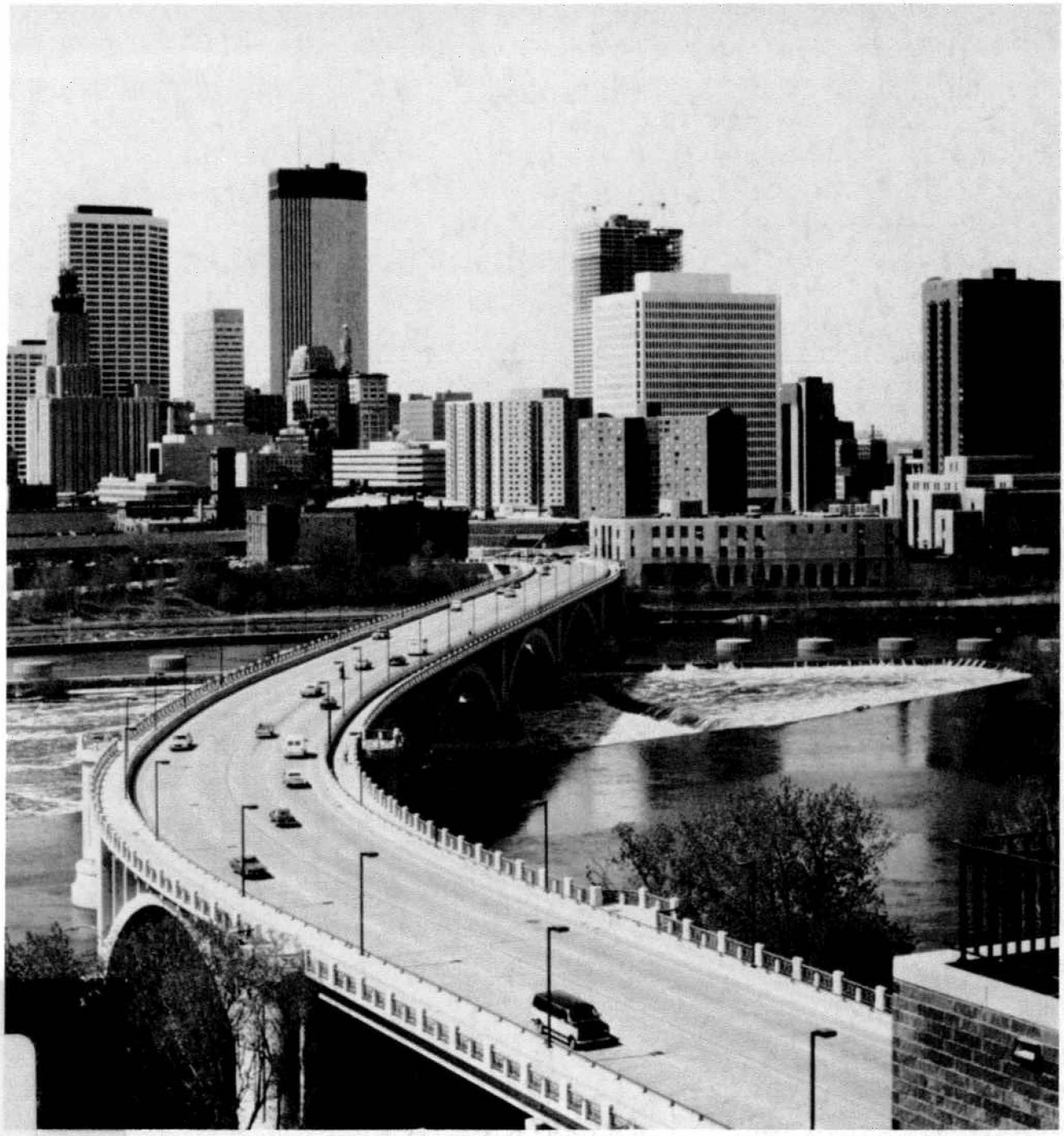
1982 Federally Coordinated Program of Highway Research and Development

U.S. Department of Transportation
Federal Highway Administration

Offices of Research,
Development, and Technology
Washington, D.C. 20590



This 1982 report on the Federally Coordinated Program (FCP) of Highway Research and Development is the ninth in a series of annual reports on the joint activities and achievements of the Federal Highway Administration (FHWA) and the States in highway research and development (R&D). This report presents a general picture of accomplishments in the FCP during the past year, the programs that coordinate the varied research activities in highway transportation, and the organization and facilities of the FHWA Offices of Research, Development, and Technology.

While supplies last, individual copies of each report in the series are available without charge upon request to the Federal Highway Administration, Office of Operations Staff, HRD-l0, Washington, D.C. 20590.

COVER: In 1976, the city of Minneapolis and the Minnesota Department of Transportation began restoring the Third Avenue Bridge, built in 1918, to preserve the bridge as a transportation facility as well as preserving its historic and esthetic value. The bridge railing was carefully removed, restored, and reinstalled; the spiral stairs were removed and a poured concrete stair structure was designed, retaining much of the sculptural value of the original spiral; and 6.1 m (20 ft) lights were installed to delineate the bridge. In addition, piers and arches were patched and refinished; spandrels were repaired; both approaches were completely replaced; and the deck, sidewalks, and traffic barriers were replaced.

NOTICE

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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April 1983

The Federal Highway Administration's Research, Development, and Technology (RD&T) program has, as the name suggests, a threefold mission. Research seeks solutions to today's problems and anticipates tomorrow's needs. The development phase refines the new technology and prepares it for application to the highway program. Finally, the new technology must be properly packaged and transferred to State and local highway agencies for implementation in the field. The new organization structure, described in this report, reflects our effort to update the RD&T program and improve its operation.

During the past year, substantial progress has been made on the expanded research facility in McLean, Va. The new Turner-Fairbank Highway Research Center, to be completed in the spring of 1983, will provide needed office space and new laboratories for the conduct of staff research.

New technology continues to emerge from the program—technology that promises greater highway safety, smoother traffic flow, and substantial savings for the highway community. Additional advances have been made in highway safety hardware and user acceptance of epoxy thermoplastic pavement markings is increasing. The Grade Severity Rating System, designed to reduce runaway truck accidents, is being field tested in five States. For intersection control, improved traffic signal warrants and guidelines for optimizing left turns have been developed.

In the construction and maintenance areas, cost-effective test procedures have been developed to maintain quality control of highway materials and construction practices. In response to growing State interest, guidelines for using engineering fabrics have been prepared and a training course will be offered. Control of metal corrosion has received substantial attention, with particular emphasis on the bridge deck problem. New knowledge of cathodic protection for bridge decks promises a potential savings of $20 billion for the highway program. In addition, research continues on calcium magnesium acetate as a nonpolluting and noncorrosive substitute for conventional deicing salts in selected sensitive environmental areas.

Other accomplishments of our RD&T program, which is a cooperative effort with State highway and transportation departments, are summarized in this annual report for Fiscal Year 1982.

R. A. Barnhart
Federal Highway Administrator

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Introduction

The concept of a partnership between the Federal Government and the State highway agencies has existed since the beginning of the highway program in 1893 when it was concerned primarily with the development and utilization of new technology. The Office of Road Inquiry, established in that year as a result of the appropriations act for the Department of Agriculture, included in its charter ". . . to make investigations in regard to the best method of roadmaking . . . and to . . . assist in disseminating information on this subject. . . ." That concept has carried over to the present research and development (R&D) program, a fact described in greater detail in the next section of this report, where various arrangements for funding and conducting the work are described. The management framework established in 1971 to coordinate and manage Federal and State activities is the Federally Coordinated Program (FCP) of Highway Research and Development. The main features of this unique program include the following:

- Coordination of Federal, State, and other research activities to solve problems with minimum duplication of effort.
- Concentration of available resources on the most critical problems.
- Implementation of useful research and development results by field evaluation, demonstration, repackaging for the practitioner, and training in new technologies.

The key concepts under which this program operates stem from the fact the States have a large measure of control over about half the Federal funds involved and also possess much of the talent needed to address the problems. The States also own and operate the majority of the highway system and therefore are closer to the operating problems and in a better position to make operational trials of new concepts. An effective R&D program without State participation is therefore not only unlikely but also incompatible with FHWA intentions.

The projects of the FCP, with the exception of some of the advanced technology explorations and development, are intended as joint efforts involving both Federal and State research resources. Because the legislation that makes Federal-aid research funds available to the States also is intended to provide resources for resolution of unique local problems, participation in the FCP projects to solve the common problems of national scope is voluntary. Each State is urged to be selective in its choice of FCP projects in which to participate, committing resources where the objectives of the projects coincide with the State's own interests.

Limited resources have been concentrated on the most urgent problems through several formal systems for problem identification and priority ranking. Research needs identified by Federal, State, and local highway officials are used as a basis for establishing new FCP projects. The final selection of projects and allocation of FHWA contract resources are subject to management review and budget priorities. The increasing restrictions on both funding and personnel resources have led to a need for improvements in this process to keep the program as responsive as possible. In FY 1982 these improvements in the review process have been mostly within FHWA, but plans are in process for extending the improvements to insure more State participation.

Implementation of research results has grown from early efforts to repackage results in a more usable form to a cooperative and comprehensive FHWA technology transfer program. This program includes other elements of the FHWA headquarters and field offices, States, cities, counties, universities, and private firms involved in highway transportation. The Offices of Research, Development, and Technology's National Highway Institute and Office of Implementation are major elements in this process, providing technical training to State personnel and preparing and disseminating technology sharing documents to local users on new emerging technologies.

The Offices of Research and Development underwent a major reorganization during FY 1982 to concentrate the reduced resources and personnel in the most effective manner and prepare for the operation of the expanded laboratory facilities at the Fairbank Highway Research Station in McLean, Va. The new organization, under the Associate Administrator for Research, Development, and Technology, is discussed in the Organizational Structure section of this report in sufficient detail to provide an understanding of the scope

and allocation of the technical work. It is significant to note that the National Highway Institute is a part of the new organization.

This year, FCP project accomplishments in this report have been grouped into the following areas, which correspond to the current FCP categories: Safety, traffic operations, environment, materials, structures, highway construction, and highway maintenance. At the close of the year, a major effort was in progress to restructure the program to aline it with changes in organization and improve its responsiveness to FHWA and State priorities.

RD&T Programs

The four elements in the FCP involving Federally supported highway R&D are the Highway Planning and Research (HP&R) Program, the National Cooperative Highway Research Program (NCHRP), the FHWA administrative contract program, and the FHWA staff research program. Virtually all work in the FHWA contract and staff programs and approximately 70 percent of work in the HP&R and NCHRP programs are devoted to FCP activities. The remaining 30 percent of the work in the HP&R program and that portion of the NCHRP committed at the discretion of the States are devoted to solving important local problems or national problems selected independently by the NCHRP program committee. This division of effort is fundamental to FHWA's highway R&D strategy, because the total number of problems to be solved far exceeds the R&D resources available. Therefore, individual States and research groups must continue to generate initiatives for solving problems not selected for emphasis in the FCP. The key is properly balancing the resources available for each of these activities.

Highway Planning and Research (HP&R) Program

Individual States and the Federal Government cooperatively support a large portion of highway R&D through the HP&R program. Each State receives HP&R funding in the amount of 1.5 percent of its total Federal-aid highway apportionment and an optional 0.5 percent for conducting highway planning and research activities.

State highway and transportation departments divide HP&R money between planning and research. Generally, about 15 to 20 percent is used for research and development, but the share ranges to 55 percent. Under the Federal-aid program, States initiate R&D studies either by using their own staff or by contracting to private or public research organizations. State-sponsored research in the HP&R program may or may not be included in the FCP, depending on whether the research addresses objectives of the FCP projects. In either case, FHWA provides technical guidance and coordination.

FHWA's responsibility for managing HP&R studies is shared between its field offices and the Offices of RD&T, depending on the dollar amount, duration, and complexity of a study.

National Cooperative Highway Research Program (NCHRP)

The NCHRP originates from a contract between the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration, and the Transportation Research Board (TRB). Research activities are selected by a special committee of AASHTO and administered by the TRB in conjunction with and with approval by the State highway officials.

Under this program, States voluntarily pool 4.5 percent of Federal-aid HP&R funds to finance research activities structured to respond to the needs of State highway and transportation departments. Because FHWA is responsible for Federal-aid funds used in NCHRP programs, it reviews project content and contractor selection. However, program selection and composition remain the prerogative of AASHTO and the participating State highway and transportation departments. Research efforts that contribute to FCP objectives are integrated into the FCP.

FHWA Administrative Contract RD&T Program

A significant portion of FHWA research and development activities is conducted by contract, because this approach provides the resources to develop practical, effective solutions to critical problems. Funding is derived from FHWA's administrative operating expenses and is separate from HP&R funds allocated to the States. Contract research is performed by private research firms, universities, nonprofit organizations, consultants, State highway and transportation departments, and other Federal agencies. Most contracts are awarded on the basis of a competitive response to a Request for Proposals issued by FHWA.

Opportunities for private, industrial, and university research agencies to participate in the contract program are numerous. Proposed administrative contract procurements are advertised regularly in *Commerce Business Daily*. Firms desiring requests for proposals should write to U.S. Department of Transportation, Federal Highway Administration, Office of Contracts and Procurement, Washington, D.C. 20590.

FHWA Staff RD&T Program

Staff research and development activities, performed by FHWA personnel, focus on important areas of the FCP not being studied elsewhere. Many staff studies are continuing efforts in major research areas, but a significant portion is geared to quick response to particular operational problems.

Approximately 15 to 25 percent of staff time is spent conducting research and development activities. The remaining time is spent on planning, administering, and monitoring research activities supported by Federal funds (both administrative contract and HP&R). An important byproduct of staff research is knowledge of the latest technological advances, which enhances the staff's ability to manage research contracts more effectively and provide technical assistance as requested by the operating highway community.

Safety

Highway transportation has played an increasingly important national role over the past seven decades. It has united the Nation by providing a flexible, low cost means of moving people and goods. However, the growth of this personal transportation system has produced some undesirable side effects, of which the most important is the large number of accidents, injuries, and deaths. In recent years, the changing automobile and limitations in funds have required a more intense look at highway safety and its component parts. The Federal Highway Administration (FHWA) and the National Highway Traffic Safety Administration (NHTSA) share responsibility for this effort with NHTSA concentrating on vehicle and driver aspects. The safety research and development (R&D) program of FHWA is designed to investigate highway related accident causes, identify and evaluate appropriate countermeasures, and develop strategies for their cost-effective implementation. Safety R&D in the Federally Coordinated Program includes projects in specific areas such as improved accident analysis, roadside hardware design, geometric design, needs of special user groups, and traffic control.

Accident Data Uses

The collection and analysis of accident, traffic, and geometric data is of major importance to any highway safety program. Good data analysis is essential to problem identification and countermeasure effectiveness. Thus, in the FCP, major research activities are directed at improving uses of existing data and understanding where and how accidents occur. Idaho, Kansas, and Utah have undertaken pilot studies to merge their data to improve its utility. (1X) [1]

[1] Numbers in parentheses refer to the FCP projects identified on page 31.

Accidents are analyzed by highway type, operational situations, and geometric features. Problem identification on urban arterials was the subject of a recently completed study. This study, conducted in 25 cities, indicated major safety problems on urban arterials are associated with commercial development, frequency of roadside obstacles, and onstreet parking. A similar study on bridge sites indicated accident rates on bridges are twice as high as nonbridge highway sections, and reducing shoulder width significantly affects bridge accident rates. Solutions to identified accident problems also require intensive evaluation. Current work is addressing the effectiveness of breakaway poles, guardrails, and impact attenuators in relation to the changing vehicle population. Accident data for these evaluations are being collected under a special study by the National Accident Sampling System (NASS) operated by NHTSA. (1K)

In many cases, accident data are not available for evaluating a specific improvement. In addition, collecting accident data takes many years and is very expensive. Research has been completed in identifying promising surrogate measures to both supplement and replace accident data in safety evaluations. Several surrogates, including side-slope for rural isolated curves and percent trucks for rural signalized intersections, are scheduled for validation. Also, a study is underway to develop a relationship between traffic conflicts and accidents. The study, which follows a National Cooperative Highway Research Program (NCHRP) study that better defined traffic conflicts, will involve field measurements of both conflicts and accidents at rural isolated curves and intersections.

Implementation of improved techniques, countermeasures, and hardware is dependent on available funds. Thus, cost effectiveness and resource allocation are important ingredients to any safety program. Recently, five States have tested and evaluated three resource allocation programs. Results show that cost effectiveness can be increased 30 percent by applying one of these programs versus the methods currently used in the test States. (1X)

Highway Safety Hardware

Research in the area of roadside safety hardware has produced a variety of innovative structural concepts with improved lifesaving potential. These new designs are the result of a continuing effort that includes simulation, design, and full-scale crash tests. Several simulation programs (HVOSM, GUARD, and CRUNCH) have been standardized and are available to States for assessing the adequacy of existing or proposed designs.

Recommendations are now available for placing guardrails on nonlevel terrain, accepting the placement of impact attenuators on curbs up to 152 mm (6 in), and using a self-restoring bridge railing for retrofitting concrete parapet/high curb combinations. (1T)

The Indiana 5A bridge rail was upgraded to eliminate snagging and successfully redirected a Honda Civic. Under a Texas Highway Planning and Research (HP&R) Program study, a new combination metal/concrete bridge rail successfully redirected a 36.3 Mg (80,000 lb) tractor-trailer approaching at a 15-degree angle and 80 km/h (50 mph). A low cost retrofit railing consisting of a thrie beam rail mounted directly on strong posts has been developed for narrow through truss bridges.

A modified thrie beam guardrail has been developed for use in upgrading the G9 thrie beam guardrail or as a new guardrail system. This guardrail has successfully redirected 0.8 Mg (1,800 lb) minicompact sedans; a 9.1 Mg (20,000 lb) schoolbus, and a 14.5 Mg (32,000 lb) bus at 97 km/h (60 mph) and 15 degrees.

Tests on wood post and steel post Breakaway Cable Terminals (BCT) have shown that, under certain conditions, minicompact sedans can be speared or overturned. Constructing these guardrail terminals straight instead of with a 1.2 m (4 ft) flare seriously degrades their performance. Work is in progress to develop a retrofit design for the wood post BCT.

Four channeling devices—a 208 L (55 gal) steel drum, the Virginia Simulated Barrel Panel, the Plastibarrel, and the Channelizer—have also been tested with minicompact sedans. In each test the accelerations were low and the vehicle remained stable after impacting two devices in a row. (1V)

Studies are in progress to provide material for use in updating and expanding the 1977 American Association of State Highway and Transportation Officials (AASHTO) "Guide for Selecting, Locating, and Designing Traffic Barriers." The new guide will identify and evaluate appropriate practices and state-of-the-art technology.

Self-restoring bridge rail for retrofit applications.

Turnout for slow-moving vehicles.

Highway Design

Current design activity is concerned with resurfacing, restoration, and rehabilitation (RRR) of highways. Determining essential changes to geometric design criteria and pavement surface characteristics is a primary focus of the research program. Specific design criteria under study include crossover crown, pavement-to-shoulder cross-slope break, side friction for superelevation, and horizontal curve criteria. During FY 1982 the maximum allowable cross-slope break was established at 8 percent on sections with full-width shoulders. Preliminary results of an evaluation of horizontal curves indicate that vehicle braking distance on horizontal curves can be as much as 25 percent longer than that required on tangent sections, and the required superelevation should be attained before entering the horizontal curve to minimize vehicle handling problems. (1J)

A new FCP project (1S), "Cost Effective Geometric Design for Changing Vehicles and Limited Resources," was initiated in FY 1982. Studies in this project will investigate the effect of changing vehicle and driver characteristics on highway design. Initial efforts are concentrating on the effect small cars, front-wheel drive, radial tires, and deviation from the point mass concept have on the calculation of side friction for superelevation. (1S)

System applications to problems on two-lane highways require solutions that cost less and have less potential for disrupting the environment. Thirteen States are evaluating several solutions for upgrading two-lane roads. These treatments include three-lane highways with two lanes designated for travel in one direction and passing either prohibited or permitted in the opposing direction, designating the shoulder for slow-moving vehicle use, and adding turnouts for slow-moving vehicles. These alternatives will be evaluated by locational criteria,

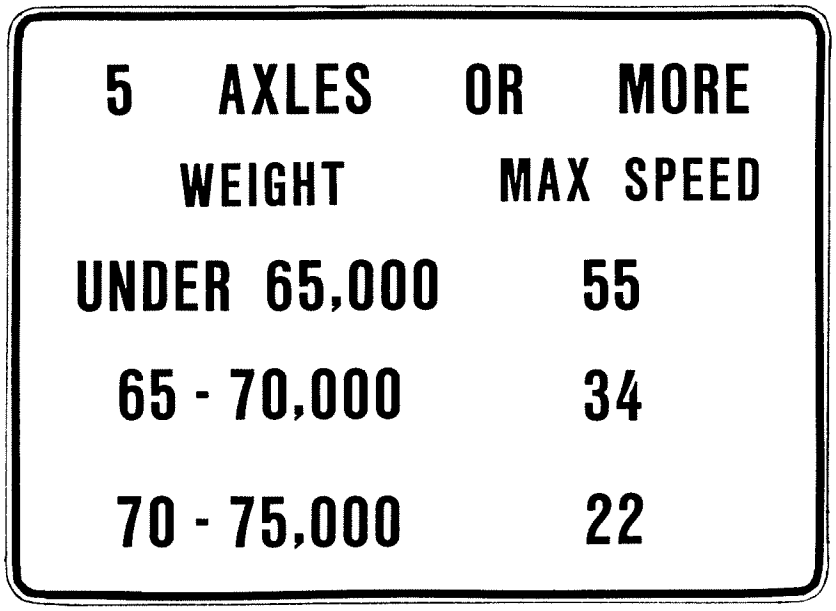
and site-specific cost-effective solutions will be identified. (1M)

Improved pavement surface characteristics are essential for improved highways. Methods for measuring and analyzing surface characteristic data have been developed. A model for normalizing pavement friction measurements for the effects of traffic and weather exposure is available. With this model, friction data can be corrected for the traffic and weather conditions during testing. The simplest set of input data, consistent with the desired accuracy, was selected so the model would be easy to use. For example, it was found that a dry-spell factor—a factor proportional to the number of days since the last significant rain—can be used instead of specific rainfall data. All other factors, such as average daily traffic, average temperature, time of year, and pavement age, are easy to obtain.

Pavement friction testers that simultaneously measure friction and the dynamic wheel load on the test wheel can be used, with no modification, for testing in nontangent sections. Testers lacking this capability can still be used by adding an accelerometer. Several States are currently field testing this system.

Noncontact infrared height sensors have been adapted for self-contained operation. They will be installed on a prototype system for simultaneous profiling of road roughness and measurement of rut depth. (1W)

In an NCHRP study, the effectiveness of partial lighting of freeway interchanges was compared to complete lighting and no lighting. Complete freeway interchange lighting on an otherwise unlighted freeway provided better visual environment, smoother traffic flow, and safer traffic operations than no lighting or partial systems consisting of one to four luminaires at each merge point. Existing complete interchange lighting systems should not be reduced to partial systems where visual quality, safety, and traffic flow are important considerations. (1P)



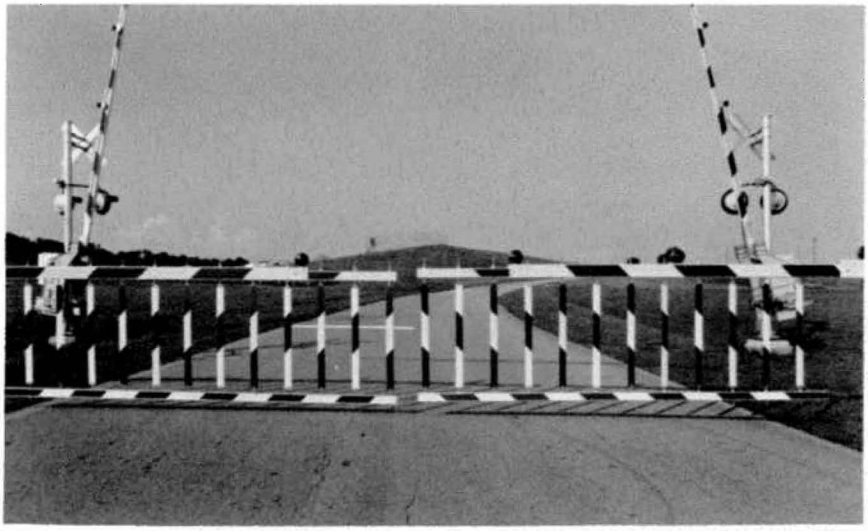
Weight-specific speed sign being tested for the Grade Severity Rating System.

Special Highway Users

A wide variety of users interact with the highway system. The overall system impact must be considered to safely accommodate all users. Commercial vehicles continue to get longer and heavier, and present specific safety problems. For the past several years, the problem of runaway trucks has been the subject of intensive study. A Grade Severity Rating System (GSRS) was developed and tested in cooperation with the trucking industry. A major problem in developing the GSRS was how to present truckdrivers with the appropriate information about a specific grade. The problem was complicated by the fact that commercial vehicles carried a variety of weights. A weight-specific speed sign was developed and tested in a laboratory simulator. The sign provides the truckdriver with safe descent speeds based on truck weight. This sign is being field tested in five States. (1U)

Other large vehicles that interact with the highway system are trains. Safety at railroad grade crossings has long been a major concern. Innovative active warning devices are now being laboratory tested and will be installed at six locations. These devices include four quadrant gates with and without skirts; standard traffic signals with bar strobes in each of the red signal heads and with a bar strobe in the cantilevered red signal head; and standard crossing flashing lights on both sides of the road, with and without cantilevered red strobes. Improved visibility of existing crossing flashing lights is also being evaluated. The most promising improved visibility alternatives are sealed beam lamps, modified lamp socket mounting arms, and prefocused lamp/reflector assemblies. (1O)

The most vulnerable highway user is the pedestrian. Currently, research activities in pedestrian safety include alternatives to existing pedestrian signals. Of particular concern are the current uses of flashing "walk" and "don't



Railroad grade crossing with four quadrant gates with skirts (skirts on one approach only).

walk" signals. These signals are intended to indicate a potential conflict with a turning vehicle and a clearance interval, respectively. Alternatives to these signals currently being tested include a 229 by 305 mm (9 by 12 in) sign that explains the meaning of pedestrian signals and a "don't start" signal lens. (1N)

Traffic Control

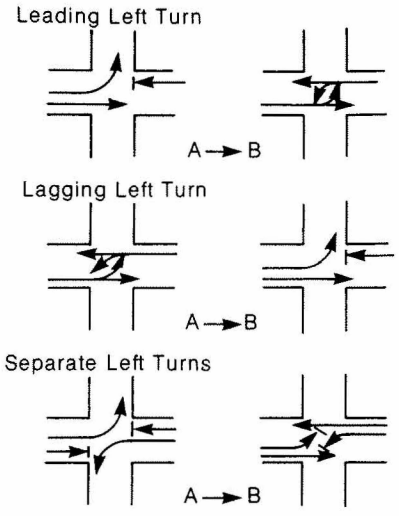
Control of various highway users and improved user information are critical elements in designing for safety. Major issues under study include legibility of signs, warrants for signals, criteria for intersection traffic control, and construction zone control. Recently completed research indicated that increased sign size rather than reflective brightness improves the legibility of signs with dark backgrounds.

A large number of accidents occur at intersections due to the conflicting vehicle movements and the problems associated with their control. An improved signal warrant, based on the availability of acceptable gaps on the main street, and guidelines for selecting the "best" left turn signal treatment have been developed. Of specific interest is an evaluation of left turn arrows that indicated drivers comply more with red arrows than red circular balls at left turn signals. (1A)

Traffic management in construction zones has resulted in the development of new designs for construction barricade rails. Results of a controlled evaluation indicated that the orange diamond on a white background was more effective in eliciting the appropriate driver response. Of particular concern in construction and maintenance zones are the situations where one side of a divided highway is closed and both directions of traffic use the remaining side. Efforts to adequately control and separate this traffic have resulted in the following findings:

- Portable concrete safety shapes are justified for short distance, high volume situations.
- Median crossovers with flat diagonal designs are the preferred method of traffic transition.
- Using portable concrete safety shape barriers on both sides of a crossover is particularly hazardous. (1Y)

A new project on speed control was initiated in FY 1982. Road markings have been shown to have no effect on speed in residential areas. Investigations will be made to determine if speed measurement devices that can be seen by drivers have an effect on vehicle speeds. (1R)



Alternative left turn treatments for signalized intersections.

Looking Ahead

Vehicles using the highway are becoming more diverse in size and performance. By 1990, 50 percent of the passenger cars are expected to weigh less than 1.0 Mg (2,250 lb). In addition, commercial vehicles will be much longer and heavier. The challenge will be to anticipate problems associated with changing fleet characteristics and develop cost-effective improvements to insure highway safety. As the major highway emphasis continues to shift from new construction to rehabilitation, improvements and changes, by necessity, will be in a retrofit mode. The safety program is designed to address these issues in a timely fashion.

Traffic Operations

Federal Highway Administration (FHWA) research and development in traffic operations concentrates on providing tools and techniques for practitioners to use to improve the operational efficiency of existing facilities and reduce fuel consumption. These tools and techniques include methods for traffic control on freeways, motorist information systems, computer simulation programs to evaluate traffic control or geometric alternatives before implementation, demand/capacity relationships, computer programs to optimize traffic signal settings or to control traffic signal systems, and electronics technology for highway communications and traffic detection.

Traffic Flow on Freeways

The Florida Department of Transportation has nearly completed the Surveillance and Control System for the Howard Frankland Bridge, which carries Interstate Route 275 across Tampa Bay. This system will divert traffic to an alternative route as a strategy to relieve congestion on a major Interstate highway link. Following system acceptance by the State, an evaluation study sponsored by FHWA will be performed.

The New York Department of Transportation has begun installation of an Integrated Motorist Information System (IMIS) to relieve traffic congestion in the Northern Long Island Corridor through the use of traffic surveillance, control, incident management, and traffic diversion. Construction is scheduled for completion in April 1985. In cooperation with State and local transportation agencies, FHWA will sponsor a comprehensive evaluation of IMIS commencing in 1985. A report documenting the design of IMIS will be available in early 1983. (2C) [1]

[1] Numbers in parentheses refer to the FCP projects identified on page 31.

Traffic congestion upstream of bottlenecks is a major problem on freeways in many large cities. A recent study examined the potential of applying the ramp metering concept to freeway-to-freeway connectors and also to entire mainline freeway sections. A report has been prepared that gives guidelines on the appropriateness of the metering technique to improve traffic flow at bottlenecks downstream of the metering locations.

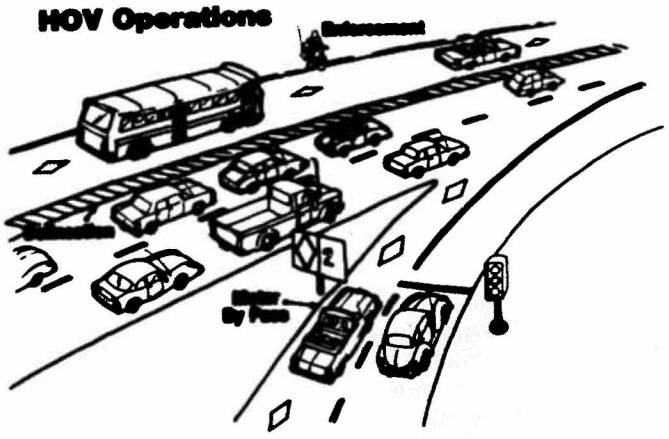
Many new transportation system management (TSM) techniques have been used to increase the number of high-occupancy vehicles (HOV's). Most of the techniques require enforcement to insure that ineligible vehicles are excluded. The State of California has completed a study of enforcement and other factors affecting the operation of HOV projects. A report covering the effect of different enforcement levels and strategies, engineering features, and public education programs on violation rates for TSM projects involving HOV's will be available in 1983. (2P)

Another report, titled "High Occupancy Vehicle Facility Development, Operation, and Enforcement" (Vols. I and II), provides guidance on the planning, design, and enforcement requirements for HOV facilities. The report is intended for traffic and design engineers, urban highway administrators, highway planners, traffic enforcement personnel, and other personnel responsible for HOV projects. A 2-day training course using this report is available from the National Highway Institute. Future revisions to this training course will take into account the California research described above. (2D)

A comprehensive reference document, "Freeway Traffic Management Handbook," was completed that combines research results and practical experience on freeway traffic management. It provides guidance to highway agencies in monitoring freeway traffic, developing freeway incident detection systems of various levels of sophistication, and implementing traffic diversion control. (2P)

Motorist Information Systems

Highway Advisory Radio (HAR) broadcasts traffic-related messages on frequencies at both ends of the AM band. A set of U.S. maps has been prepared showing where the two specific HAR frequencies can and cannot be used. These locations are restricted because either commercial stations broadcasting on frequencies adjacent to



Example of an HOV operation.

In-vehicle receiver for an Automatic Highway Advisory Radio system.

HAR's, or Travelers Information Station broadcasters (National Park Service, Forest Service, Airports, Federal Aviation Administration, Coast Guard, etc.) using the same HAR frequencies, are nearby.

A Highway Advisory Radio Message Development Guide has been developed to help station operators prepare HAR messages. The guide includes principles for constructing messages and examples of messages applying the principles to specific situations. Example messages are included for construction zones, lane blockages, route diversions, special events including parking control, inclement weather advisories, and tourist information.

A prototype of an Automatic Highway Advisory Radio (AHAR) system has been developed for test and evaluation. The AHAR system uses roadside transmitters and in-vehicle receivers to automatically provide hazard warnings, traffic advisories, or general tourist information to the motorist. The motorist can preselect the class of information to be received, for example, emergency, traffic advisory, or "trip information." (2L)

A Virginia Highway Planning and Research (HP&R) Program study to determine the extent to which drivers are confused by guide sign messages was completed. One important study finding was that drivers have trouble interpreting messages containing the word "next." The term "this exit" was favored by motorists for an exit ramp in full view. For references to two ramps, they favored the wording "first" and "second." They were confused by, and strongly opposed, the use of the word "next" for these situations.

The design and fabrication of the DOT/FHWA highway simulator was completed and it was delivered to the Fairbank Highway Research Station's new laboratory facilities. The simulator is to be installed and fully operational by summer 1983. Initial studies will address the validation of simulator measures and a variety of human factors research problems. (2N)

Metropolitan Traffic Management

The use of traffic simulation models is an inexpensive and safe way to assess the effects of proposed traffic control or geometric changes before they are implemented. Various efforts are being conducted or have been completed to enhance the applicability of these models:

- The traffic actuated signal logic in the microscopic urban network simulation model, NETSIM, has been updated and refined.
- A series of tests of practical applications of the urban macroscopic traffic simulation model, TRAFLO, has been initiated. The first test was in connection with the analysis of an urban freeway corridor in the District of Columbia.
- An integrated traffic data system is being developed to facilitate the application of these models (and signal optimization programs) by reducing the cost and time required to prepare data input, make computer runs, and use the output. (2K)

A National Cooperative Highway Research Program (NCHRP) study has been initiated to prepare a new Highway Capacity Manual for publication in late 1984 or early 1985. Material produced by various FHWA and NCHRP studies will be incorporated into the new manual. One of the FHWA studies will contribute a new procedure for estimating the capacity and quality of flow on urban arterials. Field data have been collected on 650 arterial segments throughout the continental United States. The data are being used to develop the

numerical relationships on which the procedure will be based. An interim finding concerned the passenger car equivalents (PCE's) of trucks on urban arterials: A truck's effect in the traffic stream is equivalent to up to 1.5 cars overall, and up to 2.5 cars at the intersections.

A new method to determine the capacity and level of service of individual signalized intersections was developed in an NCHRP study. Under a Kentucky HP&R study, data on saturation flow on intersection approaches have been collected, reduced, and analyzed. Factors affecting saturation flow were identified and quantified in the analysis. (2M)

Several computer programs have been developed over the years to optimize traffic signal timing in various applications. Work in this area this year included the following:

- A new demand-responsive isolated signal control strategy using dynamic programing techniques has been extended to arterials by the development of a way to coordinate signals that use this strategy. The coordination scheme allows the controller at each intersection to include in its calculations the effect its action will have on downstream intersections. (2M)

- Training courses were started for users of the Arterial Analysis Package, a new computer program that combines the most popular and useful computer programs for signal timing and traffic analysis on arterial streets: TRANSYT, PASSER II, and SOAP. (2M)

- The Signal Operations Analysis Package (SOAP) was updated as SOAP 82. Florida Department of Transportation is testing it and has prepared a user manual and software documentation. SOAP has been one of the more popular signal timing packages because its input structure is simple and it is easy to use. SOAP 82 further streamlines the package and improves its estimates of delay and stops for oversaturated intersections. (2Q)

- The current improved version of the urban network SIGnal OPtimization program, SIGOP-III, has been field tested and is now operational. Preliminary releases of the software were made available to several jurisdictions and consultants. The software and related documentation are expected to be distributed in June 1983. (2Q)

- MAXBAND, a program developed for determining traffic signal settings along arterial streets, is now being distributed to and used by various highway agencies. It uses mathematical programing techniques to maximize the green time available to platoons of vehicles moving along the arterial. (9B)

- Another signal setting method, also based on mathematical programing but minimizing vehicle delay, has been developed, called MINDELAY. (9B)

Other computer programs are used to actually operate traffic signals in real time:

- A report summarizing the capabilities of the New York Isolated Traffic Actuated Program (ITAP) was distributed by FHWA's Region 1[2] as a State Techshare Report. ITAP is a very flexible program for the control of isolated traffic actuated signals. The user can assign detectors to phases and control the assignment of phase sequencing. ITAP works with the Type 170 Traffic Signal Controller System. (2Q)

- User manuals and software documentation were prepared for the Basic Signal System (BASYS) and Eureka Distributed Multi-Level System (DMLS) control software. The BASYS software has been tested for 1 year at 12 field installations in California. BASYS is a simple traffic-responsive signal control system, which operates with the New York/California Type 170 Traffic Signal Controller. BASYS is intended as a simpler system for cities that cannot afford the sophistication of an Urban Traffic Control System (UTCS). A year of field testing of the Eureka DMLS software has begun in Eureka, Calif. The Eureka software distributes the intelligence of a control system down to area masters and the local intersection. This reduces communications costs and allows the distributed system to act as its own backup in the case of communications failures. (2Q)

- The UTCS first generation enhanced software was successfully tested in Broward County, Fla. The enhancements included the addition of new features, deletion of others, and reprograming to make the program easier to use. A pilot installation is being tested in Birmingham, Ala. (2Q)

- Guidelines were developed for operator intervention in computer-controlled signal systems using computer graphics displays. (9B)

[2] FHWA's Region 1 includes Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Puerto Rico, Rhode Island, Vermont, and the Virgin Islands.

Other Activities

Representative vehicles are being field tested to determine accurate fuel consumption and emission data for a range of operating conditions (speeds and accelerations). The results will be used to update fuel consumption and emission tables in traffic optimization and simulation models. (2K)

Limited field tests of the Wide Area Detector System (WADS), a system combining TV surveillance with automatic image processing, have been performed. The tests demonstrated the progress to date and identified remaining problems. Plans are being made to participate with industry in the next development phase. Also, the market and performance requirements for various types of WADS applications will be examined in more detail. (2L)

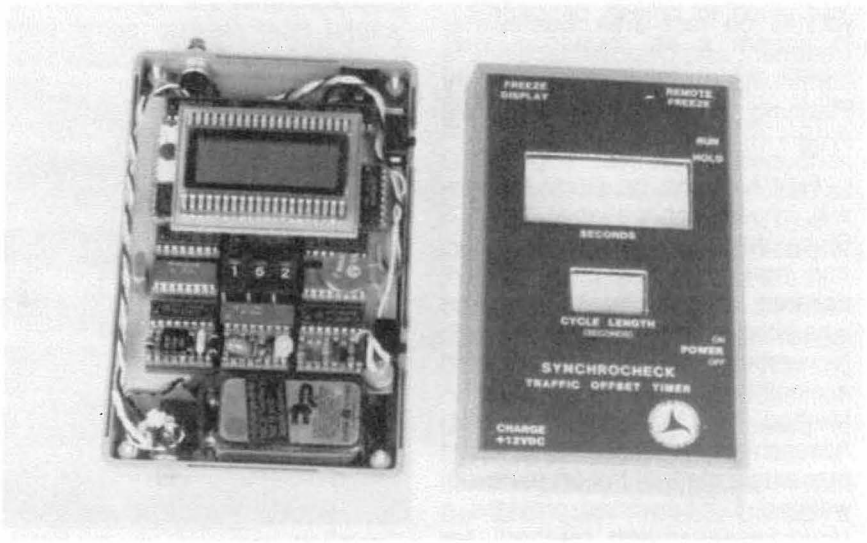
The SYNCHROCHECK–Traffic Offset Timer, developed by FHWA staff, will aid traffic engineers and signal technicians with the tedious task of checking coordinated traffic signal systems. The SYNCHROCHECK is especially tailored for the traffic engineer as an inspection aid to improve the efficiency and accuracy of measuring timing parameters in traffic signal systems. The device is currently being field tested and evaluated in seven jurisdictions. Preliminary results indicate that by using the SYNCHROCHECK, signal systems can be checked in about one-quarter the time required for checking with stopwatches. (2Q)

The Traffic Evaluator System (TES), when deployed on a street or freeway, automatically records many important traffic flow measures. New computer software for the TES, which will greatly improve the system's utility, has been completed. (2P)

The TRAF traffic simulation system has been expanded with the addition of two-lane rural road traffic simulation logic (ROADSIM). The TRAF system also contains the logic for simulating traffic on urban streets and freeways at several levels of detail. When completed, TRAF will be a single source for almost any type of traffic simulation needed to analyze the effect of highway design and traffic controls on traffic operations. (9B)

Looking Ahead

Traffic operations activities in the Federally Coordinated Program will continue to focus on increased efficiency of existing facilities, reduced energy consumption, and the effects of a changing vehicle fleet. The goal will be to provide lower cost, less labor-intensive methods of traffic control, taking advantage of advances in smaller, faster, and less costly computing and control equipment.



SYNCHROCHECK—an aid for checking coordinated traffic signal systems.

Environment

In its environmental research and development program, the Federal Highway Administration (FHWA) focuses on minimizing the impact of highways on the surrounding environment and protecting motorists from various environmental hazards. Some environmental impacts and hazards are highly visible and easily defined, while others are subtle and less tangible. Because uncontrolled impacts can be costly, potential impacts must be identified to avoid or minimize harm to the environment. FHWA environmental research and development addresses a broad range of concerns including water and air quality, noise abatement, ecological problems, and socio-economic factors.

Current research is quantifying the in-stream effects of highway runoff on aquatic ecology.

Water Quality

An ongoing major research program is determining the impacts of the highway system on water resources and developing methods to minimize or eliminate negative impacts. A four-phase program to identify and minimize the impact of highway operation on our water resources is into the fourth phase. Phase 1 identified pollutant constituents in highway runoff. This research is documented in a six-volume report series. Phase 2, now being completed, is identifying the sources and migration paths of the highway runoff pollutants. Phase 3, initiated in 1980, is determining the effects of highway runoff pollutants on receiving waters through extensive in-stream monitoring and ecological sampling. The information obtained in the first three phases will be used in Phase 4 to develop abatement technology and procedures.

A research study to synthesize the management options and effectiveness of available mitigation techniques for controlling highway runoff pollution was initiated in 1982. Research was also initiated to determine the impacts of highway maintenance on water quality. This research will also identify effective mitigation measures and alternative practices to minimize impacts.

A training course on design and operational guidelines for safety and rest area water supply and wastewater treatment, which was developed from FHWA research in this area, continues to be conducted by the National Highway Institute. Also, limited research on the effects of recreational vehicle wastes on rest area wastewater treatment and disposal facilities is continuing through the Highway Planning and Research (HP&R) Program.

FHWA began its study of highway impacts on wetlands in 1977. Since then, several small studies and implementation projects have collated and disseminated what was already known on wetlands. In November 1982, FHWA completed a significant study to develop "A Method for Wetland Functional Assessment." A two-volume report presents a state-of-the-art review of wetland functions and provides a rapid assessment method for screening functional values of wetlands. The manual uses the U.S. Fish and Wildlife Service classification system and can be applied to all types of wetlands. The method can evaluate the importance of a single wetland or compare several wetlands. It is useful for determining route location and evaluating mitigation alternatives. The development of a training course on wetlands began in 1982. This training course will focus on use of the methodology for wetlands functional assessment. An ongoing study in the National Cooperative Highway Research Program (NCHRP) is looking specifically at

Wetland research is developing guidelines for minimizing highway impacts.

the impact of highway runoff on wetlands. Future research will focus on wetland hydraulics and how changes in hydraulics may affect wetland functions. (3E) [1]

Air Quality

Research is underway to determine the effects of highways on vehicle energy and emission performance. A laboratory dynamometer and measurements of drive shaft torque are being used to determine fuel consumption and exhaust emission rates for a test fleet of representative vehicles. A series of applied external vehicle loads and speeds have been monitored to simulate a variety of highway conditions. Field trials are also being conducted using the same vehicles. Road conditions, time, vehicle speed, and drive shaft torque are recorded. A workable vehicle/highway performance prediction algorithm has been developed using disaggregated data from "mapped" representative vehicles. The algorithm will produce aggregated values of fuel consumption and air contaminant emissions rates for standard driving cycles from traffic speed model data or observed traffic speed data.

A driver performance variability investigation has shown that actual fuel usage rate variations were three times greater than laboratory-measured fuel consumption rate variations for vehicle speed fluctuations. Laboratory dynamometer test results have demonstrated that vehicle rolling resistance increases as the external load on the vehicle increases. This is a result of increased power losses to the driving tires. Rear-wheel drive vehicles operating on flat curves had increased rolling resistance. For vehicles traveling at 72 km/h (45 mph), this resulted in fuel consumption penalties of 6 percent and 13 percent at 0.1 g and 0.2 g lateral acceleration.

[1] Numbers in parentheses refer to the FCP projects identified on page 31.

TEXIN (Texas Intersection Model), an efficient highway air pollution model for locations near roadway intersections, was developed and validated for a variety of moderately developed commercial and residential plain terrain sites in California and Texas. TEXIN is a sequential model which analyzes traffic flow, predicts vehicle exhaust emission rates, incorporates downwind dispersion of air contaminants, and predicts near roadway location air quality.

The research report "A Probabilistic Approach to Near Road Impact of Air Pollutants" was published this year. The research established a mathematical basis for the concept of statistical air quality modeling. The report documents the feasibility of using a probabilistic approach for estimating highway air quality impacts.

Two major NCHRP reports were also published: "Estimating Exceedances and Design Values for Urban Ozone Monitoring Network Data" and "Methodology for Evaluating Highway Air Pollution Dispersion Models." (3F)

Noise Abatement

Enhanced design of noise barriers continues as a means of achieving effective noise abatement. To insure construction of the most cost-effective designs, OPTIMA, a barrier cost-reduction procedure, has been developed as a companion to the current FHWA Level II noise propagation-barrier attenuation prediction procedure called STAMINA 2.0. OPTIMA assesses trade-offs of noise reduction and barrier cost. Training courses and presentations on OPTIMA are being presented to highway personnel through the National Highway Institute and FHWA Demonstration Projects Division's Project No. 938, Noise Barrier Design Optimization.

Research is underway to quantify the effectiveness of optimized noise barrier design. Optimized barrier cross-sectional shape and absorptive treatment can improve barrier effectiveness at minimum cost. A standard test procedure for evaluating the acoustic effectiveness of noise barriers is also under development.

A recently completed highway construction noise model has been tested and evaluated successfully. This computer model assesses both the overall community impact and the individual effects of activities during each phase of construction. The construction noise model will be published during 1983.

Existing traffic noise prediction models incorporate many simplifying assumptions. Because these assumptions have restricted the usefulness and accuracy of noise models, recent efforts have been devoted to modeling complex sites. A newly developed noise propagation-barrier attenuation prediction procedure accounts for variations in ground slope and terrain cover through computer algorithms: The noise propagation algorithm that accepts site-specific data to characterize ground absorption and vehicle heights, and a refined algorithm to describe sound attenuation over barriers. The improved accuracy of these combined algorithms will maximize barrier effectiveness under varied highway conditions. The model is undergoing final test and evaluation during 1983.

A stop-and-go urban noise prediction model that will account for vehicles accelerating at various rates through intersections is nearing completion. The propagation of noise through urban corridors and around corners of highway intersections will be accounted for in predicting the noise level at arbitrary receiver locations.

Research also continues in development of a Tire/Pavement Noise Assessment Procedure (TIP–NAP)

Studies in noise abatement include construction noise prediction, urban noise prediction, and enhanced design of noise barriers.

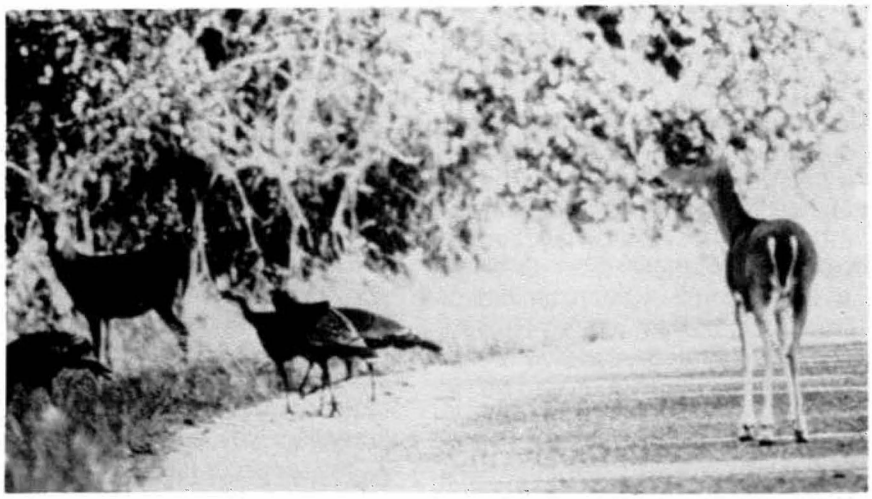
for cost-effective selection of quiet pavement designs based on site-specific conditions and development of design techniques to mitigate pavement-induced tire noise. (3F)

Ecology

FHWA's ecology program focuses on vegetation management and wildlife. Vegetation management research is conducted primarily through the HP&R program and stresses development of cost-effective procedures to insure a safe highway system with minimal environmental impact. The program includes studies on selection, establishment, and maintenance of vegetation; improved procedures for maintaining vegetation in arid areas, including improved irrigation practices; biological control of weed and insect species; optimal use of chemicals and mowing to control vegetation; and development of new varieties of low-maintenance vegetation. Regional technology transfer workshops on vegetation management will be developed during 1983. The first workshop will be held in New England and will focus on technology sharing by States in FHWA's Regions 1 and 3. [2]

A manual on "Wildlife Considerations in Planning and Managing Highway Corridors" was published. The manual discusses assessment of the impacts of highway construction and operation on wildlife as well as techniques to incorporate wildlife considerations in right-of-way management.

Wildlife research continues to focus on reducing vehicle collisions with large game species and reducing highway system impacts on wildlife and wildlife management. Although limited research is still underway on reducing collisions with wildlife, the main emphasis is on implementing the results of completed research while investigating any promising new approaches. One area for future investigation is a device for detecting the presence of large animals in the right-of-way. If successful, this device could be coupled with motorist warning systems, reducing the need for deer fencing. (3F)



The environmental research program includes the study of ways to reduce the impact of highway operation on wildlife.

Socio-Economics

Socio-economic (SE) research addresses the prediction and treatment of impacts from new highway construction or improvement projects on the social composition and economic vitality of communities. The goal of the research is to identify, evaluate, and disseminate good practices for SE impact assessment.

Data requirements for various types and levels of SE impact analysis have been established. Many potential sources, such as information and opinion surveys, maps, census data, utility company records, and city directories, have been evaluated to determine which sources can supply requisite

[2] Region 1 States are listed on page 10. Region 3 includes Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia.

data under various site-specific situations. Recommendations for collecting, locating, using, and displaying such data are being formulated.

Longitudinal studies are being performed to evaluate the applicability and validity of the identified prediction techniques. The studies re-create highway construction projects, showing the actual changes in the economic and social structure of a community that occur during highway development and after construction. Current findings show that, outside of displacement, social and economic impacts in a community tend to stabilize shortly after project construction. The impacts are felt primarily during the highway development process.

Citizen involvement programs are very helpful in identifying SE impacts, assessing their significance, and resolving conflicts, but they must be designed and monitored properly if they are to be an effective part of an SE impact assessment process. A preliminary set of effectiveness measures has been developed to facilitate setting objectives, selecting citizen participation techniques, recordkeeping, and redirecting unsuccessful, ongoing programs. These measures are presently being tested and refined in-house. The refined measures will then be applied to actual projects to determine how well they can enhance citizen participation program design and implementation. Criteria to be employed will include reductions in project delays, increased efficiency in resource utilization, and enhancement of agency credibility.

No new research studies are planned in the socio-economic area. It is felt that the dissemination of the results of the studies currently underway will adequately assist users in SE impact assessment. Many of the problems and technological shortcomings associated with current applications of SE impact assessments are expected to be resolved through the current studies. (3H)

Looking Ahead

Future environmental activities in the Federally Coordinated Program will continue to identify and evaluate highway elements that affect the quality of our environment. New problems posed by the ever-changing highway-environment relationship will be investigated to reduce adverse highway and traffic impacts and protect the environment.

Materials

Federal Highway Administration (FHWA) materials research and development covers many areas, from exploring practical alternatives to chloride salts in deicing operations to developing better ways to clean structural steel before painting. However, all these activities have a single goal—to conserve scarce highway funds by devising ways to reduce maintenance requirements and substitute more cost-effective materials for the traditional materials used in highway construction and maintenance.

Alternate Deicers

For the past 40 years, highway agencies have used rock salt (sodium chloride) and calcium chloride for highway deicing to maintain safe operation of roads and streets in adverse winter weather conditions. However, these deicers exact major penalties. Chloride ion is a primary contributor to the corrosion of steel reinforcing bars in portland cement concrete bridges, and the subsequent deterioration of the bridge members. Chloride ion also causes corrosion of the structural steel in bridges and other highway appurtenances and contributes to rusting of automobiles. Finally, deicing salts can enter surface and ground water in runoff and make it unhealthful for drinking. Chloride ion in runoff is also harmful to roadside vegetation.

In 1980, the chemical calcium magnesium acetate (CMA) was identified as an alternative to chloride deicing salts that was potentially nonpolluting and noncorrosive and had similar deicing capabilities. During the past year, a comprehensive program has been conducted to develop economical production methods for CMA, and to determine CMA's environmental acceptability and technical merits.

The key to producing CMA economically is to reduce the cost of the acetic acid required in the production. (The simplest way to produce CMA is to react appropriate amounts of dolomitic lime and glacial acetic acid.) Most acetic acid produced in the United States is synthesized from petroleum or natural gas feedstocks. The potential exists to produce acetic acid from the cellulose in biomass, at a lower cost than synthetic acetic acid, by a variety of processes such as fermentation, alkaline fusion, and acid hydrolysis.

Current research has examined the laboratory production of CMA by the anaerobic bacterial fermentation of biomass to acetic acid, and reaction of the acetic acid in the fermentation medium with dolomitic lime. An economic analysis of producing CMA by this process indicates that it could be produced for $413 per Mg ($375 per ton) using corn grain or syrup as the starting material compared with $600 per Mg ($545 per ton) using synthetic acid.

A further laboratory assessment of the probable environmental consequences of using CMA for deicing is also underway. The tolerance of selected fish species, macro-invertebrates, zoo- and phyloplankton, and a wide variety of plant species to CMA and chloride salt controls is being determined. The results to date confirm and expand upon the previous research on CMA.

Work is also in progress on the production of 180 Mg (200 tons) of CMA for delivery to two or three States in the winter of 1982–83. This CMA is being produced by the reaction of synthetic acetic acid with dolomitic lime. The material will be used in field evaluations to gain operational experience with CMA and to gage its effectiveness compared to rock salt. (4L) [1]

[1] Numbers in parentheses refer to the FCP projects identified on page 31.

Corrosion Control

As discussed above, chloride deicing salts cause severe structural damage to bridge decks by promoting the corrosion of steel reinforcing bars. The structural steel in bridges and other highway appurtenances is also subject to corrosion by chloride salts as well as by air pollutants found in major metropolitan areas.

Work is in progress to identify methods and materials, compatible with environmental and other restrictions, that will improve the control of corrosion on exposed highway structural steel. The PACE (Performance of Alternate Coatings in the Environment) program, sponsored by 25 States and FHWA, is evaluating a large number of waterborne epoxy coatings and high solids or waterborne versions of chlorinated rubber, urethane, vinyl, and acrylic coatings on test panels prepared for outdoor exposure and salt-fog exposure. In addition, coatings for previously painted surfaces are now being tested on both blast-cleaned and rusted, handtool-cleaned panels.

Research is also in progress on a multiphase study of improved field reliability of high performance coatings. Current practices associated with these coatings (such as zinc-rich primers, vinyls, epoxies, and urethanes) have been examined and the current best technology determined. For example, field topcoating of inorganic zinc primers is often plagued by excessive bubbling and blistering of the topcoat and specially designed intermediate coats. Many possible causes for this condition have been identified—high temperature, poor application procedures, and excessive zinc-rich thickness—and it appears the best method to qualify these products is to supplement laboratory testing of performance characteristics with field testing. As another example, the inspection function, so critical in the use of high performance coatings, was

Rating some of the 5,000 panels on outdoor exposure as part of the PACE project.

generally found to be lax. The primary reason for this situation appeared to be a lack of procedural definition of the inspection tasks. Inspection can be improved by designing inspection tasks in accordance with human resource engineering and defining work quality and acceptance in terms of statistical quality control.

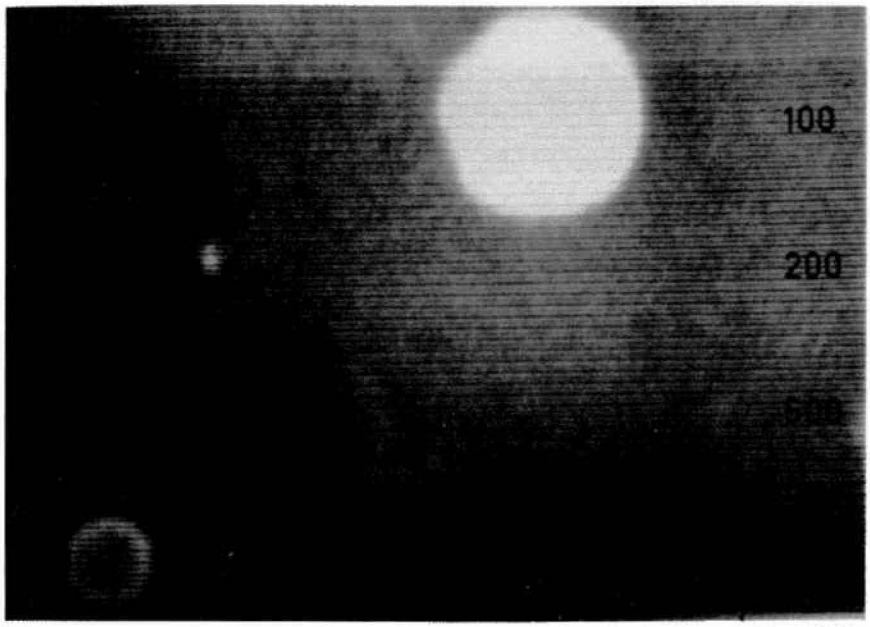
Another study is attempting to determine the need for and identify alternative coatings that can be used on inadequately cleaned metal surfaces on bridges. This situation arises where sandblasting is prohibited (for example, urban or environmentally sensitive areas) or budget and manpower limitations preclude as complete a surface preparation as might be desirable. Information on over 100 specialty coatings supposedly designed for use over poorly cleaned steel has been collected. Based on data gathered about these products, most commercially available coatings can be classified as providing protection by impregnation of rust, that is, the binder penetrates the porous rust and bonds directly to the steel surface, encapsulating the rust particles as a harmless pigment or particle in the paint. A detailed program for evaluating these specialty coatings in the laboratory and outdoors has begun.

Work has progressed on a National Bureau of Standards (NBS) study to assess accelerated corrosion and durability tests and failure detection techniques for structural steel coatings. As reported last year, commonly used accelerated tests, including salt spray and cyclic weathering, were found to give results that correlate poorly with actual service performance and are seldom reproducible. Thus, experienced users of coating systems rely on long term outdoor exposure results and consider short term results as supporting evidence only. This situation places smaller producers and users at a disadvantage by requiring very long qualification times for new coatings.

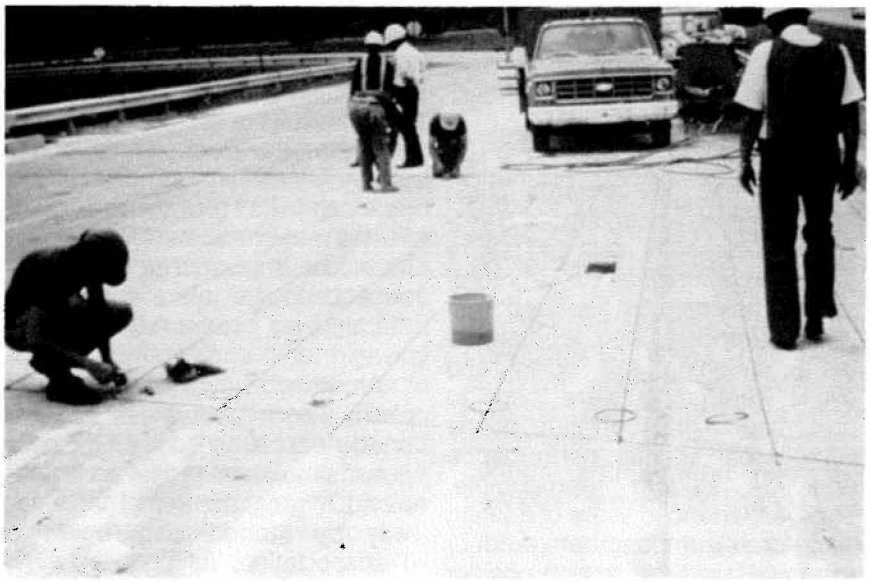
Therefore, NBS is investigating alternative approaches for short term testing. Although most people think of accelerated tests for coatings performance as tests in which the exposure conditions are accelerated, acceleration can also be achieved by early failure detection or a combination of early failure detection and accelerated exposure. Along with reliability analysis for predicting coating life, NBS has investigated early failure detection using infrared thermography (IRT).

IRT is based on the phenomenon of emission of radiation. For structural steel, IRT detects the difference in emissivity of uncorroded iron and its corrosion products. These differences appear in the infrared region of the spectrum as differences in temperature. An important benefit of thermography is its nondestructive nature; this characteristic permits the monitoring of exposed test panels through their useful life. This study has demonstrated that IRT can detect corrosion beneath a pigmented coating—corroded areas appear as hot spots compared to the steel surface. In addition, computer techniques have been developed to digitize the IRT data, allowing the quantitative measure of the percentage of rust on a steel surface and its growth with time. Further development of these methods of early detection will depend on the interest shown by the highway community.

An effort to evaluate the adaptability and usefulness of the bridge corrosion cost (BCC) computer simulation model as a real-world management tool is underway by Florida Department of Transportation. Its goal is to use the BCC model to aid in long term (5 years or more) planning of bridge maintenance. As originally developed, the model is a theoretically-based tool for predicting the cost of repainting a bridge structure at various repaint intervals. Initial evaluation of the model yielded agreement within about 20 to 25 percent when comparing predicted costs with actual costs for painting bridges in several States.



A steel panel coated with white paint appears perfect to the naked eye. However, by using infrared thermography, rust on the steel surface is evident (lighter areas).



Overall view of bridge deck at New Columbia, Pa. Platinum anodes were laid in precut slots backfilled with conductive polymer concrete.

Florida DOT has concentrated on using the model to calculate total costs of painting a bridge. Actual painting costs of approximately 100 recently painted bridges were used to refine the model; it was found adding several parameters to the model would improve its accuracy. These parameters include variations in crew sizes during painting, labor rates, rigging costs, and traffic control. Although allowing a wider range of values for these parameters increases the complexity of the BCC model, the advantage of obtaining more precise costs far outweighs the added difficulties and increases greatly the practical value of the BCC model as a management tool, both for long term planning and day-to-day operations.

In a Highway Planning and Research (HP&R) Program study, California DOT has work underway to develop a waterborne coating system with performance equivalent to the standard solvent-borne basic-lead silicochromate system. Laboratory work indicates that acrylic and styrene acrylic emulsion paints can meet the co-solvent emission limits mandated by State regulations. Field experience with these paint systems is extensive; since 1979 more than 25 bridges in California have received waterborne coating systems (including approximately one-half of the bridges painted in 1980 and 1981). The early applications were in areas with mild weather conditions where the solvent-borne lead-containing systems being replaced had a service life of 20 years. Future applications of the waterborne systems on coastal bridges will provide a more severe test of their performance capabilities. (4J)

Several new efforts were initiated in research to prevent or ameliorate corrosion of reinforcing steel in bridge decks. One effort involves the development of a total overlay configuration. It is concerned with the further development of electrically conductive polymer concretes, initially formulated by FHWA, for use on bridge decks as part of a cathodic protection (CP) system. Pilot testing of promising resins and fillers on two 9.3 m^2 (100 ft^2) sections of bridge deck test slabs using both the premixed and built-up techniques and development of a gas permeable conductive polymer concrete are underway.

Significant emphasis is being placed on using nonoverlay CP systems in bridge and parking decks. The CP system is placed in slots cut in the deck surface. The first full-scale field use of a system of this type was in June 1982 on a Pennsylvania bridge deck. Con-

struction went quite smoothly and after several months under traffic, no deterioration of the slot backfill material is evident.

An evaluation of the effectiveness of CP systems on seven bridge decks in California was concluded. The systems were installed in 1973 and 1974 and all used the more conservative 850 mv polarized potential for the cathodic protection. In general, the concepts and installations of CP on bridge decks have proven successful; rectifiers on the majority of the decks required upgrading to achieve the desired 850 mv potential. It is interesting that the natural response of a conventional rectifier to varying bridge deck resistance (produced by variations in temperature and moisture) provides adequate control of the CP current.

A study on the chloride permeability of concrete surface coatings and penetrants was completed. In a screening procedure, 102 mm (4 in) concrete cubes were immersed in 15 percent sodium chloride solution. Weight change and chloride content were the evaluation criteria. The weight change monitoring also provided information on the vapor transmission characteristics of the sealed concretes. Many materials, including boiled linseed oil, were found to be ineffective in reducing the water absorption and chloride intrusion characteristics of concrete subjected to saltwater soaking. However, certain specific formulations of different chemical materials exhibited excellent performance. (4K)

Substitute Materials

Study continues on using chemically-modified sulfur (Sulphlex) binders in highway construction. The final Sulphlex test pavement sections were constructed this year. In Arizona, a Sulphlex overlay was placed on U.S. 70 near Safford; in Texas, a Sulphlex chip seal was constructed on the I-10 service road north of San Antonio. These pavement sections will be monitored for durability and performance for 2 years. Sulphlex pavements constructed in 1980 and 1981 in North Dakota, Pennsylvania, and Michigan show distress such as raveling and thermal and reflective cracking. The Sulphlex pavements built in southern climates appear to be suffering little, if any, distress.

Laboratory work continued on Sulphlex mix and structural design methods, chemical characterization and quality control, environmental and safety assessments, development of new binders with improved engineering properties, and process design for Sulphlex binder production. (4G)

Pavement Subgrades

A comprehensive evaluation of existing methods for assessing the frost susceptibility of soils was recently completed. None of these methods has proven to be the universal test for determining the frost susceptibility of soils. Three of the methods were rated as worthy of further study and possible validation. A new test method was also developed incorporating the best features and excluding the known imperfections of some of the present tests. Two field test sites were constructed and actual frost action performance data were obtained. The four candidate methods were used to test the subgrade soils at each field site. The most efficient method will be selected from the results of a comparison between predicted and measured performance. (4D)

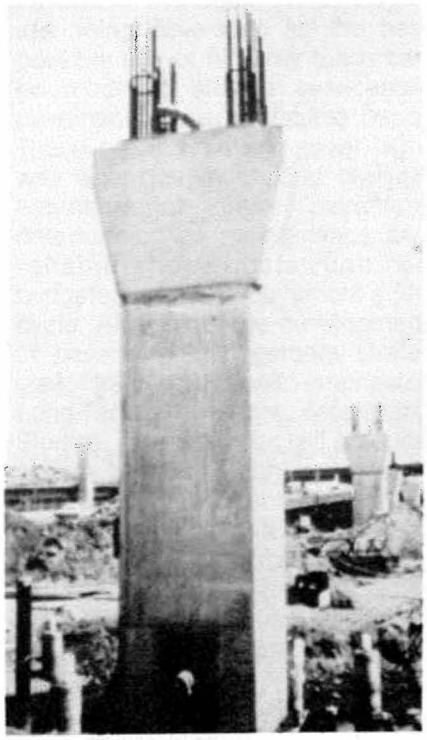
Bridge Foundations

A recent study to determine future highway bridge foundation needs resulted in the following estimated distribution of foundation types for bridges to be constructed in the next 15 years: Pile foundations—70 percent; spread footings—24 percent; drilled shafts—5 percent; caissons and other—1 percent.

A related study showed that significant savings can result from using existing foundations in bridge rehabilitation projects, provided that geometric configurations and waterway requirements are adequate. Methods for evaluating and strengthening bridge substructures and foundations were developed.

A prototype instrument has been developed for measuring lateral stresses in soils. Currently it is being modified to provide direct measurement of effective stresses and to simplify testing procedures. It will be developed further and validated through a series of field tests at sites where structure performance data have been taken.

A new contract research study has been initiated to review the state of the practice and develop improved procedures for designing spread footings for highway structures.



Instrumented pile foundation under construction in cohesionless soils, West Seattle Freeway bridge replacement project.

A comparison of design predictions with measured field performance will be based on a comprehensive data collection, storage, and retrieval system to be developed specifically for highway bridge foundations, with special emphasis on spread footings. The system will be refined and verified by monitoring 10 bridges for 2 years. Risk analysis techniques will also be used to improve the prediction methods.

A staff study to obtain information on the safety, reliability, and cost-effectiveness of existing bridge spread footing foundations was completed. The results indicated significant cost savings may be realized from using spread footings instead of pile foundations where soil and site conditions permit.

Construction is beginning on outdoor test pits for a scale model foundation pile research facility at the Fairbank Highway Research Station, McLean, Va., to expand on laboratory scale model studies presently underway. Model study findings are being correlated with other full-scale instrumented pile studies to establish optimum model scale factors. (4H)

Looking Ahead

Future FHWA materials research will continue to expand the knowledge of material properties, improve the use and durability of existing materials, and develop new materials to decrease highway construction costs and extend maintenance-free operation.

Structures

The Federal Highway Administration (FHWA) structural research and development program provides for increased service life and efficiency of pavements, bridges, tunnels, and drainage structures of both present and future highways. Structural elements of deteriorating roadway systems are being upgraded by the implementation of new technology for cost-effective rehabilitation. Advanced techniques are being developed for protecting structures on all highway systems against the extreme forces of flood, earthquake, and wind.

Highway Pavements

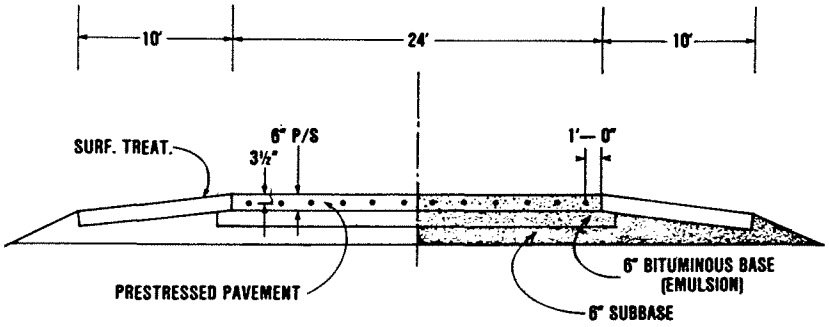
A computerized economic analysis program, EAROMAR, was developed for estimating the economic impacts of different levels of maintenance and rehabilitation activities on different pavement types and environments. It also can be used to determine the optimum balance of capital and maintenance costs for pavements under various traffic conditions. EAROMAR is currently being used to develop a framework for "Pavement Type Selection" based on life cycle costs.

The design and construction of prestressed pavements have been of interest in the United States since the early 1970's because of the potential savings in materials and the potential for improved performance at lower cost. Because of the benefits of these type pavements, detailed design procedures were developed in an FHWA contract study. In another study, a panel of highway research engineers inspected the condition of prestressed pavements constructed in Virginia, Pennsylvania, Mississippi, and Arizona. Based on their observations, the panel concluded that prestressed pavements are a viable alternative to conventional pavements. All of the prestressed pavement projects with concrete slab thicknesses of only 152 mm (6 in) performed adequately and competitively with 203 to 254 mm (8 to 10 in) conventional concrete pavements, based on similar environmental conditions and serviceability requirements. Savings in reinforcing steel are also realized because, although the product used for prestressing is more expensive than that for ordinary rebars, prestressed pavements require only 1.33 kg/m ^{2} (2.25 lb/yd ^{2}) of reinforcing steel compared to 8.9 to 11.0 kg/m ^{2} (15 to 20 lb/yd ^{2}) for continuously reinforced concrete pavements. The final report for this study presents the details of construction, post-tensioning procedures, and the expansion joint design for the four projects.

Environmental effects contribute greatly to pavement deterioration. Reducing or eliminating the effects of the extreme variations in temperature and moisture to which a pavement is subjected will decrease maintenance costs and increase the service life of the pavement. To accomplish this, new premium pavement design procedures have been developed for flexible, plain jointed rigid, composite, and continuously reinforced concrete pavements. These design procedures are currently being compiled into a handbook that will be published during 1983. (5E) [1]

A major drawback to effective pavement design is the lack of practical procedures to determine the consequences associated with various design strategies, in terms of agency and user costs. Analyses and procedures, based on modern pavement management concepts, are being developed so the best possible use of highway funds can be made to provide serviceable pavements on a continuing basis. These procedures will assist highway agencies in making realistic estimates of future pavement deterioration so maintenance and rehabilitation costs can be budgeted over the pavement's life cycle. Along with the development of pavement management strategies, this study will emphasize Long-Term Pavement Monitoring Studies. These studies will produce a data base that can be used to develop the necessary relationships for cost allocation and other planning needs, such as programing funds and prioritizing projects. An initial pilot study is planned for about 80 test sections in eight States. (5N)

PENNSYLVANIA



Typical prestressed pavement design.

[1] Numbers in parentheses refer to the FCP projects identified on page 32.

Bridge Superstructures

Research and development activities on bridge superstructures are providing ways of extending the service life of existing bridges, making bridge construction and rehabilitation more cost effective, and incorporating advanced structural material concepts in the design of new bridges. Major emphasis is being placed on improving existing design, fabrication, and erection techniques, and developing effective and realistic bridge steel fabrication quality control procedures.

A study on structural connections for modular precast concrete bridge deck panels was completed. The study included the collection and assessment of information on current practice and structural laboratory tests on selected connections. The performance of grout keys and transverse ties between deck elements and a method for connecting precast concrete deck panels to prestressed concrete girders were evaluated.

A recently completed research study determined the feasibility of establishing standards for certain types and sizes of segmental sections of prestressed concrete box girder bridges. Comments by Federal and State bridge offices, producers, and trade associations were solicited on current design and construction practices and on the research recommendations for possible standardization. The evaluation of the current state of the art of U.S. and Canadian practice identified conditions where standard sections could be used to improve the efficiency and economy of segmental bridge construction. (5K)

Steel bridge fracture control design continues to be refined through the development of more effective and realistic guidelines for preventing localized failures that may lead to the collapse of bridge structures containing fracture critical members.

Replacement of the deck on a through-girder bridge with reinforced concrete panels connected to the stringers to provide composite action.

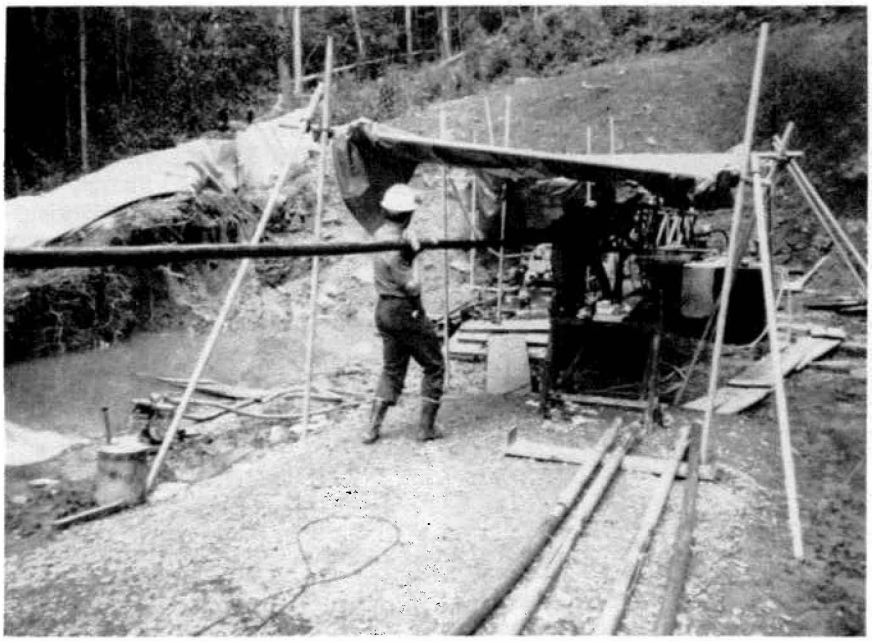
Current bridge structural inspection methodology is seeking to improve the efficiency of corrective and preventive maintenance. A new FHWA inspection instrumentation system that uses the magnetic field disturbance technique to detect breaks in steel tendons in prestressed concrete bridge members is undergoing further evaluation.

A study to develop innovative methods of upgrading structurally and geometrically deficient through truss bridges was completed. The final report documents methods for economically and rapidly increasing the roadway width, vertical clearance, and load-carrying capacity of these structures and discusses the cost effectiveness of upgrading versus replacement.

Cooperative FHWA-State field studies are continuing on the use of new vehicle weigh-in-motion (WIM) instrumentation systems installed on bridges. Through these studies and concurrent FHWA contract research studies, the ability of WIM systems on bridges to provide accurate moving vehicle weight data is being improved. A WIM system housed in a small van or trailer can be operational at a bridge site in a few hours. (5L)

Tunnels

The new FHWA subsurface exploration system developed for use at proposed tunnel sites incorporates three sensing modes—resistivity, radar, and acoustic—for obtaining geologic data from either vertical or horizontal boreholes. The elements of the system are encased in cylindrical probes operated from a Mobile Unit for Subsurface Exploration (MUSE) van that contains all guidance controls. Field data processing and data interpretation capabilities are to be installed in MUSE for translating the information obtained from the probe sensors to accurate portrayals of the subsurface geological formation and other physical phenomena encountered in the borehole. The probes, MUSE, and new data interpretation techniques were demonstrated in 1982 for logging a 305 m (1,000 ft) long horizontal underground borehole at the Cumberland Gap National Park tunnel site in Kentucky.

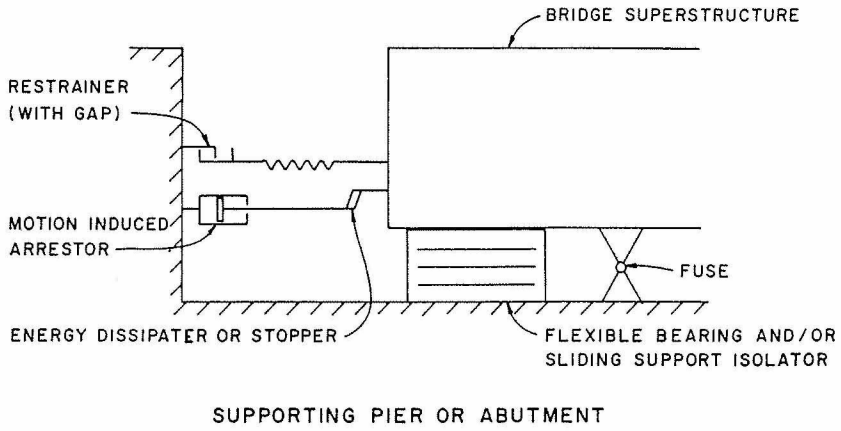


Starting the subsurface exploration sensor probes into the 305 m (1,000 ft) long horizontal borehole.

A new study initiated in the past year on preventing and controlling fires in highway tunnels will include a summary and analysis of current practice and develop improved techniques for mitigating the effects of this potentially serious hazard.

A research report was completed that describes improved design and control of grout treatment methods for upgrading weak or pervious soils prior to tunnel excavation.

Research on methods of building concrete retaining walls in slurry-filled trenches prior to excavation for a cut-and-cover tunnel has shown their cost effectiveness and technical efficiency. To provide incentives for even wider use of the technique, an implementation report on the recent design and construction of two slurry trench walls on I-75 in Atlanta, Ga., is in preparation. The walls will form permanent earth retaining structures after excavation for a depressed roadway section. (5B)



Ideal aseismic bridge bearing system.

Low-Volume Road Design

Low-volume roads carry less than 400 vehicles per day but constitute about 75 percent of the Nation's highway mileage. Guidelines were recently developed in three areas of low-volume road design and construction: Use of marginal materials, material requirements, and design and construction of low water stream crossings. Two major current research efforts on low-volume roads involve developing cost benefit data on commonly used soil stabilization methods and improving the structural performance of segmental plate metal culverts connected through slotted bolt holes. (5M)

Earthquake and Wind Resistance

This research is concerned with identifying the characteristics and magnitudes of earthquake and wind forces on highway structures and developing methodologies for implementing techniques to resist these forces and avert catastrophic collapse. It focuses on providing advanced structural design criteria and retrofit recommendations that can be specified by highway and bridge design engineers for improving the seismic and wind load response of both new and existing highway bridges, tunnels, and other structures.

New seismic design guidelines for bridges have been developed and submitted to the Bridge Subcommittee of the American Association of State Highway and Transportation Officials for consideration and adoption.

A study to develop new design concepts for fixed and expansion bearing devices on bridges to provide adequate superstructure restraint against earthquake-imposed loading was completed.

Ten expansion and seven fixed bearing concepts were identified, and analytical and experimental research was conducted on the two most promising concepts. Engineering guides will be developed for the design and use of the bearing devices most able to reduce the vulnerability of bridges to earthquake damage.

An FHWA-State cooperative research study of the aerodynamic response of the 50-year-old Deer Isle suspension bridge in Maine is continuing. Response data from the wind and motion measurement instrumentation in use on the bridge for the past year are being evaluated. A section model of the bridge is being studied in the FHWA wind tunnel.

Another FHWA-State cooperative research study involves assembly and installation of a new FHWA wind and motion measurement instrumentation system on the recently completed cable-stayed girder bridge over the Mississippi River at Luling, La. Section model studies of this bridge conducted previously in the FHWA wind tunnel provided essential data for the bridge designers.

A research study to develop analytical procedures for evaluating the aerodynamic stability of long, slender, steel bridge columns with elastic end constraints was completed. The final report presents a method that takes into consideration realistic column end conditions. (5A)

Flood Hazards

A large-scale laboratory study has been initiated to determine the damage that can be expected from flood overtopping of highway embankments. Quantification of this component of risk analysis will greatly enhance the cost-effective design of highway stream crossings.

A research study has begun on the design of rock riprap for the protection of highway encroachments on large streams. It will include field evaluations of performance of existing design procedures.

Methods to assess stream channel instability and the potential problems encountered at highway stream crossings and flood plain encroachments are described in a recently published report. Channel instability is manifested as lateral bank erosion, progressive degradation of the streambed, or natural scour and fill of the streambed. Lateral stability is related to stream type.

Laboratory scale model studies on the spacing, size, shape, permeability, and orientation of channel spurs are currently underway in a sand bed test facility. Based on these study results and field evaluation of spur performance, a manual will be prepared to provide guidance for the selection and design of various types of spur and jetty structures.

Energy dissipation of culvert flow remains a complex and difficult problem. In an Ohio Highway Planning and Research (HP&R) Program study a laboratory investigation of precast concrete internal ring energy dissipators for culverts is being conducted. The purpose of the study is to expand the data base for different arrangements of roughness rings and to develop structural and hydraulic design guidelines.

A Texas HP&R study investigated the hydraulic performance of safety grates over culvert openings with varying degrees of clogging from debris. The study also examined entrance losses (for both inlet and outlet control flow) for a culvert inlet design that is both flared and mitered to the embankment slope. This combination is in common use but is not covered in hydraulic design circulars.

An implementation package was developed to provide information on the design of pumping stations for highway storm drain systems where gravity flow is impossible or uneconomical. Discussions include pump station siting, hydrologic and hydraulic considerations including pump cycling, and operating details important to maintenance personnel. A complete guide specification is presented in the appendix. (5H)

Looking Ahead

New bridge and pavement design and rehabilitation technology is being continually developed to provide enhanced cost-effective service performance of existing and future structural elements of the Nation's highway systems. The daily problems experienced by highway and bridge engineers in the field serve as constant reminders of the need for continued vigorous structural research and development activity.

Highway Construction

Federal Highway Administration (FHWA) activities in highway construction are directed toward research and development of new technologies to improve construction methods, quality of construction, productivity, and contract administration. Special attention is being focused on training for highway personnel as well as implementing pavement management and construction engineering management systems.

Construction Materials and Controls

Recycling asphalt paving materials continues to grow as a major construction technique. The construction process, however, is generally considered more advanced than structural design methods, material testing procedures, and construction control specifications used for this process. Research in these areas will establish procedures necessary for optimum use of recycled asphalt pavements.

A nationwide data bank on projects that use recycled asphalt paving materials is being developed. The data bank can be used to evaluate performance of the recycling processes, equipment, materials, design procedures, and pavement performance.

Research is also underway to develop or modify existing paving mixture design procedures to produce durable recycled paving materials and establish criteria for mixture design procedures. The structural engineering properties of recycled bituminous paving mixtures are being characterized so State highway agencies can better design recycled pavement sections and predict their relative performance.

A new study in FY 1983 will seek optimum mix designs for representative cold mix recycled bituminous paving materials. This study will also evaluate physical and chemical behavior between aged asphalts and recycling agents, including high penetration asphalts. (6C) [1]

Roller-mounted nuclear gage for monitoring asphalt concrete density and temperature.

A program was initiated to improve test equipment for construction quality control. The equipment should allow testing of new material as soon as possible after placement, rather than days or weeks later when massive quantities have already been placed. The program activities include:

- Developing a nuclear backscatter density gage that mounts on rollers used in asphalt concrete construction. The instrument gives the roller operator continuous feedback on the density and surface temperature of asphalt concrete during compaction and provides a permanent record of the final pavement density.
- Fabricating a second generation prototype of the Consolidation Monitoring Device—a nuclear backscatter density gage that mounts on a slipform paver and automatically and continuously monitors the consolidation of fresh portland cement concrete pavements.
- Developing equipment for monitoring the smoothness of newly placed concrete during paving operations. This equipment will provide immediate feedback and minimize the need for expensive grinding of hardened concrete to meet smoothness specifications.
- Evaluating new methods for measuring the cement and water content of freshly mixed portland cement concrete by several State highway agencies. (6F)

The costs of quality control testing programs, as well as the high costs of pavement failures due to construction and materials problems, are leading highway agencies to take a new look at quality control specifications. FHWA has initiated a new research project to develop specifications and test procedures that measure attributes which truly reflect performance.

During the past year, a major attempt to correlate the results of common field tests with the performance of portland cement concrete pavements neared completion. Data from five States show that thickness, strength, and air content are the quality indicators

[1] Numbers in parentheses refer to the FCP projects identified on page 32.

that have the largest effects on performance.

Researchers also began assessing the cost effectiveness of tests and sampling frequencies used in paving construction and materials quality control. The assessment will be based on the relationships between test results and performance, where available, and include such factors as initial cost and quantity of a product, criticalness of performance, and typical failure rates and variabilities encountered with the material. (6G)

Pavement Construction

Two workshops in Pavement Management (PM) were conducted this past year. Many PM topics were discussed (such as, data needs, pavement evaluation equipment requirements, methods for pavement ratings, rehabilitation design procedures, and PM strategies) and State and local highway agencies were able to exchange ideas and concerns about their pavement programs. A final workshop is planned in FY 1983.

As more and more miles of the Interstate system and other highways reach their design service lives, maintaining satisfactory serviceability is becoming an important problem. A recently completed study provides guidance on the design of flexible pavement overlays. Work on a rigid pavement overlay procedure is continuing, as is a study to develop improved treatments to reduce reflective cracking in asphalt concrete pavement overlays. A final report on "Rigid Pavement Rehabilitation by Means Other Than Overlay" is being prepared. It will present data on various types of retrofit load transfer devices for jointed concrete pavements. Those showing promise were conventional dowels and a precast joint assembly.

Work on improving subdrainage and shoulders of existing pavements was completed and the results published in five reports.

Reestablishing load transfer devices during rigid pavement repair.

Trench in shoulder area with subsurface drainage pipe in place.

This will provide the pavement engineer with a systematic means for determining whether existing pavement distress is related to poor drainage and recommendations for the most appropriate type of treatment. (6D)

To help State highway agencies eliminate the causes of premature distress in rigid pavements and to improve design, construction, and maintenance procedures, research is underway to (1) develop an optimized pavement joint design procedure using fewer dowels, shorter dowels, dowels with improved coatings, and dowel placement tolerance criteria to alleviate the rigid pavement joint problem; (2) prevent pumping of rigid pavements by using laboratory and field evaluations as inputs for the design analysis; and (3) develop an improved, practical, and implemen-

table procedure for the structural design of roadway shoulders.

New research in FY 1983 will include a study to develop a practical and implementable structural design procedure for composite pavements. A number of States are experiencing excellent performance from composite pavements, although the individual design approach varies from State to State. (6E)

Methods of Construction

Over the past 10 years, dryer-drum mixing plants have been replacing conventional batch plants. However, there has been a growing concern about the quality of materials produced by these plants, especially with regard to long term properties/performance. An evaluation of paired projects indicates that no significant long term performance differences exist between asphalt concrete mixtures produced by drum mix plants versus conventional plants. Performance indicators included measurements of bleeding/flushing, raveling, rut-depth, cracking, roughness, and skid resistance. There is, however, evidence that the asphalt cement in mixtures produced by drum mix plants may harden or age faster in the field than the same materials produced in a conventional batch plant. On the other hand, initial asphalt cement hardening during mixing appears to be less in drum mix plants than batch plants. Many States have increased the minimum mixing temperature and decreased the permissible moisture content in the discharged mixture.

Removal of concrete from bridge decks prior to placement of polymer concrete overlays has been a serious problem for many years. Inadequate removal results in debonding. An airless shot blaster has been tried and results are promising. With this system steel shot is impinged onto the deck and the debris is vacuumed off; the steel shot is reclaimed and continuously recycled. Unlike sandblasting, there is no stray dust or cleanup and the technique is less dependent on operator proficiency. The built-up polymer concrete overlays placed on two bridge decks using this technique have not shown signs of debonding. (6H)

Construction Personnel

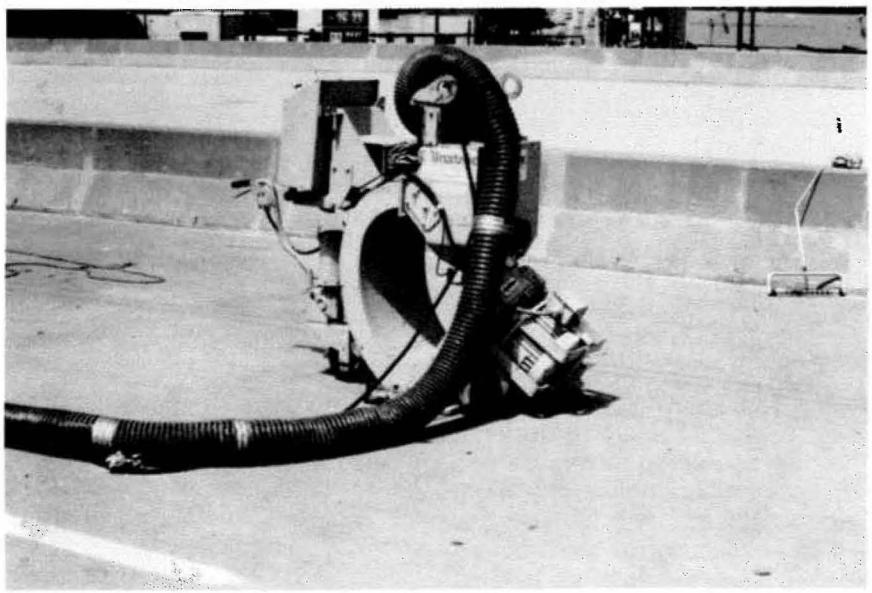
A nationwide survey conducted several years ago on premature failures in highway pavements indicated that one of the contributing factors was the lack of experienced, trained inspectors. Often, the newer, younger, and more inexperienced individual on a construction project becomes the inspector. Obviously training is needed to provide qualified inspectors. Toward this goal, a technician-level course in the basic principles and practices for quality asphalt concrete pavement construction has been developed. A similar course in portland cement concrete pavement is being developed. (6I)

Construction Management

A quality assurance program that can be economically implemented by small governmental agencies is being developed. A construction management system including design, construction, sampling and testing by inspectors, and acceptance criteria is being established in Pulaski County, Ark. A general assurance program for other small governmental agencies is also being prepared.

A national pooled-fund study to develop guidelines for the administrative settlement of contract claims will be starting soon. Twenty-five States are participating in this 2-year study to identify current methods and develop general guidelines for settling claims and/or avoiding costly litigation procedures.

The Department of Justice has been investigating bidding collusion on highway construction contracts. In States where investigations have uncovered such practices, the costs to highway agencies have been extraordinary. A study to develop computer programs to detect bidding collusion



Shot blast unit used to clean bridge decks. The vacuum and electric generator are not shown.

and unusual bidding patterns will be underway soon. In another study, factors affecting highway construction productivity will be identified. (6J)

Special Asphalt Concrete Mixtures

Since the early 1970's, a significant amount of asphalt pavement distress has been observed on pavement projects. In most cases, the distress cannot be attributed to premature asphalt aging or structural weakness. Introduction of variant foreign and domestic base crude sources may have contributed to changes in the chemical or physical nature of the asphalt being supplied to any given area. The resulting product is not necessarily inferior, but it is usually different from that previously supplied. The chemical or physical nature of asphalt cement may need to be modified by additives or admixtures to optimize its compatibility with available mineral aggregates.

Research is underway to investigate the material and structural properties of asphalt-rubber materials. A pooled-fund study will determine the relationships among binder, mixture, and structural properties of asphalt-rubber systems and relate them to field performance. Appropriate specifications and recommended design and construction procedures for properly testing and handling the materials will be developed.

Previous research indicates that lime is the most effective additive available as an antistrip agent in asphalt concrete mixtures. Research to be initiated in FY 1983 will include a study that will provide recommendations on the most effective method for introducing lime into asphalt concrete mixtures. (6K)

Looking Ahead

Future construction research in the Federally Coordinated Program will focus on improving construction methods, quality, productivity, and contract administration. The overall objective is to provide standardized methods, procedures, and materials that will result in significant reductions in highway construction costs through effective construction and management techniques. As in previous years, the guiding factors in selection of construction research activities will be unresolved problems identified in the research needs study documented in 1979 as well as new problems identified in future needs studies.

Highway Maintenance

The current annual expenditure for maintaining the Nation's highway system is approximately $14 billion, or about 27 percent of the total expended for highways by all levels of government. Virtually all of the $14 billion is spent by State and local governments, with more than one-half being spent by the local highway agencies. Contrasted with highway construction, where almost one-half of every dollar spent is for materials and supplies, maintenance activities are labor- and equipment-intensive. In response to these concerns, Federal Highway Administration (FHWA) maintenance research and development focuses on optimizing maintenance activities to reduce costs and manpower requirements and extending the effective service life of the highway facility. FCP Project 7A, "Improved Highway Maintenance Practices," is developing better ways for maintaining highway pavements, roadsides, and structures and improving traffic services. Project 7C, "Maintenance Management," is developing information systems to improve management of maintenance resources and improve techniques for transferring maintenance technology.

Cleaning a ditch parallel to the roadway.

Heater-mixer for supplying hot asphalt for pothole patching.

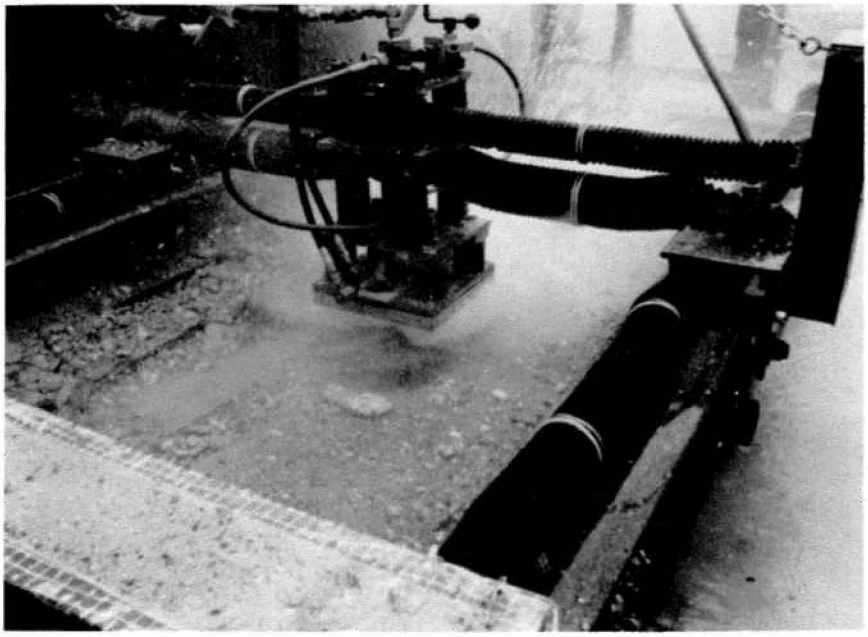
Value Engineering

Value Engineering (VE) is a unique approach to improving technology dissemination. Through VE studies, several highway agencies evaluate a selected maintenance activity to determine unnecessary and inefficient practices. Efforts are then directed toward optimizing the operations to save time and money. In the past year, VE studies on mowing and drainage maintenance were completed and reports on the studies were published. Studies were initiated on crack and joint sealing and on repairing guardrails, median barriers, and impact attenuators. A new study extending the use of Value Engineering to the local level will be initiated in FY 1983. Six medium-size cities in the Northeast will select a maintenance activity and perform a VE analysis to optimize expenditures. (7A) [1]

[1] Numbers in parentheses refer to the FCP projects identified on page 32.

Pavement Maintenance

Colorado completed testing of an automated pothole patcher in 1981. The equipment performed satisfactorily and was recommended for use in rural and suburban areas. Negotiations for production of the patcher are underway between the equipment's designer and manufacturing firms.



High-pressure water jet removing bridge deck concrete.

Guidelines on current pothole patching practices were prepared for highway maintenance personnel responsible for patching pavements. The techniques and materials presented have been developed by research and used successfully under various climatic and weather conditions.

A high-pressure water jet for cutting and removal of deteriorated concrete before patching or replacement has been developed. A prototype machine has been fabricated and was successfully field tested on a bridge deck in the fall of 1982. Research is underway to improve the performance of the cutting heads and increase the mobility and ease of operation.

Research will be initiated in 1983 to investigate the problems of patching high volume roadways. This research will attempt to develop methods for pavement patching that minimize traffic disruption while optimizing the effectiveness of the patch. (7A)

Technology Transfer Workshops

Six States participated in a Maintenance Technology Transfer Workshop on "Snow and Ice Control" held in Homewood, Ill. This was the first in a series of planned workshops. These workshops are intended to bring State maintenance engineers together to discuss common problems and share innovative solutions. The second Maintenance Technology Transfer Workshop, on "Pavement and Shoulder Maintenance," was held in Denver, Colo., in October 1982. (7A)

Calcium Magnesium Acetate

A workshop to develop field test guidelines for evaluating Calcium Magnesium Acetate (CMA) was held in Kansas City, Mo., in December. The workshop provided a forum for the 23 States participating in the pooled-fund study to manufacture 180 Mg (200 tons) of CMA. (7A)

Maintenance Management

The concept of maintenance management systems has gained widespread acceptance by highway agencies during the last decade. Recently, emphasis has been placed on Equipment Management Systems (EMS). To help implement EMS, FHWA is sponsoring informative EMS symposiums nationwide. The third symposium was held in May 1982 in Idaho. A final symposium is planned in California in 1983. (7C)

Improved Transfer of Maintenance Technology

Improving the transfer of maintenance technology is a high priority of the FCP Category 7. A study titled "Methods for Effective Transfer and Implementation of Maintenance Technology" was initiated in FY 1982 to develop a technology transfer program best suited for the highway maintenance research program. (7C)

Looking Ahead

New areas of emphasis in the highway maintenance program will include identifying and developing new techniques to disseminate innovative maintenance technology to users, particularly at the local level, and developing an interface for pavement management systems and maintenance management systems.

Federally Coordinated Program Categories and Projects

The structure of the Federally Coordinated Program provides a framework for classifying the major program areas and distinguishing the sub-elements of these areas. The major program areas are classified into *categories*, each category is divided into *projects*, and each project is subdivided into *tasks*. Individual studies within tasks are the smallest identifiable elements in the program.

Progress reports of each project are prepared annually. While supplies last, individual copies of these reports are available each January, without charge, to highway-related agencies and universities. Requests should be sent to the Federal Highway Administration, HRD-10, Washington, D.C. 20590.

FCP projects active in FY 1982 are listed below. Numbers that follow projects indicate the page(s) in the preceding research sections of this report where project activities are described.

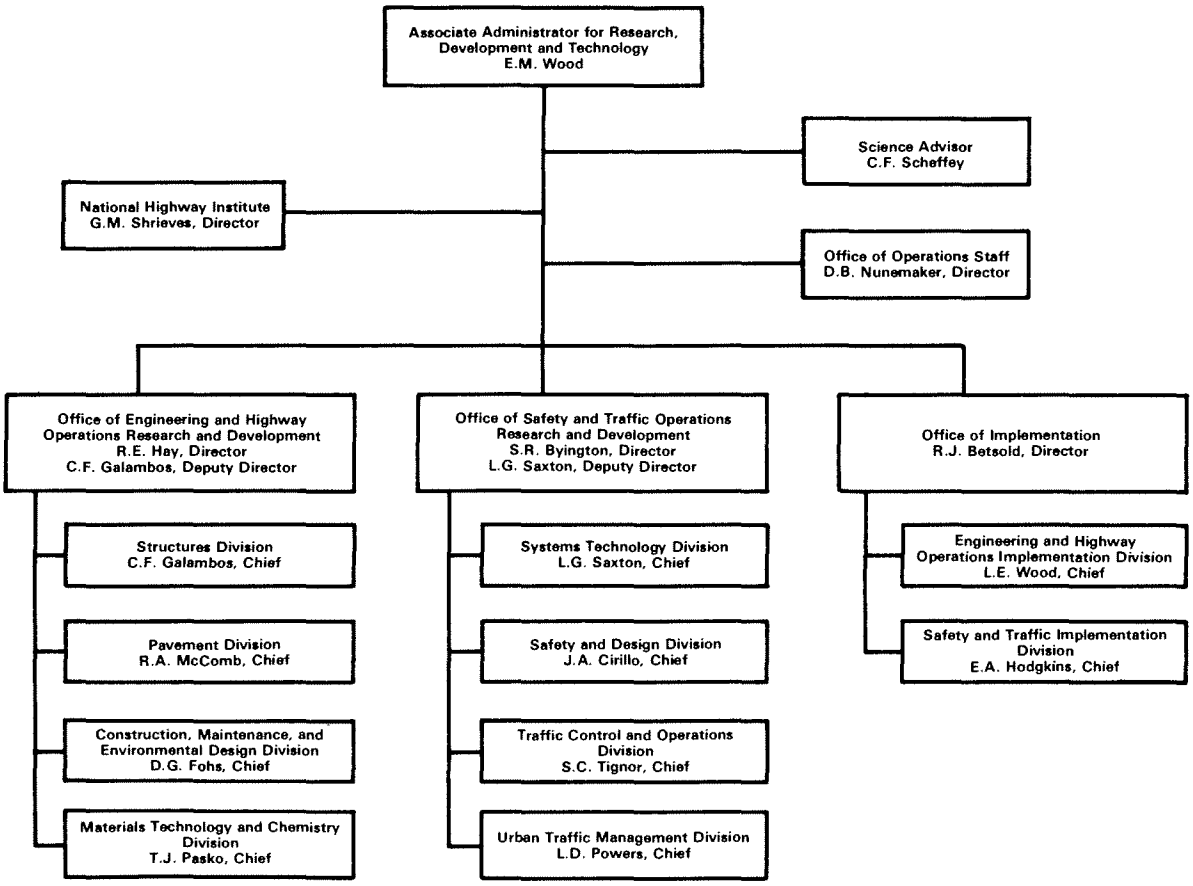
Organizational Structure—Offices of Research, Development, and Technology

Reorganization

In July 1982 the Federal Highway Administration (FHWA) Offices of Research and Development were reorganized and renamed the Offices of Research, Development, and Technology (RD&T). The purpose of the reorganization was to reflect changing programs and priorities and emphasize the importance of the technology transfer process, improve management communications and operations, and accommodate necessary personnel reductions.

Major features of the new organization, shown in the chart below, include the following:

- The National Highway Institute (NHI) was transferred intact from the staff of the Federal Highway Administrator to the Associate Administrator for RD&T because of the close relationship between NHI's and RD&T's missions, especially in technology transfer functions. The change also allows a more efficient sharing of personnel and administrative operations.
- A Science Advisor position was established.
- An Office of Operations Staff was created.
- Three major offices were created—Office of Engineering and Highway Operations Research and Development, Office of Safety and Traffic Operations Research and Development, and Office of Implementation. The remaining line staff were organized into 10 divisions that are functionally alined to better parallel the programs and organizational structure of the other FHWA operating offices.
- Management levels below the division level, such as groups, were eliminated.



- The mechanical, electronics, computer, and publications functions previously under one division were reassigned as follows:

  Mechanical—Materials Technology and Chemistry Division,

  Electronics—Systems Technology Division,

  Computer—Safety and Traffic Implementation Division, and

  Publications—Office of Operations Staff.

Following are brief descriptions of the organizational elements within the Offices of RD&T.

Associate Administrator for Research, Development, and Technology

The Associate Administrator for RD&T serves as principal advisor to the FHWA Administrator on all research, development, implementation, national highway related training, and technology transfer coordination matters as they relate to the FHWA missions, programs, and objectives. The Associate Administrator also provides executive direction over the organizational elements within the Offices of RD&T.

Science Advisor

The position of Science Advisor was established to provide a central point of advice and assistance to the Associate Administrator in technical matters related to the RD&T program. In this capacity, the Science Advisor assesses and reviews the long-range and advanced technology research program, analyzes critical technical problems and issues and recommends a unified technical approach, serves as focal point or chief consultant on significant RD&T technical assistance efforts, and advises on the development and administration of technical policy. In addition, the Science Advisor maintains overall technical liaison for RD&T with other research related elements in the public and private sectors and represents FHWA in various national and international scientific activities.

Office of Operations Staff

The Office of Operations Staff is responsible for budget management, program analysis, personnel, publications, and related support functions. The staff was formed by combining the previous Program Analysis Staff, the Technical Information Staff, and the staff of the Administrative Program Coordinator.

Budget related activities include:

- Formulating and developing the RD&T contract and support budgets, preparing documents for the various budget submissions (FHWA, DOT, Office of Management and Budget, and Congress), preparing appeals to budget reductions, and providing responses to questions asked during the budget reviews and hearings.

- Administering the current year contract and support budgets. This involves the financial tracking of all contract documents, such as requisitions, executed contracts, contract modifications, and purchase orders.

- Principal coordination and contact for the National Cooperative Highway Research Program and the Highway Planning and Research Program.

- Serving as the focal point for administrative and policy matters associated with the contract and support programs.

The program analysis function involves a continuing review and assessment of the RD&T program and operations. The results of this independent review are used in planning the RD&T program and allocating resources.

The Office of Operations Staff also serves RD&T in the areas of personnel and staff management. This includes tracking and coordinating personnel actions and providing information on administrative and policy matters.

The publications function includes the processing and publication of about 150 research reports and technology sharing documents each year. Most of these documents are available from the National Technical Information Service in Springfield, Va., or from the U.S. Government Printing Office.

Other publications edited and coordinated by the staff include the following:

- *Public Roads, A Journal of Highway Research and Development.* This journal, published since May 1918, includes articles by researchers in both the public and private sectors, announcements of recently published research reports and technology sharing documents, and brief descriptions of new R&D in progress. It is the principal medium for reporting highway and highway transportation research and development results to professionals and specialists in the highway field as well as to public officials responsible for the efficient use of a multi-billion dollar program in Federal-aid highway funds. Subscriptions for this quarterly journal are available from the Superintendent of Documents, U.S.

Government Printing Office, Washington, D.C. 20402, for $10 per year ($2.50 additional for foreign mailing), payable in advance.

- FCP Annual Reports. The 1982 report is the ninth in the series of these reports.

- Index of R&D Reports. The current edition was published in 1981. An update is planned for FY 1983. Copies of the current edition are available from the Office of Operations Staff, HRD-10, Federal Highway Administration, Washington, D.C. 20590.

The publications function also involves providing advice and assistance to RD&T staff on publications related matters.

National Highway Institute

As stated above, the National Highway Institute (NHI) was transferred to the Offices of RD&T because of the close relationship of the missions of NHI and RD&T, especially in technology transfer (T^2) functions. The NHI develops and administers, in cooperation with the State highway departments, educational and training programs for FHWA, State, local, and foreign highway department employees. Training has become a major element in the T^2 process because the need for safer highways and better operations coupled with higher costs and lower budgets requires our engineers and administrators to make critical decisions based on current knowledge of new research and technology. Training is now, more than ever, an essential activity for all disciplines within the highway community.

NHI is organized into three program areas—State Programs, University and Industry Programs, and International Visitors Programs.

State Programs is responsible for identifying current and future training needs and for developing training to satisfy the identified needs in cooperation with FHWA program and field offices. The focus is on training courses that are not readily available from consulting firms or educational institutions and that State highway agencies would not ordinarily develop for themselves. The training course offerings are geared toward topics involving new and rapidly changing technology and are frequently an integral part of FHWA's overall T^2 effort to communicate the results of recent research and new technology. In the past year, 59 courses were offered and 388 presentations were made to a total of 11,514 students.

In addition to offering training courses, State Programs provides training assistance through the use of "one-half of 1 percent funds." The 1970 Highway Act (23 U.S.C. 321(b)) authorizes States to use up to one-half of 1 percent of their urban, primary, and secondary system Federal-aid apportionments for training purposes. Since the program began in 1973, 28 States have used "one-half of 1 percent funds" to finance 448 training projects. Fifteen States participated in the program in 1982.

University and Industry Programs has been heavily involved in T^2 since NHI was formed in 1971. This office promotes technology transfer through the college curriculum program, technology transfer centers, and the fellowship/scholarship program. The college curriculum program was established in October 1975 so that educational materials developed for FHWA-sponsored training courses could be included in the curriculums and short course offerings of technical institutes, colleges, and universities. Through this program, the benefits from dollars already spent to develop training curriculums are extended. Closely alined with the college curriculum program is the program for Technology Transfer to Local Agencies. This program unites State transportation agencies with universities to form 10 centers for transferring new technology to local agencies. The fellowship/scholarship program assists State and local highway agencies in developing needed staff resources through formal education by offering fellowships/scholarships for part-time and full-time study in any needed discipline in the highway transportation field. Awards of fellowships and scholarships for the 1982–83 academic year are as follows:

	Full-time	Part-time
Fellowships (graduate)	14	23
Scholarships (undergraduate)	22	28
	36	51

To meet national needs, this program has been expanded to include the development of special purpose programs in safety and pavement management.

The International Visitors Program is one of the prime contributors to the dissemination of highway technology, not only in the United States but internationally as well. In FY 1982, this program provided training and orientation for 327 international highway officials interested in highway practices in the United States. The International Visitors Program enables top-level foreign highway officials and other highway professionals to receive indepth exposure to the United States and equally important, enables these professionals to meet and exchange ideas with American colleagues, observe methods and practices, study at academic institutions, and develop the networks of communication that will mean lasting personal and professional ties transcending national barriers. Because the bulk of the training and orientation is conducted at various State highway

and transportation departments, technology transfer becomes a two-way street at the grass roots level between international visitors and State engineers.

Office of Engineering and Highway Operations Research and Development

The new Office of Engineering and Highway Operations Research and Development (R&D) is responsible for all research and development work in the areas of structures, pavements, materials, construction and maintenance management, and environment. This function is carried out by four divisions: Structures Division; Pavement Division; Construction, Maintenance, and Environmental Division; and Materials Technology and Chemistry Division. Under the new organization several activities have been consolidated that formerly were in separate divisions. The Structures Division now is responsible for foundation research and hydraulics, in addition to its traditional function of structural design research. The Pavement Division now is responsible for both materials and design as well as surface characteristics. The Construction, Maintenance, and Environmental Design Division's areas of responsibility are denoted by its name; in addition, this Division is responsible for geotechnical engineering. The Materials Technology and Chemistry Division is responsible for new materials, corrosion, and cementitious materials. In addition to the organizational changes, staff throughout the Office of Engineering and Highway Operations R&D who were formerly concerned only with research are now involved in development activities as well. This change should further facilitate the movement of research results into usable products.

Office of Safety and Traffic Operations Research and Development

The new Office of Safety and Traffic Operations Research and Development, which includes four divisions, is responsible for all aspects of safety research (except pavements) and research related to traffic operations and control. The consolidation of the safety function and the traffic function, which more closely parallels the organizational structure of other FHWA operating offices, improves problem identification and implementation of findings.

The Systems Technology Division is responsible for human factors research, including safety research related to night driving; research on methods for improving driver guidance, information, and communication systems; and research on the concept of an automated highway system.

The Safety and Design Division conducts safety research in the areas of geometric design (the compatibility of geometric standards with the changing vehicle population), roadside hardware (the development, design, and test of hardware that must perform for a widening range of vehicle sizes), large truck safety (the impact on safety of legislation allowing commercial vehicles to be longer, wider, and heavier), safety problem identification, and safety program cost effectiveness.

The Traffic Control and Operations Division is responsible for safety research to evaluate and improve traffic control devices and address the needs of special highway users. Areas of study include traffic control in construction and maintenance zones, safety and operational problems on two-lane rural highways, railroad-highway grade crossing safety, bicyclist and pedestrian safety, and the cost effectiveness of safety countermeasures.

The Urban Traffic Management Division develops and tests simulation techniques designed to ease traffic congestion on city streets and freeways, such as traffic control optimization programs for traffic signal systems. This division also conducts research on traffic management strategies and improved methodology for the calculating of level of service and highway capacity.

Office of Implementation

Although the R&D programs conducted by the two Offices described above produce a substantial amount of new technology that is potentially useful to the highway community, the cost savings and other benefits are not obtained until the technology is actually used by State and local highway agencies. To bridge the gap between research and practice, FHWA provides a vigorous technology transfer (T^2) program. The Office of Implementation was created to reflect the strong emphasis placed on T^2 in the RD&T organization. Activities of the Office include:

- Evaluation of research findings to determine potential applications.
- Field tests and evaluations to determine durability and utility of new methods, procedures, products, and materials under actual operating conditions.
- Refinement and translation of research materials and documents for ready use by practicing engineers and administrators.
- Sponsorship of conferences and other meetings to exchange technical information and share operational expenses.

- Provision of techshare materials and technical assistance to expedite new technology applications.
- Preparation and pilot testing of training courses for new technology emerging from the R&D program.
- Development of promotional materials and activities to encourage State and local adoption of proven technology.
- Collaboration with other FHWA T^2 elements, including the National Highway Institute and the Demonstration Projects Division, to provide a fully coordinated national T^2 program for highway transportation.

The two divisions in the Office of Implementation are functionally alined and titled to reflect the respective R&D offices that are the principal sources for the new technology. The divisions and major program areas are as follows:

- Engineering and Highway Operations Implementation Division:
  - Maintenance and Environment
  - Structures, Soils, and Hydraulics
  - Construction and Pavements
- Safety and Traffic Implementation Division:
  - Traffic Systems (includes FHRS computer center)
  - Safety and Design

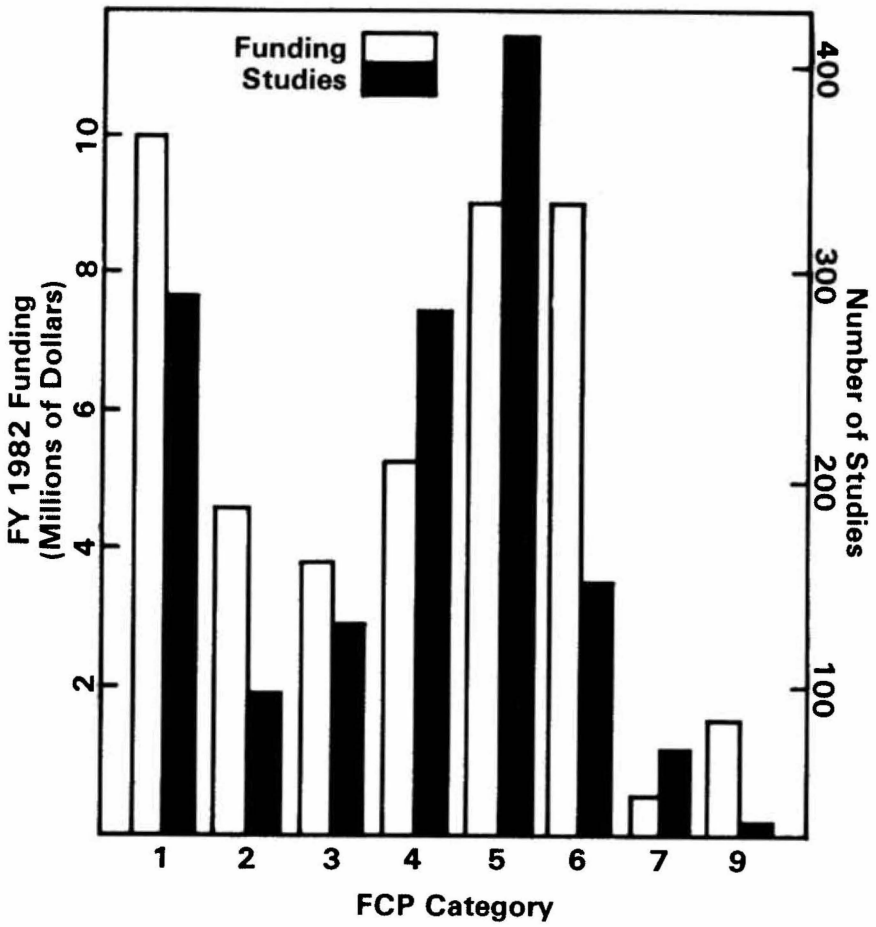
Funding and Support

FHWA Funding of Research and Development

The four Federally supported programs of highway research and development are the Highway Planning and Research (HP&R) Program, the National Cooperative Highway Research Program (NCHRP), the FHWA administrative contract program, and the FHWA staff research program. FCP funding by these four sources is shown in the table below. Allocation of studies by FCP category is shown for each source. FY 1982 funding (in millions of dollars) for the entire RD&T program is summarized by FCP category in the bar chart. These amounts include program management costs.

Funding Source	Total Amounts (millions of dollars)
HP&R studies	$19.0
NCHRP studies	3.2
FHWA contract studies	19.0
FHWA staff studies	2.5
Total Program, all sources	$43.7

R&D Activity by FCP Category



Number of Active Studies

Category	*HP&R*	*NCHRP*	*Contract*	*Staff*	*Total*
1	100	7	168	15	290
2	31	3	49	15	98
3	85	3	37	2	127
4	197	8	65	11	281
5	318	8	82	14	422
6	88	1	54	3	146
7	12		41		53
9			22		22
Total	831	30	518	60	1,439

RD&T Participants and Support for Agencies

All 50 States and numerous localities receive Federal-aid funds or administrative contract funds to participate in the FCP. Research is performed by commercial firms, universities, associations, institutes, State highway and transportation departments, and several Federal agencies in addition to FHWA. Moreover, FHWA works cooperatively with other elements of the U.S. Department of Transportation (DOT) on problems of mutual concern.

FCP management and coordination activities include support of the Transportation Research Board (TRB) of the National Academy of Sciences and the Highway Research Information Service (HRIS). A major function of TRB is to disseminate information on active and completed highway-related research. HRIS, a component file of the Transportation Research Information Service (TRIS) data base, is a computer-based information storage and retrieval system for highway research. It is based on input from nearly 4,000 domestic and foreign sources. Major contributions come from TRB, FHWA- and State-sponsored studies, other agencies in DOT, and information services with which TRB has made informal exchange agreements.

Other organizations also receive support through the FCP: The International Road Federation, for annual inventories of highway research and development activities in 59 countries; and the Materials Reference Laboratory (National Bureau of Standards) for establishing uniformity in tests and procedures used by FHWA and the States. This RD&T support to agencies is continued through specially designated funding.

Turner-Fairbank Highway Research Center

The expanded research facility at the Fairbank Highway Research Station in McLean, Va., was completed in the spring of 1983. The new complex, renamed the Turner-Fairbank Highway Research Center after Francis C. Turner, Federal Highway Administrator from 1969 to 1972, provides the Federal Highway Administration with additional laboratory space for the conduct of staff research. The design of the new facility focuses on a marriage of space, light, and functionality and will provide 7 432 m^2 (80,000 ft^2) of laboratory, office, and support service space. Construction on the new facility began in the fall of 1980; this is the first major new construction at the site since 1942 when construction began on the original buildings.

The new facility is designed as three separate sections. The first is a three-story office wing, which also houses conference areas and a human factors laboratory. The second is a light laboratory wing, which provides facilities for a highway driving simulator, a pavement components laboratory, an experimental vehicle preparation area, a highway communication and electronics laboratory, and a highway noise laboratory. The third wing of the building contains two major heavy laboratories—a structures laboratory and a highway hydraulics laboratory. The three sections of the building are joined at a central atrium, which provides a visual focal point for integrating the sections into a single unit.

The thoroughness with which the facility is designed and constructed is demonstrated by the special characteristics of the structures laboratory, whose floor is composed of a four-celled structural box girder that has been fully instrumented as a research module itself. This feature will provide information about internal stresses created within the structural box girder when a test specimen is placed under load.

The size of the laboratories in the new facility will allow full scale testing of the structural components for bridges and pavements. Construction techniques can be

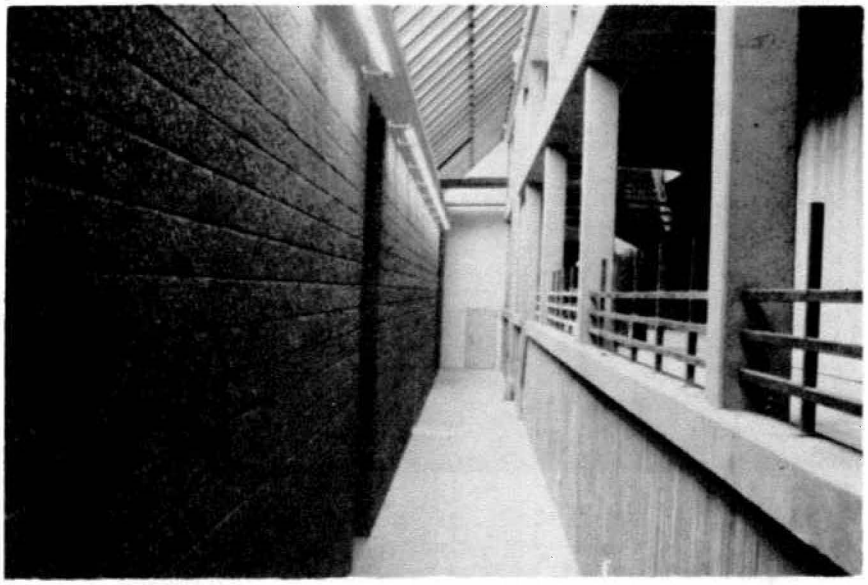
Front view of the Turner Building.

developed for cost-effective roadway systems that will absorb the loads and environmental stresses for longer periods of time than present designs.

Capabilities built into the facility make it possible to design, analyze, critique, and evaluate not only new major structural materials but to examine thoroughly and with great detail existing structural materials and highway components to ascertain their remaining life expectancy or, in some instances, determine the mode of failure.

The computer image generated highway driving simulator and pupilometer measuring capabilities make it possible to observe and analyze the reaction of drivers to roadway situations that are unusual, dangerous, obscured by the environment, or potentially life-threatening.

The potential of the facility for evaluating a wide variety of highway engineering problems is exciting. FHWA looks forward to full use of these unique laboratories and the development of new advances to provide a highway system with enhanced safety and operational capabilities.



An atrium with skylights joins the office wing, light laboratory wing, and heavy laboratory wing. A fluted block wall at the entrance to the light laboratories (left) provides an architectural focal point.

At the rear of the building are entrances to the structures laboratory, experimental vehicle preparation area, and the pavement components laboratory.

The outfitted woodworking and electronics shops.

Construction Progress—Beginning to End

HRD-10/3-83(4.3M)