So feeding money into the research arm pays off at some percentage level. Sometimes the percentage is high, if you do the research well. If you don't do it well, if you don't have information transfer linkages and so on, then you can carry out research and have no payoff at all. All too often, that's the kind of research that has been done, and it's earned research a bad reputation. NCHRP has done much better. It has advertised its success, through publication of the synthesis reports that put together the big picture. As a result, NCHRP is recognized as an agency that fosters innovation, that doesn't just consume money to carry out research and produce reports that gather dust on a shelf.

TRNews: ***As president of AASHTO, you must be aware of the long-standing relationship between AASHTO and TRB, and, of course, NCHRP. How do you view this relationship?***

Larson: Well, it's one of these truly synergistic relationships. The AASHTO people take a portion of their money to fund TRB, and then serve as part of the board. They don't control TRB, but help to influence its direction. They in many ways guide the various programs, in particular the NCHRP program more than any other, but I would say that both sides are well served by the relationship. The synergism from having committed people on both sides, working in slightly different structures, is a very useful thing to enjoy.

TRNews: ***Any program is only as good as the people who run it. Any comment?***

Larson: Well, I've known the NCHRP directors going back to the first one, Earl Campbell; I worked closely with Bill Goodwin; I have spent many, many hours with Krieger Henderson. And Bob Reilly, more recently, has been close to us as we have worked in the SHRP program. Really, there has been a cast of giants peopling that enterprise, and that's why it has gone so well.

AASHTO's National Cooperative Highway Research Program: Solving Problems in Highway Transportation for a Quarter of a Century

HUGH M. GILLESPIE

As the first light of dawn comes up over the Atlantic, the pilot of a Boeing 747 airliner begins the gradual descent into John F. Kennedy International Airport in New York. Below, an early motorist, stranded on a Connecticut toll road with a flat tire, gratefully dials an emergency number on a roadside call box. Far to the south, across the jungles of Brazil, the morning rush hour along Rio de Janeiro's Copacabana moves through the city's intersections.

On the other side of the world, it is evening. Japan's freeways are crowded as Tokyo's workers drive home to the suburbs, and in Sidney, Australia, the neon lights of King's Cross reflect on the rainswept automobiles in the busy streets. It is noon in Tel Aviv, Israel; automobiles and buses jostle for position between the ancient churches and

H. M. Gillespie is Director of Communications, International Road Federation.

Current members of the Cooperative Research Programs technical staff include *(left to right)* Louis MacGregor; Harry Smith; Robert Reilly, director; Robert Spicher, associate director; Ian Friedland; and Crawford Jencks.

CRP Director Robert Reilly (*left*) with Associate Director Robert Spicher.

the tall office buildings. Back in Los Angeles, California, a technician monitoring the freeway system detects an early morning accident and dispatches a team of paramedics.

These workers and travelers are a world apart; yet they all have something in common: their labors and journeys have been made easier and smoother for a quarter of a century as a result of the National Cooperative Highway Research Program (NCHRP).

NCHRP is a unique contract research effort designed to respond quickly and efficiently to the needs of state highway and transportation departments through the solution of pressing operational problems in highway transportation. Although NCHRP is based in the United States, the findings of its research have been translated and implemented all over the world.

NCHRP activities are carried out in coordination with TRB's research correlation service visit program, conferences and workshops, publications program, library and information services, 165 standing committees, and annual transportation research meeting.

Need for Cooperative Research Identified

The idea of a cooperative research effort was conceived in 1959 by leaders representing the American Association of State Highway Officials (AASHO) [now the American Association of State Highway and Transportation Officials (AASHTO)] and the Bureau of Public Roads (now the Federal Highway Administration) when the Interstate highway system was just beginning. Duplication of research efforts among states was causing concern; in one instance, 32 states were found to be separately researching the same problem. The idea that states might pool their funds in a cooperative research effort offered obvious advantages.

The question was, Who would conduct a cooperative research program? The logical agency to administer such a program was the Highway Research Board (HRB) (now the Transportation Research Board) because of its track record in managing the AASHO Road Test, and because of its recognized objectivity and prominent position in highway research. In addition, HRB could readily obtain advice on virtually any transportation-related subject from the tremendous reservoir of professional expertise represented within the National Research Council.

On June 19, 1962, a three-way agreement was signed by the National Academy of Sciences–National Research Council, AASHO, and the Bureau of Public Roads to inaugurate a program of systematic, well-designed research to provide the most effective approach to the solution of many problems facing highway administrators and engineers. That program was NCHRP.

The AASHTO Connection

NCHRP has been sponsored since 1962 by the American Association of State Highway and Transportation Officials, in cooperation with FHWA. Emphasis is placed on cooperation between AASHTO committees and NCHRP to (a) ensure that the committee knows what it needs to know to make better use of NCHRP and (b) focus on ways in which the particular research needs of that committee might fit into NCHRP and make it easier for that committee to benefit from NCHRP on a continuing basis.

Currently, more than one-half of the members of the AASHTO Bridge Committee serve on NCHRP project panels.

Joanne Robinson, administrative secretary, works with Crawford Jencks, senior program officer, on assembling project panels.

In many cases, the findings and recommendations of NCHRP research are referred to the appropriate AASHTO committee for action. For example, in 1984, 11 items on the agenda of the AASHTO Subcommittee on Bridges and Structures were directly related to NCHRP studies, and during the next 3 years, recommended specifications will be produced in 28 NCHRP projects in a format suitable for consideration by the AASHTO Bridge Committee.

NCHRP Project Panel on Hydraulic Analysis of Bridges on Streams With Movable Beds and Banks (Project 15-11) meets to evaluate proposals.

Francis B. Francois *(left)*, executive director of AASHTO, and Robert D. Reilly chat at TRB Annual Meeting.

At the September 1985 AASHTO meeting in Seattle, Washington, Richard Braun, then president of AASHTO and chairman of AASHTO's Select Committee on Research, said: "The credibility of recommendations from NCHRP research is especially high in the eyes of the AASHTO committees because the members know the project was monitored and the results were scrutinized by a panel that includes technical experts and experienced practitioners."

Given the importance of NCHRP's close relationship with AASHTO and the strength of the panel system, NCHRP is well prepared to begin its second 25 years, continuing to produce significant improvements in highway practice in coordination with the other parts of the highway research system. According to Francis B. Francois, executive director of AASHTO, "Because of its ability to serve the research needs of AASHTO committees, NCHRP is a unique and vital part of the total highway research picture."

Panels of Experts Guide NCHRP Research

From the beginning, NCHRP has relied heavily on the expertise of the people who serve on its panels. Panel members are drawn from state departments of transportation, local governments, federal agencies, industry, and universities, and provide guidance on the technical aspects of research projects. Currently, more than 900 members from 44 states, the District of Columbia, Puerto Rico, and Canada serve on these panels. Their work is coordinated by NCHRP's 17-member staff (8 professionals and 9 support members).

The value of this voluntary service is impossible to estimate accurately. However, by means of a conservative calculation, it can be shown that if each panel member contributes 2 days a year to the program, on the basis of a daily consultant fee of $200, NCHRP benefits from more than $250,000 of donated services each year.

State highway agencies recognize that, in addition to the contributions made by panels to the effectiveness of NCHRP research, they and their employees who serve as panel members also benefit directly. The benefit comes from their participation in meetings in which experiences related to a particular problem are exchanged with other practitioners and researchers. The value of the knowledge panel members carry back to their agencies far outweighs the cost for travel expenses and staff time spent at panel meetings.

Research Focus

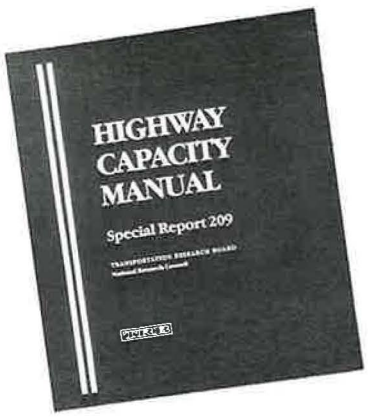
NCHRP research is generally focused on problems of immediate concern that can be solved through applied research. NCHRP research over the years has proven its ability to provide solutions to topical problems in a short time frame. This focus is not usually aimed at achieving spectacular breakthroughs; the typical NCHRP project is intended to

produce steady, incremental progress in specific areas of highway practice. However, there are occasional exceptions; two examples are cited of projects that will have major, far-reaching impacts.

Early in 1985, NCHRP research culminated in the publication of the third edition of the *Highway Capacity Manual*, which is expected to be TRB's most widely distributed report. First published in 1950, the manual was revised in 1965; almost 40,000 copies of this second edition, which has been translated into at least three languages, were distributed. The manual is a required text in most graduate transportation programs and is generally considered the primary reference for planning, design, and operational analysis of highway capacity. More than 30 panel and committee meetings were held to work on the third edition of the manual during its 8 years of development. Each of the 14 chapters underwent at least three drafts and three cycles of review and revision; each draft chapter was sent to a minimum of 32 reviewers and as many as 200—a process that produced more than 750 pages of reviewers' comments. This extensive review resulted in a manual that has been widely accepted in the transportation field.

The second example of NCHRP research that has had a major impact was the preparation of the *Guide for Design of Pavement Structures* published by AASHTO in April 1986. This 2-year, $575,000 project involved a concentrated effort by a team of 16 consultants working with an AASHTO task force and the NCHRP panel and staff. Drafts of the 600-page guide were reviewed by the AASHTO task force, the NCHRP panel, each of the 50 state highway and transportation agencies, the AASHTO Subcommittee on Design, and representatives of appropriate private industries. The review of the three drafts of the guide produced approximately 150 pages of reviewers' comments. Staff and task force participation in meetings held to work on the guide involved more than 500 days of effort.

The *Guide for Design of Pavement Structures* is based on the best information available on pavement design procedures for new construction, reconstruction, and rehabilitation. It is intended to replace the *AASHTO Interim Guide* published in 1972. The cost of meeting pavement needs on the federal-aid highway system through the year 2000 has been estimated at more than $200 billion. During this period of increased emphasis on pavement problems, this guide will be used extensively by most state highway agencies, as well as by cities, counties, consultants, and foreign countries.



The *Highway Capacity Manual*, one of TRB's best-selling publications.

These two publications—the *Highway Capacity Manual* and the *Guide for Design of Pavement Structures*—provide important guidance in an increasingly complex industry, representing, as they do, the distillation of knowledge, experience, and discussion among the leading experts in the transportation field.

Funding for Highway Research Increases

In this 25th year of operation for NCHRP, it is appropriate to look back at NCHRP's first quarter century.

During the first 25 years of its existence, NCHRP administered 462 research projects that had a total value of approximately $70 million. Each year the program has typically consisted of from 7 to 10 new projects, along with the continuation of a smaller number of projects funded in earlier years. Funding for each new project usually ranges between $150,000 and $300,000.

Until a few years ago, annual funding for NCHRP remained steady at just below $5 million a year, a figure that was far too low in light of the number of research problems suggested by AASHTO for consideration—as many as 188 in a single year. Moreover, during that same period, inflation severely deflated the purchasing power of the research dollar.

This situation was alleviated by the passage of the Surface Transportation Assistance Act of 1982, which resulted in an approximately 50 percent funding increase for NCHRP. Because of this increase, and because of the accumulation of balances from earlier fiscal years, the current program (fiscal year 1987) is the largest ever. It comprises 31 new projects and continuations, and is funded at more than $7.25 million.

The year 1987 could be designated the year of highway research because for the first time funding for highway research in the United States will exceed $100 million. Of this amount, about 6 or 7 percent will go to NCHRP, and $30 million will be allocated to the recently created Strategic Highway Research Program (SHRP).

SHRP Research Compatible With NCHRP

The Strategic Highway Reserch Program and the National Cooperative Highway Research Program are compatible research programs. NCHRP, along with the FHWA's Contract Research Program and the states' Planning and Research Program, will continue to conduct research in areas that are not within the scope of SHRP.

In the words of Thomas B. Deen, executive director of TRB and one of the prime movers of the SHRP program, "No one should think that the areas of pavements, bridges, and maintenance covered by SHRP are the only ones needing research. One of the advantages of SHRP is that existing research budgets can be relieved to focus on some of these other important research areas

while SHRP tackles the big six. If SHRP is successful in demonstrating the effectiveness of focused large-scale research, perhaps other topics can be identified in the future for such concentrated efforts."

TRB Executive Director Thomas Deen discusses highway research needs during TRB's Annual Meeting.

Who Benefits From NCHRP Research and How?

Although high-visibility research occupies the spotlight from time to time, the routine, incremental research carried out under NCHRP contracts continues to pay dividends to many. Since the inception of NCHRP, the findings of its research projects have resulted in economic, technical, and social benefits, not only to the sponsors and originators of the research, but also to agencies and communities all over the world.

The economic, social, and environmental benefits of transportation research are reflected in the wide range of subjects covered by NCHRP. Moreover, benefits for one transportation mode have overflowed into other modes. For example, a research project designed to develop a well-defined information and signing system for highway drivers was adapted by the Transportation Systems Center, U.S. Department of Transportation, to provide control signs for pilots at New York's Kennedy International Airport. The results of the study were published in *NCHRP Report 123, Information Requirements and Transmission Techniques for Highways Users.*

Specific examples of who benefits from NCHRP research and how are as varied as the number and types of research projects completed. Nevertheless, a few examples will be given.

• In the late 1960s and early 1970s, NCHRP allocated $97,000 for research on erosion control in roadside drainage channels, advocating the use of riprap to line such channels. The Connecticut Department of Transportation used the riprap on a trial basis and reported an initial cost saving of more than $90,000—virtually repaying the entire cost of the research. Colorado, Kansas, Minnesota, New York, and Wisconsin also adopted the procedure, which was published by the Soil Conservation Service of the U.S. Department of Agriculture.

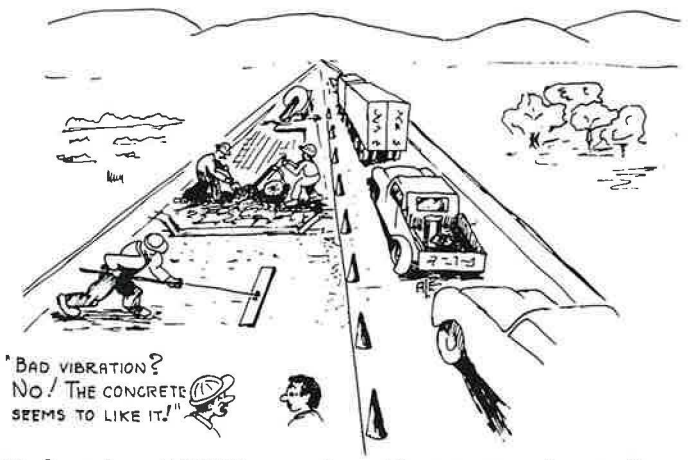
• Approximately 600,000 highway bridges and 400,000 railroad bridges exist in the United States, more than one-half of which are more than 40 years old. Almost one-half are classified as deficient, according to FHWA, which estimates that it will cost about $50 billion to remedy the problem. Because of the extent of this problem, more than one-third of NCHRP funding has been allocated for bridge research during the past 5 years. It is in this area that the cost-benefit ratio of NCHRP research has been shown to be particularly effective.

• During the past 20 years, welding has been used extensively in the construction of steel bridges. The welding process inevitably results in residual stresses and discontinuities whereby fatigue cracks can develop over a period of time. In a recent NCHRP report a technique known as peening, or impacting the area of the weld with an air hammer to inhibit the cracking process, was recommended. After cracking was found on a 28-span steel bridge on In-

After 13 years of exposure to high-volume truck traffic, cracking was found on this 28-span steel bridge on Interstate 95 in Connecticut; based on the results of NCHRP research, a new technique called peening was used to retrofit the approximately 700 cover-plate ends, resulting in a saving of more than $1 million.

terstate 95 in Connecticut, the decision was made to retrofit approximately 700 cover-plate ends on the bridge; peening was used as an alternative to bolted splices throughout. At an approximate cost of $50 per joint for peening, compared with $2,000 for a bolted splice, the savings on this structure exceeded $1 million. Because similar fatigue cracking will probably develop on many other bridges throughout the United States that were designed using specifications that were later improved, the eventual savings from this research project may be many millions of dollars.

- For some time, engineers have been concerned about the possible damage to freshly placed concrete caused by vibrations from traffic in the adjoining lane. Two years ago, $250,000 was allocated for NCHRP research on this problem, but when the panel met to develop the scope of work, the actual existence of such a problem was questioned. The panel decided to spend $25,000 of the allocated funds for a preliminary study, in which it was concluded that there was no evidence of damage to fresh concrete caused by the action of adjacent traffic. The panel recommended that no further action be taken. Not only was $225,000 returned for future NCHRP research, but the findings of the truncated study resulted in a savings of at least $1 million in traffic-detour costs in each of several state departments of transportation in only 1 year.



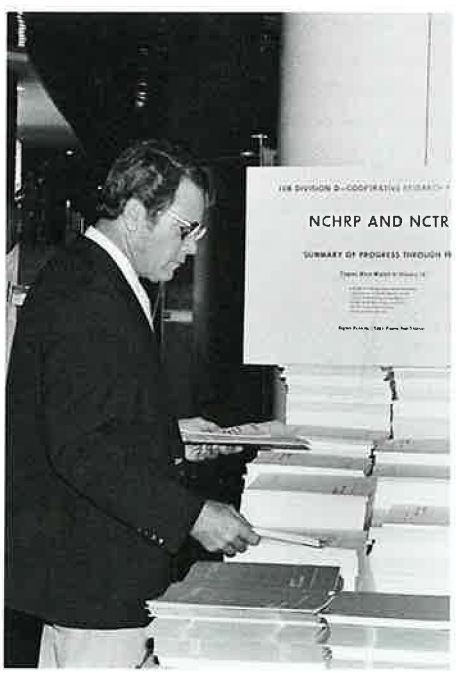
Findings from NCHRP research enable states to reduce traffic-detour costs on bridge-deck rehabilitation projects.

Disseminating Research Findings

Highway officials and researchers are continually faced with transportation-related problems that have already been researched by other agencies and individuals, but that may not have been adequately reported and publicized. As a result, valuable time and money can be spent "reinventing the wheel." Costly research findings may go unused, and a vast repository of knowledge and experience may lie unused and untapped by those who need it most.

To alleviate this wasteful situation, 18 years ago NCHRP initiated a project called Synthesis of Information Related to Highway Problems (NCHRP Project 20-5). The purpose of this project is to collect and evaluate useful knowledge from state highway and transportation departments, educational and research agencies, and the private sector on problems of widespread interest, and to publish the findings in the NCHRP report series *Synthesis of Highway Practice*. The first synthesis report, *NCHRP Synthesis of Highway Practice 1: Traffic Control for Freeway Maintenance*, was published in 1969, and 123 others have been published since then. More than 30 synthesis studies are currently in progress.

NCHRP publications disseminate research results so that administrators and engineers can put solutions to use as they become available.



The value of the synthesis approach has been recognized at federal, state, and local levels. As stated in a 1977 FHWA communication: "We wish to commend the Transportation Research Board for the excellent Synthesis of Highway Practice program. We find the synthesis material very useful as a single source document that summarizes for us the present state of the art along with a suggested method for improving practices."

Synthesis reports have been translated into at least three languages. They have formed the basis for legislation and for training programs, and have been adapted and reprinted by state and municipal governments.

Since 1962, 411 reports have been published in the regular NCHRP report and synthesis series. Projects in the NCHRP's most recent program year cover a wide range of subject areas, reflecting the interests of AASHTO and the expertise of committee and panel members. Subjects range from highway financing to bridge strengthening; from geosynthetics to traffic signing; and from roadside rest areas to admixtures for concrete.

The findings of this research will continue to benefit the mobility of the United States and the world as they have done for a quarter of a century.