential, commercial, and industrial sectors, and mobile consumption from the transportation sector. The commission also found that municipalities with higher density populations tend to produce lower per capita emissions.

EPA assists State and local governments by providing technical guidance on inventory preparation and is engaged with the Delaware commission in a pilot for developing a standard national protocol for carrying out GHG emissions inventories at the metropolitan level. For fact sheets and other resources for inventory development, see http://epa.gov/climatechange/emissions/state_guidance.html.

Conclusion

Although emissions of traditional pollutants from mobile sources have declined steadily in the United States over the past 30 years, GHG emissions from surface transportation sources are increasing. "We, as transportation professionals, take this trend seriously and are in the process of reaching out to new stakeholders and partners to expand their knowledge on transportation and climate change issues," says Gloria Shepherd, associate administrator for FHWA's Office of Planning, Environment, and Realty (HEP). "We are working to develop both mitigation and adaptation strategies."

Various FHWA offices, including Operations, Infrastructure, Federal Lands Highway, and HEP, are coordinating their climate change policies, activities, and programs. In December 2008, Shepherd created a new Sustainable Transport and Climate Change Team, which is led by April Marchese, director of HEP's Office of Natural and Human Environment, and team leader Robert Ritter.

"The team is made up of a diverse group of individuals with expertise in various climate change-related areas," says Shepherd. "I created the team to coordinate climate change issues within HEP and FHWA because climate change issues will ultimately impact a variety of internal and external functions and programs."

The team is active in a number of new initiatives, including additional research on adaptation issues, development of an FHWA strategy to address adaptation to climate change effects, and creation of a framework for conducting assessments of transportation infrastructure vulnerable to climate change. The team also is involved in the ongoing assessment and analysis of transportation-related GHG mitigation strategies, scenario planning workshops focused on climate change, and research on how to better integrate sustainability practices into the transportation decisionmaking process. Results of these efforts will help to inform and educate USDOT, other Federal agencies, and transportation stakeholders.

Diane Turchetta is a transportation specialist in FHWA's Office of Planning, Environment, and Realty. She works primarily on transportation and climate change issues. Turchetta received her B.S. in public administration from The Pennsylvania State University and her master's in public administration from Virginia Polytechnic Institute and State University.

For more information, see www.fhwa.dot.gov/hep/climate/index.htm, or contact Diane Turchetta at 202-493-0158 or diane.turchetta@dot.gov.

Reclaiming Roads



*by Audrey Copeland,
Cecil Jones, and
John Bukowski*

A national effort is underway to capitalize on the economic and environmental benefits of recycling asphalt pavements.

(Above) A tandem steel-wheeled vibratory roller is compacting a high-RAP mixture on a highway in Deland, FL.

According to the National Asphalt Pavement Association (NAPA), more than 90 percent of U.S. roads and highways are paved with hot-mix asphalt (HMA). As the Nation's infrastructure ages, Federal, State, and local transportation agencies face a growing demand for the raw materials needed to maintain and rehabilitate these roads. Responding to the shrinking supply of raw materials and the rising costs of aggregates and binders, HMA producers are turning to

reclaimed asphalt pavement (RAP) as an alternative to virgin materials and a valuable ingredient in HMA.

RAP is the product of milling and removing asphalt from roadways and stockpiling it at HMA plants. A stockpile can include RAP from multiple roadways. If a contractor does an effective job of milling RAP from a roadway, often no further processing is needed before its addition to new HMA. In many cases, however, especially where large amounts of it are to

In-Place Recycling Resources

The three most common methods of recycling RAP into HMA are hot-mix recycling at the plant, hot in-place recycling, and cold in-place recycling. To learn more about in-place recycling techniques, consult these Federal Highway Administration (FHWA) guidance documents:

- *Cold In-Place Asphalt Recycling Application Checklist* (FHWA-IF-06-012), www.fhwa.dot.gov/pavement/preservation/ppcl12.pdf.
- *Hot In-Place Asphalt Recycling Application Checklist* (FHWA-IF-06-011), www.fhwa.dot.gov/pavement/preservation/ppcl11.pdf.
- *Cold In-Place Recycling State of Practice Review*, www.fhwa.dot.gov/PAVEMENT/recycling/cir.

Additional information is available from the Asphalt Recycling & Reclaiming Association's publications *Basic Asphalt Recycling Manual*, *Full Depth Reclamation Manual*, and *Cold Recycling Manual*. For more information on pavement recycling, visit FHWA's Web site at www.fhwa.dot.gov/pavement/recycling/index.cfm.

be used, contractors further process RAP through sizing or fractionating (separating RAP into at least two sizes, typically a coarse fraction and a fine fraction).

Departments of transportation (DOTs) and contractors use the RAP as a substitute for a portion of the aggregate and asphalt binder in paving projects. They mix the RAP in with virgin aggregate and binder—in varying proportions—and transport the material to jobsites, where crews place it on roadways. DOTs also use RAP in other construction applications such as granular base or subbase, stabilized base aggregate, or embankment and fill material.

According to a Federal Highway Administration (FHWA) survey, as of 2007, the average amount of RAP incorporated into HMA mixtures by State DOTs was 12 percent by weight. Historically, State DOT specifications have set limits on the maximum amount of RAP permitted in HMA and further restrict the material's use in surface layers, certain mixture types, and large or critical projects. The restrictions largely stem from the fact that RAP amounts greater than 15 percent can require changes in the binder performance grade and additional tests. In addition, DOTs are concerned about the consistency, quality, durability, and performance of high-RAP pavements, and whether mixtures with high amounts of RAP might yield inferior pavements with shorter service lives.

In 2008, however, sharp increases in asphalt costs coupled with diminishing supplies of acceptable quality aggregate prompted the

asphalt paving industry to push for using higher percentages of RAP. Evidence from a variety of real-world applications indicates that proper mix design, material processing, and production best practices can create high-quality, durable mixtures with higher RAP percentages.

"Now, most State DOTs are seriously considering the economic and environmental benefits of using RAP in greater proportions," says Peter Stephanos, director of the FHWA Office of Pavement Technology. Increasing public concern for the environment and stricter regulations are driving demand for greener construction practices and sustainable pavements. "The challenge now facing DOTs is permitting greater amounts of RAP while maintaining high-quality pavement infrastructure," Stephanos says.

The Case for Greater RAP Use

The two leading reasons for using RAP in asphalt pavement are its economic and environmental benefits. Reusing asphalt pavement reduces the amount of more expensive virgin aggregate and asphalt binder required. Using RAP typically lowers the unit cost of HMA, both in terms of reuse of aggregates and asphalt binder. The most economical use of RAP is in asphalt mixtures that go into the intermediate and surface layers of flexible pavements, where the RAP actually replaces a portion of the more expensive virgin binder.

Because aggregate, the most mined resource in the world, is non-renewable, using RAP conserves the

virgin resource itself, as well as the energy and transportation costs that go into obtaining it. In addition, using RAP greatly reduces the amount of construction debris going into landfills. Because RAP can be used again and again, it creates a cycle of asphalt reuse that optimizes use of natural resources and helps sustain the asphalt pavement industry.

How Much Progress?

According to NAPA, U.S. production of asphalt pavement material is around 500 million tons (454 million metric tons) per year, including about 60 million tons (54.4 million metric tons) of reclaimed material—RAP—that transportation agencies reuse or recycle directly into pavements. In addition, agencies reuse or recycle about 40 million tons (36.3 million metric tons) of RAP into other pavement-related applications every year. Thus, about 100 million tons (90.7 million metric tons) of RAP are used each year, compared to 72 million tons (65.3 million metric tons) used annually in the early 1990s. Asphalt pavement has the distinction of having the highest recycling rate, by percentage, of all recycled materials because virtually all reclaimed asphalt is reused or recycled.

In 2007 the North Carolina Department of Transportation (NCDOT) conducted a survey on behalf of FHWA and the American Association of State Highway and Transportation Officials (AASHTO) to determine the level of RAP use across the United States. The survey also revealed the potential for increasing RAP use across the Nation. For example, only 10 States were using up to 30 percent RAP in the intermediate layer, and only 2 States were using up to 30 percent RAP in the surface layer. NCDOT conducted the survey again in 2009, and half the States reported greater RAP use after 2007.

Although many State DOTs used more RAP in HMA in 2009 compared to 2007, high proportions of RAP (greater than 25 percent) are still not common. Many State DOTs permit more than 25 percent RAP in HMA layers; however, fewer than half actually use more than 20 percent RAP.

The question remains: Why do more than half the States use less than 20 percent RAP in HMA? The

Binder Selection Guidelines for RAP Mixtures (AASHTO M 323)

Recommended Virgin Asphalt Binder Performance Grade (PG)	RAP Percentage
No change in binder selection	<15
Select virgin binder one grade softer than normal (Select a PG 58–28 if a PG 64–22 would normally be used.)	15–25
Follow recommendations from blending charts	>25

Source: AASHTO.

the dust-to-binder ratio specifications required by Superpave, the consistency/variability of RAP, and lack of quality control by contractors.

Remaining Challenges

The mix design process for HMA with RAP is similar to mix design for virgin HMA, except when the RAP percentage is greater than 25 percent. For RAP percentages more than 25 percent, additional testing of the RAP binder might be necessary to use blending charts for determining the required virgin binder performance grade. Despite the similarity in mix design, some challenges remain for maximizing RAP use and routinely using high RAP content.

First, the current binder selection guidelines for RAP mixtures (AASHTO M 323 Standard Specification for Superpave Volumetric Mix Design and AASHTO R 35 Standard Practice for Superpave Volumetric Design for Hot-Mix Asphalt) are based on the assumption that substantial mixing occurs between the virgin binder and RAP binder. But no method exists to

determine the amount of blending that actually occurs.

To estimate the blending of high-RAP mixtures, the AASHTO standards specify blending charts. The charts optimize the amount of RAP to use if the performance grade of the virgin binder is known. The charts call for expensive, time-consuming binder extraction and recovery tests that use hazardous solvents. Many highway agencies are reluctant to specify amounts of RAP that require this additional testing, and many contractors are not equipped to perform tests that involve hazardous solvents.

Improving Designs For High-RAP Mixes

The National Cooperative Highway Research Program (NCHRP) develops advanced pavement technology that supports FHWA's goal to increase the life of asphalt pavements. One ongoing NCHRP project, Improved Mix Design, Evaluation, and Materials Management Practices for Hot Mix Asphalt with High Reclaimed Asphalt Pavement Content,

aims to evaluate and propose necessary changes to existing specifications, such as AASHTO M 323 and AASHTO R 35. The study will develop a mix design and analysis procedure for high-RAP HMA that ensures long-term performance.

The expected mix analysis procedure will include performance-related tests and key criteria to address permanent deformation, fatigue cracking, low-temperature cracking, and moisture susceptibility. Further, the procedure will identify any promising methods to assess the durability of HMA.

As part of the NCHRP project, the National Center for Asphalt Technology (NCAT) has joined with the University of Wisconsin–Madison and University of Nevada, Reno, to develop methods for evaluating RAP binder characteristics without using hazardous solvents. The study also will determine accurate methods for characterizing RAP aggregates. The researchers expect to incorporate the study's results into the NCHRP's mix design and analysis procedures.

National Effort to Increase RAP Use

To promote best practices for increased RAP use, FHWA initiated the Reclaimed Asphalt Pavement Expert Task Group to provide technical input to advance use of reclaimed asphalt materials in paving applications. The group provides highway agencies with critical information regarding RAP, technical guidance on high-RAP projects, and direction on research activities. The group is composed of experts from State DOTs, FHWA, AASHTO, NCAT, and NAPA.

The task group's first goal was to identify the most critical needs for increasing RAP use. After determining the top 10 needs, the group formed task subgroups to target each need, and the larger group meets twice a year to discuss progress.

One subgroup developed information for highway agencies and contractors interested in increasing their RAP use. For example, the task group developed *Designing HMA Mixtures with High RAP Content: A Practical Guide*, a joint publication of FHWA, AASHTO, and NAPA. The document is one of the most up-to-date publications available for designing and producing high-RAP mixtures. The guide covers materials



A crew in Deland, FL, checks to ensure a high-RAP pavement is level.

evaluation, mix design, plant verification, and quality control when using high percentages of RAP. Also, the task group published an article, "How to Maximize RAP Usage and Pavement Performance," in the September/October 2009 issue of *Hot Mix Asphalt Technology*.

The expert task group's efforts already are making an impact in the marketplace. For example, until recently the Arizona Department of Transportation (ADOT) had a low risk tolerance for using RAP because of past failures. In fact, for years ADOT did not allow RAP to be used in HMA at all. In late 2007, however, ADOT began reconsidering its stance on RAP in response to requests from contractors who pointed to RAP's ability to help control costs in the face of spiking asphalt prices. That same year, the expert task group met in Arizona and invited ADOT and industry representatives to present their concerns about using RAP. ADOT was encouraged after hearing about the positive experiences other States had with using RAP. By summer 2008, ADOT had successfully constructed three projects using RAP. FHWA engineers and other task group members subsequently provided input to help ADOT draft specifications for RAP use, allowing up to 25 percent in layers below the surface and up to 20 percent in surface layers.

Another task subgroup developed a best practices document summarizing the state of the practice and providing indepth guidelines for incorporating RAP in asphalt mixtures. The document is in the final stages of development and will be published as an FHWA report.

Motivated by the expert task group's efforts to evaluate the performance of RAP mixtures, the Florida Department of Transportation (FDOT) is reviewing its pavement management database to glean information on completed projects that used RAP. "The data are showing that there is no real difference in performance as a function of RAP content," says Jim Musselman, State bituminous materials engineer for FDOT. "So far, we have not found data that would indicate high-RAP mixtures perform worse than low-RAP or no-RAP mixtures. In fact, in some cases, high-RAP pavements are lasting longer than virgin material pavements."

Top 10 Needs for Greater RAP Use

1. Performance tests for evaluating RAP mixtures
2. Best practices for mix design and construction, including advantages of RAP and guidelines for producing a quality mix with varying levels of RAP
3. Ability to evaluate RAP without hazardous solvents
4. Determination of necessary changes in binder performance grade
5. Determination of amount of comingling between binders (RAP/virgin) at HMA plants
6. Field performance data on high-RAP mixtures
7. Ability to replicate plant heating in labs for virgin and RAP binder blending
8. Assistance to States with no or low-percentage RAP specifications and current practices
9. Improved understanding of variability of RAP (such as aggregate, asphalt content modification, binder characterization)
10. Implementation of best practices for processing RAP, including evaluating the need for fractionation

Mobile Laboratory Evaluates Performance

Stemming from technical discussions among members of the expert task group, FHWA and industry partners have initiated several demonstration projects across the United States that are using high proportions of RAP (25 percent or more). The objectives of the field projects are to document mixture design processes; assess procedures for production, construction, and performance testing; and highlight best practices.

FHWA, along with NCAT and other partners, is working with State DOTs to establish experimental plans for design, production, placement, and evaluation of high-

percentage RAP mixes on high-volume roadways. As with virgin mixtures, the DOTs need to consider RAP's aggregate characteristics, effective binder content (volume of effective binder), asphalt binder properties, in-place mix density, and conditions during placement.

FHWA's Mobile Asphalt Pavement Mixture Laboratory provides the mixture design replication and performance testing of RAP and control mixes, including dynamic modulus, fatigue, and low-temperature testing. The participating State DOTs also perform quality assurance testing. The mobile lab is able to provide probable performance information and evaluate binder blending based on mixture properties using the Asphalt Mixture Performance Tester (see "Evaluating the Field Performance of Asphalt Mixtures in the Lab," *PUBLIC ROADS*, January/February 2005).

So far, the lab has participated in high-RAP field projects in Delaware, Florida, and Kansas. In each case, the State DOT approved higher RAP percentages than its specification allowed.

Using Best Practices in High-RAP Field Projects

Best practices for processing, stockpiling, and plant production are crucial to maintain the quality and consistency of the RAP aggregate, the mix, and the final pavement, especially with mixes containing higher percentages of RAP. "In fact, high-quality, high-RAP mixes could be impossible without use of processing and production best practices," says David Newcomb, vice president of research at NAPA.

The field demonstration projects highlighted some of the best practices, such as proper milling of the existing roadway, processing and fractionating for uniformity and final blend consistency, and flexibility in plant operations.

The Delaware project is a \$52 million, multiyear, multiproject turnpike improvement program that includes widening I-95 near Wilmington. The Delaware Department of Transportation (DelDOT) placed more than 80,000 tons (72,600 metric tons) of HMA, including base, binder, and surface layers. DelDOT used the high-RAP mixture in the binder layers of the pavement and the surface

High-RAP Field Projects

State	% RAP Permitted in Intermediate Layer (as of 2007)	% RAP Permitted in Surface Layer (as of 2007)	% RAP Used in Project	Date of Paving
Florida*	≥30%	0%	45%	December 2007
Kansas	25%	25%	30%–40%	May 2008
Delaware	20%	10%	30%–35%	Summer 2008

Source: FHWA.

*WMA process used.

layer on the shoulder. Eventually the shoulder will carry traffic when it becomes part of the mainline as a right lane, after another interchange project is completed in 3 years.

At the time of the bidding process, DelDOT specifications limited RAP use to 20 percent. However, the contractor requested and was approved to use up to 35 percent RAP. DelDOT was confident in the contractor's ability because the contractor had successfully used RAP for 7 years.

"Our HMA supplier on this project put a lot of money into plant and operations, and [the investment] has paid off in terms of DelDOT's satisfaction," says James Pappas, the agency's chief materials and research engineer. "The supplier maintained a captive stockpile for this project and processed the RAP, which led DelDOT to agree to higher RAP percentages."

The contractor routinely mills the RAP off the roadway and stockpiles it for future use in HMA. The contractor invested in a crushing process and screens to fractionate the RAP into three sizes: 100 percent passing the 0.5 inch (1.3 centimeters), plus #4 size materials (where #4 is a sieve with a standard designation of 0.19 inch, or 4.76 millimeters), and minus #4 size materials.

"Overall, the project went very well and DelDOT is pleased," says Pappas. "This was a pioneering project that opened the eyes for the whole State in terms of increasing RAP use." In fact, DelDOT plans to increase the amount of RAP permitted in its specifications for 2010. In terms of costs, DelDOT calculated savings of \$7–\$8 per ton for liquid asphalt conserved with the higher RAP use in this project. "This translates to a definite overall savings of \$5 to

\$10 per ton of HMA for DelDOT and the taxpayers," Pappas says.

In Florida, FDOT milled and repaved a portion of State Route 11 in Deland using 45 percent RAP in combination with the water-injection, warm-mix asphalt (WMA) process. The project was the first large production in which FDOT allowed that much RAP combined with the use of the WMA process. To use up to 45 percent RAP, the contractor employed a softer binder and fractionated the milled RAP.

"Overall, we are pleased with the quality we have seen as we have moved toward using higher amounts of RAP [more than 40 percent]," says FDOT's Musselman. "There have been no construction or performance problems noted to date. Most contractors realize that it takes a little more effort in terms of paying attention to detail, but there is an economic benefit for them to use more RAP." Since January 2009, partly due to the project's success, FDOT has increased its permitted amount of RAP to 20 percent in surface layers and unlimited amounts in intermediate and base layers. As an exception, when polymer-modified binders are used, FDOT limits the RAP content to 20 percent in all layers.

The Kansas project was located on U.S. Highway 83, a major north-south route heavily used by trucks. The project was unique in that the contractor set up a mobile HMA plant near the jobsite and was allowed to use up to 40 percent RAP.



Conveyors deposit piles of fractionated RAP into stockpiles at an HMA supplier in Florida.

Also, the FHWA Mobile Asphalt Pavement Mixture Laboratory was onsite to collect data and determine volumetric properties as increasingly greater percentages of RAP were substituted into the mix. The contractor milled the RAP from the existing highway and avoided transportation costs, but ultimately used a 30 percent RAP mix. The flexibility to adjust the amount of RAP used was critical to meet quality assurance requirements. The feed system included the RAP cold feed and scalping screen to ensure no oversize particles went into the mix.

"This was one of the first high-RAP projects for the Kansas DOT," says Mike Crow, of the Kansas Asphalt Pavement Association. "The finished highway is nice and smooth."

In the Pipeline

As the public continues to push for more sustainable infrastructure and greener technologies, using RAP can play a critical role in creating sustainable highways. Many State DOTs are interested in using greater percentages of RAP for cost savings, and most State projects have the potential to use more.

FHWA, along with partners AASHTO, NAPA, and NCAT, is leading the national effort to increase responsible RAP use and provide guidance on overcoming barriers to adoption, especially for mix design and performance. Through the expert task group, FHWA will continue to document the long-term performance of RAP projects to highlight successful practices and share lessons learned in using higher percentages of the material.

"As we continue to develop more effective test methods for analyzing blending between virgin and RAP binders and evaluating the performance of high-RAP mixtures, we expect to see support for and use of RAP in roadway projects become increasingly widespread," says Randy West, director of NCAT.

Audrey Copeland, Ph.D., is a materials research engineer on the Pavement Materials and Construction team at FHWA's Turner-Fairbank Highway Research Center in McLean, VA. She manages the Binder Rheology Laboratory and is responsible for



These photos show a RAP cold feed (top) and a scalping screen (right), which prevents oversize particles from entering the plant, at work at a mobile HMA plant in Kansas.

research and development activities for asphalt pavement technologies to increase the lifespan of flexible pavements. Previously she was a highway engineer in FHWA's Office of Pavement Technology, where she led the national effort to increase RAP use. She holds a doctorate in civil engineering from Vanderbilt University and an M.S. and B.S. in civil engineering from Tennessee Technological University.

Cecil Jones, P.E., recently retired from NCDOT, where he served as the State materials engineer and chaired the AASHTO Subcommittee on Materials' Recycling Task Force. His responsibilities included overall management of the materials quality system and management of laboratory and field quality assurance operations for materials and manufactured products used on North Carolina's State-maintained highways. He has a B.S. in civil engineering

from North Carolina State University and is a registered professional engineer. He currently is president of Diversified Engineering Services, Inc.

John Bukowski is a senior pavement engineer and the Asphalt Technology Team Leader in the FHWA Office of Pavement Technology. He is responsible for identifying and leading development and implementation of innovations in asphalt pavement technology. He has more than 35 years of pavement technology experience through positions with FHWA, the Asphalt Institute, and the military. He has a B.S. in civil engineering from the University of Pittsburgh and a law degree from The Catholic University of America.

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Watching Out for Senior Walkers

by Essie Wagner

An NHTSA workshop educates local transportation engineers, law enforcement officers, elected officials, and others on how to increase safety for older pedestrians.

Senior Americans—those aged 65 and older—are a challenging population when it comes to delivering information on pedestrian safety. Retirees cannot be reached through workforce programs, and senior centers serve only a small minority of the population. However, considering that most senior pedestrians have been walking successfully for six decades or more, transportation safety professionals might well wonder whether such information is needed.

Unfortunately, it is. Compared with other age groups, older pedestrians are at greater risk of being killed in traffic incidents. In 2008, pedestrians aged 65 and

older accounted for 803 deaths or 18 percent of all pedestrian fatalities and an estimated 7,000 (10 percent) of all pedestrian injuries. That same year, the fatality rate for pedestrians aged 65 and older was 2.1 per 100,000 people—a higher rate than for any other age group.

Demographic pressures add to this challenge. According to the U.S. Census Bureau, people aged 85 and older are the fastest growing segment of the population. The baby boom generation will begin turning 65 in 2011, pushing the number of older Americans from today's 13 percent of the population to more than 19 percent by 2030.

The National Highway Traffic Safety Administration (NHTSA), sister agency to the Federal Highway Administration (FHWA), is charged with saving lives and preventing injuries on the Nation's roads through education, research, safety standards, and enforcement activities. In the last 5 years, NHTSA staff reviewed

research on pedestrian safety with the goal of developing a program that could make a lasting difference.

The NHTSA researchers found that protecting pedestrians requires a comprehensive approach: Education, enforcement, engineering, and encouragement all have important roles to play in creating the safest pedestrian environments. NHTSA also recognized that having a measurable impact requires action at the local level, where decisions about these activities are made.

To address these challenges, NHTSA and the University of North Carolina's Highway Safety Research Center (UNC/HSRC) developed a Pedestrian Safety Workshop to help older walkers stay safe, while opening the door to collaboration with engineers from local departments of transportation (DOTs), law enforcement personnel, and local decisionmakers. In 2008 and 2009, UNC/HSRC conducted a series of pilot workshops in Greenbelt, MD, Arlington, VA, and

(Above) In a classroom in Greenbelt, MD, seniors, local transportation engineers, and other professionals participate in a pilot run of the NHTSA Pedestrian Safety Workshop. Photo: Austin Brown, Pedestrian and Bicycle Information Center (PBIC).

Facilities like this crosswalk in Florida encourage seniors such as these two women to obtain exercise by walking.

Las Vegas, NV, to test the concept and refine the instructor materials. Each audience offered a different dynamic, contributing to NHTSA's refinement of a set of instructional materials published under the title, *Pedestrian Safety Workshop: A Focus on Older Adults*. (See "For more information" on page 48.)

The half-day workshop targets older pedestrians, local DOT engineers, law enforcement personnel, traffic safety education professionals, and influential decisionmakers such as elected officials. The workshop aims to foster interaction among these groups so that individuals learn names and faces, and they can call on each other as resources after the workshop is over. In the past, bringing together these key parties was not necessarily a priority for transportation professionals when addressing pedestrian safety. However, the new workshop is focusing on this need.

Says Brian McLaughlin, NHTSA's senior associate administrator for traffic injury control, "We absolutely must do a better job of protecting older pedestrians because the status quo isn't working."

A Comprehensive Approach

Pedestrian safety problems rarely have single solutions. For example, drivers making right turns at red lights without coming to complete stops can put pedestrians at risk. The engineering solution might be to prohibit these turns or modify the turning radius to slow drivers' speeds. Another approach is for law enforcement officers to issue citations to drivers who fail to stop completely. Still another option is for the transportation community to employ educational measures to remind pedestrians and drivers to watch out for one another, particularly at high-risk locations.

These approaches involve a mix of short-term and long-term, low-cost and more costly solutions. They also involve tradeoffs. For example, prohibiting right turns on red might reduce the level of service at an



www.pedbikeimages.org, Dan Burden

intersection. But that step might be necessary because the goal is to find the best solution that will have an immediate and lasting impact.

Obtaining political permission to put various options into play also is important. To that end, involving elected officials in selecting the appropriate countermeasures is valuable, especially given the various agencies and different roles and responsibilities involved in each measure. For a guide to selecting countermeasures, see *PEDSAFE* at www.walkinginfo.org/pedsafe/pedsafe_ca_crashtypes.cfm. Also see *How to Develop a Pedestrian Safety Action Plan* (FHWA-SA-05-12) at www.walkinginfo.org/library/details.cfm?id=229.

Workshop Content

In developing the Pedestrian Safety Workshop, NHTSA and UNC/HSRC wanted to make it easy for any interested person regardless of age or transportation background to obtain the instructional materials and deliver the half-day event. To support that aim, the partners produced a guide that walks instructors through the process of conducting a workshop, including becoming

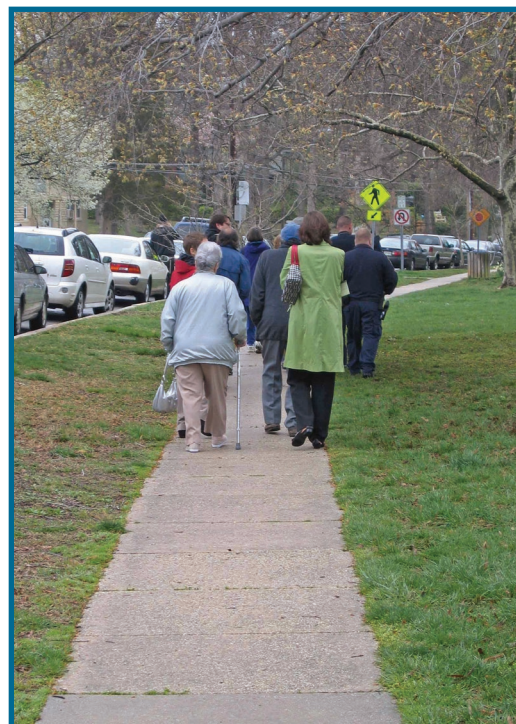
familiar with the content, publicizing the workshop, and preparing to teach. The guide also covers securing the participation of relevant disciplines and gathering handouts, both those included in the guide and those locally developed. Finally, the guide contains scripts and speaker notes for seven modules, which run in length from 10 to 45 minutes:

1. Welcome and Introduction.

A brief description of the purpose and structure of the workshop.

2. *Walking and Older Adults*. A fundamental grounding in the benefits of walking for older adults and

These workshop participants are taking their observational walkabout on a narrow sidewalk in Greenbelt, MD.



Austin Brown, PBIC



This heaved sidewalk in Arlington, VA, creates a tripping hazard, especially for senior pedestrians like this one who uses a walker.

the broader community, and the problems that make ensuring safety a challenge.

3. *Watching Out for Us.* A special module for a general audience, containing practical information related to risky situations and what participants can do to be safer when walking.

4. *The Walking Environment.* A basic presentation on pedestrian infrastructure, including sidewalks and trails, pedestrian crossings, and the influence of infrastructure on motor vehicle speed.

5. *Completing the Picture.* A sampling of education, enforcement, and encouragement programs from across the country that address topics such as speeding, health promotion, and the value of walking.

6. *Taking an Observational Walk.* A brief walk around the workshop's neighborhood and a return to the classroom to discuss the experience, with a focus on challenging situations and measures that could make walking more appealing and safer.

7. *Discussion and Next Steps.* A wrap-up in which the instructor encourages participants to express how they intend to use what they learned to improve pedestrian facilities and safety.

The third module, *Watching Out for Us*, is designed to be a stand-alone workshop targeting older pedestrians. Containing 30 minutes of practical information, the module is appropriate for use at senior wellness classes, community centers, or

other settings where older people look for information. The module identifies specific situations that are particularly challenging to older pedestrians and provides actions that, if followed, will keep the older pedestrian safer. The take-away-and-use format of the materials offers participants a tangible way to take action after the workshop by increasing the likelihood of them sharing key safety messages with other older adults.

Within the context of the complete workshop, the sixth module, *Taking an Observational Walk*, stands out as the single most thought-provoking experience for participants. The 20-minute walk—essentially around the block with people from each discipline walking with and listening to the older participants—is an eye-opening and humbling experience, according to the professional participants.

In the three pilot workshops, participants observed opportunities for engineering, enforcement, education, and encouragement actions to play a role in improving conditions. For example, participants noted missing sidewalk links and poorly maintained sidewalks (engineering), delivery vans blocking curb ramps and crosswalks (enforcement), and

pedestrians crossing against signals (education and enforcement). They also saw motorists driving into gym parking lots, a clear opportunity for encouraging walking for exercise. Participants also saw firsthand how seemingly minor inconveniences to the average pedestrian, such as water pooled at the base of a pedestrian curb cut, can be major barriers to safe mobility, particularly for individuals who use assistive devices such as scooters, wheelchairs, and walkers.

Another aspect of the workshop includes information about the functional changes that older people are likely to experience and how those changes influence their ability to move around in the community. Functional changes show up as slower walking speeds, vision and hearing changes, and sometimes the addition of assistive devices such as walkers and scooters.

Each of these functional changes can result in safety challenges. For example, poor visual acuity might make it difficult for a person to see and interpret a crossing signal on a pole six lanes away. The workshop also addresses common crash situations involving older pedestrians, including specific actions they can take to remain safe. Older participants in the workshops expressed appreciation for the applied nature of the presentations



Shown here is a delivery vehicle blocking the sidewalk and forcing pedestrians into the street during the Arlington walkabout.

Photo: Austin Brown, PBIC.

This pedestrian stops and looks past a vehicle before deciding that it's safe to continue crossing.

and suggested that some of the presentations might be valuable to other age groups as well.

Professionals and the Public Work Together

One key component of the workshop is that participants include professionals from various disciplines, and they are called on throughout the presentation to clarify or amplify the instructor's points. One senior participant remarked, "I liked that you brought in people who were experts in the various aspects of what we were talking about. You brought in a main agenda... and they elaborated on that."

Ask local transportation engineers and planners about their challenges in dealing with the public, and many will cite the time it takes to help the public understand why a neighborhood's preferred strategy for addressing a problem cannot be implemented. For example, the engineering staff might have to explain that a four-way stop is not warranted at the intersection of two minor roads. Other disciplines might have similar experiences with these "you-can't-do-that" issues.

In developing the workshop, the team tailored messages and activities to establish a common basis for discussion across disciplines. The reasoning was that summarizing some of the things that *can* be done by various partner disciplines can be helpful. When the public approaches professionals to ask for changes or the establishment of various programs or activities, this approach helps ensure that reasonable activities and feasible alternatives are available. The message to senior participants in the workshop is: "This is how to work with these professionals."

Benefits Brought Out at The Pilot Workshops

Having the right professionals attending the workshops helps older participants by introducing them to the right engineering, enforcement, and education actions to ask for and the right behaviors to follow to keep them safer as pedestrians. The Las Vegas pilot workshop,



for example, helped a local group identify safety issues and solutions. Providing pedestrian safety education is one of the activities of the Safe Community Partnership, a local Las Vegas coalition whose mission is to reduce fatalities and injuries that result from traffic crashes. The partnership hosted and publicized the pilot workshop.

According to Erin Breen, director of the partnership, "The great-

est value of the program is that it gives advocates an opportunity to identify and address walking issues within the senior population, which are somewhat different from [those that affect] the general population."

Bringing in local engineers and planners not only improves the quality of the workshop for the older participants, but also it helps the professionals gain understanding of the challenges faced by senior

Sample of Practical Advice Provided at the Workshops

Common Crash Situations	Actions Pedestrians Should Take
<i>Multiple Threat</i> —A driver in one lane stops for a pedestrian but blocks the pedestrian from view by a driver in the adjacent lane, so that motorist fails to brake.	The pedestrian should stop at the edge of the stopped car and confirm that the driver in the next lane has stopped.
<i>Parking Lots</i> —Drivers in backing vehicles might be unable to see past adjacent parked vehicles and back into pedestrians who are walking across the lot.	Pedestrians should look for backing lights and for cars that are starting to move. Listen for engine noise. When in doubt, pedestrians should wait for drivers to drive on or to see them.
<i>Turning Vehicles</i> —Drivers making left turns often are looking at oncoming traffic and forget about pedestrians in the crosswalk. Drivers turning right tend to look to the left for oncoming traffic and might not notice pedestrians crossing.	Pedestrians should always look for turning vehicles and expect drivers not to see them. By anticipating drivers' actions, pedestrians can protect themselves better.
<i>Moving Between Parked Cars</i> —A driver starting up a parked car usually does not expect to see a pedestrian weaving between parked cars.	Workshop instructors always discourage this action but also recognize that people might do it anyway. If there are no other options, pedestrians should look to be sure that neither car is likely to start moving.
<i>Low Lighting</i> —Twilight and early evening are high-risk times for older pedestrians. More of them are killed in late afternoon and early evening hours than at other times of the day.	Pedestrians should make themselves visible. Bright clothing during the day and retroreflective gear and flashlights for twilight and night can help drivers see pedestrians a few seconds sooner, enabling the motorists to stop more quickly.
<i>Alleys and Driveways</i> —A driver exiting an alley sometimes does not expect pedestrians, or buildings might block the motorist's view.	Just as in parking lots, pedestrians should listen and look for vehicles exiting or entering alleys. Treat driveways like any other intersection and anticipate driver actions.



The driver of this car in Seattle, WA, did not yield to the pedestrian who was already in the crosswalk. As part of an enforcement effort (note motorcycle police officers on the right), the driver received a citation for the violation.

pedestrians. This knowledge helps the professionals focus on specifics (such as missing sidewalk links between a bus stop and a senior center) and to develop a plan to address such concerns.

David Goodman, bicycle and pedestrian programs manager in Arlington County, VA, notes the value of professionals having the opportunity to try out assistive devices in neighborhoods near the workshops' venues. "Using a walker or wheelchair on streets and sidewalks that many of us were already familiar with was one of those eye-opening experiences that really drove home the importance of basic maintenance and attention to details." Often the necessary fixes are relatively inexpensive but can make a big difference in an older person's ability to move safely throughout a community, Goodman adds.

Law enforcement officers noted in particular the workshops' value in providing opportunities to network with engineers and decisionmakers. They also expressed a desire to increase pedestrian enforcement activities that support older community members.

Traffic safety education professionals, whose work includes encouraging citizens to walk, expressed appreciation for the diverse set of participants. For example, in Greenbelt, MD, one attendee was blind. According to Karen Haseley, therapeutic recreation supervisor with the Greenbelt Community Center, the participation of a visually impaired person "opened up a whole new perspective relating to disabilities and traffic safety for both the older participants and the professionals."

Beyond the Workshop

The workshops help professionals identify their counterparts in other organizations and foster ongoing collaboration. For example, in Las Vegas a core group of workshop participants continues to meet periodically. In Greenbelt, the city sponsored a second pedestrian workshop for a more general audience, with the goal of raising awareness of pedestrian safety issues among motorists and pedestrians.

To become involved, a community need only download the workshop materials. In addition, NHTSA is conducting a second round of pilot workshops in selected communities to develop technical support and evaluate the program by ensuring that behavior is changed. Each community will define those changes by such steps as implementing improved law enforcement programs, new engineering treatments, or nighttime pedestrian safety improvements (such as pedestrians taking steps to make themselves more visible).

The workshops themselves are not a solution to pedestrian safety problems. As Haseley says, "Pedestrian pathways and sidewalks are always an issue." But the workshop is the begin-

Placing utility poles such as this one and other obstacles in the sidewalk can force pedestrians into the roadway, creating unsafe situations.

ning of a solution. The materials are a catalyst that professionals and communities can use to begin taking action to improve pedestrian safety and accessibility. By attending a workshop, professionals can help older people stay safe by helping the presenters apply a comprehensive approach to pedestrian safety.

Essie Wagner is a program analyst at NHTSA, where she manages older driver and pedestrian safety activities. She has an M.A. in applied psychology, human factors, from George Mason University. Prior to joining NHTSA in 1998, she served as a contractor at FHWA's Turner-Fairbank Highway Research Center.

*For more information, contact Essie Wagner at 202-366-0932 or esther.wagner@dot.gov. To receive a CD-ROM of the workshop materials, please go to NHTSA's traffic safety materials catalog (www.nhtsa.dot.gov/people/outreach/media/catalog/Index.cfm), search for *Pedestrian Safety Workshop*, and follow ordering instructions. An online version of the workshop is available from the *Pedestrian and Bicycle Information Center* at www.walkinginfo.org.*





by Tracy Scriba

A Decade of Safety Success

The national effort to raise awareness of dangers near roadway construction passes a major milestone.



Sometimes a small idea really catches on. National Work Zone Awareness Week, now in its 11th year, is proof: What began as a small event in a single Virginia Department of Transportation (VDOT) district has grown into a national program that involves virtually every State in the Union.

Statistics suggest the effort is having a positive effect on safety. According to the National Highway Traffic Safety Administration's Fatality Analy-

sis Reporting System, the number of work zone fatalities has decreased in the United States every year since 2002. Data show that crashes in work zones caused 720 fatalities in 2008. That figure represents a 39 percent decrease from 2002, when 1,186 work zone fatalities occurred.

As National Work Zone Awareness Week enters its second decade, a look back reveals how the campaign took root, what strategies have proven effective at improving safety, and what work remains to be done.

Virginia: The Beginning

The first known Work Zone Awareness Week occurred April 7-11, 1997, in VDOT's Bristol District, in southwestern Virginia. The district's employee involvement team thought it would be a good idea to spend a week focusing on work zone safety to raise employees' awareness before they went to work on the roads for the year. The district

scheduled the awareness week to coincide with the start of daylight saving time, the informal start of construction and travel season.

The internal awareness campaign went well and the district shared the idea with David Rush, VDOT's statewide engineer II/work zone safety program manager, and VDOT's public affairs office. The agency decided to take the campaign statewide in 1998, adding an external awareness component as well in recognition of the fact that motorists play an important role in reducing work zone crashes, injuries, and fatalities.

To ensure widespread involvement in the new statewide campaign, VDOT's commissioner directed the central office and each district to form teams to plan, coordinate, and implement the campaign. VDOT also formed a statewide coordinating committee to provide suggestions and share ideas, develop and distribute training materials

(Above) National Work Zone Awareness Week, now entering its second decade, provides an opportunity for the highway industry to remind its employees and the public about safety in work zones. The traveling National Work Zone Memorial (shown here), sponsored by the American Traffic Safety Services Association, lists the names of roadway workers, drivers, and public safety personnel who lost their lives in work zones.
Photo: ATSSA.

Evolution of Work Zone Awareness Week

- 1997 – VDOT's Bristol District develops an internal awareness campaign.
- 1998 – VDOT launches statewide public awareness campaign.
- 1999 – Caltrans initiates "Slow for the Cone Zone" public awareness campaign.
- 1999 – ATSSA, FHWA, and AASHTO agree to create National Work Zone Awareness Week.
- 2000 – First national event is held in Springfield, VA.
- 2001 – National event held on National Mall in Washington, DC.
- 2002 – National event held in Capitol Heights, MD, including dedication of traveling National Work Zone Memorial.
- 2003 – National event held at Freedom Plaza in Washington, DC.
- 2004 – First use of theme for national campaign. National event held at Springfield, VA, work zone.
- 2005 – National event held on Maryland side of Woodrow Wilson Bridge Project.
- 2006 – First evening national event, held on National Mall in Washington, DC, highlights theme of night work.
- 2007 – National event held on Virginia side of the Woodrow Wilson Bridge Project.
- 2008 – National event moved to Sacramento, CA, the first time the national event is held outside the Washington, DC, area.
- 2009 – National event held at Federal Lands Highway work zone across Potomac River from Washington, DC.
- 2010 – New York City hosts national event.

and work zone keepsake items (key chains, magnets), and prepare statistics and taglines to distribute to the media. The committee also obtained \$20,000 through a safety grant from the Virginia Department of Motor Vehicles to support these activities.

The goals of VDOT's internal campaign were to raise employees' awareness of the dangers associated with work zones and to increase their dedication to ensuring that their work zones function properly. The campaign also sought to enhance teamwork and support between field and central office employees.

The internal campaign included encouraging workers to wear

high-quality safety vests and ensure proper operation of the lights on work vehicles. VDOT recommended tying orange ribbons on the vehicles' antennae and driving with the headlights on as visible reminders of the campaign's purpose. The department also created a training video, "What's Wrong With This Work Zone," and distributed it and other materials across the State to promote discussions of safety during daily crew meetings.

In the external component of the campaign, VDOT sought to increase the public's awareness of the dangers of traveling through work zones and encourage safe driving habits in work zones. The public outreach included radio ads, public service announcements (PSAs) developed with the Virginia Road and Transportation Builders Association (now the Virginia Transportation Construction Alliance), and work zone safety tips displayed at rest areas. Additional partners in the campaign included the Virginia State Police and a consortium of insurance companies called DRIVE SMART Virginia.

According to Rush, taking the program statewide and partnering with the police helped generate media attention. "We held press conferences at rest areas along the interstate in many of our districts and held safety breaks where our employees could talk with motorists stopping at the rest areas about driving safely through work zones," he says. "A few press conferences were held in work zones, where reporters were able to feel the speed of passing motorists while they stood behind the concrete barriers."

The effort seems to be paying off. Rush says Virginia has cut work zone fatalities to an average of 11 per year. "Since we have been doing this for over 10 years, we have greatly reduced the number of worker fatalities in work zones," he says. "And we have a much lower number of work zone and fatal crashes than other States that maintain fewer lane miles than Virginia, which has the third largest State-maintained roadway system in the country."

A California Campaign

Meanwhile, on the West Coast, the California Department of Transportation (Caltrans) saw the number of work zone crashes, injuries, and fatalities in the State increase significantly in 1998, despite efforts to promote safety. These crashes rose 20 percent that year to a record high of nearly 7,000.

In response, the following year Caltrans launched an expanded public awareness campaign to encourage drivers to slow down and drive more safely in work zones. In 2000, the department decided the expanded campaign needed a new theme to replace the previous slogan of "Give 'em a BRAKE," which dated to 1982. The department explored various ideas through focus groups and ultimately settled on "Slow for the Cone Zone"® for its campaign theme.

That expanded public awareness campaign complemented Caltrans's now nearly 20-year internal campaign to promote work zone safety among employees and honor those who lost their lives on the job. The internal campaign began as a small annual gathering



Full road closure can provide safety benefits to workers and motorists while dramatically reducing the duration of a project. States have begun using short- and long-term closures more often when feasible, such as the 18-month closure used for this project on I-670 in Columbus, OH.

Planning for Annual Caltrans Highway Workers Memorial Day Event

Based on its years of experience planning its Workers Memorial Day event, Caltrans shares the following outline of steps and tips that could assist other States interested in developing similar events.

Steps

- Establish date and location.
- Obtain necessary permits.
- Identify any fallen workers from past year and collect contact information for their families.
- Identify honor guard.
- Identify and schedule greeters to distribute programs and memory ribbons.
- Personally invite families of those who died in past year and send invitations to all families of fallen workers on record from previous years.
- Invite dignitaries, including locally known emcee; State, Caltrans, and FHWA officials; union representatives; and industry partners.
- Order needed items (such as orange memory ribbons and a podium).
- Arrange for needed support staff (photographer, for example).

Tips

- *Create a checklist for action items and items that must be ordered or created.* Examples include creating a program, posters, and press releases, and requesting sponsorship from the State Senate or Assembly transportation committee chairperson.
- *Choose a memorable focal point for the event.* Caltrans creates an orange cone display as a diamond-shaped caution sign around the California State seal.
- *Include onsite visual aids.* Caltrans brings remnants of crashed vehicles and collage boards of photos of other crashes, arranges work vehicles at the curb with "In Memory" message boards, hosts the traveling National Work Zone Memorial during the event, and displays a memorial wreath.
- *Find special ways to honor the fallen.* Caltrans creates a program with the names and photographs of each fallen worker from the past year, obtains resolutions from officials (the Governor, for example) in memory of those recently killed, and hosts a reception for families where the resolutions are presented.
- *Provide special treatment to family members.* Arrange for parking, provide instructions and a map, escort them to reserved seats in front, and provide flowers to each family member.
- *Coordinate with key individuals as they arrive at the event.* Caltrans has a check-in location for families, speakers, and dignitaries and a contact list of cell phone numbers for everyone involved.
- *Be prepared for inclement weather.* Preparations such as reserving a tent in case of rain and having windsocks for microphones in case of wind can save the day.
- *Email department staff in advance to encourage them to attend.*



At California's 2008 Workers Memorial Day event, the Caltrans Honor Guard Team honors the three fallen Caltrans workers that year, each remembered by one of the cones in front displaying a black name band.

Caltrans

in someone's office, then expanded to fill a conference room, and in 2002 grew into a major outdoor event in Sacramento's Capitol Park.

By 2004 Caltrans's annual Worker Memorial Day had moved to its current location on the steps of the State capitol. Caltrans also plans other safety awareness events the same week, such as Lights for Life, which encourages employees to drive their work vehicles with the headlights on all week, and a safety stand-down, which invites all 23,000 employees to attend a variety of classes and evaluations to improve safety.

Worker Memorial Day is the culmination of a year of planning that begins in August of the previous year. Planning begins with establishing a date (usually a Tuesday or Wednesday in mid-April to elicit more media coverage), obtaining a permit for the capitol grounds, and identifying any fallen workers from

the past year and obtaining contact information for family members so they can be invited to the event.

Caltrans has a tradition of using an honor guard of 12 highway workers who represent those who lost their lives on the job. During the ceremony, the honor guards wear special uniforms and pay their respects to fallen coworkers by carefully passing orange cones from the center of a diamond-shaped cone display to the outside border. Each cone contains the name of a fallen worker printed on a black band wrapped around the cone. The event receives significant support from the donor-funded Caltrans Transportation Foundation.

"Honoring our fallen workers and getting to know their families has been a very emotional and rewarding experience that has been a highlight in my career," says Tamie McGowen, Caltrans assistant deputy

director for public affairs. "It has been incredible to see what started as a small office gathering many years ago morph into such a tremendous and deserving tribute to those who gave the ultimate sacrifice."

Going National

How did what started as individual State events become a national effort? As with many successful initiatives, National Work Zone Awareness Week had a champion.

VDOT's Rush, believing there is strength in numbers, thought it made sense to conduct the campaign nationwide, so he brought the idea to a meeting of the American Traffic Safety Services Association's (ATSSA) Safety and Public Awareness Committee at the 1998 ATSSA annual conference. With the committee's backing, a week later Rush gave a presentation on the idea to ATSSA's board of directors. The board liked

Goals of 1999 Agreement Creating National Event

- Increase public awareness of need for greater caution and care while driving through work zones to reduce fatalities and injuries.
- Establish and promote a common set of safety tips for motorists.
- Increase public sector, industry, and worker awareness of the value of training and best practices regarding work zone safety.
- Establish a nationwide program to promote work zone safety.
- Communicate to workers and contractors the effects of motorist frustration with delays on their driving behavior and suggest possible actions to alleviate that behavior.
- Engage interested parties involved in work zone safety as partners.

the idea and decided to support creation of a national campaign.

In early 1999, ATSSA staff discussed the idea with the Federal Highway Administration (FHWA) and American Association of State Highway and Transportation Officials (AASHTO), seeking their leadership as partners in launching the first National Work Zone Awareness Week. By December 1999 the three organizations had signed an agreement to create the national campaign.

Under the agreement, ATSSA would take the lead in coordinating national activities such as the official kickoff, AASHTO would promote the event among State departments of transportation (DOTs), and FHWA would share information about the event with the media, the public, and contractors through all its offices nationwide. All three organizations would identify coordinators and seek other partner organizations.

The set of national partners quickly expanded to include the American Road & Transportation Builders Association (ARTBA), The Associated General Contractors of America (AGC), and the three Washington, DC, area DOTs—VDOT, District Department of Transportation (DDOT), and the Maryland Department of Transportation's State Highway Administration (SHA). Together, the partners established an executive committee and decided that the host location for the national event would rotate among the three DOTs, with the first national event to be

held at a work zone in Springfield, VA, in April 2000. The partners also decided to keep the national event linked to daylight saving time, in early April. (The event remains scheduled in April even though daylight saving time was changed to March beginning in 2007.)

At that first event, the partners invited the media and gave interviews to promote the goals of the national event. Instead of the typical ribbon-cutting ceremony when a highway job is completed, the partners held a ribbon-tying ceremony during which they tied orange ribbons on vehicle antennae. The event also included remarks from a family that traveled from North Carolina to share its story about a loved one who had been killed in a work zone. "The media took to the family's story the most and used it in their coverage to help convey a personal message of the importance of work zone safety," Rush recalls.

Growth Over 10 Years

After the first national event, other States quickly joined in the effort by holding their own events, often following the model set by the national executive committee. Today virtually every State DOT holds an annual work zone awareness event. Following are some snapshots of States' experiences.

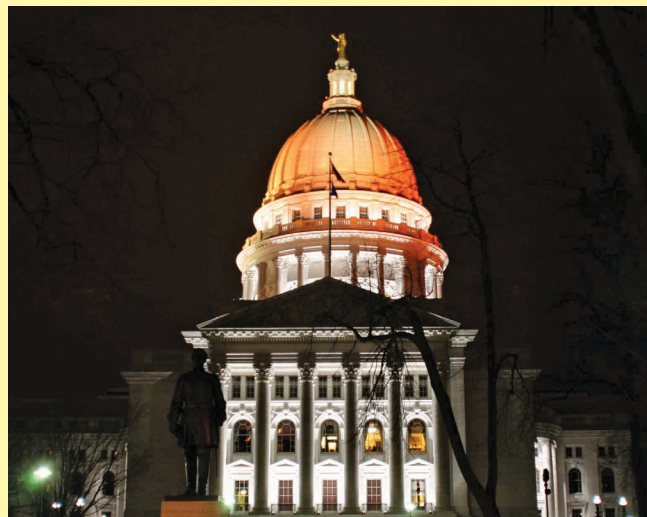
Florida. According to the Florida Department of Transportation (FDOT), typical activities in the State associated with National Work Zone Awareness Week include lobby displays in FDOT headquarters, FDOT district offices, and the State capitol; a work zone video playing continuously in district office lobbies; an ATSSA meeting with the Florida House and Senate to promote the week's safety

In 2008, WisDOT arranged to have Wisconsin's capitol dome lit with orange lights (shown here) as a memorial to workers who had died or been injured in work zones.

messages; educational folders/flyers distributed by FHWA; and promotional items given out by FDOT.

FDOT also has created PSA campaigns that are scheduled to run around the time of National Work Zone Awareness Week and continue during part or all of the year. In 2005, in response to an increasing trend of traffic crashes, injuries, and fatalities in Florida work zones, FDOT created a campaign that began during the national awareness week and ran for the remainder of the year. To enhance the campaign's effectiveness, FDOT partnered with other organizations and tackled the problem from several angles, including engineering, enforcement, and public information and education.

From the engineering and enforcement side, the department deployed motorist awareness systems (MAS) on construction projects located on multilane, high-speed (55 miles per hour, 88.5 kilometers per hour, or greater) facilities that had lane closures when workers were present. The goal was to manage speeds and increase driver awareness of the workers in the work zone. The MAS included law enforcement officers, "Speed Limit When Flashing" portable regulatory speed limit signs, radar speed display units, and portable changeable message signs. FDOT also used safety-related messages on variable message signs around the State to publicize awareness week and funded speed enforcement operations in advance of work zones to increase police presence and encourage safer driving. The department changed the specifications for sign sheeting to



WisDOT

Since 2006, VDOT has held a recognition event at its Workers' Memorial, shown here, as part of its statewide observance of Work Zone Awareness Week.

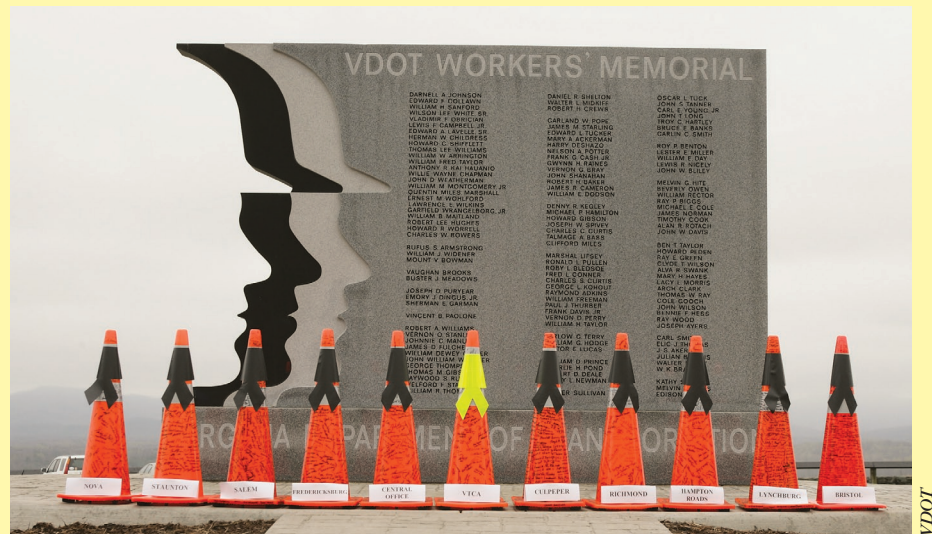
require highly reflective fluorescent orange for all work zone signs.

On the education side, FDOT developed PSAs with the theme "Work Zone Safety. It's Everyone's Job." The campaign included print materials and a new Web site, www.itseveryonesjob.com. FDOT estimates the Web site had about 30,000 hits, more than 20,000 brochures were handed out, and about 6 million people heard or saw the PSAs.

Building partnerships can make a big difference. In 2008, FDOT created new 30-second PSAs on work zones, two for television and one for radio. FDOT wanted to reach all markets across the State but had a budget of only \$25,000 for a 90-day media buy, so it sought the support of partners. The Florida Association of Broadcasters, which operates a statewide media partnership for nonprofits, bought time in volume and gained the statewide market saturation that FDOT wanted. The association also was able to broker extra placements due to availability of spots in the PSA rotation cycle, extending the original 90-day campaign to 240 days at no additional cost. Other partners making the statewide campaign possible were the Florida Transportation Builders' Association and Florida Institute of Consulting Engineers, each of which donated \$25,000.

Wisconsin. The Wisconsin Department of Transportation (WisDOT) has used PSAs and displays in government buildings and at special events to raise awareness of work zone safety. In addition, WisDOT persuaded the Governor to proclaim Work Zone Awareness Week and have the capitol dome lit with orange lights for April 20–25 in 2008. The orange lighting served as a memorial to workers who were killed or injured in work zones.

Also in 2008, WisDOT introduced an 11-minute educational video and new set of television and radio PSAs that took a strong emotional approach by featuring people who had been directly affected by crashes in work zones. The agen-



cies thought that showing a "slice of life" of those affected by work zone crashes might be more effective than just telling people what to do.

Filming the stories of those featured in the PSAs inspired WisDOT officials to develop a special program held at the State capitol in April 2008. WisDOT invited the surviving families of all workers killed in work zone crashes since 1980 (the earliest records WisDOT had) to attend the event. During the program, WisDOT introduced the new video and some of the PSAs and invited surviving family members to come forward to receive flowers to place beside photos of their loved ones on a nearby table. "Lighting the dome and holding the ceremony at the capitol attracted much media attention, including a lead story on several local TV stations that evening," says Michael Goetzman, program officer in WisDOT's Office of Public Affairs.

Virginia. VDOT has continued its statewide campaign every year since 1998. During Work Zone Awareness Week, VDOT sends a daily message on work zone safety to employees and records a short video from the commissioner that is shown to employees during safety meetings. Employees also receive keepsakes, such as a key chains, lunch bags, or flashlights (used the year the national theme was night work), to remind them to work safely. VDOT also airs PSAs to educate the public and has done extensive outreach to teenagers. Since 2006, the agency has held a recognition event at the VDOT Workers' Memorial located off I-64

near Charlottesville. In addition, the department and FHWA's Virginia Division Office continue to offer safety information at rest areas across the State during awareness week.

California. Caltrans has learned many tips from its extensive campaigns. One is to create messages that motorists can personally relate to, which echoes WisDOT's experience with its PSAs, and to tell drivers specific ways to be safe (allow more following room and avoid using cell phones, for example). Caltrans also finds it helpful to target messages to drivers at traffic schools and to students in high school driver's education classes, an approach that VDOT has used as well.

Promoting the National Event

Not only did National Work Zone Awareness Week grow geographically, it grew in the use of symbols, guest speakers, and themes. In 2001 the national event introduced the "field of cones" display, which featured a formation of orange cones set out to signify all those who died in work zones that year. This made for a dramatic display on the National Mall in Washington, DC, where passersby could see the cones and visit one of the nearby tables or tents to ask what was going on and thus become more aware of work zone safety. The cone display caught on and has since been used whenever practical at the national event, as well as at many State DOT events.

In 2001 the tradition of having key public officials speak at the national event began with then-U.S.



Transportation Secretary Norman Mineta as the featured speaker. In 2002, the featured speaker was Congressman James Oberstar (D-MN), at the time the ranking Democrat on the House Transportation and Infrastructure Committee. He has continued to support the event over the years. Since then, key public officials have regularly participated as guest speakers.

In 2002, ATSSA debuted the National Work Zone Memorial, a traveling exhibit upon which the names of those killed in work zones across the country are inscribed. The memorial has become a regular feature at National Work Zone Awareness Week events, as well as other work zone safety events.

Role of Themes

Themes became part of the national effort in 2004. FHWA officials suggested use of a theme conveying that the roadway is analogous to an “office” for road workers. The idea was to appeal to motorists who could relate to how strange it would be to have cars and trucks driving by just inches from their desks. The idea caught on and became the theme for that year. The message was reinforced by a poster showing a VDOT photo of a desk and workers on the road. Then-Federal Highway Administrator Mary Peters also helped reinforce the message by giving interviews while wearing a hard hat and reflective vest, seated at a desk set up onsite at the Springfield Interchange project in Virginia.

Recognizing that more than four out of five fatalities in work zones are motorists or their passengers, the themes have often focused on motorists. In 2005 the theme focused on enforcement to encourage motorists to obey the posted speed limits set for work zones. The 2006 theme reflected the growing amount of night work performed on U.S. roads and kicked off with a nighttime event.

A team from FHWA held a brainstorming session to develop ideas for a theme for the 2007 campaign and proposed “Signs of Change,” which the committee adopted. “Signs of Change” had several meanings. First, the theme was a reminder to motorists that when they see orange signs they should be ready for changed road conditions ahead. Second, it communicated to the public and motorists to be patient because road work is a sign of an improved travel experience coming in the near future. Third, it pointed out that DOTs are changing some of their traditional approaches by using new techniques and technologies, such as accelerated construction and intelligent transportation systems (ITS), to manage traffic in work zones and improve motorists’ experiences driving in and around work zones.

Road Show

In 2008 the national event took to the road, all the way to Sacramento. Caltrans requested the opportunity to host the event, and the executive committee agreed that moving

Themes have played an important role in National Work Zone Awareness Week since 2004. The first theme, “The Worker’s Office Is the Roadway,” took center stage when then-FHWA Administrator Mary E. Peters set up her desk here on the site of a Virginia work zone for the national kickoff event.

the event to a different State every other year would help increase media exposure. The events in between will continue to be held in the Washington, DC, area, which was the original host due to its standing as a national media hub.

Caltrans picked the theme for 2008, using its successful “Slow for the Cone Zone” campaign. “Caltrans drew on its experience to host a memorable event and make the first installment of the ‘road show’ a great success,” says Safety and Design Team Leader Ken Kochevar with the FHWA California Division Office. An estimated 1,000 people attended, including more than 100 family members of fallen workers from as far away as Utah.

After the Washington, DC, area event in 2009, the road show heads to New York City in April 2010.

Assessing Results

What has been the impact of 10 years of National Work Zone Awareness Week events? VDOT’s Rush notes that his agency has seen work zone fatalities decrease, dropping from 17 to 11 to 7 annually from 2006 to 2008, even though almost the same number of contracts and similar dollar values of work were done each of those years. Based on talks with motorists at rest areas, VDOT officials believe there is growing understanding of the dangers of work zones. Rush adds, “Our employees really appreciate the public’s efforts to be more aware of how they are driving in work zones. The safer they drive, the fewer crashes we’ll have.”

Goetzman says WisDOT also sees positive effects. “It seems that when we run our PSAs aggressively it does affect the number of people killed in Wisconsin work zones,” he says. For example, he notes that between 2000 and 2002, when WisDOT ran new PSAs, there were 7 or 8 work zone fatalities each year, while in

Awareness Week Themes

Year	Theme
2004	The Worker's Office Is the Roadway
2005	Enforcement: Slow Down or Pay Up
2006	Night Work: Working at the Speed of Night
2007	Signs of Change
2008	Slow for the Cone Zone
2009	Drive to Survive, Our Future Is Riding on It
2010	Work Zones Need Your Undivided Attention

the years before that Wisconsin saw double-digit fatalities. Fatalities were again higher leading up to the latest PSAs—14 in 2006 and 11 in 2007—but after the PSAs were released in 2008, fatalities again dropped, to 8.

California's data on work zone crashes, injuries, and fatalities indicate that not only is awareness up, but the campaigns appear to have influenced behavior as well. Through surveys, Caltrans estimates that more than half the State population is aware of the "Slow for the Cone Zone" slogan, and 86 percent of drivers said the slogan had an impact on their driving in work zones. From 1998 through 2008, crashes fell nearly 36 percent, motorist injuries went down almost 41 percent, and motorist deaths fell more than 16 percent—all while traffic and the number of work zones increased on State highways.

California, Virginia, and Wisconsin officials each point to their National Work Zone Awareness Week campaigns as being a key component in improving work zone safety and awareness. The States also cite other efforts, including designing more effective work zones, training workers, and improving traffic control setups in the field, as playing important roles in improving work zone safety. California officials also note that having work zones as a challenge area in the State's Strategic High-

way Safety Plan has contributed to gains in work zone safety. To leverage the educational component of its work zone awareness campaign, FDOT has collaborated with FHWA to provide maintenance of traffic training to more than 57,000 State DOT employees, local government officials, and contractors between 2000 and 2008. The training is provided at various times throughout the year and lasts for 3 days, with a final exam given at the end of the course. Certification for those completing the training lasts 4 years.

Nationally, over the 10 years since the first awareness week, practices such as accelerated construction and full road closures have grown more popular and helped reduce workers' exposure in the work zones where they have been used. Use of ITS technologies to keep travelers informed, manage queues, and automate enforcement, and use of data and process reviews to identify areas for improvement, also have grown and helped increase safety and mobility in work zones.

During the same period, Federal regulations have expanded to require a more comprehensive approach to work zone planning and implementation (23 CFR 630 Subparts J and K) and the use of high-visibility safety apparel by workers. As a result of Subpart J, all States have developed work zone policies for the systematic consideration and management of work zone impacts. Resources like the National Work

Zone Safety Information Clearinghouse (www.workzonesafety.org) and FHWA's work zone Web site (www.fhwa.dot.gov/workzones) have expanded to provide a broader array of information on effective practices. All of these efforts work together with the outreach efforts of awareness week to advance safe and smooth traffic flow in work zones.

Work zone safety affects both motorists and workers, and the trends in both areas have been heading in the right direction. Yet more remains to be done to save lives and prevent injury. National Work Zone Awareness Week will continue to be a rallying point for FHWA, State DOTs, and others committed to highway safety.

Tracy Scriba is a program manager with the Work Zone Mobility & Safety Team in the FHWA Office of Operations. She is responsible for program areas related to work zone data and performance measures, best practices, and ITS technologies. Prior to joining FHWA, she worked as a consultant on transportation and environmental issues for more than 10 years. She has a systems engineering degree from the University of Virginia.

For more information, contact Tracy Scriba at 202-366-0855 or tracy.scriba@dot.gov.

When the national event went on the road in 2008, Caltrans hosted it in Sacramento. In front of the State capitol, attendees are seated around orange traffic cones arranged in memory of fallen workers.



Caltrans

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July 26–29, 2010 • Arlington, VA
(Washington, DC, Metro Area)

The national conference on fraud awareness will bring together program and project managers, contracting officials, auditors, engineers, investigators, and others involved in all aspects of local, State, and Federal oversight of highway, transit, and airport projects.

The conference will feature government (including congressional) and industry perspectives on oversight of economic recovery investments, fraud schemes, red flag indicators, prosecution of criminal and civil cases, and much more.

For featured speakers, topics, and other information, visit the Web site.

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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

"Every Day Counts" Initiative to Rely on Partnerships

In November 2009, Federal Highway Administrator Victor Mendez announced the launch of an initiative to reduce delivery times for highway projects, accelerate the deployment of innovative technologies, and reduce the Federal Highway Administration's (FHWA) environmental footprint. One of the main strategies that FHWA will use to achieve the initiative's goals involves establishing and/or enhancing partnerships and facilitating the sharing of information within the transportation community.

Partnerships and information sharing are especially critical to accelerating deployment of innovative technologies. FHWA plans to bring together Federal agencies, States, universities, and the private sector to leverage resources, knowledge, and expertise to move innovation forward. Many innovative approaches, such as accelerated construction practices, have proven to yield dramatic improvements in the delivery of highway projects, save money, and increase safety. The Every Day Counts initiative aims to break down barriers to innovation deployment and push market-ready innovations into the mainstream to benefit road users across the country.

Working through partnerships with organizations such as the American Association of State Highway and Transportation Officials (AASHTO), National Association of County Engineers, The Associated General Contractors of America, and State departments of transportation (DOTs), Every Day Counts will leverage the industry's collective ingenuity, innovation, imagination, and inventive capacity.

For more information or to share ideas related to the Every Day Counts initiative, email everydaycounts@dot.gov.

FHWA to Participate in International Research Collaboration

In October 2009, FHWA joined the Forum of European National Highway Research Laboratories, an international organization representing the interests of more than 30 research and technical centers in Europe, Israel, South Africa, and, now, the United States. The forum engages in road engineering research on topics such as safety, materials, environmental issues, telematics (that is, the convergence of wireless technology, global positioning systems, and onboard electronics in automobiles), and economic evaluations.

Michael E. Trentacoste, associate administrator of the FHWA Office of Research, Development, and Technology, accepted the membership offer on behalf of FHWA. Joining the forum supports the agency's goal to build international relationships and institutionalize cooperation in transportation research. FHWA received strong support for its application from national laboratories in the Czech Republic, France, and the Netherlands.

The Turner-Fairbank Highway Research Center will manage FHWA's participation, which includes developing a research capabilities framework that provides a platform for future international collaboration. FHWA also will participate in research coordinators' meetings three times a year to identify opportunities for collaboration. Initial activities might include sharing plans for research and completed research results, implementing the Strategic Highway Research Program (SHRP 2) results, and identifying targeted projects for future collaboration.

New USDOT Council to Promote Department's Safety Focus

Secretary of Transportation Ray H. LaHood convened the first meeting of a newly formed USDOT Safety Council in October 2009 to coordinate safety efforts across the Department's 10 operating administrations. The council's goals are to further enhance the focus on safety throughout the Department and to improve the impact of USDOT's crosscutting safety programs.

Chaired by Deputy Secretary of Transportation John Porcari, the council includes the heads of each of USDOT's operating administrations: FHWA, the Federal Aviation Administration, Federal Motor Carrier Safety Administration, Federal Railroad Administration, Federal Transit Administration, Maritime Administration, National Highway Traffic Safety Administration, Pipeline and Hazardous Materials Safety Administration, Research and Innovative Technology Administration, and the Saint Lawrence Seaway Development Corporation. The Safety Council will serve a broad-based leadership role and help break down organizational stovepipes, facilitating an even stronger safety culture.

Technical News

Now Available: Report on Designing for Safer Speeds

The University of Connecticut, funded by the Connecticut Department of Transportation through the Connecticut Cooperative Transportation Research Program, recently studied how physical characteristics of the roadway and the roadside environment affect actual vehicle running speeds. The study also looked at how observed vehicle speeds relate to motor vehicle crashes.

Researchers observed vehicle speeds using radar speed guns at about 300 sites in urban, suburban, and rural areas across Connecticut at locations without horizontal curves or traffic control devices to impede traffic flow. They also noted roadway and roadside characteristics, such as lane width, onstreet parking, and the aesthetics or beauty of a road environment, which an

earlier study suggests decreases speed, and developed statistical prediction models to learn more about how free-flow vehicle speeds, roadway and roadside characteristics, and crash incidence and severity relate.

The resulting report, *Designing Roads That Guide Drivers to Choose Safer Speeds*, demonstrates that through careful, intentional selection of roadway and roadside design elements, it is possible to influence the running speed of traffic on a road. The factors associated with higher average running speeds are wide shoulders, large building setbacks, and residential locations. The factors associated with lower average speeds are onstreet parking, sidewalks, and downtown or commercial locations. According to the report, drivers seem to take cues from elements of the roadway and roadside environment to decide how fast to drive, independent of the posted speed limit and other considerations that might be important to the community for reducing speeds.

For more information, visit www.ct.gov/dot/LIB/dot/documents/dresearch/JHR_09-321_JH_04-6.pdf.
Connecticut Department of Transportation

Policy and Legislation

New Guidance on Public Sector's Reporting of GHG Emissions

In October 2009, President Barack Obama signed an executive order committing Federal agencies to report and reduce their greenhouse gas (GHG) emissions by setting 2020 reduction targets. Drawing on its experience in creating GHG reporting protocols primarily for the business sector, the World Resources Institute (WRI) consulted with agencies from all levels of government to develop an accounting framework suitable for U.S. government operations. The standard, called the Greenhouse Gas Protocol Public Sector Standard, is intended to be a flexible management tool to help government agencies meet multiple GHG emissions reporting objectives. The standard also will serve as the basis from which implementation requirements for the Federal executive order will be further specified.

According to Stephen Russell, an associate at WRI leading the standard's development process, "Globally, the government sector is responsible for a huge volume of greenhouse gas emissions, and the executive order sets an important milestone and example for the management of these emissions."

The guidance emphasizes the operational control approach for inventories (that is, only accounting for emissions from those activities that an organization controls) and offers guidance on how to account for leased buildings and vehicle fleets. The standard also recommends that local governments consult the Local Government Operations Protocol for guidance that is compatible with the Public Sector Standard and specific to city, county, and municipal organizations.

For more information, visit www.ghgprotocol.org/the-public-sector-works-with-ghg-protocol-to-develop-a-new-standard.

WRI

Public Information and Information Exchange

Washington, DC, Opens East Coast's Largest Bike Transit Center

In late 2009, the east coast's largest bicycle center and the Nation's most state-of-the-art bike facility opened its doors in Washington, DC. A project of the District Department of Transportation's Bicycle Program and Mobis Transportation Alternatives, Inc./Bikestation®, the facility is the latest in a string of bicycle transit centers springing up across the country.



Mobis Transportation Alternatives, Inc./Bikestation

Bikestation Washington, DC, shown here, provides secure bicycle parking, a changing room, lockers, repair services, retail sales, and bike rentals.

Bikestation Washington, DC, is located outside Union Station near the U.S. Capitol, which enables commuters to take public transportation to the station, pick up their bicycles, and ride to work, shopping, or entertainment. The facility can house more than 100 bicycles in its 1,600-square-foot (149-square-meter) freestanding, ultramodern glass and steel design.

According to a high-ranking USDOT official, Bikestation Washington, DC, is "a model of the sustainable, livable mobility this Nation needs now."

For more information, visit www.bikestation.com/washingtondc.

Georgia DOT to Focus on Solicited Public-Private Partnerships

Legislation adopted by the Georgia General Assembly in 2009 mandates that all public-private partnership projects be solicited by the Georgia Department of Transportation (GDOT)—meaning the department will no longer pursue unsolicited proposals. Instead, projects must be specifically identified and private sector proposals specifically requested by GDOT. In light of this legislation, GDOT decided to focus its entire program on a solicited process and not pursue six unsolicited proposals received prior to the legislation's adoption.

GDOT officials believe that by focusing on solicited projects only, they will be able to advance the partnership program more systematically and in accordance

with the department's overall transportation plans. As required in the legislation, GDOT created a new division to manage the partnership program and anticipates initiating a solicitation for its first public-private partnership project by summer 2010.

For more information, visit www.georgiaP3.com.

GDOT

APWA Announces New Certification Recipients

The American Public Works Association (APWA) announced that 20 public works infrastructure professionals earned credentials as Certified Public Infrastructure Inspectors and eight public works fleet professionals earned credentials as Certified Public Fleet Professionals in November 2009.

The APWA inspector certification program promotes the creation and maintenance of quality infrastructure in communities by advancing the knowledge and practice of construction inspection. Likewise, the public fleet certification program ensures individual competency and promotes excellence in fleet management. APWA's credentialing programs aim to benefit the public works industry and communities by providing recognized standards that lead to an improved workforce and delivery of services.

For lists of certified professionals and more information about APWA's professional development initiatives, visit www.apwa.net/certification or contact Certification Manager Becky Stein at 816-595-5212 or bstein@apwa.net.

APWA

Diverging Diamond Interchange Wins Best Innovation of the Year

The science and technology news magazine *Popular Science* recently selected the diverging diamond interchange (DDI) as one of its "2009 Best of What's New: 100 Best Inventions of the Year." The interchange earned a spot in the engineering category for its "new pattern for beating traffic," according to the December 2009 issue.



Cathy Morrison, Missouri DOT

This aerial shot shows Springfield, MO's award-winning DDI, which eases congestion and improves safety.

The DDI design improves both safety and mobility by minimizing signal phases and more effectively serving left-turning motorists. FHWA estimates that the diverging diamond configuration, first implemented in the United States in Springfield, MO, in June 2009, makes possible more than 600 left turns onto a freeway per hour per lane—double that of an ordinary interchange in which drivers cross oncoming traffic. Benefits of the DDI also include faster and cheaper construction compared to other interchange types. FHWA's Office of Research, Development, and Technology played a major role in identifying, evaluating, and assisting the Missouri Department of Transportation in constructing the Springfield intersection design featured in the magazine.

For more information on the Springfield DDI, including an animated demonstration of how to drive through the interchange, visit www.modot.mo.gov/springfield/major_projects/Greene/I-44andRoute13.html.

Reporting Changes Of Address

PUBLIC ROADS has two categories of subscribers. One includes the organizations and people who receive the magazine without charge; the editorial office of the magazine maintains the mailing list for this group. The other category is the group of people and companies that pay to receive the magazine; the mailing list for this group is maintained by the Superintendent of Documents for the U.S. Government Printing Office.

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by Katy Jones and Karen Yunk

FHWA Launches Online Clearinghouse For Crash Modification Factors

Transportation professionals continually strive to determine more effective ways to identify, implement, and evaluate cost-effective solutions to improve roadway safety. One question that often arises is, "What is the best countermeasure to apply at this intersection?" A crash modification factor (CMF), which is used to estimate change in the number of crashes expected after implementing a countermeasure, can help engineers answer such questions. But until recently, CMFs were not available in a centralized location. Recognizing the need for up-to-date and easily accessible CMF information, the Federal Highway Administration (FHWA) established the Crash Modification Factors Clearinghouse.



The home page of the "CMF Clearinghouse" Web site.

The clearinghouse (at www.CMFClearinghouse.org) offers transportation professionals a Web-based repository of CMFs and related resources.

"The new clearinghouse provides an excellent tool for use in the development of safety projects around [our] State," says Kelly Becker, regional traffic engineer with the North Carolina Department of Transportation. "It is my hope that it will be a central location for our traffic engineers to reference modification factors."

CMFs at Work

CMFs help transportation professionals make evidence-based decisions with the goal of improving roadway safety and reducing motor vehicle crashes. For example, imagine that an intersection is experiencing 100 angle crashes and 500 rear-end crashes per year. If you apply a countermeasure that has a CMF of 0.80 for angle crashes, then you can expect the number of angle crashes to drop to 80 per year following the implementation of the countermeasure ($100 \times 0.80 = 80$). If the same countermeasure also has a CMF of 1.10 for rear-end crashes, then you would expect

to see an increase to 550 rear-end crashes per year after installation ($500 \times 1.10 = 550$). Engineers can perform similar calculations to determine a countermeasure that offers the optimum overall improvement in safety. In this way, CMFs enable engineers to compare the safety effectiveness of alternative treatments and help them conduct benefit-cost analyses to prioritize treatment locations.

Crash reduction factors (CRFs) too are represented in the clearinghouse because of their widespread use. Both CMFs and CRFs are displayed side-by-side on the basic search results page as well as on each CMF details page. A CRF reflects an estimate of the percentage reduction in crashes after implementing a given improvement. A CRF of 46, for example, represents a 46 percent reduction in crashes at a particular site.

Using the Web Site

At the clearinghouse's launch in late 2009, it contained more than 1,800 CMFs for more than 400 countermeasures. To find CMF information, Web site users can conduct a quick keyword search from the home page or narrow their search by countermeasure, crash type, crash severity, and roadway type. The site also has an advanced search feature that enables users to search by more detailed parameters, such as intersection type, traffic control, area type, and more. Users then can export their search results into a Microsoft® Excel® spreadsheet or an Adobe® Acrobat® PDF document for easy reference and dissemination.

Another purpose of the Web site is to educate transportation professionals about the application of CMFs. The site includes an overview of CMFs and a glossary of terms related to their use. Frequently asked questions address issues such as the difference between CMFs and CRFs and how to apply multiple CMFs to one location. The clearinghouse also includes a comprehensive resources section with links to information on training, publications, and other resources.

Transportation professionals also can submit their own CMF studies for inclusion in the clearinghouse. CMF studies sent to the database will undergo a review process, which evaluates each study according to its design, sample size, standard error, potential bias, and data source to determine whether it meets the minimum requirements for inclusion.

"The Web site is very user friendly and most, if not all, traffic/safety engineers will use this site quite often," says Tom Hammonds, Highway Safety Improvement Program (HSIP) coordinator with the West Virginia Department of Transportation. "I will bookmark this site on my computer at work."

For more information, visit www.CMFClearinghouse.org or contact Karen Yunk at 609-637-4207 or karen.yunk@dot.gov.

Katy Jones is the manager for research information and education programs at the University of North Carolina Highway Safety Research Center.

Karen Yunk, P.E., is the HSIP implementation manager with FHWA's Office of Safety Programs.

by Becky Crowe and Robin Grier

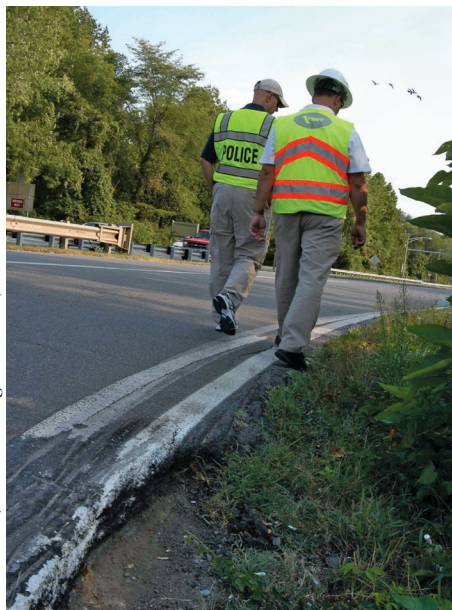
RSA Training Helps Virginia Reach Stellar Levels

Although Virginia has the third-largest State-maintained highway system in the country, the Virginia Department of Transportation (VDOT) has drastically reduced its construction program since 2002. Faced with older infrastructure and reduced budgets, Virginia planners and safety engineers are working together to identify locations in each of the State's systems operations regions that have critical safety and congestion problems. Through a new initiative known as the Strategically Targeted Affordable Roadway Solutions (STARS) program, the State aims to mitigate these challenges by implementing low-cost and high-benefit improvements at select locations.

The STARS program partners with State and local transportation planners, traffic and safety engineers, and operations staff to identify where safety and congestion issues overlap on Virginia roadways. The program consists of four major components: selection of study areas, detailed studies, development and prioritization of recommendations, and programming and implementation. A major focus of the STARS program is to conduct road safety audits (sometimes known as road safety assessments, or RSAs) to identify improvement opportunities. To ensure success in this critical area, VDOT has held multiple RSA trainings through the National Highway Institute (NHI).

Training with Hands-On Experience

The NHI Road Safety Audits/Assessments course (FHWA-NHI-380069) provides practical information on how to conduct an RSA, including how to select locations, build multidisciplinary teams, and execute the steps necessary to perform a successful audit. Participants learn how to



Dan Nabors, Vanasse Hangen Brustlin, Inc.

RSA team members perform a field observation at a STARS site, looking for potential safety problems, such as this steep dropoff in the pavement's shoulder.

improve transportation safety by applying RSAs to reduce the number and severity of crashes. The course covers such topics as the history, stages, and legal considerations related to RSAs.

According to participant feedback on the course, the most valuable part of the training is the hands-on application. During the training, participants work in teams to perform essential elements of an actual RSA. Teams analyze data, perform a field review, develop recommendations based on their expertise, and present the recommendations to the road owner for consideration. This experience provides participants with the firsthand knowledge necessary to conduct an RSA.

"We continue to receive requests for the NHI course in Virginia," says Stephen Read, Highway Safety Improvement Program (HSIP) manager with VDOT. "The course is very helpful to us as it provides the team approach know-how for conducting RSAs. The training has really provided us with a strong foundation for meeting the goals of the STARS program—to reduce injuries and deaths from motor vehicle crashes."

Peer-to-Peer Visit Highlights Successes

Since VDOT's first RSA training session in 2005, the department has made extraordinary progress toward its STARS goals. VDOT has performed more than 200 RSAs, including more than 75 in the heavily congested northern Virginia region. After performing an RSA, VDOT incorporates the recommendations directly into the corresponding application for HSIP funds.

In July 2009, VDOT hosted a peer exchange with staff from the Rhode Island Department of Transportation (RIDOT) and the Federal Highway Administration's (FHWA) Rhode Island Division to discuss the success of the STARS program. Throughout the event, VDOT stressed the important role that the NHI training has played in the success of the STARS program. Rhode Island participants reviewed firsthand a site where VDOT had recently completed an RSA, enabling RIDOT staff to ask questions of the VDOT RSA team.

"This exchange gave us the opportunity to see how another State has innovatively dealt with its congestion issues," says RIDOT State Traffic Engineer Robert Rocchio. "And it's obvious that Virginia's program greatly benefited from NHI's RSA training. We are optimistic that we will too."

Recommendations from STARS were incorporated into Virginia's 2035 State Highway Plan, which will be released in the first half of 2010.

For more information, contact Robin Grier at robin.grier@vdot.virginia.gov. For more information on NHI's RSA course, visit www.nhi.fhwa.dot.gov.

Becky Crowe is the RSA program manager at FHWA.

Robin Grier is the assistant division administrator for transportation and mobility planning at VDOT.

Communication Product Updates

*Compiled by Zachary Ellis of FHWA's
Office of Corporate Research, Technology,
and Innovation Management*

Below are brief descriptions of communications products recently developed by the Federal Highway Administration's (FHWA) Office of Research, Development, and Technology. All of the reports are or will soon be available from the National Technical Information Service (NTIS). In some cases, limited copies of the communications products are available from FHWA's Research and Technology (R&T) Product Distribution Center (PDC).

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:

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Requests for items available from the R&T Product Distribution Center should be addressed to:

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Email: report.center@dot.gov

For more information on R&T communications products available from FHWA, visit FHWA's Web site at www.fhwa.dot.gov, the Turner-Fairbank Highway Research Center's Web site at www.tfhrc.gov, the National Transportation Library's Web site at <http://ntl.bts.gov>, or the OneDOT information network at <http://dotlibrary.dot.gov>.

Safety Evaluation of Improved Curve Delineation (TechBrief) **Publication No. FHWA-HRT-09-046**

As part of an effort to support strategic highway safety plans, FHWA organized 26 States to participate in the Evaluations of Low Cost Safety Improvements Pooled Fund Study. The purpose of this pooled study is to estimate the safety effectiveness of several unproven, low cost safety strategies identified in the National Cooperative Highway Research Program Report 500 series.

This report, *Safety Evaluation of Improved Curve Delineation*, examines the safety effectiveness of improved delineation on horizontal curves through signing upgrades. This strategy is intended to reduce the frequen-

cy of curve-related crashes by providing more conspicuous signing and lane markings. The study examined the effects of this strategy on specific nonintersection crash types, including total crashes, injury and fatal crashes, lane departure crashes, total crashes at night, and lane departures at night. Because the safety effectiveness of this strategy has not been documented thoroughly, this study attempts to provide a crash-based evaluation through scientifically rigorous procedures, including evaluating 89 sites in Connecticut and 139 sites in Washington.

The researchers conclude that delineation improvements for curves have the potential to reduce crashes and crash severity on two-lane rural roads. Based on the installations in Connecticut and Washington, the combined results indicate substantial and highly significant crash reductions: injury and fatal (18 percent), dark conditions (27.5 percent), and dark condition lane departure (25.4 percent). Given the potential to reduce crashes, the researchers justify curve delineation improvements as a cost-effective safety improvement, particularly at curves with hazardous roadsides, high traffic volumes, and low curve radii.

The document is available at www.tfhrc.gov/safety/pubs/09046/index.htm. Printed copies are available from the PDC.

Improved Corrosion-Resistant Steel for Highway Bridge Construction Knowledge-Based Design (TechBrief) **Publication No. FHWA-HRT-09-053**

Increasingly, the transportation community is using weathering steels for construction of new highway bridges. Weathering steels provide significant construction and maintenance cost savings because there is no need to paint the steel, and these steels are more durable than common construction steels. However, the current weathering steels still have shortcomings; for example, they cannot be used in marine and other high-saline environments. This report details research to identify ways to develop low-cost steels with improved weathering characteristics.

Research for this project focused on an extensive analysis of available data regarding the weathering performance of steels in different environments, the effects of various conventional and nonconventional alloying elements on weathering of steels, and the mechanisms leading to reduced corrosion rates for those steels. The report describes earlier designs for weathering steels as purely empirical and as focused on a small number of conventional elements such as manganese, silicon, chromium, nickel, copper, molybdenum, and phosphorus in a narrow concentration range. Rather than adjusting concentrations of these elements for only marginal improvements, the report suggests using less



common alloying elements such as tungsten, titanium, aluminum, and rare earths to achieve more significant increases in weathering performance.

Researchers conclude that these less frequently used elements could improve the weatherability of steel significantly. The researchers also conclude that weathering steel should not be designed solely on its weathering characteristics. Instead, the composition should be optimized with respect to weathering characteristics, strength, ductility and fracture properties, ease of processing and fabrication, cost, and minimization of adverse health effects.

The document is available at www.tfhrc.gov/structure/pubs/09053/index.htm.

The Value of Research: Telling the R&T Story Publication No. FHWA-HRT-09-050

FHWA plays a leadership role in shaping and executing a national research and technology program. The agency collaborates with State, industry, and academic partners to provide the foundation for researching and developing innovations to improve the Nation's transportation system. This document highlights examples of valuable FHWA research, translated into applications of ground-breaking technology that improve the transportation system's performance in terms of safety, reliability, effectiveness, and sustainability.

The report covers FHWA's mission-driven research in the following areas: enhancing system performance, reducing traffic congestion, improving safety, working in partnership to address climate change and quality of life, and maintaining infrastructure integrity. The report also looks at the future of new research initiatives.

The document is available at www.tfhrc.gov/about/09050/index.htm. Printed copies are available from the PDC.

Building Freight Professional Capacity In the 21st Century

Publication No. FHWA-HOP-09-020

FHWA's Freight Professional Development (FPD)

Program aims to enable transportation professionals to improve their skills and knowledge so they can help integrate freight movement into the development and operation of the Nation's transportation system. This brochure describes many of the resources available through the FPD Program.

As detailed in the brochure, the FPD Program offers a broad range of professional capacity building opportunities, including training courses, workshops, seminars, and peer-to-peer exchanges. It also provides access to information, resources, and tools that improve understanding of how freight moves across the transportation network and how best to facilitate that movement while minimizing its impacts.

The document is available at www.ops.fhwa.dot.gov/publications/fhwahop09020/capacity.htm.



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Conferences/Special Events Calendar

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May 5-7, 2010	16 th International Conference on Urban Transport and the Environment	Wessex Institute of Technology Transactions on the Built Environment	Limassol, Cyprus	Claire Shiell + 44 (0) 238 029 3223 cshiell@wessex.ac.uk www.wessex.ac.uk/10-conferences/urban-transport-2010.html
May 12-14, 2010	Structures Congress/ North American Steel Construction Conference	Structural Engineering Institute of American Society of Civil Engineers and the American Institute of Steel Construction	Orlando, FL	Elizabeth Robelet 312-670-5421 robelet@aisc.org www.aisc.org/nascc
May 30-June 2, 2010	International Conference on Safety and Mobility of Vulnerable Road Users: Pedestrians, Motorcyclists, and Bicyclists	Transportation Research Board (TRB) and Forum of European Road Safety Research Institutes	Jerusalem, Israel	Conference Secretariat 972-3-6234557 reutk@d-u.co.il http://vulnerableroadusers.d-u.co.il
June 6-9, 2010	International Bridge Conference®	Engineers' Society of Western Pennsylvania and American Road & Transportation Builders Association	Pittsburgh, PA	Conor McGarvey 412-261-0710, ext. 11 c.mcgarvey@eswp.com www.internationalbridgeconference.org
June 6-10, 2010	Environmental Research Needs Workshop and Summit	Center for Transportation and the Environment at North Carolina State University, Federal Transit Administration, Federal Highway Administration, and TRB	Raleigh, NC	Kate Quinn 202-366-7909 kate.quinn@dot.gov
July 11-14, 2010	Western Association of State Highway and Transportation Officials Annual Meeting	Hosted by North Dakota Department of Transportation	Bismarck, ND	Peggy Anderson 701-328-2671 peganderson@nd.gov Laurie Martin 701-328-2584 lmartin@nd.gov www.washto2010.com
July 12-15, 2010	National Local Technical Assistance Program and Tribal Technical Assistance Program Conference	See conference Web site for list of sponsors.	Oklahoma City, OK	Doug Wright 405-744-6049 douglas.wright@okstate.edu www.ltapt2.org
August 8-11, 2010	ITE Annual Meeting and Exhibit	Institute of Transportation Engineers (ITE)	Vancouver, British Columbia	Sallie C. Dollins 202-289-0222, ext. 149 sdollins@ite.org www.ite.org

Correction: PUBLIC ROADS added helmets to two of the photographs in the article "Handy Lessons From Overseas on Walking and Bicycling" in the January/February 2010 issue (pages 29 and 32) to conform with U.S. bicycle safety practices. However, European practice is to focus on increasing safety by encouraging greater numbers of bicyclists through bicycle-friendly policies rather than focusing on helmet use. PUBLIC ROADS regrets the photo alterations.



SAVE THE DATE

National Work Zone Awareness Week April 19–23, 2010 NEW YORK CITY



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