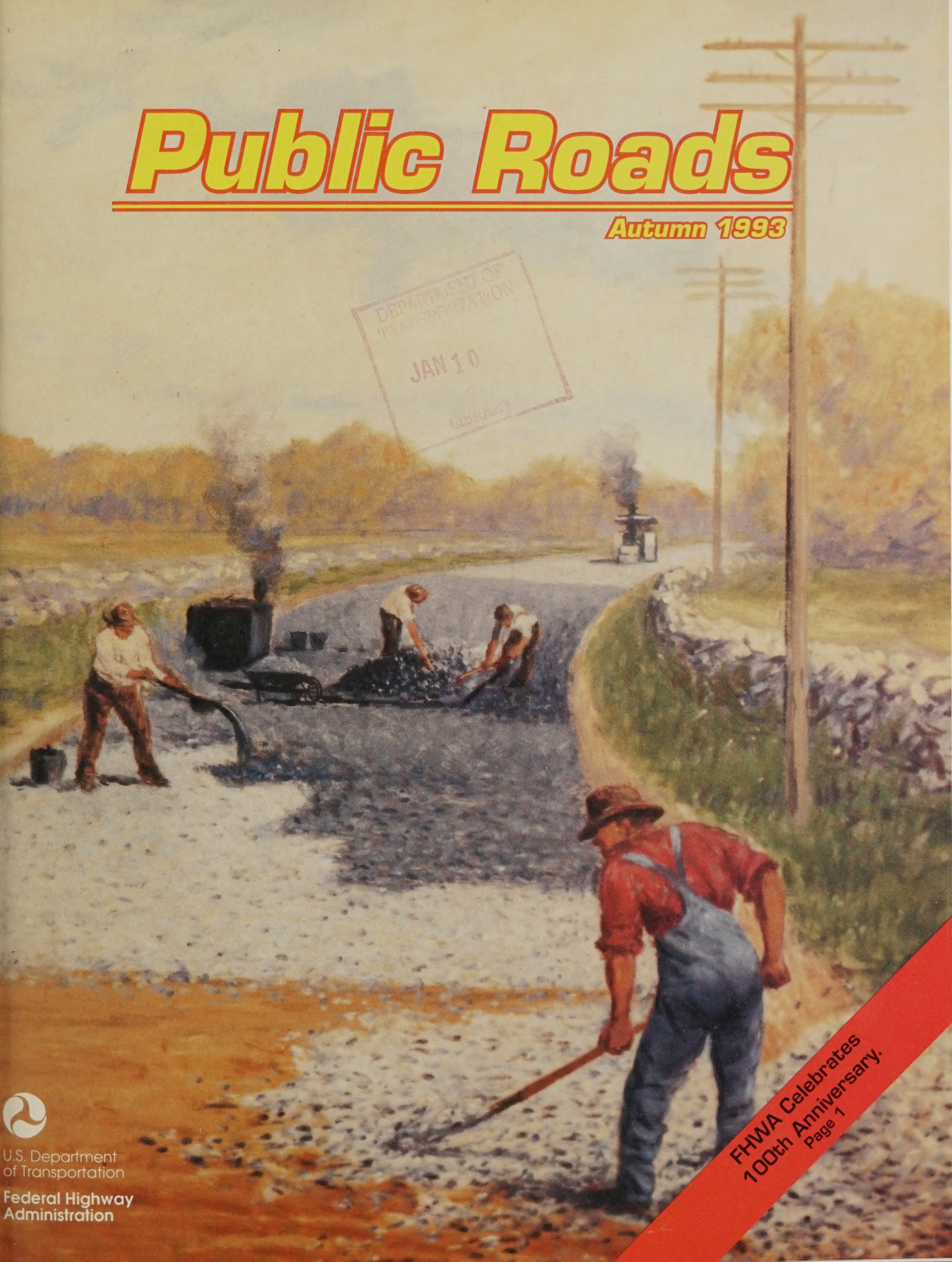
Public Roads

Autumn 1993



FHWA Celebrates 100th Anniversary.
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Public Roads

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COVER:
This painting, one of a series of 109 by the late Carl Rakeman (1878-1965) on the theme of American transportation development, illustrates a bituminous macadam pavement experiment in the early 20th century. Conducting research and sharing the results of research are the two oldest missions of the Federal Highway Administration.

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The Secretary of Transportation has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department.

A peaceful campaign of progress and reform:

The Federal Highway Admistration at 100

by Richard F. Weingroff

On October 3, 1993, the Federal Highway Administration (FHWA) celebrated 100 years of service to the country. General Roy Stone, the agency's first head, called the movement to improve the nation's roads a "peaceful campaign of progress and reform." Today, the 68,800-kilometer (42,800-mile) Dwight D. Eisenhower System of Interstate and Defense Highways is the most visible result, but the peaceful campaign continues as the FHWA adapts to the intermodal demands of the 1990s.

Origins

In the second half of the 19th century, the railroads dominated interstate travel, and the limited pre-railroad network of roads fell into neglect. In the 1880s, however, the growing popularity of a new mode of transportation, the "ordinary" bicycle—the type with the large front wheel—was the first sign of change. The speed and individual mobility afforded by the bicycle created a nationwide craze—complete with bicycle clubs, clothes, races, and touring guides—for what appeared to be the next important mode of transportation. With the introduction of the "safety" bicycle with two wheels of the same size and the pneumatic tire in the late 1880s, the craze became an economic, political, and social force in the United States. By 1890, over one million bicycles were being manufactured in the country each year.

In the late 1880s the safety bicycle with two wheels the same size and pneumatic tires replaced the ordinary bicycle.

The biggest problem was that, outside the cities, the nation's bad roads made bicycling a laborious, dangerous process. As one contemporary slogan put it, the roads were, "Wholly unclassable, almost impassable, scarcely jackassable!" The Good Roads Movement was a response to this problem. Bicycle groups, led by the League of American Wheelmen (L.A.W.), and manufacturers, led by Col. Albert Pope, worked at the federal, state,

and local levels to secure road improvement legislation.

To build support for the movement, the bicycle groups tried to interest the farmers and their state and national organizations. The message was that bad roads, by increasing transportation expenditures, cost more than good roads. But the farmers weren't interested; they didn't want to be taxed to benefit, as they saw it, the city "peacocks" who wanted to get their relaxation riding bicycles at the farmers' expense. As a result, the Good Roads Movement was dominated by bicycle interests until the late 1890s.

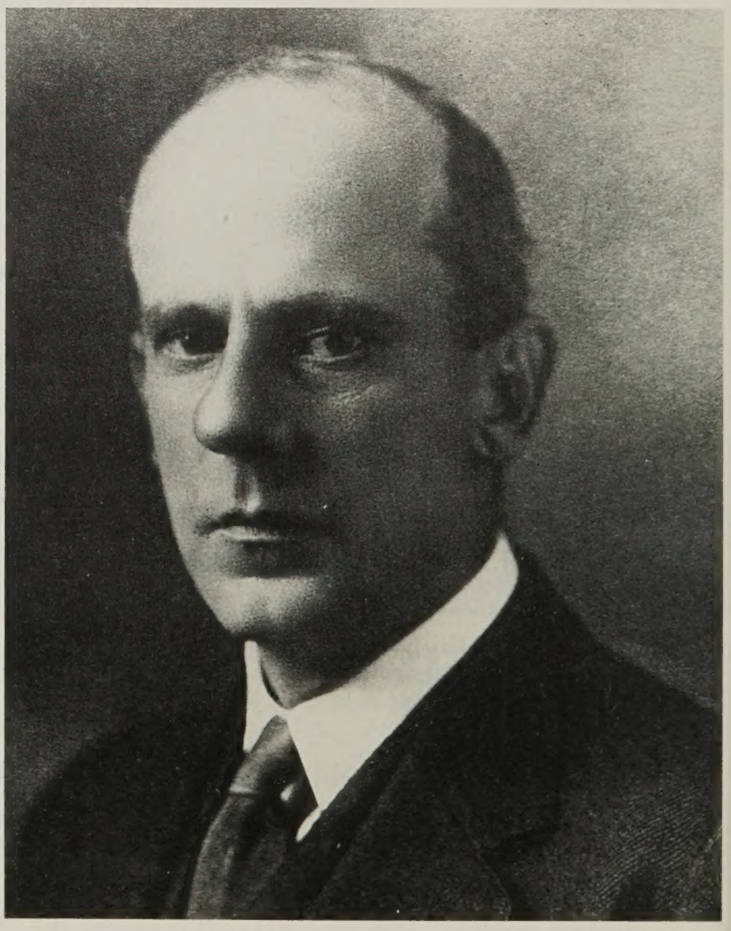
General Stone, a Civil War hero and civil engineer, was one of the leaders of the movement, which rallied around a bill he had drafted in 1892 for consideration in the Congress. The bill called for creation of a two-year National Highway Commission to formulate plans for a national school of roads and bridges, to collect and disseminate information, and to prepare a comprehensive road exhibit for the Chicago World's Columbian Exposition, which was to open in April 1893. The measure passed the Senate, but despite intense lobbying by Stone, the L.A.W., and other groups, failed in the House of Representatives.

In January 1893, Representatives Allan Durburow of Illinois and Clarke Lewis of Mississippi succeeded in adding a provision to the Agriculture Appropriation Act of 1894 to provide $10,000 "to make inquiry regarding public roads" and to disseminate the information. The Congress approved the act on March 3, and it was signed by President Benjamin Harrison that same day, his last in office.

Incoming President Grover Cleveland, beginning his second nonconsecutive term on March 4, chose J. Sterling Morton to be Secretary of Agriculture. Morton, a former secretary and acting governor of the Nebraska Territory and the founder of Arbor Day, adhered to principles of rigid economy and strict conservatism. His initiation of the road inquiry reflected these principles.

On October 3, 1893, he signed a letter to General Stone, who had been chosen special agent and engineer for road inquiry. This letter is the charter for the new Office of Road Inquiry (ORI), the FHWA's first predecessor. After enunciating the statutory goals of the Appropriations Act, Morton reminded Stone that the work "will need to be of gradual growth, conducted at all times economically . . . [with] no considerable expenditure for the present." Morton added that, "It must be borne in mind that the actual expense in the construction of these highways is to be borne by the localities and states in which they lie." The ORI began life in two small attic rooms of the main Agriculture Building, with General Stone and a stenographer, Robert Grubbs, being its first two employees.

Stone began by writing letters to the governors, their secretaries of state, the members of Congress, railroad presidents, and state geologists, with a general circular to the public, asking for information on



Top- Martin Dodge was appointed interim director of the Office of Road Inquiry in August 1898 when his predecessor, General Roy Stone, vacated the office to serve in the Spanish-American War. Stone returned to the post for nine months in 1899 and then resigned. Dodge became the director and served until 1905.

Right- Logan Waller Page in 1905 became the first director of the newly created Office of Public Roads, and he served until 1919. As director, he began a series of investigations that won international acclaim for the laboratories he directed.

highway laws, the location of materials suitable for roadbuilding, and rail rates for hauling roadbuilding material. Responses in hand, Stone completed the ORI's first bulletin by December 4, 1893: *State Laws Relating to the Management of Roads. Enacted from 1888-93*. Eight more bulletins, most based on the new information, were released by the start of the next fiscal year (FY) in July 1894.

The ORI's annual budget was small ($10,000 for its first three years, $8,000 for the next four years, then $10,000 again), but Stone and his small staff of full- and part-time employees made the most of it. In addition to publishing technical and promotional literature, Stone was a popular speaker at good roads conventions, helped states draft road legislation, and initiated tests of road materials. He also cooperated with the Post Office Department in its experiments with Rural Free Delivery (RFD), begun in 1896, a program that finally convinced the nation's farmers of the value of good roads and brought them into the Good Roads Movement.

One of Stone's most enduring successes was the object lesson road program, begun in 1897. The idea, borrowed from Massachusetts, was to build short stretches of road to educate local engineers and, on the theory that "seeing is believing," create support for increasing funding for road improvements. Federal engineers or part-time special agents directed the work, but equipment was donated and most of the remaining cost was paid by the sponsors. The program was one of the ORI's most popular, with demand far exceeding the agency's resources.

On October 13, 1899, General Stone resigned. By then, largely through his efforts, the ORI had become the recognized national leader of the Good Roads Movement. Historian Bruce Seely summarized Stone's accomplishments, as well as the stamp he left on the agency he founded:

In the end, he pioneered three enduring patterns of activity for the ORI: build a reputation for technical knowledge, promote the gospel of good roads, and utilize cooperation to reach those goals. The first fulfilled the office's mandate from Congress, and the second grew from the promotional goals of the Wheelmen, but the third was Stone's hallmark, even if it was necessitated by a small budget.

An improved Tennesse post road in 1903.

General Stone died on August 5, 1905, and was buried with full military honors at Arlington National Cemetery.

Turning Point: Birth of the Federal-aid Highway Program

In 1899, Martin Dodge, a former president of the Ohio State Highway Commission, was appointed director of the ORI, which was renamed the Office of Public Road Inquiries (OPRI). He expanded the promotional and technical activities of the agency, including cooperating with railroad companies and good roads promotional groups as a sponsor of Good Roads Trains. The trains toured the country from 1901 to 1903, demonstrating roadbuilding techniques with equipment borrowed from the manufacturers.

In an economy move, Dodge established the agency's first field structure to continue the popular object lesson road program and keep in touch with local developments. He divided the country into four divisions, with a full-time special agent in charge of the Eastern Division and part-time special agents for the Southern, Middle, and Western Divisions. To head the Eastern Division, Dodge chose Logan W. Page, a geologist who in 1900 had established the OPRI's laboratory for testing road materials in the Department of Agriculture's Bureau of Chemistry.

In addition, Dodge launched the first inventory of all rural roads in the United States. Begun in 1904, the survey required over 60,000 communications—printed and typewritten—and several years to compile. Of 3,462,522 km (2,151,570 mi) of rural public roads, only 247,288 km (153,662 mi) had any kind of surfacing.

Dodge also pushed the OPRI into its next incarnation by helping to persuade Congress to increase the budget to $30,000 in 1903 and to elevate the agency to permanent status within the Department of Agriculture. The Agriculture Appropriation Act of 1906, signed by President Theodore Roosevelt on March 3, 1905, merged the OPRI with Page's Division of Tests to form the Office of Public Roads (OPR). The annual budget was $50,000 and the OPR was authorized to include 10 full-time positions. The act also provided that the director of the OPR "shall be a scientist and have charge of all

scientific and technical work." Dodge, a lawyer, was not eligible.

Logan Page was appointed director of the OPR. As Seely has shown, Page moved the OPR into the forefront of the Progressive movement, which put its faith in an "ideology of reform through apolitical expertise." He expanded the object lesson road program and the testing laboratory, revived good roads trains (1911-1916), built experimental roads to test building methods and materials, and increased the agency's lecture schedule—from 150 in 1905 to 1,135 in 1912. He also entered into a formal agreement with the Post Office Department to make OPR engineers available to inspect proposed RFD routes.

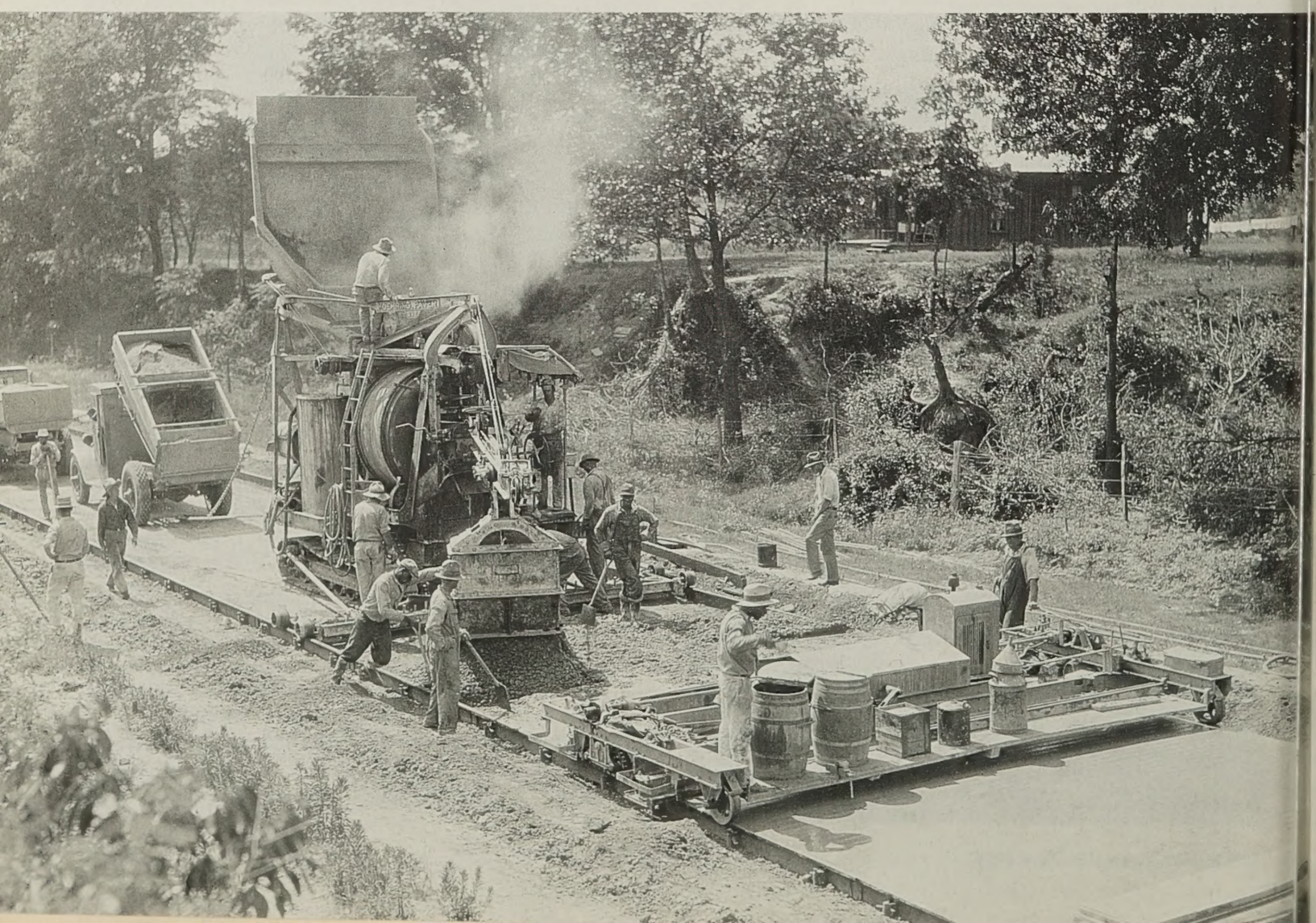
As with Page's predecessors, he believed in cooperation, that working with, rather than dictating to, the highway community would get the best results. When the state highway agencies decided to form their own organization, Page was present at the creation of the American Association of State Highway Officials (AASHO) in December 1914. Although the OPR had provided advice on forest trails since 1905, Page worked out a formal agreement with the Forest Service, also part of the Department of Agriculture, in 1913 and began an expanded program for roads in national parks. To handle this work, Page established a Division of National Park and Forest Roads in 1914.

By this time, the growth in automobile travel had increased pressure on the federal government to provide funds for road building outside federal reserves. The issue wasn't whether the federal role would expand—the issue was how. The key issues were whether the federal government would build the roads or provide aid to states or counties; whether the emphasis would be on getting the farmer out of the mud or building long-distance roads; and how much aid would be provided.

To help find answers, the Post Office Appropriation Bill for FY 1913 appropriated $500,000 for an experimental post road program, which the OPR administered in cooperation with states and counties. From the standpoint of road improvement, the experimental program had limited success, but it provided valuable experience that helped shape the OPR's mission. The most important lesson was that cooperating with the nation's 3,000 diverse counties would be a lot more difficult than working with the 48 states.

In December 1915, AASHO ratified a federal-aid bill that largely reflected Page's Progressive views, including his preference for a federal program of aid to technically proficient state highway agencies. The bill was introduced by Senator J. H. Bankhead of Alabama, and Page and the OPR and Rural Engineering (OPRRE), as the OPR had been renamed in 1915, provided extensive technical assistance during the debates on Capitol Hill in 1916. The final version of the Bankhead Bill, modified but still reflecting Page's views, was signed into law by President Woodrow Wilson on July 11, 1916, launching the federal-state partnership known as the Federal-aid Highway Program.

Concrete mixer at work on federal-aid primary road near Memphis, Tennesse (1929).



The Federal Aid Road Act of 1916 authorized $75 million over five years—but only $5 million for the first year—to be apportioned by formula—based on land area, population, and post road mileage—to state highway agencies. Funding was restricted to rural post roads and the federal share of project costs was 50 percent, with a limit of $10,000 per mile. The states would prepare the plans and control construction and maintenance, subject to federal approval and inspection. The act also authorized $10 million for roads on federal lands.

Regulations implementing the new law were drafted, and Page invited the states to Washington for an August 16 meeting to comment on them. The day before, AASHO members met at the Raleigh Hotel to prepare their suggestions. On Wednesday, August 16, the formal meeting took place in the auditorium of the National Museum—today's Smithsonian Museum of Natural History—with 35 states represented. Virtually all of the states' suggestions were adopted. The regulations were issued September 1, 1916, less than two months after enactment of the law.

Turning Point: Clarification of the Federal-aid Highway Program

To accommodate the new program, Page established the agency's first formal field organization of 10 district offices with delegated operating responsibility and authority. He also reorganized the Washington headquarters, grouping all existing divisions into the Engineering Branch and the Management and Economics Branch, and providing for two general inspectors who reported directly to him.

At the start of the program, 11 states did not have a state highway agency and many others required legislative changes to comply with the 1916 law. By June 1917, all the states except one were in compliance, with technical experts in charge of agencies that had the authority to administer the federal-aid program. The exception was Indiana, which was delayed by a state constitutional challenge.

In April 1917, the initial federal-aid highway program was severely hindered by United States entry into World War I. The war reduced the supply of men and materials for road work. Meanwhile, the nation's road network was under severe stress. The railroads were unable to handle all war shipments, giving the fledgling trucking industry the opportunity to fill the void—with even the best roads suffering the consequences. By war's end, only five federal-aid projects, totalling 28.3 km (17.6 mi), had been completed.

On December 9, 1918, Page died of a heart attack while attending a meeting of AASHO's Executive Committee in Chicago. Page's successor almost didn't take the job. Thomas H. MacDonald, chief engineer of the Iowa State Highway Commission, was asked to take over the Bureau of Public Roads (BPR), as the OPRRE had been renamed in 1918, but he hesitated because the $4,500 salary was too low. He took the job on April 1, 1919, pending review of compensation. On July 1, 1919, he was appointed chief of the bureau with a salary of $6,000 and retained the position, through various title changes, until March 1953.

As with Page, MacDonald's tenure was marked by the spirit of cooperation and consensus. He never lost sight of the view expressed in his first communication, dated May 25, to BPR field staff: "Our success will depend largely upon the attitude of mind and confidence we establish on the part of the state officials."

Legislation in 1919 increased federal-aid highway funding, but the states, hampered by inflation, postwar strikes, shipping problems, and shortages, were slow to respond. This limited progress, three years into the program, gave competing forces within the highway community the opportunity to revive the arguments that the Federal Aid Road Act of 1916 had been intended to settle—notably the debate over federal versus federal-aid construction and over long-distance versus farm-to-market roads.

The turning point that made the Federal-aid Highway Program a success came in 1921. MacDonald worked with AASHO to draft legislation that addressed the major concerns about the program. The proposal retained the federal-aid principle, but satisfied supporters of long-distance roads by restricting funds to a federal-aid system, to be linked at state lines, comprising 7 percent of total public road distance— 322,134 km (200,170 mi) out of 4,601,914 km (2,859,575 mi)— and requiring that paved surfaces should be at least 5.5 meters (18 feet) wide.

In these and other ways, the Federal Highway Act of 1921, signed by President Warren G. Harding on November 9, resolved the decade-long debates over highway policy and unified the highway community behind MacDonald, who emerged from the debates as its technical and political leader. With the program solidified and post-war problems resolved, a highway improvement boom began in the 1920s that coincided, but did not keep pace with, the continuing growth in auto travel—vehicle registrations totalled 10.4 million in 1921 and 26 million in 1931.

MacDonald and the BPR were involved in wide-ranging activities during the 1920s, aside from administering the Federal-aid Highway Program. Research aimed at finding the best roadbuilding techniques, particularly in light of the increasing volume of heavy trucks, continued throughout the decade. In November 1920, MacDonald helped found the National Advisory Board on Highway Research—renamed the Highway Research Board in 1925, and the Transportation Research Board in 1974—to address fundamental questions in highway transport. The BPR launched transportation surveys in cooperation with the states to examine every aspect of highway transportation, from ownership of motor vehicles to driver behavior.

In other areas, the BPR worked with AASHO to create the U.S. numbered highway system (1925-1926) to replace the names—the Lincoln Highway, the National Old Trails Road, and over 250 others—that had been given to the country's main highways by private booster groups. In October 1925, MacDonald was appointed a delegate to the Pan-American Road Congress in Argentina, leading to United States support for the Pan American Highway (Alaska to Argentina) and a direct role in construction of the Inter-American Highway. Work on

federal lands also continued, with new agreements covering forest and park road construction. In 1921, MacDonald established the Western Regional Office in San Francisco, under Dr. L. I. Hewes, to administer this work and the Federal-aid Highway Program in 11 western states and Alaska and Hawaii.

During the Depression, economic pump priming legislation under Presidents Herbert Hoover and Franklin Roosevelt continued federal funding for road building. The funding was aimed at creating jobs quickly, rather than achieving the connected system of good roads that was the primary goal of the Federal-aid Highway Program. Because of state financial difficulties, the legislation temporarily abandoned the matching share concept that was fundamental to the program.

On July 1, 1939, the BPR was renamed the Public Roads Administration (PRA) and shifted to the new Federal Works Agency. By then, the distance of paved roads had increased from 622,800 km (387,000 mi) in 1921 to 2,199,900 km (1,367,000 mi). But increasing numbers of vehicles had created congestion in urban areas while the higher speeds possible in the more powerful cars of the time combined with out-of-date highway designs to create safety problems nationwide—and a call for better highways.

Turning Point: Launching the Interstate Highway Program

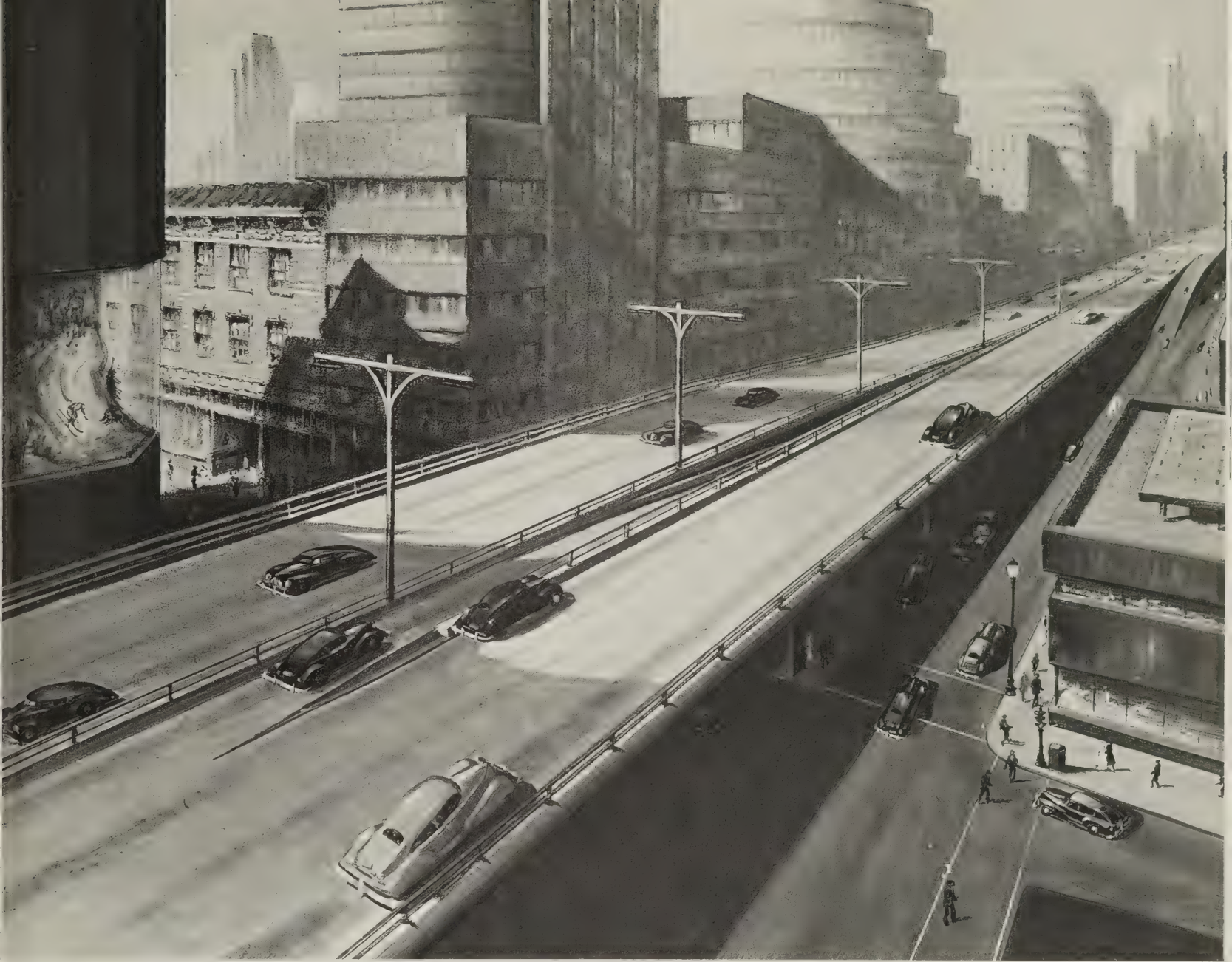
By the early 1930s, proposals to build a network of superhighways for the United States were common, a vision waiting for the right moment. In part because of the job-creating potential of such a network, President Franklin Roosevelt was enthusiastic. He favored a self-supporting network of toll superhighways on "excess right-of-way" that could be rented and eventually sold to help pay for the network. Given the continuing interest, the Congress, in Section 13 of the Federal-Aid Highway Act of 1938, called for a study of a toll network consisting of no more than three east-west and three north-south routes.

The study was assigned to the BPR, which reported its findings in a 1939 report entitled *Toll Roads and Free Roads*. The report demonstrated that a network of six toll superhighways would not be financially feasible. Instead, the report endorsed "A Master Plan for Free Highway Development," the first formal description of the future interstate system. The plan called for a 42,970-km (26,700-mi) non-toll network, with possible routes identified on the basis of statewide surveys conducted during the 1930s that showed where traffic volumes were highest.

In 1941, the President appointed the National Interregional Highway Committee, headed by MacDonald, to study the need for a nationwide expressway system. The committee had essentially completed its work by year's end, but America's entry into World War II following the attack on Pearl Harbor in December delayed completion.

During the war, civilian

BPR constructed the Tooth Rock Tunnel on the Columbia River Highway in Oregon, 1936-37. The old highway can be seen above the tunnel portal.



Sketch from *Interregional Highways* (1944) shows elevated section of urban expressway (from original caption: "Show window at the elevated level dressed appropriately with the kind of large display that would be needed for comprehension by express traffic").

road building was, as in World War I, put on hold for the most part. The PRA focused on war-related activities, such as enhancing road access to defense plants, but its most remarkable achievement was the Alaska Highway. In February 1942, President Roosevelt approved construction of a road across Canada from Dawson Creek, British Columbia, to Big Delta, Alaska, as a way of ensuring land access in the event of a Japanese invasion of Alaska. From March to October 1942, the U.S. Army along with civilian contractors under direction of the PRA constructed a pioneer trail to open the route to essential traffic. In 1943, contractors working for the PRA rebuilt the 2,250-km (1,400-mi) road, in some cases on new location. At war's end, the Alaska Highway was turned over to Canada for maintenance and has since become the main land link to the state.

In 1943, the Congress added a provision to the Federal-Aid Highway Amendment Act calling for a national expressway study. In response, President Roosevelt transmitted *Interregional Highways*, the study prepared by MacDonald's committee, to Congress in January 1944. This report refined the concept presented in the 1939 master plan and recommended a rural network of 54,550 km (33,900 mi), plus 8,050 km (5,000 mi) of urban routes.

With the report in hand, Congress acted. The Federal-Aid Highway Act of 1944, signed on December 20, called for designation of a 64,375-km (40,000-mi) network, to be called the National System of Interstate Highways. Routes were to be selected by the state highway agencies, with PRA concurrence, but no funds were authorized for the new network. Following coordination with the states and the Department of Defense, the PRA announced selection of the general location of 60,670 km (37,700 mi) on August 2, 1947.

The 1944 act did not provide funds specifically for construction of the interstate system. The importance of the National System of Interstate Highways was such that the states were expected to give priority in the use of regular federal-aid funds for its construction.

For the most part, though, that did not happen and only a small amount of mileage was constructed. The first funding for the interstate system, approved in 1952, amounted to $25 million annually in FYs 1954 and 1955, followed by 1954 legislation authorizing $175 million a year for FYs 1956 and 1957. During this early period, therefore, little work on the toll-free network was accomplished, although the success of the Pennsylvania Turnpike, the first 260-km (160-mi) segment of which opened in 1940, prompted several states, particularly in the densely populated Northeast, to construct toll superhighways in interstate system corridors.

The PRA was transferred to the Department of Commerce in 1949 and renamed the BPR. MacDonald retired in July 1951, but stayed on—in a job that now paid $16,000 a year—at President Harry Truman's request. Shortly after President Dwight D. Eisenhower's first term began on January 20, 1953, MacDonald left office, after 34 years, on March 31, 1953, replaced by Francis V. duPont.

Development of the interstate system had a strong new advocate in the White House. As a young officer in 1919, the President had participated in the first transcontinental army convoy, which took nearly two months to go from Washington, D.C., to San Francisco, and thereby learned the value of good two-lane roads. During World War II, he had seen the efficient German autobahn network first hand and recognized its value. Given these experiences, the new president was committed to providing such highways for the United States.

He appointed a committee, under General Lucius Clay, to devise a plan for financing the network. The committee's report, transmitted to Congress in February 1955, proposed to complete the interstate system at a cost of $27 billion in 10 years. Bonds would be issued to finance construction, to be repaid over 32 years from the existing two-cent federal motor-fuel tax. Clay's plan failed in 1955, largely because conservative members of Congress objected to the $12 billion in interest payments that would go along with the proposed $20 billion bond sale.

Despite extensive debate in and out of Congress in 1955, no alternative plan emerged that was acceptable to the many competing forces contending for a share of the vast program. The interstate system had considerable support, but even its supporters disagreed on the details.

In 1956, Congress approved a plan for an expanded 66,000-km (41,000-mi) National System of Interstate and Defense Highways, as it was now called, that gave each of the competing forces something with which to be satisfied. The new Highway Trust Fund, an accounting mechanism for restricting highway user tax revenue to highway purposes, met the president's goal of avoiding deficit spending by including a an anti-deficit provision. Taxes on truckers went up, but not too much to lose their support. Urban areas did not get the control they wanted, but the bulk of funding would be spent in the cities. Rural officials, who did not believe the interstate system would benefit them, received continued funding for federal-aid secondary roads.

President Eisenhower signed the Federal-Aid Highway Act and the Highway Revenue Act of 1956 on June 29, ushering in the interstate era. His role had been to push for its construction, without insisting on financing details that would have jeopardized the primary goal. In October 1990, the name of the system was changed by federal law to honor his role: The Dwight D. Eisenhower System of Interstate and Defense Highways.

The Interstate Era Gets Underway

Bertram D. Tallamy, chairman of the New York State Thruway Authority, was Eisenhower's choice to get the program underway. Tallamy was the second federal highway administrator and the first to be confirmed by the Senate. The first administrator, John Volpe, held the office on an interim basis, from October 1956 to February 1957, until Tallamy was confirmed and took office in 1957.

At first, the interstate highway program ran into serious problems that prompted speculation on whether the program should be scrapped: allegations of corruption, financial problems, and protests against construction of the interstate routes.

An article in the July 1960 issue of Reader's Digest, entitled "Our Great Big Highway Bungle," was typical of the many articles and television reports of corruption. According to the subhead, "Haste, waste, mismanagement and outright graft are making a multibillion-dollar rathole out of the Federal Highway Program." The BPR responded to the allegations in several ways, including detailed rebuttals and speeches pointing out that the abuses were minor within the context of the much larger, efficiently run program.

When Rex Whitton became federal highway administrator in 1961, he confronted the problem by strengthening procedures—for example, instituting unannounced sampling of materials nearly every month—and establishing an office of audits and investigations, headed by a former agent of the Federal Bureau of Investigation. Meanwhile, a special investigative committee of the House Committee on Public Works, established in 1959 under Representative John A. Blatnik, found that some allegations were valid, but confirmed the BPR's, the states', and industry's view that, overall, the program was well run.

The first sign of financial trouble was the release, in January 1958, of the 1958 Interstate Cost Estimate, the first to be based on detailed information from the states. During the debates in 1955 and 1956, the BPR had estimated the cost of the 64,375-km (40,000-mi) proposed network to be $27 billion—federal share: $25 billion. The 1958 estimate, which by law covered only 62,035 km (38,548 mi) of the authorized distance—66,000 km (41,000 mi), later expanded to 68,880 km (42,800 mi)—indicated the cost would be $37.6 billion. A few months later, in August, legislation increased annual authorizations for the interstate program, in part because of the higher cost, to accelerate completion, and to pump public works funding into a recessionary economy. The legislation also temporarily set aside the pay-as-you-go feature of the Highway Trust Fund, with the resultant shortfall in revenue made up by

borrowing from the general treasury and imposing quarterly limitations on spending. The result of these financial difficulties was concern that the program was too costly.

The Federal-Aid Highway Act of 1959 temporarily increased the federal gas tax by a penny, to four cents, and lowered interstate authorizations to address immediate fiscal problems. For the longer range, Congress approved legislation in 1961 restoring the pay-as-you-go provision, making the four-cent gas tax permanent, and adjusting other highway user taxes, thus restoring the fiscal solvency that has characterized operation of the Highway Trust Fund ever since.

The third problem facing the interstate program was more difficult. Protests against urban freeway construction began soon after the program was authorized. The first formal recognition of the problem occurred in September 1957. During a conference in Hartford on "The New Highways: Challenge to the Metropolitan Region," city planners, led by critic and author Lewis Mumford, urged suspension of all urban interstate construction until comprehensive land use plans could be developed. During the early 1960s, the problem was compounded by increasing criticism of the adverse environmental impacts of interstate construction in rural as well as urban areas.

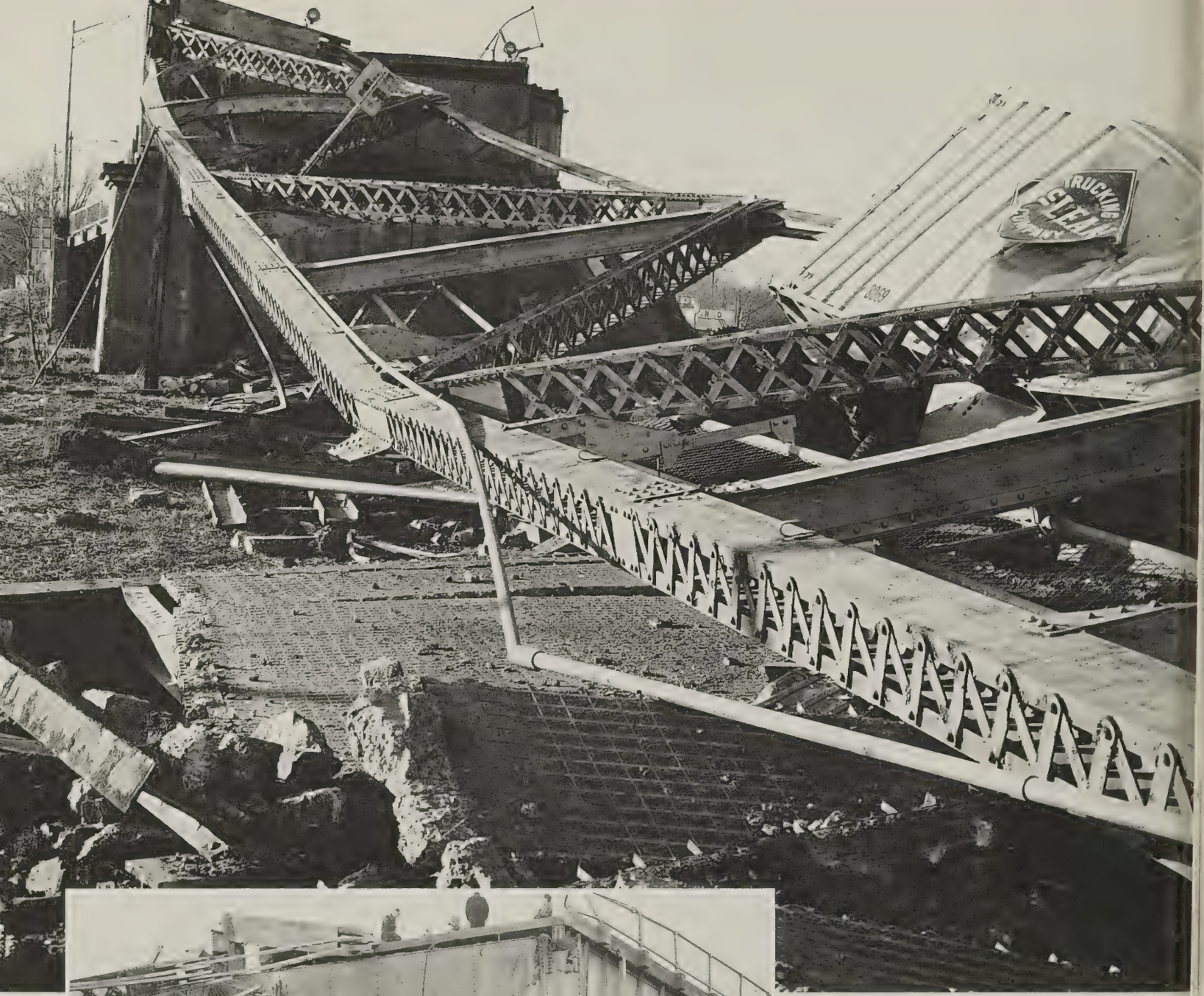
The problems confronting the interstate highway program, particularly the urban and environmental controversies, were a shock to the highway community, which had expected to apply technical expertise to the new program for the benefit of a grateful nation. Instead, the highway community was on the defensive.

The BPR's response to the new challenge was diverse. The agency, for example, joined with AASHO in national conferences on urban planning and in working with urban groups to find better ways to fit the new freeways into an urban setting. The Federal-Aid Highway Act of 1962 included an early legislative attempt to address the problem, requiring the planning process to be "continuing, cooperative, and comprehensive."

Similarly, to address environmental concerns, the BPR modified its policies, for example by issuing instructions in 1963 regarding assessment of impacts on fish and wildlife areas. But as with urban problems, legislative solutions were required, notably the National Environmental Policy Act of 1969, which resulted in formal environmental assessment of all federal-aid highway projects, and the Department of Transportation Act of 1966, which applied Section 4(f) restrictions on construction of roads on publicly owned land in a public park, recreation area, or wildlife and waterfowl refuge of national, state, or local significance unless there is no feasible and prudent alternative and the program includes all possible mitigation to minimize harm.

These steps helped, but could not resolve all controversies. Accordingly, the Federal-Aid Highway Act of 1973 authorized withdrawal of controversial interstate segments and substitution of urban mass transportation projects (expanded to allow substitute highway projects by the Federal-Aid Highway Act of 1976). Although controversies continued, the withdrawal option provided a safety valve that brought many interstate battles to an end, beginning with the 1974 withdrawal of portions of I-95 and I-695 in Boston and ending with withdrawal of I-205 bus lanes in Portland, Ore., in 1989.

Vibrating deck pour on I-10 at Southern Avenue, Phoenix (1967).



Collapse of the Silver Bridge in 1967 with the loss of 46 lives sparkled national concern about bridge safety. These photographs show the damage on the Ohio end of the bridge.

The Department of Transportation Act also changed the name of the BPR. On April 1, 1967, the agency became the Federal Highway Administration, part of the new U.S. Department of Transportation. The Bureau of Public Roads became one of three bureaus of FHWA, the others being the Bureau of Motor Carrier Safety—now the Associate Administrator for Motor Carriers—and the National Highway Safety Bureau—which became the National Highway Traffic Safety Administration (NHTSA) in March 1970. On August 10, 1970, the agency was again reorganized, and the BPR was

abolished, bringing to an end a name that dated to July 1, 1918, when Logan Page was director.

Although the FHWA's primary goal has been completion of the interstate system, the years since the start of the interstate highway program have included many other activities:

- FHWA has continued its extensive program of cooperation with other federal agencies in the construction of roads on federal lands. Facilities such as the Blue Ridge Parkway, including the award-winning Linn Cove Viaduct, are nationally recognized scenic highways.

- Safety has been a continuing focus. Hazard elimination and rail-highway crossing safety programs, design changes such as the concept of a forgiving roadside, and the shift of traffic from conventional roads to the interstate system have combined with NHTSA vehicle safety initiatives and the efforts of private groups to lower the fatality rate to under two per 100 million vehicle miles (compared with, for example, 3.3 in 1980).

- Motor carrier safety programs have played an important part in this reduction. These programs were strengthened by passage of the Commercial Motor Vehicle Safety Act of 1986, which required bus and truck drivers have a single commercial driver's license based on uniform standards for testing drivers; creation of a central clearinghouse for complete driving records; and mandatory penalties for serious traffic violations and felony convictions.

- After the loss of 46 lives in the collapse of the Silver Bridge between Point Pleasant, W.Va., and Gallipolis, Ohio, on December 15, 1967, national concern about bridge safety led to the establishment of the National Bridge Inspection Standards under the Federal-Aid Highway Act of 1968 and the Special Bridge Replacement Program (SBRP) in the Federal-Aid Highway Act of 1970. The Highway Bridge Replacement and Rehabilitation Program replaced the SBRP under the Surface Transportation Assistance Act of 1978 and is funded today at over $2.76 billion a year.

- Beginning with MacDonald's participation in the 1925 Pan-American Road Congress in Argentina, the BPR/FHWA has played a growing role internationally. Construction activity has included the Inter-American Highway and additional projects in Central America, reconstruction of war-damaged roads in the Philippine Islands beginning in 1946, and construction and training programs in Asia and the Middle East. In recent years, emphasis has also been placed on development of cooperative agreements for technology sharing with countries, such as Japan and the nations of Europe, that have common problems.

- The original mission "to collect and disseminate information" has remained an important part of the program. FHWA has continued an aggressive research and implementation program on such topics as congestion, the environment, safety, and pavements and bridges. The Demonstration Projects Program, initiated in 1969, borrowed the "seeing is believing" idea of the object lesson road program and continues today under Technology Applications.

- Attempts to control outdoor advertising along the interstate system began with the Federal-Aid Highway Act of 1958, which authorized the "Bonus Program" of payments to states that agreed to control signs located within 660 feet of the interstate system in accordance with national standards (23 states participated). With support from President Lyndon Johnson's wife Lady Bird, the Highway Beautification Act of 1965 launched a new phase in the effort to control outdoor advertising, but one that has been complicated by subsequent amendments.

- The Surface Transportation Assistance Act of 1982 increased the gas tax by five cents—one

I-70 along Vail Pass, Colorado (1980), fits into extremely sensitive terrain to prevent erosion, pollution of local streams, disruption of plant life, and isolation of wild game.

cent for mass transit—and adjusted other highway-user taxes to fund restoration of highway and bridge conditions. The act also established a 10-percent goal for participation of disadvantaged business enterprises (DBE), exclusive of women business enterprises (WBE), in federal-aid highway projects. The definition of "DBE" was expanded to include WBEs in 1987. In 1992, participation by DBEs, including WBEs, exceeded 14 percent.

Turning Point: The Post-Interstate Era

Today, the interstate system is essentially complete—99.7 percent open to traffic at the end of 1992. With the end of the interstate highway program in sight, FHWA began working with the American Association of State Highway and Transportation Officials and other groups within the highway community in the late 1980s to explore options for the future.

When, shortly after taking office in 1989, Secretary of Transportation Samuel Skinner called for development of a National Transportation Policy (NTP), FHWA's earlier work helped establish the highway goals identified in the NTP, which was released in March 1990. Most notably, the NTP called for designation of a National Highway System (NHS) to consist of the interstate system and other principal arterials of national significance, improved to appropriate standards.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), embodying many of the NTP's concepts plus others initiated by Congress, is a major restructuring of the federal-aid highway program, retaining some traditional types of program while putting them in a new context. On the traditional side, ISTEA funded interstate completion and maintenance, bridge replacement and rehabilitation, and a Surface Transportation Program for all roads except those classified as rural minor collectors or local roads. It also directs the FHWA to develop a proposal for designation of the NHS, subject to congressional approval.

At the same time, ISTEA stressed increased flexibility of choice among modal options, including bicycling and walking, in making transportation choices. In other areas, ISTEA emphasized environmental enhancement, preservation rather than expansion of the highway network, strengthened statewide and metropolitan planning, greater authority for states to establish their own standards off the NHS, increased reliance on public/private partnerships to finance needed projects, revitalized research and technology transfer, particularly in the areas of intelligent vehicle-highway systems and

OFFICE OF ROAD INQUIRY TO FEDERAL HIGHWAY ADMINISTRATION

Office of Road Inquiry

(1893-1898)

Office of Public Road Inquiries

(1899-1905)

Office of Public Roads

(1905-1915)

Office of Public Roads and

Rural Engineering

(1915-1918)

Bureau of Public Roads

(1918-1939)

Public Roads Administration

(1939-1949)

Bureau of Public Roads

(1949-1967)

Federal Highway Administration

(April 1, 1967-)

CHIEF ADMINISTRATIVE OFFICERS OFFICE OF ROAD INQUIRY TO FEDERAL HIGHWAY ADMINISTRATION 1893-1993

General Roy Stone (1893-1899)

Martin Dodge (1899-1905)

Logan Waller Page (1905-1918)

Thomas H. MacDonald (1919-1953)

Francis V. du Pont (1953-1955)

Charles D. (Cap) Curtiss (1956)

John A. Volpe (1956-1957)

Bertram D. Tallamy (1957-1961)

Rex Whitton (1961-1966)

Lowell K. Bridwell (1967-1969)

Frank C. Turner (1969-1972)

Norbert Tiemann (1973-1977)

William M. Cox (1977-1978)

Karl S. Bowers (1978-1980)

John S. Hassell, Jr. (1980-1981)

Ray A. Barnhart (1981-1987)

Robert E. Farris (1988-1989)

Thomas D. Larson (1989-1993)

Rodney E. Slater (1993-)

high-speed rail, and scenic byways and recreational trails.

More broadly, ISTEA declared that the policy of the United States is to develop a National Intermodal Transportation System:

The National Intermodal Transportation System shall consist of all forms of transportation in a unified, interconnected manner, including the transportation systems of the future, to reduce energy consumption and air pollution while promoting economic development and supporting the nation's preeminent position in international commerce.

Just as the agency has adapted to each previous turning point, FHWA has been adjusting to the shape of its intermodal future. Headquarters and field offices have been restructured and such activities as the "FHWA 2000" initiative, the follow-up business planning initiatives, and diversity sensitivity training have helped prepare the agency for the future.

From the day General Stone moved into his attic office at the Department of Agriculture, the agency has been evolving. So change is nothing new for FHWA. At 100, it continues to evolve to meet the transportation needs of the nation.

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1893 In Perspective

- The stock market crashed, plunging the United States into a depression.
- Massachusetts becomes the first state to establish a highway department.
- The Dalton Gang was captured.
- The former Cherokee territories of Oklahoma were opened to settlement.
- Sir Arthur Conan Doyle, tired of his most famous creation, allowed Sherlock Holmes to plunge to his "death" at Reichenbach Falls in *The Final Problem*.
- Katherine Lee Bates wrote the words to "America the Beautiful."
- The Chicago World's Columbian Exposition honoring the 400th anniversary of the discovery of the new world opened. Nicknamed "The White City," the exposition introduced the Ferris Wheel, the zipper, and long-distance telephone service and inspired the City Beautiful movement and the Emerald City of L. Frank Baum's *The Wizard of Oz*.
- In a lecture during the Exposition, Professor Frederick Jackson Turner declared that the frontier, which had helped shape the U.S. character, was closed.
- Bicycle makers Charles E. and J. Frank Duryea inspired by reports of European automotive successes, built the first American gasoline-powered automobile to operate in the United States, on September 21 in Springfield, Mass., with Frank in the driver's seat.
- Congress defeated attempts to switch the country to the metric system.
- Colorado adopted women's suffrage.
- Stephen Crane wrote *Maggie: A Girl of the Streets*.
- Hurricane devastated Charleston, S. C., and Savannah, Ga., killing about 1,000 people.
- Edison Laboratories built film studio in West Orange, N. J.
- Antonin Dvorak composed his "Symphony No. 9 (From the New World)."
- Sigmund Freud and Josef Breuer published *The Psychic Mechanism of Hysterical Phenomena*.
- Ice hockey was introduced from Canada at Yale and Johns Hopkins Universities.

PRIMARY SOURCE: *The Timetables of American History*, Laurence Urdang, editor, a Touchstone Book.

A New Era in FHWA Leadership

Slater, Garvey Cite Employment of Technology, Protection of the Environment as Major Thrusts for FHWA

by Ronald A. Zeitz

On June 16, 1993, a new era in the leadership of the Federal Highway Administration officially began with the formal swearing-in of Rodney E. Slater as the FHWA administrator. Slater, who was confirmed by the U.S. Senate on May 28, and Deputy Administrator Jane F. Garvey wasted no time in establishing their focus and putting their imprint on the mission and direction of FHWA.

Rodney E. Slater is the 19th chief highway executive since the founding of FHWA's first predecessor in 1893.

Together with Secretary of Transportation Federico Peña, they have outlined a straightforward set of objectives for the Department of Transportation and FHWA:

- Get the economy moving and create jobs by making strategic transportation investments.
- Make these investments in ways that will help clean up and even beautify our environment.
- Integrate all modes of transportation into a seamless system for moving goods and people both within our cities and borders and to and from the United States.
- Develop and apply new technologies that will create whole new industries.
- Ensure that all of our investments improve daily life by making travel safer, more convenient, and more responsive to "customers'" needs.

In late July at the Pacific Rim TransTech Conference, Administrator Slater described these objectives as an interrelated program to meet the challenges of a revolution in transportation technologies.

"Our goal in all of our transportation investments is long term. We believe that, if we invest wisely and build partnerships, we can spur the development of new technologies—even whole industries—and contribute to a cleaner environment at the same time. Many of you here know that we are in the midst of a revolution in transportation technologies that will transform our

Jane F. Garvey is the deputy administrator of FHWA.

economy and our daily lives as much as the arrival of the railroad, commercial aviation, and the interstate system did," he said.

In the same speech, he outlined the role transportation has in fueling this revolution to expand the economy.

"We must not only follow the example set by the generation before us, which envisioned a nation linked by the interstate system," he said. "Rather, as we stand at the threshold of the 21st century, we must harness technology to increase the efficiency of our existing transportation network and enhance the role of transportation as an engine for economic growth and job creation."

Slater sees research, development, and technology as the key to better use of transportation facilities. In his confirmation proceedings he stated, "I believe that research and development at the department has to be increased, because what we have to do is find more effective and efficient usage for our various modes of transportation. IVHS (Intelligent Vehicle-Highway System) provides an excellent opportunity for us to revisit how we are using our system as it is, and it forces us to not take the easy way out of just deciding to build more highways."

Speaking to the National Conference of State Legislatures Transportation Committee, Slater praised the Intermodal Surface Transportation Efficiency Act as the crucial catalyst to developing new transportation technologies.

"ISTEA gives us a strong lead. Under ISTEA, computer-based management systems will improve our ability to monitor and to program projects for pavements, bridges, safety, congestion relief, public transportation, and intermodal transportation systems. We're making steady progress on IVHS that could revolutionize driving by increasing our navigational ability under all circumstances, making commercial vehicle operations more efficient, and perhaps allowing for control of vehicle flow," he said.

Deputy Administrator Garvey emphasizes the direct relationship between transportation technology and preserving the environment. In a speech given at the Third Interdisciplinary Conference on Urban Air Quality, she cited the almost limitless mobility that Americans enjoy because of the automobile, and she warned that the two strongly held values of mobility and environment must become more compatible.

"We must encourage and support the implementation of cost-effective strategies which do not limit mobility. These strategies include such technical advances such as cleaner-burning gasoline and diesel fuel, vehicles powered by electricity and other alternative fuels, and improved emissions control systems with stronger inspection and maintenance programs to ensure their continued effectiveness." She added that the use of alternate transportation facilities such as mass transit are efficient modes that are also environmentally acceptable.

Both Slater and Garvey preach the importance of intermodalism. Slater refers to it as "such an important part of ISTEA."

"We've seen intermodalism illustrated, dramatically, during the tragic flooding of the Mississippi," Slater observed. "Because normal transportation patterns have been disrupted, shipments that normally go by one mode are going by another or by a crazy-quilt combination of modes."

The emphasis on intermodalism stems from a lesson learned in the '80s, said Garvey. "No one transportation system can do it. We found we will need a balanced transportation system."

Both agree that diversity in the FHWA workplace is an imperative. Citing President Clinton's goal "to have an administration that looks like America," Garvey acknowledges that there is still much to be done.

Working through partnerships and cooperative relationships with states, universities, industry, foreign countries, and international organizations will become an increasingly important way to accomplish the missions of FHWA. The expansion of FHWA's global involvement has been particularly dramatic. There are many examples.

FHWA will expand the network of international technology exchange centers to acquire foreign technologies, promote U.S. expertise, and transfer U.S. technologies to other countries. FHWA recently established a technology exchange center in Finland. Information gathered through the center is circulated to the U.S. highway community through FHWA, state departments of transportation, and the Local Technical Assistance Program technology transfer centers.

A plan to provide FHWA expertise to assist Russia in improving its highway system is currently in the final stages of approval. The proposed project will rehabilitate 1,500 kilometers (932 miles) of major roads and will serve to help establish a road construction industry in the country.

The Pan American Institute of Highways, administered by the National Highway Institute, is an international network of 40 technology transfer centers in 16 countries of the Americas. These centers work together to solve the technological needs of the hemisphere, and they provide technical support to national and local governments, universities, road associations, and individuals.

Even before he had been confirmed as administrator, Slater underscored the importance of true international particpation. In his confirmation proceedings, he recalled his service as the chairman of the Arkansas State Highway Commission and said, "When I talked about transportation, I always talked about it in terms of linking Arkansas with the nation and the world because we play on an international stage and we are players in a global economy."

As the new leaders of FHWA, Slater and Garvey have affirmed the commitment of FHWA to do its part to support the national policy, as stated in ISTEA, "to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in the global economy, and will move people and goods in an energy efficient manner."

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FHWA Administrator Rodney E. Slater addresses guests at his swearing-in ceremony on June 16, 1993.

National Geotechnical Experimentation Sites

by Albert F. DiMillio and Geraldine C. Prince

Introduction

The Federal Highway Administration's Geotechnical Research Program strives to develop practical, cost-effective technology for bridge foundations, retaining walls, and embankments.

A major focus of this program is the development of a designated system of national geotechnical experimentation sites (NGES) to improve our ability to find and evaluate new techniques for constructing safer and more economical highways and bridges. With this objective in mind, FHWA teamed up with the National Science Foundation to establish a system with a national management board and individual site managers. This article describes the system to accelerate geotechnical research to solve many serious, foundation-engineering problems and difficult, soil-support problems facing the highway community today.

The stars indicate the five NGES locations.

During the last two decades, the geotechnical profession has witnessed major changes in the approach to site characterization and quantification of soil behavior. New in situ testing methods and improved field instrumentation provided valuable new tools to complement and/or create testing alternatives to laboratory procedures. These new techniques are leading to a better understanding of the static and dynamic properties of soils. Although the evolution of new techniques has been relatively rapid, duplication of effort and lack of cooperative work among the various research groups has made progress slower and more costly than might otherwise have been possible.

A lack of well-characterized, well-documented, reference sites has impeded the development and evaluation of new in situ testing methods. Such sites would allow ready comparison of new methods against known soil conditions and past testing programs. Unfortunately, in many cases, these previously studied sites are not available or are unknown to other researchers. As a result, the originators of a new method must perform their own extensive site investigation before reaching the initial objectives of the research. This increases the total project cost and wastes valuable time and effort.

Benefits from well-characterized and well-documented sites are not solely restricted to evaluation of new in situ testing methods. A prime objective of geotechnical engineering is to predict the performance of constructed facilities—with or without soil and site improvement. The profession needs to evaluate its predictive capabilities by making comparisons with records of actual field performance. Thus, new geotechnical design and construction methods may be developed and tested at these sites, addressing not only the more conventional earthwork and design problems but also environmental problems such as hazardous waste containment.

To quantify ground response and ground failure potential, geotechnical earthquake engineers badly need sites that are well-characterized and permanently instrumented to record earthquakes. The development and verification of new tools to assess site-specific liquefaction potential,

for example, require access to cohesionless soil sites where liquefaction has been observed during earthquakes and where soil characteristics are well-documented. Instrumentation of such sites could provide field records for the solution of several important problems, including the quantification of pore pressure response and deformations that develop during liquefaction. Analogous sites in clay deposits are necessary to improve our understanding of how such deposits amplify detrimental earthquake motions.

Background

In response to this recognized need, NSF awarded a grant in 1987 to the University of New Hampshire to evaluate the concept of establishing a designated national test site for geotechnical research activities. A steering committee was organized, and a workshop was planned to explore ways to facilitate the establishment of such a site. As a first step, the committee prepared a questionnaire on research interests and needs and sent it to more than 400 geotechnical engineers in universities; consulting firms; state and federal agencies; and drilling, testing, and equipment manufacturing firms. More than 200 responses were received, indicating a high degree of interest in having access to well-documented field sites. The respondents also suggested 81 different locations as potential sites.

The workshop participants met on September 26-28, 1988, at the University of New Hampshire. The 45 American and foreign geotechnical engineers were divided into five working groups prior to the workshop to start long distance deliberations on their assigned topics before the actual meeting. During the workshop, it became obvious that implementation of the workshop recommendations deserved special attention, and a sixth ad hoc working group was formed. The six working groups were:

- Site and System Management.
- Data Management.
- Implementation.
- Static In Situ and Laboratory Testing.
- Dynamic In Situ and Laboratory Testing.
- Prototype Testing and Behavior.

The workshop included both plenary sessions, in which everyone could exchange ideas, and working group meetings to develop the reports of the different groups. A key note address opened the plenary sessions and focused the group on the objectives of the workshop. This was followed by six reports on experience with large geotechnical test sites in other countries—Canada, France, Italy, Japan, Norway, and the United Kingdom.

These countries are far ahead of the United States in developing such sites, and the geotechnical profession in these countries has reaped multiple benefits from their

Site Description:

Treasure Island Naval Station (Level I)

Site I.D.: CATIFS
Location: San Francisco Bay, Calif.
Owner: U.S. Navy
Site Mgr: Mr. J. Richard Faris
Seismicity: Seismic zone: 4
Soil Types: Sand (Hydraulic Fill; 14.2 m), Med. Stiff Clay (15.2 m), M. Dense/Dense Sand (13 m), V. Stiff Clay (49.1 m)
Site Area: 0.2 ha (Fire Station #1) other locations possible
Depth to GWT: 1.5 m
Maximum Depth of Exploration: 104 m (bedrock at 91.5 m at test location)
Comments: Treasure Island is a 162 ha artificial island formed by hydraulic filling on a shoal adjacent to a large rock outcrop known as Yerba Buena Island in San Francisco Bay. The composition and consistency of the hydraulic fill varies across Treasure Island, but it is basically loose, fine to medium, silty sand with occasional clay zones. Seismologically, it is located roughly midway between the peninsula segment of the San Andreas Fault to the west and the northern segment of the Hayward Fault to the east. An earthquake of a magnitude at least 7.0 is predicted for one of these fault segments within the next 30 years, with an aggregate probability in excess of 50 percent.

This control-source spectral analysis equipment for soil profiling of subsurface conditions is measuring surface waves at the Treasure Island site.

use. The benefits include a strengthening of their position in the international geotechnical design and construction field.

The workshop participants agreed that identification and development of multiple-user sites in the United States would be most beneficial to geotechnical engineering. The survey of possible sites carried out prior to this meeting was potentially a valuable tool for experimenters in the field. Therefore, the participants recommended that it be developed into a catalog of potential sites that would identify other locations omitted from the original survey and summarize in a standardized format all available documentation for each site.

Assuming an evolutionary development of multiple-user experimentation sites, the working groups proposed a method for the eventual integration of available multiple-user sites into a U.S. system of geotechnical experimentation sites, suggested levels of data management for a corresponding nationwide data retrieval system, and recommended the minimum data base and physical requirements for sites intended to explore different problems.

Following the workshop, FHWA awarded a contract to the University of New Hampshire to develop a computerized central repository for all the data contained in the NGES catalog, plus any future data generated at the individual test sites. The cost of this project was shared by nine state departments of transportation—Iowa, Louisiana, Massachusetts, Minnesota, Nebraska, New York, Texas, Washington, and Wisconsin.

A second workshop was sponsored by NSF and FHWA at Orlando, Fla., in October 1991 to initiate the implementation of the NGES as originally envisaged at the 1988 workshop. Participants at the Orlando workshop selected a small number of sites to form the core of the national system.

The group reduced the original 81 sites to a more manageable number of 40 sites. The 40 sites had reasonably good documentation of the soil conditions and previous experimentation results, a reasonable probability of continued access for at least five years, and a soil type of sufficient interest to geotechnical researchers. An initial screening prior to the workshop identified the nine most promising candidates for the designation of national geotechnical experimentation site.

The evaluators decided that none of the sites met all of the criteria for selection and recommended establishing a national system of multiple sites according to a hierarchy of graded levels that could fluctuate as conditions changed.

Texas A&M University and Treasure Island, Calif., the two sites

Site Description:

Texas A&M University (Level I)

Site I.D.: TXAMSAND & TXAMCLAY
Location: College Station, Texas
Owner: Texas A&M University
Site Mgr: Prof. JeanLouis Briaud
Seismicity: Seismic zone: 0
Soil Types: Sand site—(SP/SP–SM) uniform, medium dense, clean to silty (13.5 m) over clay shale (16.5 m). Clay site—Highly plastic (CH), stiff (6.5 m; Clay I) to hard clay (5.7 m; Clay II) with high shrink-swell potential, over hard clay/clay shale (23 m).
Site Area: 3.2 ha
Depth to GWT: 6-7.3 m
Maximum Depth of Exploration: 30-35 m
Comments: Extensive in situ testing has been done at the sand site, as well as full-scale tests on an instrumented culvert, a ground-anchor wall, and several drilled shafts. The clay site has been used for a variety of tests on full-scale deep and shallow foundations, as well as for extensive in situ testing.

This tie-back wall (9.14 m high and 36.58 m long) at Texas A&M University was constructed and instrumented to monitor forces and displacements in the tie-back elements, soldier piles, and the face of the wall.

which came closest to meeting all of the selection criteria, were named as Level I sites. Three sites—located at the University of Houston, Northwestern University, and the University of Massachusetts—were found to have some limitation that dropped them into Level II. The remaining four finalists were designated as Level III sites, and all others were grouped in Level IV. Each site will be reviewed periodically to determine if conditions warrant upgrading to a higher level. Loss of access or other negative circumstances may also result in downgrading a site.

The Orlando workshop participants also founded a System Management Board to set policies for the use and operation of the sites and to ensure continuity, and they established positions for a system director and for individual site managers at each of the top five sites—Levels I and II—which form the central core of the system. A draft plan and suggested budget for managing the system and funding improvements to the core sites were prepared for submission to FHWA and NSF.

FHWA and NSF signed a system-support contract with the University of New Hampshire in 1992 to provide the overall management of the program and to operate and maintain the Central Data Repository. They awarded subcontracts to each of the five site owners and a part-time system director, Dr. Richard D. Woods of the University of Michigan. The board approved improvements to each site based on proposals submitted by the site managers. These improvements are currently underway.

The data base of the Central Data Repository includes graphs of representative profiles and typical plots of data for each site. Modem hookups provide remote access to individual test results and test data. This allows users to review the quality and numerical details of the results. An electronic bulletin board provides late-breaking news about various sites and programs available within the system.

The CDR is a user-friendly system shell with online computer search and data retrieval capabilities that enable geotechnical researchers to select the most appropriate site for their work. It can accommodate all essential information about each site such as generalized soil conditions, listing of all available test data, site logistics and limitations, published references, and other site information.

Conclusion

The availability of national geotechnical experimentation sites that are already well-characterized and permanently instrumented will serve to accelerate innovative research on soil behavior and foundation engineering. Future research performed at these sites will be less individually oriented, with greater documentation maintained for the benefit of other investigators.

The initial tasks of identifying appropriate sites and setting up a management program have been completed. Funding to fully define the soil properties and site conditions for each designated site has been obtained under joint sponsorship of FHWA and NSF. Other sponsors will be recruited, and a schedule of user's fees will be considered. Knowledge of the site specifics will continue to be updated in the Central Data Repository as experiments are conducted at each site and data are accumulated.

Researchers and practitioners can exchange information and ideas through the NGES system to focus their thought processes into more definable channels because they will be comparing theories and testing procedures against the same reality. This, in turn, should lead to better communication of the effects of geotechnical phenomena to the geotechnical community, thereby

University of Massachusetts—Amherst (Level II)

Piezometers are being installed at the University of Massachusetts site to monitor subsurface water levels and pressures.

Site Description:

Site I.D.: MAUMASSA

Location: Amherst, Mass.

Owner: University of Massachusetts—Amherst

Site Mgr: Prof. Alan J. Lutenegger

Seismicity: Seismic zone: 2A

Soil Types: Varved Clay—medium stiff to soft; CH, lightly overconsolidated. Upper 7.6 m are overconsolidated stiff crust. Estimated total thickness is 37 m.

Site Area: 1.2 ha

Depth to GWT: 0 to 2.5 m

Maximum Depth of Exploration: 24.5 m

Comments: The site is on a deep varved clay deposit (Connecticut Valley Varved Clay) on the University of Massachusetts, Amherst campus. A considerable body of data from field testing with a variety of tools is available, as well as a number of deep foundation tests and some laboratory data, including direct simple shear tests.

reducing the misunderstandings, inconsistencies, empiricism, and untested theories that pervade geotechnical practice today.

NGES will foster more cooperation between public agencies, universities, and private sector groups— something which has been missing from geotechnical engineering. In addition to providing a standardized base upon which to judge the results of new research, NGES will provide research sponsors like FHWA, NSF, and state highway agencies with more accountability than in the past because investigators will know that others can come to the same site and repeat the experiment.

In summary, development of well-characterized sites that are readily available to geotechnical engineering will encourage a variety of experimental activities which will lead to techniques for constructing safer and more economical structures. As an additional benefit, these improvements will make U.S. geotechnical design and construction firms more competitive in the international arena.

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Albert F. DiMillio is the geotechnology team leader in the Materials Division, Office of Engineering and Highway Operations Research and Development, at the Turner-Fairbank Highway Research Center in McLean, Va. He joined the Federal Highway Administration's Highway Engineer Training Program in 1967 after receiving a master's degree in geotechnical engineering from the University of Rhode Island. He served as an area engineer in the Indiana division office and as the regional geotechnical engineer in the Homewood, Ill., (Region 5) office before coming to TFHRC in 1975 to run the Geotechnology Research Program. In 1991, he received the American Society of Civil Engineers' James Laurie Prize, given annually to an ASCE member who has made a significant contribution to the advancement of transportation engineering. He is registered as a licensed professional engineer in

Site Description:

Northwestern University (Level II)

Site I.D.: ILNWULAK

Location: Evanston, Ill.

Owner: Northwestern University

Site Mgr: Prof. Richard J. Finno

Seismicity: Seismic zone: 1

Soil Types: Sand fill; SP, SP-SM, mostly dense to very dense, (7 m) over soft/medium clay; CL, (11.3 m) (Clay I) over stiff/very stiff clay (3.3 m) (Clay II)

Site Area: 0.2 ha **Depth to GWT:** 3-4.6 m **Maximum Depth of Exploration:** 24.4m

Comments: This site was used for the pile prediction exercise carried out in conjunction with the 1989 ASCE Foundation Engineering Congress. Field and laboratory test data are available for the Sand Fill and Clay I, as well as results of pile and pier load tests .

Researchers at Northwestern University are conducting a static load test on an instrumented pile to measure displacements and vertical load transfer from top to bottom of the pile.

Indiana. DiMillio served on the original steering committee for the establishment of the national geotechnical experimentation sites, and he currently serves as cochairman of the NGES System Management Board.

Geraldine C. Prince is a student at the Ecole Superieure de Commerce et d'Organisation in Paris, France. She was a summer intern at the Federal Highway Administration's Turner-Fairbank Highway Research Center in McLean, Va., from June to August 1993. During this time, she worked on the development of a marketing plan for the National Geotechnical Experimentation Sites Program.

University of Houston
(Level II)

At the University of Houston, a static load test is conducted on a group of nine steel pipe piles (0.3 m in diameter and 13.7 m in length); the piles, configured in a 3 by 3 square array, are fully instrumented and load tested to failure.

The piles, which are 0.3 m in diameter and embedded 12.8 m in the ground, are shown before the pile cap and load test frame were in place.

Site Description:

Site I.D.: TXHOUSTO
Location: Houston, Texas
Owner: University of Houston
Site Mgr: Prof. Michael W. O'Neill
Seismicity: Seismic zone: 0
Soil Types: Clay, (CH to CL) overconsolidated, stiff to hard, to 30 m.; similar clay deposits at ancillary site 35 km away (UH Coastal Research Center)
Site Area: 0.4 ha **Depth to GWT:** 2.1 m **Maximum Depth of Exploration:** 37 m
Comments: A number of studies of individual and group behavior of deep foundations have been carried out at this site: driven and bored piles, underreamed and straight-shafted piers. Extensive in situ and laboratory testing data are available.

The Pacific Rim TransTech Conference

A Ride Into the Future

by William Zaccagnino

More than 1,300 engineers, administrators, and leaders in the transportation industry gathered on July 25 through 28, 1993, in Seattle, Washington, for the Pacific Rim TransTech Conference. The conference, with its "Ride Into the Future" theme, was a unique opportunity for the participants, who came from 37 countries and 43 states, to exchange information on the newest and most technologically advanced solutions to the transportation challenges of the 21st century.

This was no ordinary conference. The attenders were well aware of how quickly technological change is altering existing methodologies and how our shrinking globe is encouraging—even demanding—that we adopt a more international transportation perspective.

Federal Highway Administrator Rodney Slater told participants in his keynote address, "We are already in the midst of a revolution in transportation technologies that will transform our economy and daily lives as much as the arrival of the railroad, commercial aviation, and the Interstate Highway System. Some amazing new technologies are on display—ranging from new equipment to measure bridge deck corrosion to a remotely-driven vehicle to protect maintenance crews. But these products from SHRP (Strategic Highway Research Program) are just the tip of the iceberg that DOT (Department of Transportation) is working on."

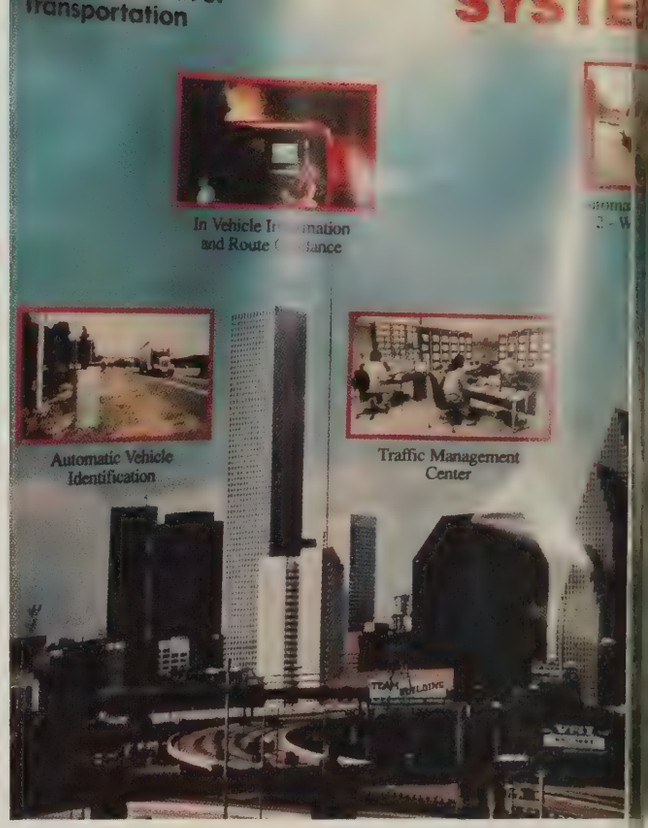
Mr. Slater described these new technologies as "the seedbeds for new industries that will create high-skilled, high-wage jobs. Clearly, the health of America's economy in the next century depends just as much on our making the right strategic investments now."

"Our country needs the vision and determination to take bold steps—some of which won't show pay-offs until the next century," Slater said. "President Clinton, Secretary Peña, and our whole Administration are committed to forming partnerships with U.S. scientists, engineers, and companies to develop and manufacture the new transportation technologies of the next century."

Dean Carlson, executive director of the Federal Highway Administration (FHWA), echoed some of Slater's remarks, and Carlson predicted dramatic changes during the next 10 years:

- Extending the life and durability of pavements will save hundreds of millions of dollars per year.
- Automatic vehicle identification will dramatically change the way we collect road user charges.
- Traffic data will be more accurate and complete.
- Serious injuries and fatalities in construction areas will be reduced.

The conference program, cosponsored by the Washington



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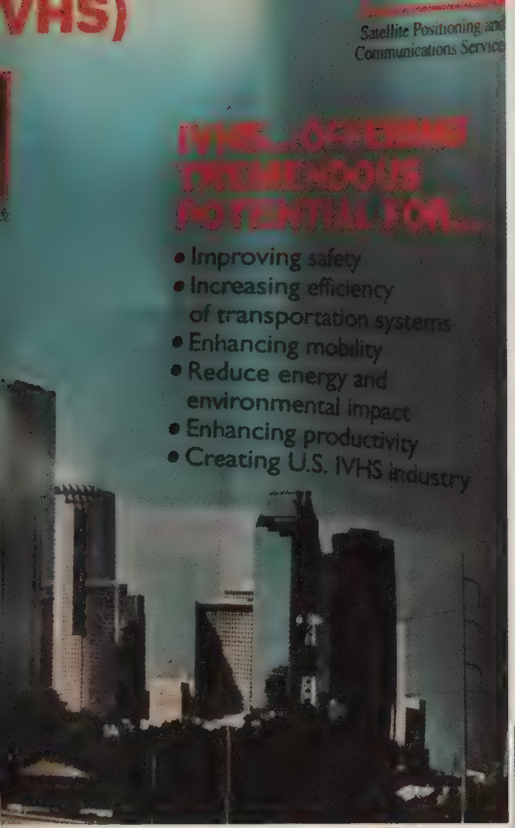
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IVHS...OFFERING TREMENDOUS POTENTIAL FOR...
• Improving safety
• Increasing efficiency of transportation systems
• Enhancing mobility
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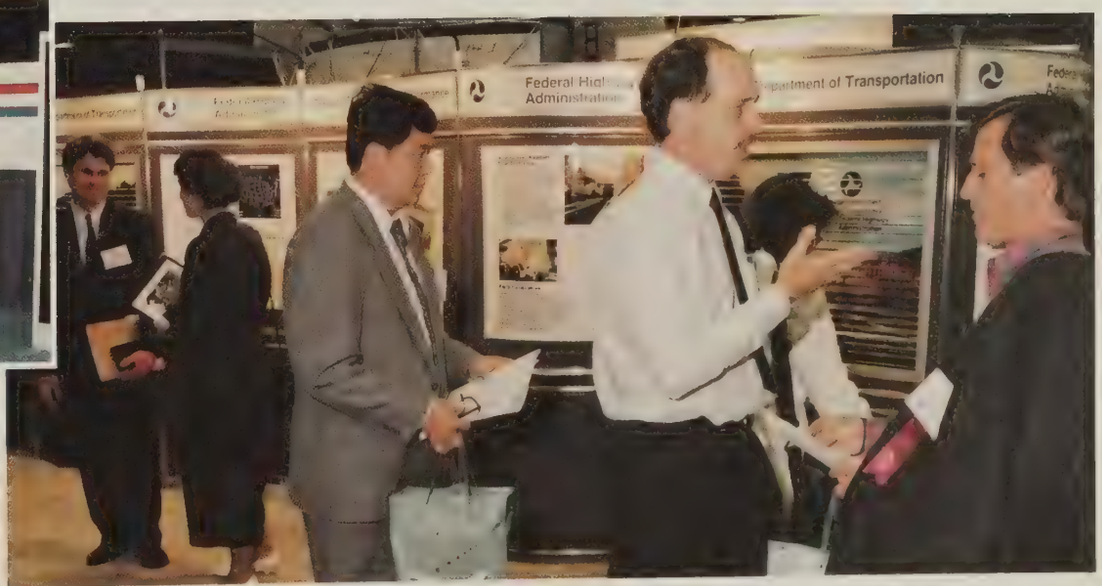
• Enhancing productivity
• Creating U.S. IVHS industry


NAY
ON
STRA
PRC
SURFACE-AIR-FLOW PERMEABILITY TEST
ATTACH VACUUM TO CONCRETE
APPLY VACUUM (BATTERY POWERED)
GAUGE READING INDICATES CONCRETE PERMEABILITY


National Highway Institute
Educational Opportunities


FEDERAL HIGHWAY ADMINISTRATION
SUPERPAVE


Federal Highway Administration
Department of Transportation

State DOT and FHWA, was divided into five concurrent tracks:

- Intermodal Ties.
- Advanced Technologies.
- Management Systems.
- Propulsion Technology.
- SHRP Products and Findings.

Participants were not limited to one track. They could attend any of the sessions, changing tracks at will.

Eight sessions in the intermodal ties track presented international perspectives on the planning, management, and operation of intermodal logistics and transportation systems. Topics included a detailed examination of the Kobe, Japan, development and the planning efforts for multimodal transportation centers in Hong Kong, Taiwan, and Los Angeles. There also were sessions on applying advanced technologies in the movement of airplane components, perishables, automobiles, and other special cargo. A study of the impact of environmental considerations on intermodal transportation rounded out the program.

The Third American Society of Civil Engineers International Conference on the Application of Advanced Technologies in Transportation Engineering (AATT-3) was held as part of the Pacific Rim TransTech Conference. The AATT-3 examined how emerging technologies in information systems, adaptive control, and telecommunications can advance the planning and operation of surface transportation systems. It emphasized state-of-the-art technology: how it can be applied, what it can achieve, when it is appropriate, and its limitations.

In the management systems track, more than 60 moderators and speakers from the Pacific Rim region and around the world discussed technology, methods, and management systems for pavements, congestion, maintenance, transit facilities, bridges, safety, and intermodalism. At one session, experts discussed new regulations and provided a futuristic look at transportation systems management in the 21st century.

Topics addressed in the propulsion technology track included high-speed ground transportation with complete programs on high-speed rail systems, new applications of high-speed rail, magnetic levitation systems, and tilt-train technology. The sessions on alternative fuels included both light duty and heavy duty applications. Light duty applications concentrated on innovations in hydrogen vehicles, fuel cell, hybrid systems technology, and electric vehicles. Heavy duty vehicles were covered with discussions of electric/battery buses, methanol-powered buses, liquefied natural gas trains and buses, and compressed natural gas buses.

The focus of the SHRP track was on SHRP's research findings that have resulted in over 130 new products, tests, specifications, devices, and methods for improving the quality of highway construction and maintenance. The conference provided an ideal opportunity for FHWA to showcase and demonstrate a wide variety of SHRP products. Speakers at the SHRP plenary session stressed the importance of integrating the new SHRP products and processes, and they discussed the role FHWA, states, and the private sector play in the implementation process.

Also exhibited were a wide variety of products and the services of more than 60 companies from Canada, Hong Kong, the United Kingdom, and the United States.

At the conference's closing luncheon, John Naisbitt, author of *Megatrends* and co-author of *Reinventing the Corporation* and *Megatrends 2000*, spoke about the global trends affecting all transportation systems.

Proceedings of the conference are available for $35, plus shipping. The two-volume set may be ordered from Bill Carr, conference administrator, at the Washington State DOT—telephone 206-705-7802; fax 206-705-6823. Most of the papers presented at the conference are included.

Cassette tapes made from the conference sessions may be purchased from Tree Farm Communications, 23703 N.E. 4th St., Redmond, Wash. 98053—telephone 206-868-0464.

William Zaccagnino is the chief of the Technology Support Branch, Office of Technology Applications, of the Federal Highway Administration. He has served as a writer-editor and transportation assistant with FHWA's Office of Research and Development and Office of Engineering during his 19-year career with the agency.

Changeable Message Signs:

Avoiding Design and Procurement Pitfalls

by Pamela P. Marston

This is a portable reflective disk CMS illuminated from within by fluorescent bulbs.

Traffic control devices, particularly signs, located along the roadway are the backbone of the traveler information system. The use of changeable message signs (CMS), which display real-time information to motorists, has assisted in efforts to improve roadway operations and safety of existing facilities. Even though the use of CMS is common on today's roadways, there are problems that prevent the optimal use of changeable message equipment. Some of the difficulties that currently exist with the procurement and implementation of CMS are due to several major issues including: inadequate specifications, insufficient definition of protocols, low bid acceptance practices, and no industry standards. This article describes the various CMS technologies and their uses, explains some of the challenges inherent with their use, and recommends solutions to the problems.

Sign Technology

Some of the more common uses of CMS include traffic warning, regulation, routing, and management. The real-time information displays assist in modifying the behavior of the driver and thereby improve the traffic flow for all motorists. CMS, as well as other types of real-time motorist information sources, can be used to address traffic developments in five operational categories: *(1)*

- Recurring problems—particularly peak-period congestion that lasts for short periods of time.
- Nonrecurrent problems—traffic from random or unforeseeable incidents such as accidents or maintenance activities.
- Environmental problems—traffic prompted by acts of nature like ice, snow, fog, rain.
- Special event traffic—traffic from events such as parades, sporting events, concerts.
- Special operational problems—traffic from highway features such as reversible, high-occupancy vehicle, exclusive, or contraflow lanes and even draw bridges, tunnels, weigh stations, airports, and toll facilities.

Traffic problems resulting from the above conditions can be significantly reduced with the use of real-time information displays like CMS. Depending upon the needs of the public agency, CMS can be either permanently located or transported to various locations.

Although there are many types of CMS on the market, they can be categorized into three different groups: light-reflecting, light-emitting, and hybrid. Briefly, light-reflecting signs reflect light received from an external source such as headlights, the sun, or illuminators. Light-emitting signs create light, either on or behind the viewing surface, with lamps located within the sign housing. Some sign suppliers have combined characteristics of both reflective and emitting technologies to create hybrid signs. *(1)*

The most common types of CMS use fiber optics, light-emitting diodes, reflective disks, or a combination of these technologies. The fiber-optic (F-O) sign uses light radiated from a halogen lamp located within the sign casing. The

light is sent through polished glass fibers and directed to the sign face. On the sign face, each F-O light guide appears as a point of light. These points of light are arranged in a matrix structure and are adjusted in size. Color filters can create almost any color sign. Messages are either flashing or static, but they are displayed only when the internal light source is turned on. Messages on the fixed-grid matrix can be either symbols—within limits—or words and can be changed almost instantaneously. *(1)* An example of a fixed-grid matrix sign is a sign that indicates whether a lane or a toll booth is open or closed to traffic.

F-O signs can also be made with tiny shutters that cover the ends of the light guides. In this sign configuration, F-O light guides are arranged in a pixel. These pixels, which are normally one inch square and contain two or three F-O light guides, are typically grouped in a five by seven array creating a character module. The character modules display the letters that constitute messages to the drivers. In a typical configuration, if there are three shuttered light guides, two of the shutters are open and lit when needed in a message. The third shuttered light guide serves as a backup and stays closed at all times, unless one of the other two shutters malfunctions and does not open. The pixels, although most commonly found in a five by seven array, can be arranged in matrices of varying heights. Symbols are harder to create with this type of shuttered F-O configuration, but word messages can be created easily and changed immediately. *(1)*

The light-emitting diode (LED) clustered matrix is a grouping of solid state devices that glow when voltage is applied. Very little power is needed to use an LED. However, because of the limited brightness and small sizes of the LEDs, many must be used to produce an effective message. Since LEDs are low voltage, they need high currents to illuminate them. A problem with the LEDs is that the intensity of light tends to decrease over time because of material deterioration and constant high temperatures. Therefore, LED clusters must be well-ventilated to prevent losing color brightness. *(1)* LEDs are most commonly found in green, red, and amber hues; white, which contrasts the best with a black background, is not available.

Reflective disk CMS use disks—circular, rectangular, and three-dimensional—made of a reflective color, usually yellow, on a dark background. The disks are permanently magnetized, pivoted, and arranged in an array so that when an electromagnet is used to flip the disk, a message is shown. Reflective disks can be internally illuminated—for example, fluorescent lights within the sign housing—or externally illuminated by the sun, headlights, or bottom-mounted lighting. If the sign is internally lit, then power is necessary whenever a message is displayed. If the sign is not light-emitting, then power is only needed when the disks are rotated or flipped.

The hybrid CMS incorporate either LED or F-O with reflective disks. In this sign technology, the reflective disk, which is black on one side and yellow—or similar contrasting color—on the other side, is used as a shutter for a light source, typically LED or F-O. When the shutter is "on," the yellow side of the reflective disk and the light emitter can be seen. When the shutter is "off," the light emitter is covered by the disk, and the black side of the disk is seen. The hybrid signs require less light from the emitter, as they are not attempting to overcome the power of the sun. The reflectors are given more visibility with the incorporation of the LED/F-O, while still reflecting the sun, headlights, or internal illumination.

Issues Concerning Optimal CMS Use

Specifications

Properly written specifications can be a safeguard for a public agency to ensure quality equipment is being purchased and used. Agencies can assure that they get the proper equipment out in the field by moving away from "cookbook" or generic specifications to a more performance-oriented document which properly reflects the transportation agency's goals and objectives. Many specification documents are concerned with how a product is made and what it looks like; they convey little interest in the product's performance. *(2)*

Agencies sometimes write general specifications, particularly for electronic equipment, because they lack knowledge of the most recent developments in rapidly developing technologies. Often the state or local agency writes the specification so generally that any CMS product or technology is applicable. If the specification is too generic, the agency may obtain inappropriate equipment that nevertheless meets the specified requirements.

Some public agencies write very general specifications because of concern about unintentional sole sourcing. United States Code Title 23, Section 112(b)(1), requires the states to foster competition in bids when federal money is involved; however, the law does allow sole-source procurement in emergencies and when it is in the best interest of the public.

If the agency obtains "low performance" equipment, who is responsible for the low quality? It is not the contractor who fulfilled all the specified requirements. Inevitably, the transportation agency that used inadequate specifications is responsible.

The problems with CMS specifications can also be evident in the way a prime contractor purchases signs for a project. The contractor's duties include the purchase and installation of the CMS. This is typical of the "all-or-nothing" approach to contract awards. Consequently, a prime contractor, who may not fully understand the public agency's present system and may know even less than the state or local agency about CMS technology, is responsible for finding signs to fulfill the contract. If the agency does not provide good CMS specifications, the contractor alone determines what is required, and the contractor is free to select the least expensive option without regard to quality. As a result, the public agency may end up with low-quality equipment.

Since the practice of contractor-purchased CMS is price driven, the

public agency needs to remove the incentive for purchasing low-quality equipment. Three suggestions that will help to assure the purchase of high-quality equipment are:

- Give to the contractor a set of specifications that is performance-oriented with strict selection criteria.
- Purchase a large number of CMS that meets the agency's specifications and give them to the prime contractors to be installed on the roads as needed.
- Require the prime contractor to pre-qualify vendors and to select a supplier with experience.

Low bidding

Low-bid acceptance combined with poorly defined specifications contributes to low-quality equipment purchased by transportation agencies. United States Code Title 23, Section 112(b)(1), states that, in projects using federal monies, a public agency shall award contracts through competitive bidding, unless the agency demonstrates a more cost-effective method of bidding or an emergency exists. The law goes on to state that the contract will be awarded to the lowest bidder that successfully meets the bidding criteria established in the bid announcement.

The public agency can use this federal regulation to its advantage by adopting criteria that bring in quality products. One method to accomplish this goal is to accept the lowest adjusted bid. With this strategy, in the bid submitted to the agency, a supplier would include a life-cycle costing analysis that would extend through the life of the project, including estimates for maintenance and operation for the duration of the contract period. All bids must be presented in a similar format so that they can be compared fairly. The agency can incorporate the life-cycle costing without sacrificing competition, as this type of bidding does not exclude anyone from the process.

The most important factor in using life-cycle costing, or any other bid practice, is that everything must be spelled out explicitly in the state or local agency's bid announcement and specifications. This is especially true for the criteria by which all the bidders will be evaluated. Then competitive low bidding can actually help the agency.

Standard protocols

One of the biggest problems associated with the use of CMS is the need for standard protocols for communications and software. In this case, protocol refers to "a set of conventions, or rules, on the format and content of messages transmitted between devices." *(3)* When a CMS is purchased by a state or local agency, it often comes with its own communications package. At one time, the need for a total package of sign, controller, and communications may have been necessary, but with the advances in electronics, standard communications and software equipment has been developed to make CMS systems much more efficient.

CMS suppliers often dictate the communications aspect of CMS systems to the public agency. Frequently, when an agency buys a sign, it must change its communications network to fit the sign and controller. This works to the advantage of the supplier because the agency now has a system that will only communicate with that supplier's brand of sign.

The transportation agency should specify the communications protocols and have the sign suppliers adhere to the agency's requirements, instead of the other way around. It is very important for the agency to be able to communicate with any sign, or groups of signs, at any given time. If signs from different suppliers cannot communicate readily with each other or the agency, then a serious problem exists.

To address this problem, the public agency should include in the CMS specification package a standard or open protocol. There are two ways to create a functional system. The first way is to accept multiple proprietary sign-driver software that communicates with the agency on standard communication equipment. The other way is to implement a central software package to be used by the agency and understood by all signs within the system regardless of the supplier.

This shuttered fiber-optic CMS is used to regulate traffic.

If the public agency is willing to maintain control over the individual proprietary software packages needed to drive the signs, the key is to have a standard interface. For example, a standard interface could be modems communicating over voice-grade lines using industry standard protocols. The controller of the CMS would receive the data from the traffic management center (TMC) and transfer it to the sign. If the TMC should purchase another CMS from any supplier, the TMC could just plug into the new sign's controller and send data with the same type of modem and phone lines. However, should the number of controlling software packages get large, the agency may need a significant amount of time and equipment to sustain the CMS network.

If the system is to use central software designated by the purchasing agency, then the issue must be addressed explicitly in the specification. For a company to be able to bid on this type of system, the public agency must provide the format in which the data must be transmitted within the communications system. The development of a central software package could be time-consuming and expensive, but the ability to control the CMS network regardless of the number of signs or suppliers could be a significant benefit to the agency.

It must be noted that using a central software package and requiring the sign suppliers to adhere to it may prevent the suppliers from adding extras—such as failure detection, multiple colors, or animation—to the sign system.

If a state or local agency has standard equipment—voice-grade lines, modems, central computing facilities—the sign supplier would be responsible for making the sign tie into the existing system. Having this standard equipment, the agency could concentrate on the sign's ability to accept the data on the communications system, make a visual display of it, and test its reliability. Having open protocols will allow the agency to use various suppliers and technologies within its system because integration and installation will be uncomplicated.

Another concern may be that a transportation agency does not have the expertise—hardware, software, or computer engineers—to control the protocols or communication systems. The agency needs to include a communications specialist on staff or to have a private firm develop the communications network. The consultant may also administer the network under an open-ended maintenance agreement and/or teach the public agency employees the system.

This is an example of a portable reflective CMS for traffic control.

Cost should not be a factor for either the public agency or the supplier in adopting more advanced computer technology. Electronic equipment is decreasing in cost, while increasing in capability. Also, adopting standards would save money for the agency because CMS installation would become routine and not every job would need to be customized. *(4)*

Warranties/guarantees

One concern with any CMS equipment is maintenance on the controller and sign. The supplier can provide warranties or guarantees for its product and services over time as specified in the contract. Although some suppliers may not like this arrangement, providing guarantees helps a company in the long run by supporting the perception that the company is reliable and confident in its quality. The use of guarantees is very common in Europe, particularly in roadway design and construction.

Although a guarantee seems to be a quick and easy solution, it can be complicated. Most importantly, the limits of the guarantee must be explicitly clear to all parties involved. Defining the criteria and exactly what is covered in the guarantee—for instance, system hardware, software, performance, sign access, and traffic control responsibilities—is vital to protect the interests of both the public agency and the supplier. Another issue is the question of proprietary information if the supplier is not available to work on a piece of failed equipment and someone else must perform the maintenance.

Independent testing, bonds, performance references, and just-in-time delivery

There are several other methods to ensure that quality products are being used on the American roadways. Some of these techniques include independent laboratory testing, multiyear maintenance contracts with bonds and/or liquidated damages, and performance references.

In several European countries, products are tested in government-approved laboratory facilities. For example, a potential CMS supplier to the French government must

This CMS combines a static guide sign wth reflective technology.

This shows a reflective flip disk CMS with full graphics capabilities.

provide a typical sign. After rigorous testing by a French laboratory, a certificate of quality is issued to the supplier. Only companies with certificates are allowed to bid on projects offered by the French government. Needless to say, this pre-qualification system protects the French government from receiving low-quality equipment that is unfamiliar. *(5)*

A system of independent lab testing may work in the United States if groups of states could agree on the specifics. For example, states in regions with similar characteristics, such as weather and topography, could jointly fund tests to make them cost-effective to all the agencies involved. Quality testing is not new to this country or even to traffic control devices; testing has been successfully done for pavement markings and signing. However, the testing facilities and procedures must be flexible so that newly developed, more advanced products are not excluded.

Combining multiyear maintenance contracts with surety bonds is a way that public agencies can make sure that the signs in the field are serviced for the duration of contract. Surety bonds are normally issued for the installation of the signs, but surety bonds could also be used to ensure that signs will be maintained for a specified length of time. Liquidated damages can be assessed against the CMS supplier if the maintenance agreement is not fulfilled. If maintenance payments are made on a yearly or as-needed basis, the penalties can be deductions from payments. If the maintenance portion has been pre-paid, then liquidated damages backed by a surety bond provides an easy means of collection. Once again, all the details concerning the duration of the maintenance contract and the surety bond must be clearly stated in the bid documents, specifications, and contract. The bonding company must be kept advised of any contract changes or concerns to ensure coverage.

Performance references can be essentially defined as a supplier's resume. These types of references are provided by the supplier and can include information such as: where its CMS have been deployed, how long the signs have been in use, and to whom at the organization using them questions should be directed. One significant issue concerning past performance requirements is that small or new firms may find it very hard to break into an existing market and bid on projects since they may not have any references for deployed equipment.

"Just-in-time delivery" means that the supplier provides the sign just prior to installation. This method, especially for large purchases, has several advantages. First, the transportation agency can save considerable costs because it is not necessary to provide storage facilities for signs waiting to be deployed. Second, the signs will not be damaged by transport or storage while waiting to be used. Third, quality control is better maintained because the supplier is not pressured to produce many signs at once.

Arizona Example

The Arizona Department of Transportation provides a good example of the way that a transportation agency can approach CMS. In 1992, ADOT bid for 19 CMS to be installed and tied into the Freeway Management System. The bid requested light-emitting F-O, LED, or F-O enhanced flip disk (hybrid) technologies which were able to run through a telecommunications system. ADOT also required from every potential supplier a declaration of guaranteed parts and an independent laboratory certification of acceptability of color output, environmental condition adequacy, line transients and of rated lives for character modules, halogen lamps, LEDs, sign control units, and communications units. ADOT also requested that the proposal include at least three customer references of installed, outdoor CMS meeting specific criteria.

ADOT requested that the potential suppliers provide a guaranteed life-cycle cost on the equipment for the 10-year life of the project. The life-cycle costing would include the cost of the signs, a yearly guaranteed electrical cost, and an annual guaranteed maximum repair cost.

The electrical and repair guarantee was a unique way to control ADOT's cost of ownership during the project. For the electrical guarantee, the potential supplier had to estimate the total cost of operating one sign for eight hours a day, on various settings, at a fixed cost per kilowatt-hour. This quantity would then be multiplied by 365 to estimate the yearly cost of operation. When ADOT receives the signs, it will randomly select signs to be similarly tested, and similar calculations for yearly cost will be done. If there is a discrepancy between the ADOT estimate of total operating cost and the supplier's estimate, then the difference will be multiplied by 10 (10-year project life). This amount will then be subtracted from the amount paid to the supplier for each sign. If the ADOT estimate for electrical cost should come in under that of the supplier, then no monies will be withheld, but none will be awarded either. For guaranteed yearly maintenance, if the cost of maintenance, including traffic control costs, should exceed the maximum, then the supplier is responsible for paying the excess regardless of who performs the maintenance—ADOT, supplier, or private firm. *(6)*

Ongoing Research

There are several ongoing research projects concerning CMS. The Texas Transportation Institute is completing a synthesis of practice as related to CMS. This project of the National Cooperative Highway Research Program includes information on technical standards, procurement and operational practices, maintenance experiences, and measures of performance.

The Turner-Fairbank Highway Research Center and The Last Resource have combined efforts to work on CMS visibility and photometry. The research includes field studies of inservice CMS and laboratory studies on luminance, visibility, color, contrast, fonts, and other variables.

The Virginia Transportation Research Council is assessing the uses of CMS on the roadways of Virginia. They are considering flash rates, information limitations, utility versus traffic conditions, and operational parameters.

Conclusions and Recommendations

The key to producing a specification that addresses the needs of the public agency without compromising any one company or technology lies in creating a performance-based specification considering the agency's goals and objectives. This type of document concentrates on performance and life-cycle costs and frees the public agency to spend more time developing the evaluation criteria and the final selection process. The competitive bidding process can be maintained even with the development of detailed specifications. The agency can specify one particular technology if there is more than one supplier or if there is justification for one technology because it meets the agency's best interest. The agency is responsible for the justification of the final choice. The agency can use economic engineering principles as stated in the bid document to support the technical selection. By implementing several improvements to the present system, a win-win situation for the supplier and the agency can occur.

Table 1 reflects some aspects that a transportation agency may consider when developing a specification. A specification document is unique and must be written to address the individual needs of an agency. Although specifications from different agencies can be similar, the detail must be specific to the user. Some of the major functional areas that may be considered include communication, maintenance, operations, testing, cost, and quality assurance. These areas are fairly broad, and as can be seen by Table 1, there are many different practices and aspects that may be selected. In any event, it is unacceptable for an agency to get a sample protocol from a supplier, change it, and hope that the equipment can be made to work properly. This way of preparing specifications is very unreliable and can leave the agency with a document that can only be satisfied by the supplier who developed the original paper. The agency must take the initiative by providing CMS suppliers with documents explaining specific, required functions, thus receiving appropriate and reliable CMS equipment for the field. If possible, it should also provide for the supplier an opportunity to exceed the specifications.

By adopting standards and common protocols throughout the system, the state or local agency may be able to take advantage of the extras that a supplier may incorporate into CMS.

Standards developed by the CMS manufacturing industry would be applicable to all suppliers regardless of technology. If the sign suppliers take responsibility for producing their own industrywide standards, then each technology can expect accurate representation. Also, if the CMS manufacturing companies work together to develop their own standards, as opposed to waiting for a government-developed document, the result would likely be more amenable to the CMS manufacturing community.

It should be the responsibility of the supplier to build the CMS to interface with the TMC; the TMC

Table 1.—Key aspects when specifying changeable message signs

Functions	Practices	Aspects to Consider
Communication	• Fiber-optic cable • Twisted wire pair • Cellular • Radio • Coaxial cable	• Common interfaces • Data rates and formats • Frequency of communication • Control software • Terrain and environment
Maintenance	• Supplier provided • Contractor provided • Inhouse·	• Bonding • Response time • Sign & software access • Proprietary information • Start of maintenance period
Operations	• Functional specifications • User interfaces	• Message failure rates • Legibility • Message verification • Ease of use • Graphics and/or text • Color and font
Testing	• Inhouse • Independent (labs) • Certification acceptance • Contractor field tests·	• Acceptance criteria • Environmental criteria • Certificates • Approved listing
Cost	• Life-cycle • Just-in-time delivery	• Initial capital costs • Lifetime electrical cost • Lifetime maintenance cost • Storage of signs • Transportation of signs
Quality Assurance	• Pre-qualifications • Post-qualifications • Approved bidders list • Warranties • Guarantees·	• Past performance • Bonding of equipment • Deployed signs • Company history

should not have to change its system just to communicate with one sign. For example, in the personal computer industry, any printer can work with any computer system because of a standard printer interface. Perhaps the CMS industry should follow the lead established by the personal computer industry and adopt similar standards and protocols. Open protocols will allow projects to be accessible to more suppliers, and the agency should be confident of receiving quality equipment for field use and be assured that many vendors can supply replacements when needed.

Given the choice of either buying a group of portable or permanent CMS to be given to prime contractors on an as-needed basis or giving the prime contracting company specifications and having it choose the signs, the public agency should purchase its own signs. By purchasing the signs in bulk and

giving them to the contractor to be installed as necessary, the agency can be sure of equipment quality and can also motivate the supplier to provide high-quality products if the initial contract is written to provide for the possible purchase of additional signs in the future. More importantly, the agency can be sure that all the signs in the system are compatible. Once the contract is awarded, the agency need only provide the signs and support personnel to the contractor during installation.

Since there is no appropriate test bed for CMS, public agencies, with the assistance of the American Association of State Highway and Transportation Officials or the American Society for Testing and Materials, could jointly establish a location for testing CMS equipment. A national laboratory facility could provide a central site that is already established for research purposes. CMS sent to this lab would be tested for minimum standards and issued a certificate of acceptance. The certificates could be presented in bid documents if required by an agency. The testing must be impartial; neither the national lab nor any participating organization would endorse any one technology or supplier.

One way a public agency can use prior performance requirements in its specifications package is to either pre-qualify or post-qualify the bidders. If the agency decides to do this, it must be sound in the justification of the final choice.

Pre-qualification refers to the process by which only qualified suppliers are invited to submit bids. The Federal Highway Administration does not have any rules regarding pre-qualification of prime contractors or subcontractors as this has always been at each state and local agency's discretion. If the agency does decide to use pre-qualifications in its project, care must be taken not to exclude any company or technologies without well-founded justification.

For post-qualification, all companies are invited to bid for a project and the company's references are submitted with its bid documents. When the agency begins the final selection process, references will be considered.

There are various types of CMS, each with its own strengths and weaknesses depending upon its application. It is the transportation agency's responsibility to develop the proper specifications so that quality equipment is installed in the system. Guarantees, warranties, performance/liquidated damages bonds, and independent testing and certification can be successful tools in helping the agency acquire and maintain an efficient and safe CMS network, avoiding the design and procurement pitfalls associated with CMS.

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ALONG THE ROAD

"Along the Road" is a hodgepodge of items of general interest to the highway community. But this is more than a miscellaneous section; "Along the Road" is the place to look for information about current and upcoming activities, developments, and trends. This information comes from Federal Highway Administration sources unless otherwise indicated. Your suggestions and input are welcome. Let's meet along the road.

FHWA Selects Electronic Recordkeeping Pilots

The Federal Highway Administration recently announced the selection of 10 electronic recordkeeping pilots. One such pilot will include electronic storage of highway project records with potential access from remote project sites.

Federal Funds Will Be Used to Evaluate San Antonio ATMS

On August 9, the Intelligent Vehicle-Highway Systems Partnership Agreement was executed for the San Antonio IVHS Operational Test. Nearly $900,000 in federal IVHS funds will be used to evaluate the Advanced Traffic Management System currently under construction.

Virginia Uses STP Funds for Transit

The Virginia Department of Transportation has taken action to use some of its Surface Transportation Program funds for transit purposes. Approximately $12.6 million, or about 30 percent of the STP flexible funds, are being used to provide statewide transit aid, consisting primarily of capital assistance to various recipients. While VDOT has in previous years used Congestion Mitigation and Air Quality Program funds for transit, this is its first use of traditional highway funding for this purpose.

Harrisburg Begins Handicap Accessibility Project

Construction is underway in Harrisburg, Pa., to install a downtown network of audible, pedestrian crossing signals; detectable warning intersection cutaways; and several dozen curb cuts in Riverfront Park along the Susquehanna River. Harrisburg intends to be the most accessible city in the state.

The state-of-the-art, audible, crosswalk signals were sponsored by several community service groups and private contributors. The signals, which will be installed at six intersections, emit a continuous, low-volume, chirping sound that changes pitch and timing when it is permissible to cross a street. The signals increase in loudness as the level of traffic and nearby noises increase.

In addition to the curb cuts in Riverside Park, more than 450 cuts will be made downtown, and another 500 cuts in various parts of the city will be made as streets are repaved.

Caltrans Is Developing a Smart Traveler Information System

The California Department of Transportation plans to introduce a Smart Traveler Information System to the public in November. The system, developed with the help of Federal Highway Administration rideshare funding, gathers up-to-the-minute information provided by transit operators, rideshare contractors, and more than 1000 detector loops embedded in the freeways of Los Angeles County. This information is then used by "Smart Traveler" to provide users with transit schedules and fare information, lists of potential rideshare partners, and freeway traffic conditions. The goals is for users to be able to receive accurate commuter-related information from multiple sources, including multimedia computer touch-screen kiosks, audiotext accessible with a touch-tone telephone, and personal computers.

New Hampshire Responds to Covered-Bridge Fires

Fires have recently destroyed covered bridges in Swanzey, Plymouth, and Newport, N.H. As a result, the state fire marshal gathered a task force of experts on July 7, 1993, to address the vulnerability of these historically important bridges. The task force included firefighters, municipal administrators, law enforcement officials, historians, economic development specialists, bridge designers and builders, transportation experts, and representatives of the governor's office. They developed an action plan that included deterrent and prevention strategies. Some of the elements of the plan are a public awareness campaign using multiple media to reach school children and adults; a neighborhood watch-type surveillance effort; local fire department contingency plans; an increase in the punishment for arson of a covered bridge; and protection systems such as automatic alarms, fire-retardant coatings, and sprinkler systems.

Several covered bridges in New Hampshire like this one over the Swift River have been destroyed recently by fire.

Florida Monitors Exposure to Asphalt Mixture Fumes

The Florida Department of Transportation conducted an experimental project to monitor worker exposure levels to fumes from an asphalt mixture modified with asphalt rubber. Emissions and fumes were monitored at three locations—the asphalt terminal, the asphalt plant, and the paving operation. The final analysis of the data did not indicate a problem with exposure levels.

Many Texas DOT Officials Retire in September

The Texas State Legislature enacted a retirement incentive for all state employees retiring by September 30, 1993. The Texas Department of Transportation estimates that 60 to 70 percent of the 2,200 eligible employees in DOT will retire. As of late July, 23 of the top 50 executives in DOT announced their retirement effective September 30. This includes the executive director, deputy executive director, all four associate executive directors, seven division directors, and 10 state district engineers. In the wake of the retirements, Executive Director-Designate William G. Burnett proposed a new organizational structure, effective October 1, for Texas DOT headquarters.

Pacific Rim Conference Held in Seattle

The Federal Highway Administration and the Washington Department of Transportation co-sponsored the Pacific Rim TransTech Conference in Seattle on July 25-28. More than 1,300 engineers, administrators, and leaders in the transportation industry, representing 37 countries and 43 U.S. states, exchanged information on the most technologically advanced solutions to the transportation challenges of the 21st century.

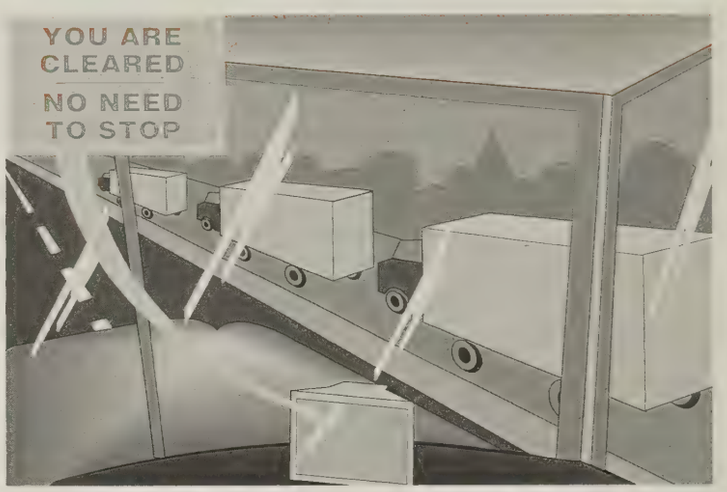
Minnesota Law Promotes Public-Private Partnership for Toll Roads

A new law in Minnesota provides for agreements between highway authorities and private companies/groups "for the development, financing, design, construction, improvement, rehabilitation, ownership, and operation of a toll facility." Development agreements must be approved by the commissioner of the Minnesota Department of Tranportation, and the Twin Cities metropolitan council must also approve developments in the Twin Cities Metro Area. Any county board or municipal council through which a toll facility passes may veto the project within 30 days of approval by the MnDOT commissioner.

The new enabling legislation provides two types of financial/ownership arrangements. One is known as a "build-operate-transfer" (BOT). Under this arrangement, the private company builds and operates the facility and, at the end of a pre-determined period, transfers ownership to the appropriate road authority. The other type is "build-transfer-operate" (BTO). Under BTO, the private company builds the facility and transfers ownership to the road authority prior to the commencement of operations, but the private company operates the facility under the terms of a lease, management agreement, or toll concession agreement with the road authority.

First "Privatization" Project in California Begins Construction

On July 26, ground was broken for four new express lanes in the median of state Route 91 from the Riverside, Calif., county line to state Route 55 in Orange County. This is the first of the California Assembly Bill 680 "privatization" projects to go to construction. It will feature an electronic toll collection system, allowing drivers to pay tolls at freeway speeds with credit card-sized transponders. Free access to toll lanes will be provided to vehicles with three or more occupants, and free or discounted access will be given to zero-emission vehicles and to drivers who are disabled veterans or handicapped.



California and Florida are among the the states testing automatic, electronic toll collections systems.

Florida Also Testing Electronic Toll Collection

The Florida Turnpike Office has conducted extensive analyses and field testing to evaluate components of electronic toll and traffic monitoring technology. An automatic toll collection system is being evaluated under the turnpike's Sun PassTM program. Sun PassTM vehicles are equipped with invehicle transponder units that communicate with toll plaza sensors and provide electronic toll collection. This technology provides increased highway capacity by allowing vehicles to pass through the toll facilities more quickly.

Rule on Roadside Barriers Is Published

The final rule implementing Section 1073 of the Intermodal Surface Transportation Act of 1991, pertaining to roadside barriers, was published in the *Federal Register* on July 16. The rule provides for an enhanced level of crashworthiness of roadside barriers and other safety appurtenances to accommodate vans, minivans, pickup trucks, and four-wheel drive vehicles.

New York Can Implement a Low-Emission Vehicles Program

In July, a federal judge reversed his previous ruling and said that the state of New York may require additional pollution-reduction equipment and longer warranties on that equipment on all cars and light trucks beginning with the 1995 model year. The judge had previously ruled that New York's low-emission vehicles strategy violated the Clean Air Act by requiring a "third type of vehicle" without simultaneously authorizing cleaner burning fuel; automakers had argued that they would be forced to develop a new pollution control system for New York's high-sulfur fuels and, hence, a third type of vehicle. In the July ruling, the judge said that he is not agreeing with the state's position, but he decided it was wrong to rule on the

issue without a trial. The American Automobile Manufacturers Association is expected to seek an early resolution of this issue. The use of low-emission vehicles to achieve emission reduction is the centerpiece of the state's strategy to attain the air quality standards. The judge also ruled that New York may not order the sale of electric cars.

Motor Carriers Office Enters Into a Cooperative Agreement to Develop Technologies

The Federal Highway Administration's Office of Motor Carriers and the Commercial Vehicle Safety Alliance have entered into a cooperative agreement to provide research, technical assistance, planning, and marketing support for FHWA's development of commercial vehicle operations/intelligent vehicle-highway systems technologies. FHWA will provide two full-time staff members and administrative support for the staff to CVSA for two years. By autumn, CVSA will select from a list of candidates with broad experience in current CVO safety program activities.

Louisiana Develops an Intermodal Transportation Master Plan

The Louisiana Department of Transportation and Development is developing an intermodal transportation master plan, which can be used as a prototype for other states. In support of this effort, the Louisiana Intermodal Transportation Conference was held in New Orleans on July 19-20.

New York DOT Uses Defense Technology

One of the most highly specialized defense research organizations will assist the New York Department of Transportation in efforts to pinpoint the cause of a failure of a major pipe culvert. The pipe had been inspected a short time prior to its collapse without any sign of a problem. Scientists from the Watervliet Arsenal's Benet Laboratory will analyze the pipe metallurgy and environmental factors in a forensic engineering attempt to identify the cause of the unexpected failure. The results may lead to improvements in inspection techniques and procedures. This transfer of technology from national defense to transportation is a first in New York.

FHWA Streamlines Bridge Design Process in New Jersey

The New Jersey Division of the Federal Highway Administration is on track in a pilot project to reduce the bridge design process for off-system bridges from the usual four or five years to one year. The standard practice, managed by counties, normally requires four different design plan submittals, separate right-of-way and utility reviews, and the normal coordinating process. On July 9, FHWA, New Jersey Department of Transportation, and the County Engineers Bridge Committee met to finalize a cooperative approach. FHWA and NJDOT developed a certification procedure for the counties to use. The state will specify loading, width, American Association of State Highway and Transportation Officials (AASHTO) specifications, and an appropriate bridge rail system and will require local certification of materials. Several, formerly built-in delays have been eliminated, and a federal/state/county engineer working group has been formed to work out the details.

Seat Belts Save Lives

After finding out that 90 percent of people killed in traffic accidents in Florida during the Memorial Day weekend were not wearing safety belts, the Florida Highway Patrol started a three-week information/enforcement blitz, leading up to the 4th of July weekend, about the benefits of using safety belts.

4th of July Was a Relatively Safe Holiday

Several states reported fewer traffic fatalities during the 1993 Independence Day weekend than during this holiday period last year. The four highway-related fatalities in South Carolina were the fewest ever in that state for the 4th of July weekend. The states credit advance media attention to highway safety and increased visibility of the highway patrol with saving lives during the holiday.

North Carolina to Add More Median Barrier Rails

The North Carolina Department of Transportation recently completed a comprehensive study of cross-median accidents from April 1, 1988, to October 31, 1991, on interstate highways in the state. These accidents, in which a vehicle crossed the median and entered an opposing traffic lane, caused 32.2 percent of the fatalities on interstates in North Carolina. Based on this study, median barrier rail will be added to 24 sections of interstate highways.

Rules Proposed to Control Heavy Truck Combinations

On July 13, the Federal Highway Administration proposed regulations to extend the life of highways by reducing the number of overweight motor vehicles transporting containers or trailers. The regulations would require parties who initiate the transfer of intermodal containers—those using at least two different means of surface transportation such as trains and trucks—to provide written certification of the gross cargo weight and a reasonable description of the contents. The proposed rule is designed to discourage motor carriers from transporting loads that are overweight under applicable state law.

Grand Jury Indicts Eight in Largest Fuel Tax Evasion Case

On June 30, a federal grand jury in New York indicted eight individuals for allegedly evading $85 million in federal gas tax on 946 million gallons of gasoline between 1983 and 1988. This is the largest federal fuel tax evasion case ever brought by the Department of Justice and brings the total evasion alleged in several indictments in the past six months in New York, New Jersey, and Pennsylvania to almost $200 million. The Federal Highway Administration fuel tax evasion project continues to play a significant role in assisting the Internal Revenue Service and state revenue agencies to combat evasion.

Virginia Starts Fourth Crumb Rubber Project

A resurfacing project on U.S. Route 1 near Richmond will be Virginia's fourth crumb rubber project. These projects have been small in scope, and at the state's discretion, none of these has been federally aided. The latest project provides for the use of about 10,000 tons of asphalt mix and an estimated 20,000 scrap tires. Since the use of crumb rubber is still being studied, state officials believe this section of U.S. 1, which has significant cracking problems, will test the degree of cracking resistance provided by the asphalt-rubber mix. The state will also study environmental and safety issues.

Use of crumb rubber modifier in asphalt mixes may be a way to reduce the scrap tire disposal problem.

Virginia Is Step Closer to Smart Highway

The Blacksburg to Roanoke highway, one of Virginia's innovative projects under Section 1107(b) of the Intermodal Surface Transportation Efficiency Act of 1991, moves a step closer to implementation with the recent approval of the final environmental impact statement. This project calls for the construction of a six-mile, four-lane highway to demonstrate intelligent vehicle-highway systems, for which $5.9 million was made available under ISTEA. The record-of-decision will be issued following the completion of the public notification process.

First CMAQ Roundtable Held in Michigan

On June 14, transportation and air quality experts from a dozen different organizations—federal, state, and local—gathered in Ann Arbor, Mich., at the first-ever roundtable discussions held at the request of the Environmental Protection Agency. These discussions focused on the goals and structure of the Congestion Mitigation and Air Quality Program. Many issues and recommendations were aired; however, no changes are anticipated at this time.

Historically Black Colleges Form a Research Consortium

On June 24-26, approximately 20 historically black colleges and minority institutions met in Arlington, Va., to form a consortium to conduct research in water resources and environmental management. The Federal Highway Administration provided planning support to the new consortium. At the meeting, participants wrote the by-laws and decided how research teams will be set up and what their specific functions will be.

Motor Carrier Study of Driver Fatigue and Alertness Begins

Two major nationwide motor carriers, Yellow Freight Systems and CF Motor Freight, are the first to have drivers "on the road" under two types of 10-hour schedules. This multiyear, $3.4 million effort began in 1989. It is a research partnership of the Federal Highway Administration and the Trucking Research Institute of the American Trucking Associations Foundation. The study is being performed by Essex Corporation in Goleta, Calif., and Scripps Clinic and Research Foundation in La Jolla, Calif.

Negotiations are nearly completed with a Canadian motor carrier to provide drivers and runs for the second part of the experiment, 13-hour daytime and nighttime driving schedules. This data collection is slated to begin early this fall. Transport Canada will share the cost of a portion of the research.

A final set of field tests, covering drivers in local/short-haul operations, is scheduled for this winter. FHWA is working with the American Trucking Associations Foundation and the National Private Truck Council to locate U.S. carriers for this part of the study.

Mississippi Bashes Trash

The 1993 Trash Bash, held the last week of March, attracted a record number of participants. Trash Bash is an anti-litter week, designated by the Mississippi Transportation Commission, in which the state's 1,531 adopt-a-highway groups collectively pick up litter on their adopted sections of highway. This collective effort draws attention to the litter problem in the state.

Tribal Leaders Learn About Road Funding Opportunities

The Federal Lands Highway Office and Bureau of Indian Affairs recently conducted four regional conferences for American Indian tribal leaders. The purpose of each three-day conference was to provide information to the tribal leaders about the Indian Reservation Roads Program and other funding opportunities offered by the Intermodal Surface Transportation Efficiency Act of 1991. Conference topics included transportation planning, management systems, coordination, and ISTEA programs and requirements. In addition to the regional conferences, other meetings were held for tribal leaders in Montana and Oklahoma.

Cherokees in North Carolina Develop Tribal Transportation Plan

The North Carolina Local Technical Assistance Program Technology Transfer Center will oversee an effort to provide transportation planning assistance, including developing a transportation plan, for the tribal government of the Eastern Band of Cherokee Indians, located in Cherokee, N.C. Section 1025 of the Intermodal Surface Transportation Efficiency Act of 1991 outlines this initiative. The center will also conduct a case study of the unique aspects of planning within the Cherokee tribal culture. North Carolina's efforts will serve as a model for other American Indian tribal governments.

National Scenic Byways Report Due to Congress in October

The National Scenic Byways Advisory Committee is a 17-member board established by the Intermodal Surface Transportation Efficiency Act of 1991 to assist the Secretary of Transportation in developing the National Scenic Byways Program. The committee will provide a report, recommending the minimum criteria and standards to be used by state and federal agencies to designate highways as scenic byways and all-American roads, to the secretary and Congress by October.

On June 2, the committee held its fourth and final meeting. Topics discussed during the meetings included the economic development and tourism benefits of the program and the importance of balancing environmental interests with economic benefits.

Massachusetts Will Conduct an Electric-Vehicle Demonstration

The Massachusetts Highway Department is embarking on a project demonstrating the use of electric vehicles. Fifty vehicles will be purchased, and recharge stations will be built at transit and "park-and-ride" facilities. The vehicles will be leased, and the project will be fully evaluated. The $2 million project is funded by the Congestion Mitigation and Air Quality Program.

"You'll Be On Video Live If You Drink and Drive"

On May 28, Idaho kicked off a campaign called "You'll Be On Video Live If You Drink and Drive." This effort is an expansion of a program started last year when the Aetna Insurance Co. provided 36 in-vehicle video cameras to the Idaho State Police for taping drunk-driving arrests. The program was so effective that 114 more cameras were purchased using funds from the National Highway Traffic Safety Administration. A full-sized campaign billboard is also planned.

Contracts Awarded to Develop IVHS Architecture

On September 13, the Federal Highway Administration awarded contracts to four consortia to develop different system architecture concepts for the Intelligent Vehicle-Highway Systems Program.

The first consortium includes Hughes Aircraft as the lead, Delco Electronics, Electronic Data Systems, General Motors, Hickling, JHK & Associates, Michigan Department of Transportation, Minnesota DOT, and Sprint.

The second consortium includes IBM as the lead, Ameritech, Louis Berger & Associates, University of Michigan, New Jersey Highway Authority, Oakland County (Mich.) Road Commission, and Siemens.

The third consortium includes Rockwell International as the lead, Apogee Research, California PATH, California Department of Transportation, George Mason University, GTE Laboratories, Honeywell, and Iowa State University.

Highway Seismic Research Council Created

The Federal Highway Administration asked the National Center for Earthquake Engineering Research to establish a Highway Seismic Research Council to provide technical and operational assistance in conducting seismic vulnerability studies of the National Highway System. The council is comprised of recognized academic, public, and private sector leaders in the fields of seismology, earthquake engineering, and highway and bridge design. The council members are divided into a technical group and a coordinating group. The technical group will be involved in technical and scientific issues. The coordinating group will provide input on issues of technology transfer and coordination with end-users including state transportation agencies and federal agencies working to reduce earthquake hazards. The first product, due at the end of the year, will be an update of a 1983 FHWA report, *Seismic Retrofitting Guidelines for Highway Bridges.*

FHWA Develops a Network of International Technology Exchange Centers

The Federal Highway Administration is developing a network of international technology exchange centers to serve as focal points to acquire foreign technologies, promote U.S. expertise abroad, and increase the transfer

of U.S. technologies to other countries. FHWA will furnish the centers, which are modeled after the Local Technical Assistance Program technology transfer centers, with technical information, research findings, training, and demonstration materials. The host country will reciprocate by providing access to its research findings and implementation materials.

FHWA recently established an exchange center in Finland. Information gathered through the center is circulated to the U.S. highway community through FHWA, state departments of transportation, and LTAP technology transfer centers. LTAP technology transfer centers in Colorado, Maine, Michigan, Minnesota, Montana, New Hampshire, Vermont, Washington, Wisconsin, and Wyoming have already linked to the Finnish center.

More Than 50,000 Commercial Vehicles Checked in 72-Hour Inspection

During a 72-hour, around-the-clock, coordinated inspection on June 8-10, more than 50,000 commercial vehicles and their drivers underwent safety checks at about 300 roadside sites throughout the United States and Canada. In this massive safety effort, called "Roadcheck '93," inspectors followed the regular practices used in roadside safety inspections. Vehicles with serious defects and drivers violating safety standards were not allowed to continue until the problems were remedied. The inspectors also collected information on hazardous materials documentation and how much training the drivers had.

In last year's three-day effort, about 46,000 inspections were conducted, and approximately 12,000 vehicles (26 percent) and 2,000 drivers (4 percent) were removed from the road. For all of the last fiscal year, 27.9 percent of the vehicles inspected and 7.2 percent of the drivers were detained.

Transporting Hazardous Materials Requires a Federal Permit

The Federal Highway Administration has proposed regulations that would require motor carriers to obtain safety permits to transport high-risk hazardous materials. FHWA published the proposals in the *Federal Register* in response to statutory directives under the Hazardous Materials Transportation Uniform Safety Act of 1990. The permit program would cover four general classes of hazardous materials: (1) class A and B explosives, (2) liquefied natural gas, (3) hazardous materials designated as extremely toxic by inhalation, and (4) highly radioactive materials. Carriers, their employees, and their agents who violate any of these regulations would be subject to the loss of their permit plus civil penalties up to $25,000 or criminal penalties up to $50,000 for willful violations.

Motor Vehicle Fatalities Are at a 30-Year Low

On June 22, Secretary of Transportation Federico Peña announced that motor vehicle fatalities declined 5.5 percent last year to their lowest level in 30 years. He attributed the decline to a decrease in alcohol-related fatalities and an increase in the use of safety belts, child seats, and motorcycle helmets.

Statistical estimates using data from the National Highway Traffic Safety Administration's Fatal Accident Reporting System show:

- Safety belts saved 5,226 lives in 1992 and almost 35,000 lives from 1983-1992.
- Child restraints saved 268 lives in 1992 and more than 2,000 lives from 1982-1992.
- Motorcycle helmets prevented 559 deaths last year and saved more than 5,800 lives from 1984-1992.
- Minimum drinking age laws saved 795 lives in 1992 and more than 13,000 from 1975-1992.

In addition, NHTSA estimates that air bags saved 500 lives through 1992 and will save 2,400 lives between 1990 and 1995. Almost all new passenger cars will have air bags by model year 1995, and FHWA has proposed that all model year 1998 passenger cars and 1999 light trucks be equipped with air bags as well as safety belts for the driver and right-front-seat passenger.

NHTSA Hails Safety Features in 1994 Vehicles

The National Highway Traffic Safety Administration said that the new vehicle side-impact standard, which takes effect this fall, will improve the safety of model year 1994 passenger cars, light trucks, and vans. NHTSA considers the side-impact standard to be the most significant safety improvement since its 1984 standard requiring automatic crash protection—air bags or automatic safety belts. The agency estimates that the side-impact standard, when fully implemented, will prevent more than 500 fatalities and 2,600 serious injuries each year.

The new rule, which amended the agency's "side-door strength" standard, was issued in 1990 and set a four-year phase-in schedule that begins Sept. 1, 1993. During the upcoming model year, 10 percent of each car maker's production must meet the new standard. This increases to 25 percent in model year 1995, to 40 percent in model year 1996, and to all new cars produced after Sept. 1, 1996. Compliance with the standard is determined by laboratory crash tests. Manufacturers generally meet the improved standard with additional energy-absorbing padding or structural upgrades.

The agency also noted that all light trucks and vans produced after Sept. 1, 1993, must have a center, high-mounted stop lamp and that 90 percent of each manufacturer's light trucks and vans must comply with the same side-door strength requirements that all cars now meet. The lighting standard is estimated to prevent up to 90,000 collisions annually, saving consumers up to $143 million and averting almost 27,000 injuries.

PBS Will Broadcast a Transportation Miniseries in 1994

In 1994, public television stations of the Public Broadcasting Systems will present "Coming and Going," a four-hour miniseries on the story of transportation in America. The series will take the viewer from coast to coast to examine the importance of mobility to our

economy and way of life—in the past, present, and future. As America passes from the "Interstate Age" into a new era characterized by intense global competition and aging infrastructure, the series explores new directions and exciting initiatives for the next century.

The first one-hour program will look at long-distance travel. It will focus on how and why our nation's character and economy are inextricably connected to our desire and need to travel.

The second program will be about the importance of freight transportation to the nation's commercial and social well-being.

The third program will journey into rural America to explore how some people have become disconnected and to illustrate how critical transportation is to rural and urban Americans.

The last program looks at the big picture, visiting several major cities to investigate how our transportation systems are being challenged and how the nation is responding. The question posed in this final episode is: "Have we met the enemy—and is he us?"

Major corporate funding for "Coming and Going" is provided by The CIT Group. Additional support is provided by the American Steel Industry together with the United Steelworkers of America, Consolidated Freightways, The GAR Foundation, the Laborers' International Union, and the UPS Foundation. The series also received a substantial grant from the Corporation for Public Broadcasting.

—WETA, Washington, D.C.

NEW RESEARCH

The following new research studies reported by the Federal Highway Administration's Office of Research and Development are sponsored in whole or in part with federal highway funds. For further details on a particular study, please contact Richard Richter, (703) 285-2134.

NCP Category A—Highway Safety

A.5: Highway Safety Design Practices and Criteria

Title: Implement, Test, and Evaluate DYNA3D/ NIKE3D Model for Safety Analysis

Objective: This contract is an interagency agreement with the Lawrence Livermore National Laboratory to develop and/or modify vehicle, dummy, and barrier models and to validate their performance against crash data. Existing crash data will be used where possible, and a limited number of new crash tests will be conducted. At the present time, four agencies are collaborating on this effort to modify the DYNA3D/NIKE3D finite element model developed at LLNL to accurately simulate vehicle crash impacts. The participating organizations are the: (1) Federal Highway Administration, (2) National Highway Traffic Safety Administration, (3) Transportation Research Board, an agency of the National Academy of Sciences, and (4) LLNL, a national defense laboratory. LLNL will apply a computer technology, previously used to simulate nuclear explosions and to simulate intercontinental ballistic missiles impacting hardened missile silos, to simulate vehicle crashes into other vehicles/roadside objects and to simulate occupants impacting vehicle interiors/belts/air bags.

The improvements in motor vehicle safety over the past few years have largely been obtained through advancements in resolving the more straightforward engineering problems associated with motor vehicle and roadway design. The safety issues remaining are far more complex and require the application of state-of-the-science computer simulation technology and tools. It is envisioned that ultimately this effort will lead to broader collaboration of government, industry, and private organizations including the state DOT research agencies, the U.S. motor vehicle manufacturers, and national and local safety groups with engineering competence.

Contractor: Department of Energy
Expected Completion Date: February 1995
Estimated Cost: $940,000

NCP Category B—Traffic Operations/ Intelligent Vehicle-Highway Systems

B.1: Advanced Traffic Management Systems

Title: Detection Technology for IVHS

Objective: The objectives are to assess the state of the art in detection systems suitable for Intelligent Vehicle-Highway Systems (IVHS); evaluate that technology and determine under which conditions it should be used; and if current technology is not suitable, develop functional specifications for an IVHS detection system.

Contractor: Hughes Aircraft Company
Expected Completion Date: January 1994
Estimated Cost: $751,924

B.2: Advanced Traveler Information Systems

Title: Electromagnetic Compatibility Testing for IVHS Systems

Objective: The objective is to establish a resource to conduct evaluations of the electromagnetic compatibility of various proposed IVHS communications components, operating singly and in combination. Many of the issues to be investigated will be drawn from the IVHS system architecture development effort. Sophisticated simulations, anechoic chambers, and antenna test ranges will be employed to perform this testing. Testing will be performed on a task order basis.

Contractor: Institute for Telecommunications Sciences
Expected Completion Date: March 1996
Estimated Cost: $1,350,000

B.3: Commercial Vehicle Operations

Title: Traffic Operations and Control for Older Drivers—Reimbursable Agreement
Objective: The purpose of the study is to measure the deceleration characteristics and reaction times of older drivers when faced with various levels of time-to-onset and duration of the yellow signal phase.
Contractor: U.S. Army Test and Evaluation
Expected Completion Date: May 1994
Estimated Cost: $36,500

Title: Development of a National Automatic Vehicle Identification Standard
Objective: This study will first determine the services to be provided by automatic vehicle identification and the requirements of a system to provide those services. Existing systems and standards will then be reviewed to determine how they meet these requirements. Based on this review, a proposed national standard will then be developed. Finally, a prototype system will be developed to demonstrate the feasibility of the proposed standard.
Contractor: National Institute of Standards and Technology
Expected Completion Date: December 1993
Estimated Cost: $266,964

NCP Category C—Pavements

C.6: Long-Term Pavement Performance Evaluation

Title: Electrochemical Bridge Protection
Objective: This work continues Strategy Highway Research Program study C102. Florida will purchase/fabricate a solar-powered, intermittent cathodic protection system and will install it on the Howard Franklin Bridge on I-175 over Tampa Bay. Texas will purchase/fabricate the necessary null probes to be installed on Port Isabel Causeway on Queen Isabella PR100 on Padre Island. Virginia will purchase/fabricate the necessary null probes to be installed at structures #2900 and #2901 on I-95 over the Rappahannock River in Stafford County.
Contractor: States of Florida, Texas, and Virginia
Expected Completion Date: March 1994
Estimated Cost: $60,000

NCP Category D—Structures

D.1: Bridge Design

Title: Advanced Composite Cable-Stayed Bridge Systems Development
Objective: The objective of this project is to develop alternative bridge systems for a cable-stayed freeway crossing over I-5 at the University of California at San Diego. This detailed bridge systems development is an independent and necessary step to provide a detailed technical plan for any first application of advanced composite materials and technologies in a cable-stayed bridge structure.
Contractor: University of California
Expected Completion Date: April 1994
Estimated Cost: $1,600,000

D.3: Hydraulics and Hydrology

Title: Scour Performance of Bridges During Floods
Objective: This project extends the existing agreement with the U.S. Geological Survey to collect field data on bridge scour. Work includes planning and coordinating field data collection by state district personnel, assembling field crews to collect data during floods for areas that do not have cooperative studies, maintaining a repository of field data, and developing prediction equations from a national perspective.
Contractor: U.S. Geological Survey
Expected Completion Date: April 1998
Estimated Cost: $565,590

NCP Category E—Materials and Operations

E.3: Geotechnology

Title: Solid Waste Processing for Engineering Use in Infrastructure Construction Materials
Objective: This study will determine the feasibility of using recycled plastic in highway construction. Environmental agencies are establishing policy to eliminate the current practice of waste disposal. At this time, municipal authorities are unable to cost-effectively reduce the amount of landfill waste. During the last several years, state highway agencies (SHAs) successfully used some waste materials in highway construction. Many SHAs are now proposing to use recycled plastics. This investigation is part of an overall effort to develop innovative highway construction materials.
Contractor: Polytechnic University, Brooklyn, New York
Expected Completion Date: December 1993
Estimated Cost: $25,000

Title: Development of Piezocone for Use in Centrifuge Testing and Validation of Methods for Interpreting Cone Penetration
Objective: In recent years, the Cone Penetrometer Test has proven to be extremely useful in determining in situ soil profiles and properties. However, there is a need to develop a sound theoretical model to validate empirical relations currently being used to interpret field data. This investigation will conduct the CPT in the centrifuge on soil samples and compare the results to soil properties measured by conventional laboratory tests. An experimental data base will be developed to formulate a theoretical CPT model to evaluate existing CPT interpretation methods.
Contractor: National Science Foundation
Expected Completion Date: June 1994
Estimated Cost: $9,980

NCP Category H—R&D Management and Coordination

H.2: Special Contracts or Studies

Title: Advanced Highway Research with Texas A&M Research Foundation
Objective: This is a program of research grants in six program areas of the Office of Advanced Research. The objective is to develop technologies that have long-

range applications in making construction materials and operations more cost-effective. The following four advanced highway research studies—with Construction Technology Laboratories, Illinois Institute of Technology, SRI International, and University of Arkansas—are part of this program.
Contractor: Texas A&M Research Foundation
Expected Completion Date: August 1994
Estimated Cost: $1,249,969

Title: Advanced Highway Research with Construction Technology Laboratories
Objective: The objectives of this grant agreement are to: (1) identify the limitations of existing girder cross sections relative to the use of high-strength concrete, (2) examine the feasibility of modified cross sections that can be used to take advantage of the higher strength concretes that are currently available, (3) investigate the use of alternative construction systems that can be used with high-strength concrete, and (4) define existing factors that serve to limit the applications of high-strength concrete in bridge girders.
Contractor: Construction Technology Laboratories
Expected Completion Date: August 1994
Estimated Cost: $49,826

Title: Advanced Highway Research with Illinois Institute of Technology
Objective: The objective of this grant agreement is to conduct field trials with a full-scale prototype road survey system that uses an innovative concept of pavement distress identification and monitoring.
Contractor: Illinois Institute of Technology
Expected Completion Date: August 1994
Estimated Cost: $49,643

Title: Advanced Highway Research with SRI International
Objective: The objective of this grant agreement is to demonstrate that the fracture surface topography analysis can provide micro-fracture information that can be correlated with acoustic emission signals to improve the current ability to interpret these signals.
Contractor: SRI International
Expected Completion Date: August 1994
Estimated Cost: $49,967

Title: Advanced Highway Research with University of Arkansas at Little Rock
Objective: The objective of this grant agreement is to construct a generation imager optimized for aggregate analysis.
Contractor: University of Arkansas
Expected Completion Date: August 1994
Estimated Cost: $49,929

RECENT PUBLICATIONS

The following are brief descriptions of selected publications recently published by the Federal Highway Administration, Office of Research and Development (R&D). The Office of Engineering and Highway Operations R&D includes the Structures Division, Pavements Division, Materials Division, and Long-Term Pavement Performance Division. The Office of Safety and Traffic Operations R&D includes the Intelligent Vehicle-Highway Systems Research Division, Design Concepts Research Division, and Information and Behavioral Systems Division. All publications are available from the National Technical Information Service (NTIS). In some cases, limited copies of publications are available from the R&T Report Center.

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5285 Port Royal Road
Springfield, Virginia 22161

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Federal Highway Administration
R&T Report Center, HRD-11
6300 Georgetown Pike
McLean, Virginia 22101-2296
Telephone: (703) 285-2144

Performance Monitoring of Joint Load Transfer Restoration. Contract No. DTFH61-P-01198.

by Office of Engineering and Highway Operations R&D

Faulting and deflections at joints on the experimental load transfer restoration project on I-10 near Tallahassee, Fla., were monitored between 1986 and 1991. This report presents the results of the analyses of the performance data collected and summarizes the performance of the load transfer restoration project.

The NTIS number for this publication is PB93-210060; the cost is $27 for a paper copy or $12.50 for a microfiche.

Disposal of Waste from Highway Materials Testing Laboratories. Publication No. FHWA-RD-91-125.

by Office of Engineering and Highway Operations R&D

This report documents the findings of a research program designed to ascertain the types, amounts, and current disposal methods of hazardous waste produced by state highway materials testing laboratories and to develop guidelines for the best disposal/reclamation technology available. Most agencies have implemented changes to reduce the burden of escalating costs, logistical problems,

and resource recovery legislation associated with waste disposal. Extraction of asphalt mixtures was found to generate the most solvent waste, but cleaning operations also produce large quantities of waste. Terpene solvents are being successfully used for extraction in at least 12 states and are being evaluated in several more states. The expected impact of present and future environmental regulation will be to further reduce the use of chlorinated solvents for industrial purposes because of environmental, safety, and health concerns.

The NTIS number for this publication is PB93-210052; the cost is $27 for a paper copy or $12.50 for a microfiche.

Cathodic Protection Developments for Prestressed Concrete Components.
Publication No. FHWA-RD-92-056.

by Office of Engineering and Highway Operations R&D

The effects of cathodic protection on the embrittlement of high strength steel embedded in concrete were studied. The results show that cathodic protection will generate hydrogen on the steel if the potential of the steel is more negative than the thermodynamic hydrogen evolution potential. The atomic hydrogen generated will enter the steel and cause a loss in ductility that will adversely affect the steel's performance if a notch is present. Studies are continuing on full-scale beams to study this effect and effective cathodic protection criteria.

Conductive paint anode systems were tested to shed light on the causes of anode deterioration. Anode disbondment is largely the result of acids generated between the anode and concrete interface. Studies are continuing on several methods to improve the long-term bond strength between the anode and concrete.

The NTIS number for this publication is PB93-207645; the cost is $36.50 for a paper copy or $17.50 for a microfiche.

Side Impact Crash Test and Evaluation Procedures for Roadside Structures Crash Tests.
Publication No. FHWA-RD-92-062.

by Office of Safety and Traffic Operations R&D

This report contains recommendations for performing and evaluating side-impact crash tests using roadside structures, such as luminaire supports, guardrail terminals, and utility poles. A 50-km/h full broadside test using a small car is recommended. Evaluation criteria include recommendations for structural adequacy, occupant risk, and post-collision trajectory. The occupant risk criteria use indices obtained using anthropometric dummy test devices.

The NTIS number for this publication is PB93-208437; the cost is $17.50 for a paper copy or $9 for a microfiche.

Development of a Plan for Upgrading Vehicle-Barrier Response Simulation Capabilities.
Publication No. FHWA-RD-92-070.

by Office of Safety and Traffic Operations R&D

The study presents a long-range plan for upgrading capabilities and software for simulation of vehicle-barrier response for vehicles impacting roadside safety structures. The capabilities of the existing software were first reviewed; this was followed by a review of available nonlinear finite element software. An upgrading plan with detailed recommendations was then developed. It was recommended that DYNA3D should be used as the main software for barrier nonlinear analysis and that ADAMS or the enhanced version of HVOSM should be used for vehicle handling. A knowledge-based front end should be made available with expert advisors to make it easy for users to convert physical data into input data. Data bases should be made available for standard barriers and vehicles. The software may be used by a variety of users—from field engineers to R&D engineers—for a variety of purposes—from evaluation of simple barriers and the design of barriers to very sophisticated crash and failure studies.

The NTIS number for this publication is PB93-189918; the cost is $19.50 for a paper copy or $9 for a microfiche.

Side Impact Crash Testing of Roadside Structures.
Publication No. FHWA-RD-92-079.

by Office of Safety and Traffic Operations R&D

This report contains a summary of 12 side-impact crash tests performed at the Federal Outdoor Impact Laboratory to evaluate the performance of several types of roadside structures. The tests are described, and the results are presented. The results of these tests are then combined with earlier test series, and statistical models that predict responses of hypothetical anthropometric dummies are developed. These preliminary models could be used to evaluate the risk to occupants.

New and Emerging Technologies for Improving Accident Data Collection.
Publication No. FHWA-RD-92-097.

by Office of Safety and Traffic Operations R&D

This study identified and examined technologies and reviewed the current processes related to the collection and management of motor vehicle traffic accident data. The study identified the technologies that are most promising in terms of improving the quality, accuracy, completeness, and timeliness of the accident data and/or reducing the demands on police officers, accident investigators, data coders, and data entry personnel. The technologies that were examined in detail included the following: form readers/optical scanners, laptop and notebook computers, pen-based portable computers, identification technologies including magnetic stripe, bar codes, "smart" cards, Automatic Vehicle Identification (AVI), the Global Positioning System (GPS), and location technologies. Detailed reviews of the processes, procedures, reporting requirements, and management of information related to traffic accident data were conducted for a sample of nine states. Interviews were conducted with people involved at all levels of the accident data collection and analysis process, including police officers, data coders, key-entry personnel, safety analysts, state and local traffic engineers, and computer systems/information management

personnel. Additionally, the applications of various technologies to the accident data collection and analysis process or a related process were identified and researched.

Luminaire Support Capability Program
FOIL Test Number 91F052.
Publication No. FHWA-RD-92-114.
FOIL Test Number 91F053.
Publication No. FHWA-RD-92-115.
FOIL Test Number 91F054.
Publication No. FHWA-RD-92-116.
FOIL Test Numbers 91F055 and 92F006.
Publication No. FHWA-RD-92-117.
FOIL Test Numbers 91F056 and 91F057.
Publication No. FHWA-RD-92-118.
FOIL Test Numbers 92F002 and 92F004.
Publication No. FHWA-RD-92-119.
FOIL Test Numbers 92F003 and 92F005.
Publication No. FHWA-RD-92-120.

by Office of Safety and Traffic Operations R&D

These documents contain the results of tests performed at the Federal Outdoor Impact Laboratory in McLean, Va., on luminaire supports using an 818.2-kg (1800-lb) class vehicle. Some of the reports provide the results of two tests—a low-speed test at 8.9 m/s (20 mi/h) and a high-speed test at 26.8 m/s (60 mi/h). The purpose of the tests was to evaluate the safety performance of the luminaire support based on the latest criteria specified by FHWA.

Test number 91F052 tested a luminaire support manufactured by Millerbernd Manufacturing Company of Winsted, Minn. The poles were made of steel and were mounted to FOIL's universal foundation plate. The results of the test indicate that the progressive shear base luminaire support, model IHB8-400, does not meet all of the applicable FHWA criteria.

Test numbers 91F053 and 91F054 tested luminaire supports manufactured by Flemington Aluminum & Brass Foundry of Flemington, N.J. The poles were made of steel and were mounted to an aluminum transformer base that was mounted to FOIL's universal foundation plate. The results of the tests indicate that transformer base luminaire supports, base model TB-2 and model TB-2A, do not meet all of the applicable FHWA criteria.

Test numbers 91F055, 92F006, 91F056, and 91F057 tested luminaire supports manufactured by Highline Products Corp. of Old Saybrook, Conn. The poles were made of fiber glass and were mounted to FOIL's universal foundation plate. The results of the tests indicate that the anchor-based luminaire supports, model 300 series and model 200H series, meet all of the applicable FHWA criteria.

Test numbers 92F002, 92F004, 92F003, and 92F005 tested luminaire supports manufactured by Highline Products Corp. The poles were fiber glass and were installed in S-2 weak soil. The results indicate that the direct burial luminaire supports, model 200H series and model 300 series, meet all applicable FHWA criteria.

The NTIS numbers for these publications are: PB93-189215, PB93-189223, PB93-189231, PB93-189249, PB93-189256, PB93-189264, and PB93-189272, respectively; the cost is $17.50 each for a paper copy or $9 each for a microfiche.

Pavement Testing Facility—Phase I Final Report. Publication No. FHWA-RD-92-121.

by Office of Engineering and Highway Operations R&D

This report summarizes the work performed at the Pavement Testing Facility during its first phase of research from October 1986 to April 1989.

PTF is a permanent, outdoor, full-scale pavement testing laboratory located at the Turner-Fairbank Highway Research Center in McLean, Va. The purpose of the facility is to quantify the performance of test pavements trafficked under accelerated loading. The facility consists of several instrumented test pavements and the Accelerated Loading Facility testing machine. Formal operation of the facility began in October 1986.

The report includes a discussion of the construction and instrumentation of the PTF test pavements. It describes the operation of ALF and the data collection procedures used at PTF. The report also summarizes the environmental, pavement response, and performance data collected during this phase. The report also provides an assessment of the strengths and weaknesses of accelerated testing with ALF.

The NTIS number of this publication is PB932-06662; the cost is $27 for a paper copy or $12.50 for a microfiche.

Evaluation of Natural Sands Used in Asphalt Mixtures. Publication No. FHWA-RD-93-070.

by Office of Engineering and Highway Operations R&D

Five tests for sands were studied to determine if they could distinguish good performing natural sands from poor performing natural sands when used in asphalt mixtures. The tests were: National Aggregate Association Method A, direct shear, American Society for Testing Materials Method D 3398, Michigan Department of Transportation Method MTM 118-90, and a flow rate method. Performance was based on the effects of the sands on pavement rutting. The best methods for predicting how the sands would perform in pavements were the flow rate method, ASTM Method D 3398, and NAA Method A. The flow rate method is the easiest to use followed closely by the NAA method. ASTM Method D 3398 is very time consuming.

The combined effects of shape, texture, gradation, and quantity of the sand on the susceptibility of an asphalt mixture to rutting was evaluated using the U.S. Army Corps of Engineers Gyratory Testing Machine , the Georgia Loaded Wheel Tester, and the French Laboratoires des Ponts et Chaussees (LPC) Pavement Rutting Tester. The gyratory stability indexes and gyratory elastoplastic indexes from the GTM did not differentiate the poor from the good quality sands. The GTM data could not establish how much natural sand can be incorporated into a mixture. The Marshall design data and the rut depths from the LPC Pavement Rutting

Tester and GLWT also did not differentiate the poor from good quality sands. All rut depths were below the maximum allowable limits. Other mixture tests or variations of the tests used in this study are needed.

The NTIS number of this publication is PB93-217289; the cost is $19.50 for a paper copy or $9 for a microfiche.

Crush Characteristics of the Ford Festiva, FOIL Test Numbers 91F049, 92F032, and 92F033.
Publication No. FHWA-RD-93-075.

by Office of Safety and Traffic Operations R&D

This report contains the results of three crash tests conducted at the Federal Outdoor Impact Laboratory. The tests, performed in 1991 and 1992, involved three Ford Festiva two-door sedans impacting an instrumented rigid pole. The tests obtained a representative data set of Festiva's crush characteristics. The final results are presented as average data plots of the Festiva's crush characteristics. The average curves represent the Festiva's crush characteristics to be modeled by a surrogate test vehicle.

The NTIS number of this publication is PB93-189116; the cost is $17.50 for a paper copy or $9 for a microfiche.

Long-Term Pavement Performance Information Management System Data Users Guide.
Publication No. FHWA-RD-93-094.

by Office of Engineering and Highway Operations R&D

The Long-Term Pavement Performance (LTPP) Information Management System (IMS) Data Users Guide provides an overview of the IMS of the LTPP Program initiated under the Strategic Highway Research Program and currently managed by the LTPP Division of FHWA. This report is aimed to assist the researchers in understanding the types of data collected under the LTPP program, how to request the data, the available formats of the IMS data, and how to use the output from the data base. The guide also briefly describes the background of the LTPP Program, the data flow through IMS, the data quality control checks, and sample reports generated from the LTPP data.

The NTIS number of this publication is PB93-216901; the cost is $17.50 for a paper copy or $9 for a microfiche.

A Study of the Use of Recycled Paving Material—Report to Congress.
Publication Nos. FHWA-RD-93-147 and EPA/600/R93/095.

by Office of Engineering

Section 1038(b) of the Intermodal Surface Transportation Efficiency Act of 1991 required the Department of Transportation and the Environmental Protection Agency to conduct a study of asphalt pavements containing scrap tire rubber and synthesize the experience with other recycled materials. The highway construction industry has a long history of using recycled products for highway construction. This report summarizes some of the industry's experiences and, where sufficient information exists, it provides documentation regarding the economic savings, technical performance, threats to human health and the environment, and environmental benefits of using recycled materials in highway devices and appurtenances and highway projects.

A supporting document to this study is a research synthesis report, Publication No. FHWA-RD-93-088, titled *Engineering Aspects of Recycled Materials for Highway Construction.*

The NTIS number of this report to Congress is PB93-219061; the cost is $17.50 for a paper copy or $9 for a microfiche.

Development of Relationship Between Truck Accidents and Geometric Design: Phase I.
Publication No. FHWA-RD-91-124.

by Office of Safety and Traffic Operations R&D

The purpose of this study was to establish empirical relationships between truck accidents and highway geometric design. First, statistical frameworks based on Poisson and negative binominal regression models were proposed. Preliminary models were then developed using accident and road inventory data from the Highway Safety Information System. The model results based on data from one of the HSIS states, Utah, were used for analysis and for suggesting areas in which the quality and quantity of existing HSIS data can be enhanced to improve the developed models. Despite the limitations in the Utah data, some encouraging preliminary relationships were developed for horizontal curvature, length of curve, vertical grade, length of grade, shoulder width, number of lanes, and annual average daily traffic (AADT) per lane (a surrogate measure for vehicle flow density). Goodness-of-fit test statistics indicated that extra variations (or over dispersion) existed in the data over the developed Poisson models for all three roadway classes studied—rural interstate, urban interstate and freeway, and rural two-lane undivided arterial. Subsequent analysis suggested that a future study can be performed to enhance the predictive power of these preliminary models by including detailed truck exposure information, such as time of day, truck type, and weather conditions; by considering more explanatory variables, such as roadside design and superelevation; and by reducing the sampling errors of vehicle exposure data for both AADT and truck percentages.

The NTIS number of this publication is PB93-217206; the cost is $27 for a paper copy or $12.50 for a microfiche.

Traffic Maneuver Problems of Older Drivers: Final Technical Report.
Publication No. FHWA-RD-92-092.

by Office of Safety and Traffic Operations R&D

This project includes a literature review and accident analysis that supported the hypothesis that age differences affect motion perception capabilities, representing a likely source of specific traffic maneuver problems for older drivers. Two sets of experiments were conducted. In the first experiment, drivers in three age groups—18 to 55, 56 to 74, and 75 and older—estimated from both stationary and moving perspectives the time-to-collision (TTC) of an approaching vehicle. The conflict vehicle approached at varying speeds and was removed from view of the test subject at varying times and distances relative to the

subject. In the second experiment, drivers viewed a dynamic roadway scene containing an approaching conflict vehicle; the subjects had to judge the last safe moment to make a particular traffic maneuver in relation to the conflict vehicle. This determined gap judgment measures. Both the TTC and gap judgment measures were obtained under laboratory conditions using various display methodologies in a driving simulator. Limited controlled field validation data were also obtained for both types of dependent measures, using the same test sample. Recommendations for counter-measures to accommodate older driver difficulties with turning maneuvers at intersections were developed.

The NTIS number of this publication is PB93-219079; the cost is $36.50 for a paper copy or $17.50 for a microfiche.

TECHNOLOGY APPLICATIONS

The following are brief descriptions of selected items that have been completed recently by state and federal highway units in cooperation with the Office of Technology Applications and the Office of Research and Development, Federal Highway Administration. Some items by others are included when they are of special interest to highway agencies. All publications are available from the National Technical Information Service (NTIS). In some cases, limited copies of publications are available from the R&T Report Center.

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6300 Georgetown Pike
McLean, Virginia 221012296
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COM624P—Laterally Loaded Pile Analysis Program for the Microcomputer, Version 2.0. Publication No. FHWA-SA-91-048.

by Office of Technology Applications

Computer program COM624P has been developed for analyzing stresses and deflection of piles or drilled shafts under lateral loads. The program is especially written for highway engineers who wish to run the analysis on microcomputers. The technology on which the program is based is the widely used p-y curve method. The program solves the equations giving pile deflection, rotation, bending moment, and shear by using iterative procedures because of the nonlinear response of the soil.

The program provides a user-friendly, menu-driven input and a graphics output in a microcomputer environment. The version of the program COM624P for the microcomputer was developed in 1989. The program included several new features such as: generating p-y curves for rock, capability of analysis of piles in sloping ground, improved solution for multi-layered soils, and a variety of boundary conditions at the pile head for selection. The current version 2.0 has more improvements including a subroutine to compute the ultimate bending capacity and the flexural rigidity of piles.

The user documentation provides detailed information to enable the user to employ the program conveniently and effectively. The documentation consists of three parts—Part I, Users Guide; Part II, Engineering Background; and Part III, Systems Maintenance.

Design of Bridge Deck Drainage (Hydraulic Engineering Circular No. 21). Publication No. FHWA-SA-92-010.

by Office of Technology Applications

The manual provides guidelines, procedures, and illustrative examples for designing bridge deck drainage systems, and it stresses the advantages of designing to minimize the complexity of these systems. The manual is a compendium of bridge drainage design guidance. Drainage system design is approached from the viewpoints of hydraulic capacity, traffic safety, structural integrity, practical maintenance, and architectural aesthetics. System hardware components, such as inlets, pipes, and downspouts, are described. Guidance for selecting a design gutter spread and flood frequency is provided. System details and existing computer models are discussed. For the user's convenience, all design graphs and nomographs appear in an appendix.

SPILE—A Microcomputer Program for Determining Ultimate Vertical Static Pile Capacity. Publication No. FHWA-SA-92-044.

by Office of Technology Applications

This report introduces a microcomputer program to determine the ultimate vertical static pile capacity of piles in cohesive and cohesionless soils. The report presents the equations, analytical procedures, and empirical curves used by the program. It also provides examples of the user-friendly data entry form capabilities. The program is coded in Turbo Pascal 5.0 language and uses friendly input menus and data checking routines to take full advantage of the "stand-alone" (single-user) characteristics of the IBMPC.

The NTIS number for this publication is PB93216802; the cost is $27 for a paper copy or $12.50 for a microfiche.

EMBANK—A Microcomputer Program to Determine One-Dimensional Compression Settlement Due to Embankment Loads.
Publication No. FHWA-SA-92045.

by Office of Technology Applications

This report introduces a microcomputer program for computing one-dimensional compression vertical settlement due to embankment loads. For the case of a strip symmetrical vertical embankment loading, the program superimposes two vertical embankment loads. For the increment of vertical stresses at end of fill, the program internally superimposes a series of 10 rectangular loads to create the end-of-fill condition. The report presents the equations and analytical procedures used by the program and provides examples of the capabilities of the user-friendly data entry form. The program is coded in the Turbo Pascal 4.0 language and uses friendly input menus and data checking routines to take full advantage of the stand-alone (single-user) characteristics of the IBM-PC.

The NTIS number for this publication is PB93-219046; the cost is $27 for a paper copy or $12.50 for a microfiche.

Communications Handbook for Traffic Control Systems.
Publication No. FHWA-SA-93-052.

by Office of Technology Applications

This handbook enables transportation engineers to plan, select, design, implement, operate, and maintain communication systems for traffic control. It is designed to aid transportation officials, communications engineers, and traffic control engineers. It provides information on communications media, system architectures, decision-making processes, and trade-off analyses. The handbook serves as a guide for agencies wishing to initiate a traffic control system that incorporates functional, effective, reliable, and economical communications and to those wishing to update an existing communications system for traffic control.

Implementation Plan—Strategic Highway Research Program Products.
Publication No. FHWA-SA-93-054.

Organizational Membership—Implementation Plan—SHRP Products (June 1993).
Publication No. FHWA-SA-93-055.

by Office of Technology Applications

The first document presents the strategic plan for the FHWA Strategic Highway Research Program products implementation program. It identifies and describes the internal and external organizational structure, partners and partnerships, roles, and the traditional and innovative implementating mechanisms and supporting functions of the program. The plan provides the framework to develop the detailed product implementation plans. The document attempts to convey the broad scope and purpose of each component without burdening the reader with excessive information. The organizational membership document lists the members of the executive committees, the SHRP Implementation Coordinating Group, the Technical Working Groups, and other committees involved in the program.

National Governors' Association Truck Accident Data Collection Program: Officer's Manual.
Publication No. FHWA-SA-92-035.

National Governor's Association Truck Accident Data Collection Program: Instructor's Manual.
Publication No. FHWA-SA-92-036.

by Office of Technology Applications

Large truck and bus safety is a vital concern to the public, industry, and government. The traffic accident data currently available are insufficient to develop sound policies and recommendations regarding the safe operation of these vehicles. To overcome this deficiency, the National Governors' Association in cooperation with FHWA developed the National Truck Accident Data Plan to encourage state and local police to gather the necessary accident data. The NGA program standardizes the definitions of truck and bus and the criteria for a reportable accident. Additionally, the program identifies more than 30 data elements essential to evaluate truck/bus safety at the national level.

The Officer's Manual is designed for state and local law enforcement personnel; the Instructor's Manual is especially designed for training course instructors. Both provide guidelines for determining whether a truck/bus accident is reportable under the NGA program, present detailed instructions for reporting each of the data elements, and group the instructions under five major headings—vehicle information, carrier information, driver information, accident location/environment information, and general information. The Instructor's Manual also includes lesson plans, introductory information, and visual aids.

The NTIS number for the Officer's Manual is PB93-205714; the cost is $19.50 for a paper copy or $9 for a microfiche.

The NTIS number for the Instructor's Manual is PB93-206936; the cost is $19.50 for a paper copy or $12.50 for a microfiche.

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