Innovative Highways
A New Era Begins

The nation's highway system is entering a new, innovative era, judging from three events that have occurred recently. First, the Transportation Research Board has just released a report entitled *America's Highways: Accelerating the Search for Innovation.* Published as part of TRB's Strategic Transportation Research Study (STRS), this report identifies six high-priority, high-payoff targets for a large-scale, concentrated research effort.

Second, on July 17, 1984, the American Association of State Highway and Transportation Officials (AASHTO) endorsed the STRS Program and decided to seek legislation that would direct 1/4 of 1 percent of federal-aid highway funds in support of the program.

Third, on the basis of a recent Congressional report, *Highway Transportation Infrastructure Research and Technology*, early indications are that the U.S. Congress may be receptive to this proposal. This report recommends renewing the nation's commitment to highway and bridge materials and structures research, increasing the proportion of funds available for research, and concentrating research support on a small number of critical high-payoff research problems.

The STRS, AASHTO, and Congressional recommendations are nearly identical in terms of how highway research should be reoriented to meet the needs of the future. In addition, Federal Highway Administrator Ray A. Barnhart has been an enthusiastic supporter of the proposals that are emerging. Together, these developments reflect a widespread sentiment that major new initiatives to stimulate innovation in the highway sector will be a reality in the very near future.

Strategic Transportation Research Study (STRS): Highways

According to the STRS Report, state, local, and federal transportation officials need more than money to arrest the spreading deterioration of the nation's public highway system; they also must develop better methods to construct and maintain those highways. To help achieve this goal, the STRS Report released by the Transportation Research Board recommends an intensive 5-year program to revamp selected areas of highway research that have been neglected in recent years. Chief among these areas are research on asphalt, cement and concrete, long-term pavement performance, maintenance techniques, corrosion protection of concrete bridges, and chemical control of snow and ice on highways (see Table 1).

The STRS Report points out that the nation's $1 trillion investment in 4 million miles of public highways is supported by a relatively small and decentralized research effort: "[H]ighway

Looking over first copies of the recently published report by the Transportation Research Board Study Committee for a Strategic Transportation Research Study (STRS): Highways are *(left to right):* Thomas B. Deen Executive Director of TRB, which conducted the study and published the report entitled *America's Highways: Accelerating the Search for Innovation;* Ray A. Barnhart, Administrator of FHWA, the sponsoring agency; William A. Ordway, President of AASHTO, which unanimously voted to implement the recommendations of the study; Thomas D. Larson, Secretary of PennDOT and Chairman of both the TRB Study Committee and the newly created AASHTO STRS Task Force; and Francis B. Francois, Executive Director of AASHTO.

funds are so broadly distributed that no single organization can attack the major problems that plague the industry."

What is essential, according to the study committee, is an independent research effort to concentrate attention on a few specific goals, unhindered by "special interests" or "organizational barriers." The study notes that establishing such a program is especially ap-

TABLE 1 Assessment of High-Priority Highway Research Areas

	Asphalt	Long-Term Pavement Performance	Maintenance Cost-Effectiveness	Protection of Concrete Bridge Components	Cement and Concrete in Pavements and Structures	Chemical Control of Snow and Ice
Probability of a big payoff	High	High	High	High	Medium	High
Has research on this topic been neglected in recent years?	Yes	Yes	Yes	No	Yes	Possibly
Degree to which organizational barriers now impede research	High	High	Medium	Low	High	Low
Likelihood that research findings will be usable	High	High	High	High	High	Medium
Scale of effort required for successful project	Large	Large	Small	Large	Medium	Medium
Does the research require greater unity of effort, now splintered?	Yes	Yes	Probably	Probably	Yes	Probably
Do changes in national policy create a common, multistate research need?	Possibly	Yes	Possibly	No	No	Yes
Do major technological changes require research here?	Yes	No	Possibly	Possibly	Possibly	Possibly
Likely magnitude of impact on safety and environment	Medium	High	High	High	Medium	Medium

"The appropriation by Congress in 1982 of $58 billion in federal aid for highways . . . must be matched by a serious concerted research effort to find better ways to build, maintain, and operate the highway system of the future."

propriate in light of the $58 billion the Congress earmarked in 1982 for federal aid to highways. "The appropriation by Congress in 1982 of $58 billion in federal aid for highways . . . must be matched by a serious, concerted research effort to find better ways to build, maintain, and operate the highway system of the future."

The STRS Program was launched at a time when financial support for highway research had dwindled to record lows, and when some highway administrators were questioning the value of this activity.

The study committee found that, after adjusting for inflation, since 1973 state and federal governments have reduced by 50 percent spending on highway research. The approximately $70 million per year currently expended on highway research represents about 0.15 percent of total highway expenditures, a level "far smaller than the research commitment of virtually all other industries." For example, other "low technology industries" such as rubber, paper, and steel spend eight times as much per dollar of sales on research activities as does the highway industry.

A major reason for the lack of highway research funding, according to the STRS Report, is the "extreme fragmentation" of the transportation industry. Operation of the U.S. highway system is divided among thousands of federal, state, county, city, and private organizations. This structure "impedes innovation because . . . no one organization has the resources or the incentives to undertake major research" to improve facilities or reduce costs. In addition, the report notes that budgetary pressures, election priorities, and high turnover in top highway management positions have favored short-term, highly visible projects over longer-term functions such as research.

Although there have been some restrictions on the amount and structure of highway research, there have been remarkable results over the decades. Researchers have shown great ingenuity in overcoming the numerous practical problems involved in building highways. Existing research activities are ideally suited to addressing many of the unique problems associated with specific climates, soils, materials, and other local circumstances encountered by the highway industry. The TRB Study Committee stressed in its report that because this existing research capability is essential, the new program that is being proposed must not displace these valuable ongoing efforts.

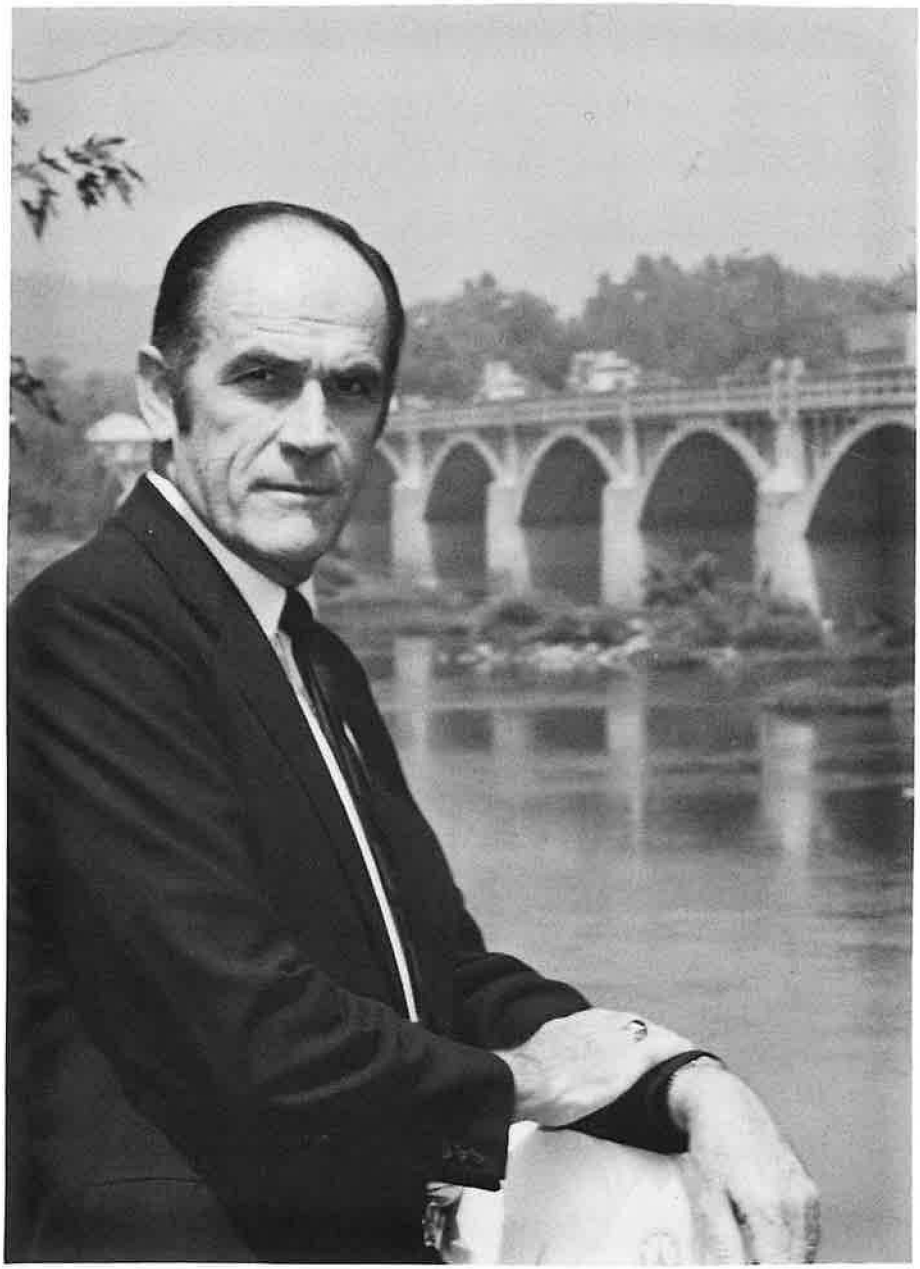
Nevertheless, as a result of its structure, the highway industry has overlooked or neglected several of its biggest problems. Research designed to fill these technological gaps must meet many

Members of the TRB Study Committee for a Strategic Transportation Research Study: Highways were Thomas D. Larson, Pennsylvania Department of Transportation, Chairman; Duane Berentson, Washington State Department of Transportation; Donald W. Collier, Borg-Warner Corporation; Francis B. Francois, American Association of State Highway and Transportation Officials; Robert N. Hunter, Missouri Highway and Transportation Department; Harold L. Michael, Purdue University; Thomas D. Moreland, Georgia Department of Transportation; Daniel T. Murphy, Oakland County Executive, Michigan; William A. Ordway, Arizona Department of Transportation; Richard S. Page, The Washington Roundtable, Seattle; Bruce H. Pauly, Eaton Corporation; Daniel Roos, Massachusetts Institute of Technology; and Joseph L. Schofer, Northwestern University. Damian J. Kulash, Transportation Research Board, served as the Study Director.

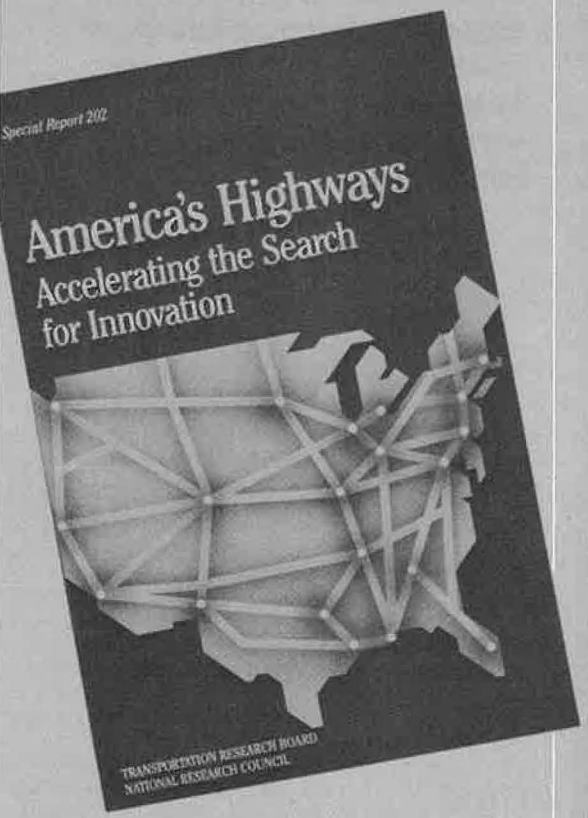
stringent tests. The STRS Report outlined a strategy for screening potential research areas to identify the most promising areas as the basis for a national program. Specifically, the strategy of the TRB Study Committee involved the answers to the nine questions that are outlined on pages 6 and 7.

On the basis of the answers to these questions, the STRS Report concluded that a concerted and coordinated research effort in the following six areas would offer the greatest benefits for improving the safety and productivity of the national highway system: asphalt, long-term pavement performance, maintenance cost-effectiveness, corrosion protection of concrete bridges, cement

The approximately $70 million per year currently expended on highway research represents about 0.15 percent of total highway expenditures, a level "far smaller than the research commitment of virtually all other industries."



Dr. Thomas D. Larson, Secretary, Pennsylvania Department of Transportation, chaired the TRB Study Committee that produced TRB Special Report 202 *America's Highways: Accelerating the Search for Innovation.* He is also Chairman of the STRS Task Force established by AASHTO.



The complete report of *TRB Special Report 202–America's Highways: Accelerating the Search for Innovation* (price $18.60) is available from the Transportation Research Board, National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

1. *Will the research yield big payoffs if successful?*

Many areas of feasible highway research will potentially deliver payoffs far in excess of the necessary original investments. For example, even if research on better asphalt paving materials yielded only a 1 percent reduction in the cost of pavements, this reduction would save $100 million a year–far in excess of the total of $70 million or so now spent on research for highways. Much greater savings would probably result in view of the frequency of premature pavement failures and the ever greater demands that increased traffic and weights of vehicles make on pavements.

2. *Is the research area currently neglected?*

When measured against potential payoffs, virtually all highway research is neglected. However, some categories are funded much more inadequately than others. Research on asphaltic materials, for example, represents only a minuscule fraction of highway research, even though more than 93 percent of all paved roads and streets are surfaced with paving mixtures or surface treatments containing asphalt.

3. *Will the project deal with important research areas previously hampered by institutional or organizational barriers?*

Improvements in highway products and processes lag when procurement procedures (specifications and low bids) do not encourage the purchase of better products and processes. The profitability of proprietary products, the emphasis on life-cycle costs within procurement processes, and the pressure to buy local materials and services must be considered in choosing realistic research objectives.

4. *Can the research findings be used?*

Research often fails to change practice because of limited understanding, organizational inertia, inflexible standards, preoccupation with first costs, mistrust of change, or a desire to perpetuate jobs. A research program designed without taking into account such obstacles will fail. Nevertheless, determining what is achievable is probably the most difficult, albeit the most crucial, judgment in the entire research process. Training requirements, organizational changes, investment in equipment, cash flow requirements, personnel implications, and legal liabilities of new approaches can make or break the acceptance of research findings.

Technical research personnel are not necessarily in a position to make these judgments, and, similarly, administrators and political leaders may not be fully aware of the technological options that might be developed. Both viewpoints are needed to identify promising research topics.

5. *Does the research require a large-scale effort?*

Most of the $70 to $75 million now spent on highway research is parceled out in problem-specific contracts of $30,000 to $300,000. Such small-scale efforts can be effective in addressing clear, well-defined problems. However, highway research funds are so broadly distributed that no single organization can attack the major problems that plague the industry.

Pavement performance, in particular, requires long-term research because of the long design life of pavements. The careful evaluation of

paving materials and techniques under long-term field conditions could substantially reduce the life-cycle costs of maintenance and construction. Increasing fundamental knowledge of how pavements perform under diverse circumstances and using this knowledge to improve those pavements will require a substantial commitment of time, funds, and research direction.

6. *Does the research require an integrated or national approach?*

Existing highway research procedures are likely to overlook processes such as highway construction that include a sequence of distinctly autonomous steps, each managed by a different organization or unit. Because more than one organization is involved at each stage, none is able to evaluate and control the other stages. A prime example is the construction of an asphaltic pavement, which involves many major steps from mining crude oil to constructing the pavement and opening the road to traffic. The various links in the construction chain are managed by oil companies, refineries, batching plants, aggregate producers, construction companies, and federal, state, and local highway departments. Each depends on the work of the others, but none is able to control the others. However, research on improved binding materials could lead to products and specifications that stimulate more efficient use of resources by all of the organizations involved.

7. *Does the research respond to new and potential changes in national policy?*

Because of the immense variety in local materials, building conditions, and topographic features, the strong problem-solving research capability of state agencies is essential. At the same time this decentralized research structure can lead to duplication, particularly if shifts in national policy create new operational issues simultaneously in all states and counties (e.g., the 55-mph national speed limit or increases in truck size and weight limits). The most efficient and timely response to such changes is to create a coordinated research effort that can immediately address the operational implications of the policy change in all of the states.

8. *Does the research use or respond to other technological changes?*

Technological changes in highway vehicles, communications, materials, and other sciences bring new opportunities and new challenges to all states and counties. If research to tap this potential is too fragmented, it may be incremental and duplicative. Also, not all organizations have the resources or skills to monitor properly new developments in technology. Even more stable technologies, such as asphalt, are subject to far-reaching changes when shifts in petroleum distribution and refining processes occur. Various new technologies, such as miniaturized electronics generated in the space program, may have many more highway applications than are currently being explored.

9. *Will the research affect safety or the environment significantly?*

In addition to major cost savings, research also can help to save some of the 46,000 lives lost each year on the roads and to prevent the suffering of many of the more than 3 million persons injured. For example, research to prevent deterioration of bridge decks could reduce the hazard now posed by potholes and pavement irregularities on bridges and other places where there are no obstruction-free maneuvering zones.

The STRS Report concluded that a concerted and coordinated research effort in the following six areas would offer the greatest benefits for improving the safety and productivity of the national highway system: asphalt, long-term pavement performance, maintenance cost-effectiveness, corrosion protection of concrete bridges, cement and concrete, and chemical control of snow and ice.

and concrete, and chemical control of snow and ice. The proposed 5-year Strategic Highway Research Study is summarized in Table 2.

In addition to the areas identified in the STRS Report, many other areas, including traffic engineering, improved planning techniques, new applications of computers, investment decision making, and financial analysis, appear to offer promising opportunities for research. In its selection of topics, the TRB Study Committee confined its attention to those subjects that require a particularly large-scale, concerted research focus. Many areas in which research will be productive have not been singled out for the STRS Program because existing research structures are capable of addressing them.

Implementation of the new approaches developed under the STRS Program will require careful attention. The committee anticipates that other organizations and individuals will follow its recommendations and implement its findings. The preface to the STRS Report acknowledges "that the widespread and effective application of innovative materials and techniques will also require changes in training, procurement practices, and other phases of implementation that cannot be thoroughly addressed until the findings of the proposed research are known."

The TRB report, *America's Highways: Accelerating the Search for Innovation*, was prepared by the Study Committee for a Strategic Transportation Research Study: Highways, chaired by Thomas D. Larson, Secretary, Pennsylvania Department of Transportation. Funding for the study was provided by the Federal Highway Administration, U.S. Department of Transportation.

TABLE 2 Overview of Proposed Strategic Highway Research Study

Research Area	Objective	Projected 5-Year Costs ($ million)	Potential Results
Asphaltic materials	Define Chemical and physical characteristics of asphalt and their relationship to performance in pavement systems.	50	Better quality control and better materials; and improved design capability and performance predictions. Potential saving of $100 million per year.
Pavement performance	Assess long-term performance of various pavements under various loading and environmental conditions. (Studies would continue for three additional 5-year terms of data collection and analysis.)	50	New capability to assess and select alternative pavement maintenance and rehabilitation strategies; and improved design and construction techniques. Potential saving of $10 billion.
Maintenance cost-effectiveness	Develop improved procedures for administering and controlling maintenance programs; develop new processes, equipment, and materials; and improve productivity of maintenance program.	20	New management systems and increased maintenance productivity. Potential saving of $150 million per year.
Concrete bridge component protection systems	Develop new methods to stop further deterioration of existing chloride-contaminated bridge decks and other components.	10	More effective techniques for removing chloride from concrete or protecting concrete from chloride contamination? Potential saving of $400 million per year.
Cement and concrete	Understand chemical and physical phenomenon of hydration; evaluate new options such as recycled concrete and energy saving components; and develop nondestructive testing methods.	12	Ability to produce a better quality and more durable concrete. Potential saving of $50 million per year.
Chemical control of snow and ice	Reduce the use of salt through management techniques and optimum use of mechanical or thermal removal plus alternative chemicals.	8	Reduction in corrosion and environmental problems without a reduction in the level of service of snow and ice control programs. For example, potential savings from a decrease in automobile corrosion could be $45 million per year.

AASHTO Takes the Initiative

Even before the TRB Study Committee for STRS had completed its work, state highway executives and research administrators were becoming aware of the study findings and took steps to explore them further. In January 1984 the AASHTO Executive Committee charged the AASHTO Select Committee on Research (SCOR) to recommend a plan for managing and implementing the STRS effort, and to provide technical amplification of each of the six research areas identified by STRS.

In response, the SCOR engaged expert consultants in each of the six areas to examine the STRS problem statements, to evaluate alternative research tasks, and to recommend preliminary research designs to achieve the study objectives. The SCOR held a special meeting in April 1984 to review these activities, and found the focus of the STRS Report to be appropriate and workable.

Under the direction of the SCOR, the National Cooperative Highway Research Program prepared a report, "Strategic Transportation Research Study Technical Design," which examines the six areas identified by the STRS Report in substantial detail. The SCOR reviewed this report and reached a number of conclusions in each of the six areas.

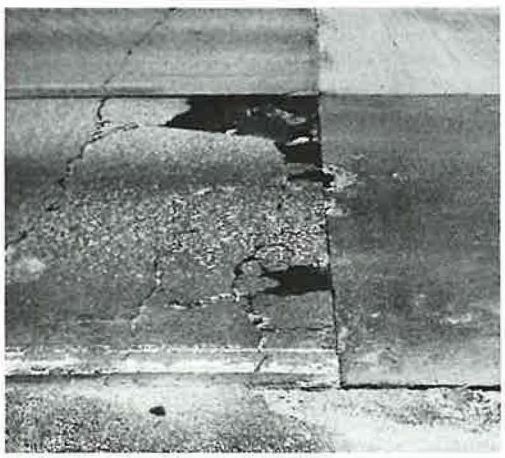
ASPHALT

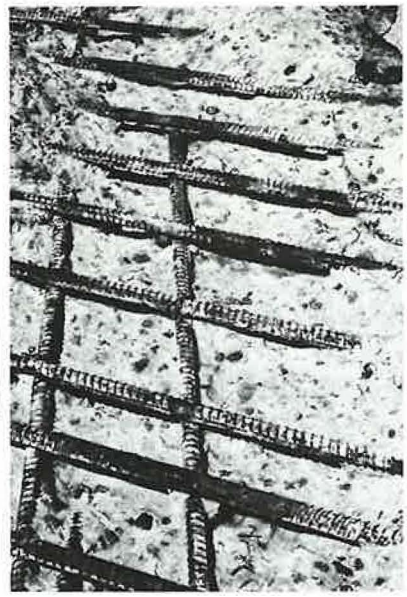
The SCOR concluded that

> A major contributor to premature pavement failure is the lack of understanding of the fundamental properties of the materials involved and how to control them for optimum pavement performance. The problem is aggravated by the wide variations in asphalt and aggregates composition as a function of source and changes in materials with time.

The SCOR divided needed research into five major groups: (a) chemical and physical properties of asphalt cements; (b) design and development of improved testing and measuring systems; (c) relationships between pavement performance and properties of asphalt cements; (d) development of performance-based specifications; and (e) development of improved binders through asphalt modification.

Asphalt concrete paving operations.





Top
Maintenance workers sealing cracks and joints.

Above
Development of data base for pavement performance may help prevent premature failure.

Right
Corroded reinforcing steel in bridge deck.

LONG-TERM PAVEMENT PERFORMANCE

The SCOR found that a key to better pavement performance is

> to develop a data base for pavement performance over a wide range of conditions and service life factors that can be used to answer questions about pavement management and design. It is intended that the results of the field study be used as the basis for validating or modifying existing pavement design performance prediction models and the development of pavement rehabilitation design equations and procedures.

The SCOR noted that the Federal Highway Administration has recently initiated considerable activity in this whole area, and that these efforts are complementary to the STRS research and will be integrated with it.

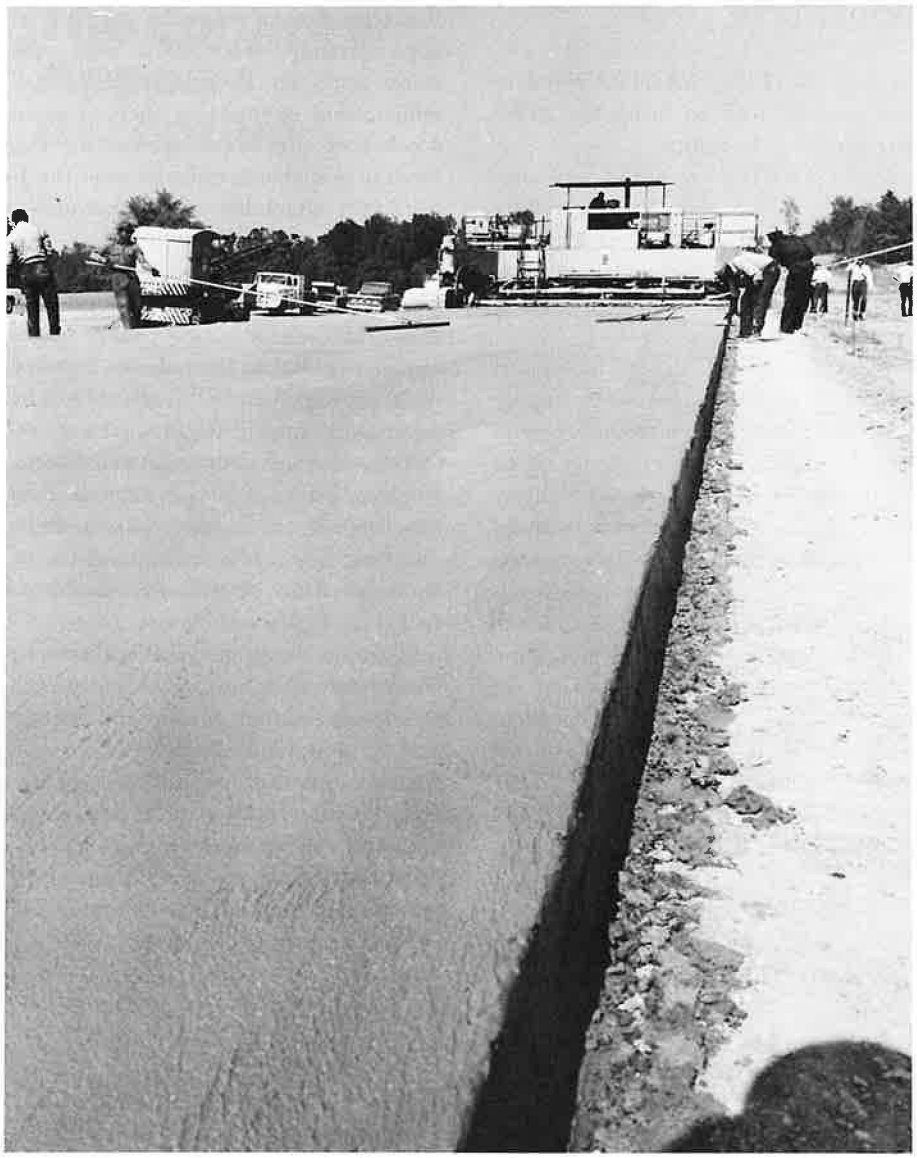
MAINTENANCE COST EFFECTIVENESS

The SCOR concurred that a comprehensive program of research for highway maintenance is needed to improve maintenance planning, performance, and evaluation. The program should include activities in two major fields: (a) development of technology for improved productivity in maintenance activities; and (b) development of new and better management systems to improve maintenance operations and program administration.

PROTECTION OF CONCRETE BRIDGE COMPONENTS

The SCOR reported:

> Corrosion of steel embedded in aboveground components of concrete highway structures has resulted in widespread deterioration and extensive maintenance costs. In general, the corrosion has been linked to the presence of chlorides in deicing salts, seawater or aggressive soils. While much progress has been made in the last 15 years to improve protective systems, there is still a lack of understanding of the mechanisms of corrosion of steel in concrete. More effective and economical techniques are required for both new construction and rehabilitation.



Left
Concrete pavement construction.

Below
Rotary snow plow dispersing windrow formed by V-plow unit.

CEMENT AND CONCRETE IN HIGHWAY PAVEMENTS AND STRUCTURES

The SCOR identified problems in mechanisms of setting and strength development in concrete, production placement, quality control, nondestructive testing, and durability of concrete. The committee called for research in four areas: (a) chemistry of cement and concrete; (b) quality control and condition analysis through nondestructive testing; (c) durability of concrete; and (d) mechanical behavior of concrete.

CHEMICAL CONTROL OF SNOW AND ICE ON HIGHWAYS

The SCOR stated:

> Research priority needs to be given to reducing the large quantities of corrosive deicing chemicals presently used on the nation's highways. This is best accomplished by improvements in mechanical snow and ice removal, development of effective alternative deicing chemicals, fundamental studies of the mechanism of ice-pavement bonding, a search for more effective methods of introducing energy preferentially to destroy this bond, and a large-scale demonstration of an urban maintenance control system using modern sensor and communications technology.

The President of AASHTO, in cooperation with the Federal Highway Administration, established a STRS Task Force to oversee and guide the pre-implementation planning effort.

RESOLUTION

On July 17, 1984, AASHTO voted to take several steps to bring the STRS Program closer to reality.

First, AASHTO accepted and supported the STRS plan for a carefully focused highway research effort in six subject areas, and made implementation of this program research a high priority effort for AASHTO.

Second, AASHTO agreed to support passage of federal legislation to finance the STRS highway research program. Such legislation would set aside up to 1/4 of 1 percent of federal-aid highway funds authorized for apportionment by the Federal Highway Administration on a mandatory basis for this purpose.

Third, AASHTO supported immediately undertaking a pre-implementation program to prepare a final design for implementation of STRS. The President of AASHTO, in cooperation with the Federal Highway Administration, established a STRS Task Force to oversee and guide the pre-implementation planning effort.

Fourth, AASHTO agreed to hire a full-time interim director to guide the pre-implementation research program design effort, and identified responsibilities, budget, and source of funds for the interim director and associated staff.

Fifth, AASHTO authorized that funding for the technical supporting contracts required for the pre-implementation effort should be obtained from the National Cooperative Highway Research Program, in the amount of approximately $600,000, with the states and the Federal Highway Administration committing themselves to accelerated procedures for making this funding available in order to meet the 1- to 2-year timetable of the pre-implementation effort.

Finally, AASHTO concurred that while the STRS Program is essential, it does not cover all subject areas where research is vital to the nation's highway program, and therefore it should not be seen as a substitute for existing research efforts. Existing research efforts, whether federal, NCHRP, or individual state sponsored, should continue to be encouraged in order to respond to the wide spectrum of technical challenges facing the highway industry.

Together, these steps reflect a strong commitment to confront some of the most serious and persistent highway problems, and to search for innovative ways to combat them. The message from the states is clear. The next set of decisions will be taken by the U.S. Congress; and, judging by a recently released report, there may be favorable reception by the Congress.

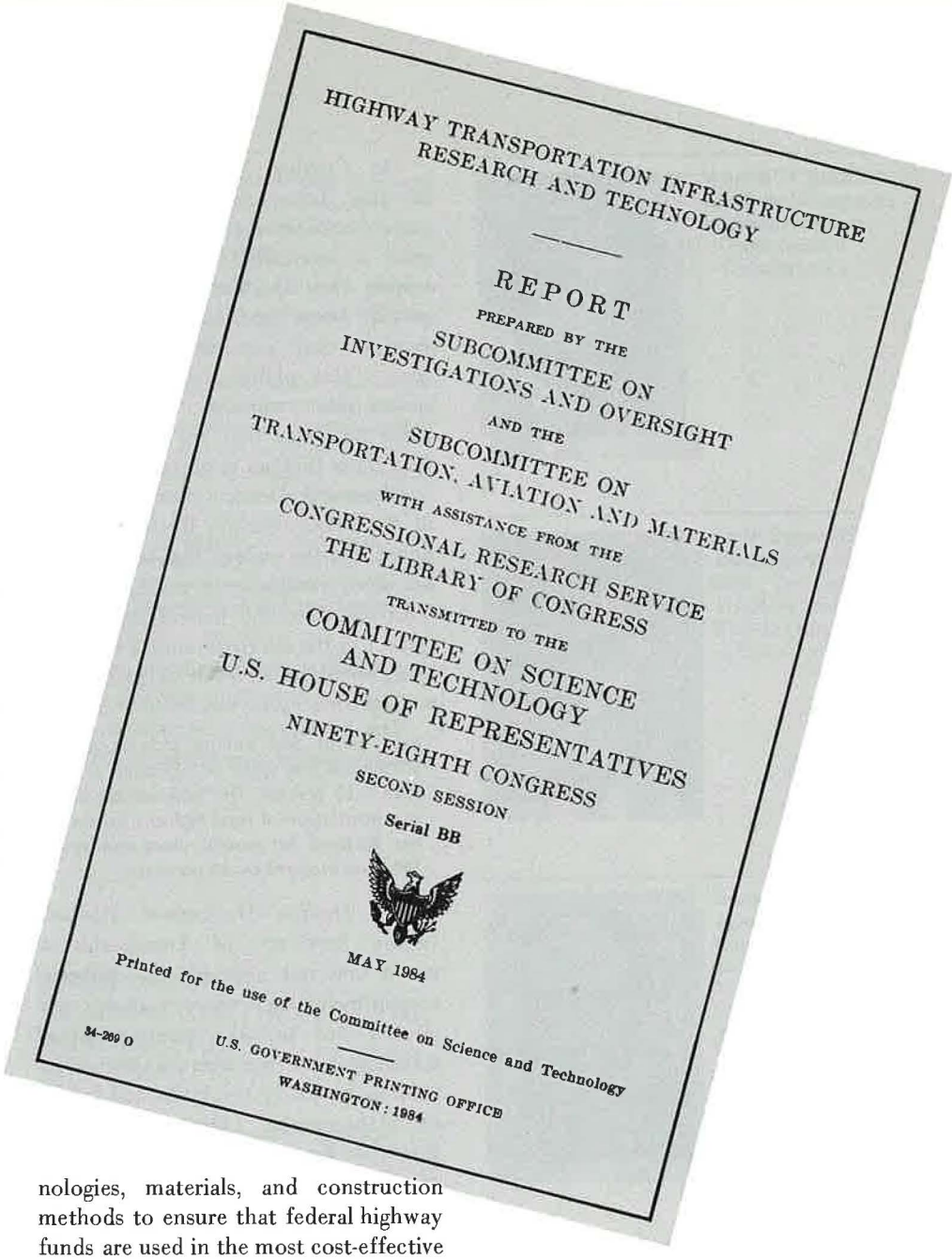
Members of the AASHTO STRS Task Force are: Thomas D. Larson, Pennsylvania Department of Transportation, Chairman; Ray A. Barnhart, Federal Highway Administration; Duane Berentson, Washington State Department of Transportation; Thomas B. Deen, Transportation Research Board; Francis B. Francois, American Association of State Highway and Transportation Officials; Mark G. Goode, Texas State Department of Highways and Public Transportation; Robert N. Hunter, Missouri Highway and Transportation Department; Harold W. Monroney, Illinois Department of Transportation; Thomas D. Moreland, Georgia Department of Transportation; and Charles V. Wootan, Texas Transportation Institute.

The Congress Appears Receptive

In June 1983, in the wake of intense national publicity about the nation's infrastructure problems, the Subcommittees on Investigations and Oversight and on Transportation, Aviation and Materials of the U.S. House of Representatives Committee on Science and Technology held a series of joint hearings "to examine the state of the research effort and the technological development that will support the necessary repair and reconstruction." The purposes of these hearings were "to assess the current status of highway transportation infrastructure research activities and funding; to explore effective ways to enhance national priorities for on-going transportation infrastructure research programs; to examine ways to promote research progress; to encourage applications of research findings, and to achieve timely results from research efforts."

Congressman Albert Gore, Jr., Chairman of the Subcommittee on Investigations and Oversight, stated: "Considering both the importance of our nation's highways to commerce, industry, and recreational activities and the staggering estimates of repair and replacement cost—placed by some at a major part of the total cost of trillions of dollars—the need for and importance of a well-directed and targeted research effort becomes clear."

Congressman Dan Glickman, Chairman of the Subcommittee on Transportation, Aviation and Materials, stated: "Although the recently enacted Surface Transportation Assistance Act will provide increased funding for highway and bridge rehabilitation, we must also renew our commitment to the research that supports that effort. This committee is particularly interested in assuring the use of improved technologies, materials, and construction methods to ensure that federal highway funds are used in the most cost-effective manner possible."


HIGHWAY TRANSPORTATION INFRASTRUCTURE
RESEARCH AND TECHNOLOGY

REPORT
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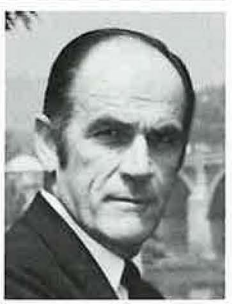
LEVEL AND ORGANIZATION OF RESEARCH

During the Congressional hearings, many highway administrators, heads of research institutions, academic experts, corporate research executives, and representatives of industries that supply materials for highway construction were questioned. Much of what they said fits squarely with the STRS recommendations. Following are some of the testimony and statements by these individuals.

Charley V. Wootan, Director, Texas Transportation Institute

Thomas B. Deen, Executive Director, TRB

Thomas D. Larson, Secretary, Pennsylvania Department of Transportation



Dr. Charley V. Wootan, Director of the Texas Transportation Institute, testified that the federal program is increasingly "directed toward solving very specific problems and in getting those problems solved in the shortest time possible." In Wootan's view, "this philosophy causes us to concentrate unduly on attacking those problems that are urgent rather than those that are important."

Thomas B. Deen, Executive Director of the Transportation Research Board, noted that the scale of highway research has been declining in recent years at both the state and federal levels. With respect to the approximately $40 billion being spent by all levels of government on highways each year, Deen noted that

> only about $60 million plus or minus $5 million was spent on research, or less than 0.15 percent. Our research spending as a proportion of total highway programs has declined for several years and since 1965 has dropped by 40 percent.

Dr. Thomas D. Larson, Pennsylvania's Secretary of Transportation, noted that not only was the financial commitment to research being neglected, but also the management of transportation research in many instances. In noting the faults and foibles of management, Larson commented that when he took over the management of the Pennsylvania Department of Transportation, he was so swamped with pressing issues that "it was 2 years before I could ask questions about research in my agency." Further, Larson noted that the average tenure of a U.S. Secretary of Transportation is about 2 years, and because other pressing matters dominate the secretary's thinking during the first years, the result is that a "responsible secretary will never get to R&D simply because operational problems will subsume him."

Larson also observed that a research subject does not always get management attention even when it has enormous implications: operating departments "have budgets of perhaps $1 to $2 billion." Against this background, he noted that a research program, even if it saves a million dollars, would appear relatively small to officials involved in operations. Larson concluded that "research has suffered because we have not had continuity of management and management that was attuned to technological advance." He also cited management insensitivity to the value of innovations, noting that managers are not attuned to the kind of thinking that recognizes the financial significance of innovations.

Deen noted that the structure of highway research is highly decentralized—a structure that has some clear advantages but also leaves some gaps:

> We are vastly more capable today in areas of pavement design, safety features, traffic operations, planning methodology, bridge construction and preservation than we were in the past. As critical as our current maintenance and other highway needs are, they would even be greater were it not for these advances.

Deen acknowledged the wisdom of the historical decision to manage and carry out research as closely as possible to the operating agencies that must make use of the results. But he also observed that, as a result, highway research

> is funded not only by the Federal government, but by most of the States, a number of turnpike authorities and a few of the larger counties and cities and also private sector suppliers . . . . Studies directed to the problems are actually carried out within operating agencies, universities, consulting firms, and private laboratories.

Deen called the process a "grassroots operation," and observed that even though the current decentralized process is appropriate for our main efforts, it "has some shortcomings." He stated:

> Perhaps the biggest of these is its apparent inability to focus large efforts on single problems, however deserving they might be. Most projects emerge in units of $150,000 to $400,000 and projects larger than a half million dollars are very rare. Yet some problems cannot be effectively attacked without mounting larger, more comprehensive efforts. While the vast majority of our research programs facing industry today can best be handled by this unfocused, decentralized approach, there are a few areas where these are inadequate.

PARTICULARLY PROMISING RESEARCH AREAS

The STRS Report identifies six areas for particularly promising research, and these same areas were cited repeatedly in the Congressional hearings. In his testimony, John B. Kemp, Secretary, Kansas Department of Transportation, focused on bridge problems.

> Of our approximately little over half million bridges in the Nation, 45 percent are either structurally deficient or functionally deficient. I think that the important matter of that, even more important than that number, is that the number of deficient bridges is expected to increase in the future. This is attributable in large part to the fact that 37 percent of the bridges were built in the period of 1940 and earlier. Kansas has 4.4 percent of the Nation's bridges, but we have 5.9 percent of the Nation's deficient bridges. The price tag on the bridges alone is about $47.6 million, and that is just really a drop in the infrastructure need bucket.

Patrick J. McCue, Policy and Federal Programs Director at the Florida Department of Transportation, pointed to the need for research on how to make economical "use of what is put there."

> It is easy to talk about getting exotic materials to build roads, but the fact of the matter is that the common materials like limestone, cement and asphalt are there and that is what we will probably use. What we need is research into the best ways of using what we have as opposed to finding something different that might eventually be better.

When questioned about top research priorities, Kemp responded:

> I think pavement management certainly would have to come high on any list that we would have in Kansas because we spend such a big share of our total construction and investment dollar on pavement. We are developing a pavement management system but we are just finding our way.

John Mladinov, Executive Deputy Commissioner, New York State Department of Transportation, put high priority on maintenance.

> There should be increased research aimed at the maintenance area, improved materials, improved techniques, methodology. That is part and parcel of the management program as well. That is what pavement management is all about, to maximize the capability and at the least cost of keeping the facilities in operation.

In his statement, Paul N. Pappas, Secretary, Florida Department of Transportation, noted:

> We believe that major advancements can still be realized through scientific analysis of the basic properties of materials used in construction of transportation facilities. I am talking about materials as common as cement, asphalt, and the aggregates mixed with them to construct highways. The properties of asphalt, in particular, have changed dramatically as a result of alternatives in the refining process, reflecting changes in world uses and prices of oil by-products.

Representatives from different parts of the highway industries also pointed to shortcomings in the current array of research programs and organizations.

FINDINGS AND RECOMMENDATIONS OF THE CONGRESSIONAL SUBCOMMITTEES

The testimony by state officials and others involved in highway research appears to have made a substantial impression on the Congressional Subcommittees. In their findings, the Subcommittees concur that

> support for highway research has declined significantly in the last 20 years. Research spending as a proportion of total highway spending is currently less than 0.15 percent, and is clearly not adequate to support the substantial investment in the Nation's highway infrastructure.

Further, they found that

> current highway research programs emphasize small-scale projects, and are fragmented to the point where it is not possible to produce timely solutions to the complex technical problems of national application and importance.

To address these problems, the House Subcommittees recommended that the Department of Transportation prepare

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Patrick J. McCue, Policy and Federal Programs Director, Florida Department of Transportation

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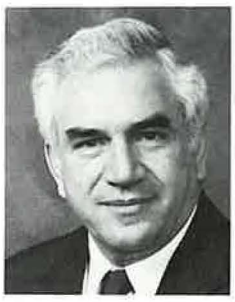

Paul N. Pappas, Secretary, Florida Department of Transportation

Congressman Albert Gore, Jr.: "We are beginning a big, new wave of expenditures, enormous in scope, focused on repair and maintenance . . . [it is] appropriate for us to have a focused, comprehensive research effort at the beginning of that wave."

an increase in funds allocated to transportation research, and that the Department

> provide the institutional mechanisms for conducting large-scale research programs focused on major national priorities in highway infrastructure research and technology. Such policy should emphasize the consolidation of Federal, state and private sector funds for a more concerted attack on a smaller number of critical high-payoff research problems.

The specific critical high-payoff items that are recommended also coincide with the STRS recommendations. The two House Subcommittees found that:

> Research programs to increase the quality and durability of a number of high-cost highway materials show the most promise for decreasing the cost of maintaining the highway infrastructure. For example: A 10 percent improvement in the average life of asphalt pavement would save $1 billion annually within a few years. Development of a noncorrosive de-icer would save much of the $6 billion annual expenditure for corrosion to bridge decks and vehicles. Research on new materials and the application of new materials such as fiberglass reinforced concrete likewise offer substantial savings to American taxpayers.
>
> The Subcommittees recommend that the Department of Transportation develop and initiate a research program focused on increasing the quality and durability of high total cost highway and bridge materials. Such a program should include high-priority emphasis on increasing the life of asphalt and portland cement concrete pavements and the application of new materials for highway and bridge construction and rehabilitation.

In closing the Congressional hearings, Congressman Albert Gore, Jr., compared the bold, visionary thinking that led to the ASSHO road test with the situation today. He noted that "we are now at a very similar point in time. We are beginning a big, new wave of expenditures, enormous in scope, focused on repair and maintenance." Congressman Gore stated that it is "appropriate for us to have a focused, comprehensive research effort at the beginning of that wave." He stressed that he was willing to work with the industry and that he would "pursue this vigorously."

Beginning of a New Era

This resurgence of interest in highway research is healthy and long overdue. It portends a new era for highway innovation, giving the industry improved materials and processes, and giving researchers more opportunities—and more responsibility—to solve some costly, pervasive, stubborn problems. It promises a flurry of activity to generate innovative ideas. The idea is not new: past research has yielded continual innovation even when support was highly constrained, and when the demands being placed on highways were escalating unpredictably. William J. Young of the Portland Cement Association has cited three reasons why roads and bridges need repair. First, "most of the Interstate system has simply outlived its 20-year design life. That is as long as it was supposed to last. . . . [Second] the traffic on many highways is three to four times greater than expected at the time the roads were built . . . . [Third] the allowable vehicle weights have increased in the past two decades." He concludes: "The wonder is not that our highways are in need of rehabilitation, but that they are still performing as well as they are."

There is no question that the highway industry, and the research organizations that assist it, have adjusted ingeniously to changes in the type and amount of traffic, to advances in technological capability, to the shifts in public policy, and to changing expectations in the economic and social context surrounding highways. All of the recent developments in STRS, AASHTO, FHWA, and the Congress indicate the beginning of a new era. Although innovation is no stranger to highways, this growing renewal of interests will bring an unprecedented scale and concentration of activity, and promises to make a substantial contribution toward revitalizing the nation's highway infrastructure.