

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE

23

**GETTING RESEARCH
FINDINGS INTO PRACTICE**

HIGHWAY RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING

HIGHWAY RESEARCH BOARD 1974

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GETTING RESEARCH FINDINGS INTO PRACTICE

RESEARCH SPONSORED BY THE AMERICAN ASSOCIATION
OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
IN COOPERATION WITH THE FEDERAL HIGHWAY
ADMINISTRATION

AREA OF INTEREST:
TRANSPORTATION ADMINISTRATION

HIGHWAY RESEARCH BOARD
DIVISION OF ENGINEERING NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES—NATIONAL ACADEMY OF ENGINEERING 1974

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Highway Research Board of the National Academy of Sciences-National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to its parent organization, the National Academy of Sciences, a private, nonprofit institution, is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the Academy and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are responsibilities of the Academy and its Highway Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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The project that is the subject of this report was a part of the National Cooperative Highway Research Program conducted by the Highway Research Board with the approval of the Governing Board of the National Research Council, acting in behalf of the National Academy of Sciences. Such approval reflects the Governing Board's judgment that the program concerned is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

The members of the advisory committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the advisory committee, they are not necessarily those of the Highway Research Board, the National Research Council, the National Academy of Sciences, or the program sponsors.

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PREFACE

There exists a vast storehouse of information relating to nearly every subject of concern to highway administrators and engineers. Much of it resulted from research and much from successful application of the engineering ideas of men faced with problems in their day-to-day work. Because there has been a lack of systematic means for bringing such useful information together and making it available to the entire highway fraternity, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Highway Research Board to undertake a continuing project to search out and synthesize the useful knowledge from all possible sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series attempts to report on the various practices without in fact making specific recommendations as would be found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available concerning those measures found to be the most successful in resolving specific problems. The extent to which they are utilized in this fashion will quite logically be tempered by the breadth of the user's knowledge in the particular problem area.

FOREWORD

By Staff

Highway Research Board

This report will be of special interest to highway administrators, researchers, and others in highway management whose responsibilities include the implementation of research findings. A wide variety of organizational processes that have been applied successfully by individual highway agencies in transferring research findings to practical application, and that might be adaptable to use in other agencies, are described.

Administrators, engineers, and researchers are faced continually with many highway problems on which much information already exists either in documented form or in terms of undocumented experience and practice. Unfortunately, this information is often fragmented, scattered, and unevaluated. As a consequence, full information on what has been learned about a problem is frequently not assembled in seeking a solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem. In an effort to resolve this situation, a continuing NCHRP Project, carried out by the Highway Research Board as the research agency, has the objective of synthesizing and reporting on common highway problems—synthesis being defined as a composition or combination of separate parts or elements so as to form a whole greater than the sum of the separate parts. Reports from this endeavor constitute a special NCHRP Report series that collects and assembles the various forms of information into single concise documents pertaining to specific highway problems or sets of closely related problems. This is the twenty-third report in the series.

With the tremendous increase in highway activity that followed the close of World War II came an unparalleled increase in the number, size, and complexity of problems to be faced by highway agencies. To cope with these problems, the research efforts of most agencies were greatly intensified. As research activities increased in size and scope, many agencies soon recognized the desirability and necessity for formalizing their processes, programs, and assignment of funds to research to maximize their outputs in this area. More recently, many agencies have found it necessary to institute consciously managed efforts to translate research results into practice to assure the realization of a full return from research expenditures.

This report of the Highway Research Board describes implementation procedures that have been applied with success by a number of highway agencies under a wide variety of organizational structures. The processes in several instances are subjected to detailed dissection so that the important elements can be easily recognized. Most successful procedures were found to be constructed around the premise that effective implementation is a continuous process that begins at the earliest stage of planning of a research endeavor and remains active until utilization of the product of the endeavor is realized. One or more of the processes that are described should be adaptable to use in almost any type of highway organization.

To develop this synthesis in a comprehensive manner and to insure inclusion of significant knowledge, the Board analyzed available information (e.g., current practices, manuals, and research recommendations) assembled from many highway departments and agencies responsible for highway planning, design, construction, and maintenance. A topic advisory panel of experts in the subject area was established to guide the researchers in organizing and evaluating the collected data and for reviewing the final synthesis report.

As a follow up, the Board will attempt to evaluate the effectiveness of this synthesis after it has been in the hands of its users for a period of time. Meanwhile the search for better methods is a continuing activity and should not be diminished. An updating of this document is ultimately intended so as to reflect improvements that may be discovered through research or practice.

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Information on current practice and ongoing research was provided by several highway agencies. Their cooperation and assistance were most helpful.

GETTING RESEARCH FINDINGS INTO PRACTICE

SUMMARY

Time, money, and resources invested in research cannot be justified unless the research findings are utilized. The primary use of research results is either to change current practice—those methods and procedures used to design, construct, and maintain highways—or to verify it. In order to change practice, it is usually necessary to change the “media of practice” (plans, specifications, standards, handbooks, manuals, etc.).

Research findings must be evaluated before they can become a part of practice. Their benefits are weighed against increased costs, manufacturing problems, construction difficulty, training requirements, and anticipated maintenance before a final decision is reached. Although some highway agencies have procedures for timely evaluation, others have a “wait and see” attitude that depends on successful implementation efforts of adjacent states.

Distribution of research reports and technical literature continues to be a problem within highway agencies. Some agencies believe that the number of reports that must be reviewed is too great. Others find difficulty in understanding reports that are written in highly technical terms rather than the language of the potential user. Research digests and the selective assignment of reports to certain individuals (having specific interest in their subject matters) have helped to relieve and redistribute the reading load.

In many agencies, the research organization plays a leading role in getting research findings into practice. Special committees or groups that revise specifications, standards, manuals, and other media-of-practice documents have proven helpful for evaluating and implementing research results.

The implementation process actually begins with the definition of a proposed research project. A statement of needed research should outline how the anticipated findings will affect existing practice, how they can be used, and how they can be implemented. To involve the “right” people during the research planning phase is most important. Many agencies are placing operational personnel and potential users on committees and panels that help plan and monitor research efforts.

Many researchers and practitioners agree that failure to include in the research contract provisions for use of the findings delays implementation. One solution is to provide funds for the preparation of draft specifications, guidelines, and, in some cases, field testing.

Computerized information services help the researcher and practitioner monitor research results and technical reports. One new service permits a subscriber to dial directly into a computer system via telephone to request data.

Seminars and conferences provide an opportunity for the researcher and the potential user to discuss research findings. The attendance and participation of highway representatives, representatives from suppliers, manufacturers, and contractors contribute to getting research findings implemented.

The evaluation process is concerned not only with the validity of the research and its findings but also with real value of the findings to the media of practice. Some research findings are not implemented because the trade-offs are unfavorable.

Without some form of product evaluation, agencies have been susceptible to misrepresented products. Agencies are now reporting progress with product evaluation. The AASHTO-FHWA program for compiling lists that indicate test results helps to eliminate duplication of work and to lessen the chance that unsatisfactory materials may be used.

Workshops, demonstration projects, and visual aids help promote research findings and encourage their implementation. The FHWA Implementation Program has developed specially packaged user material designed to instruct agencies in the use of new products or procedures.

The FHWA Federally Coordinated Program of Research and Development in Highway Transportation provides for a comprehensive and cooperative federal-state approach to use of research findings. This program emphasizes the development of an environment that is conducive to implementation efforts. Key factors in developing this environment are to stimulate the interest of top management to give its full cooperation and support; involve practicing engineers in the research and development process; provide sufficient funds for the necessary implementation field test and evaluation; provide solutions to real problems; present research findings in a language that can be readily understood or a form that can be immediately used; provide educational programs; and provide a management framework that is flexible, avoids duplication of effort, minimizes coordination requirements, responds to needs, and does not involve a lot of red tape.

To get research findings into practice, several principles should be observed:

- Research planning must include consideration for implementation of findings.
- A research planning team must include potential users.
- Research must be monitored to enable timely use of its findings and its modification or termination, if warranted.
- Research reports must be written promptly and in the language of the user.
- Reports should be distributed to appropriate persons within and without each agency.
- Negative results also should be reported and disseminated.
- Evaluation of research and its findings must be made before deciding whether or not findings should be implemented.
- Procedures must be available for getting research findings into the media of practice.

INTRODUCTION

WHY GET RESEARCH FINDINGS INTO PRACTICE?

"From the first gasp on, research is the process of reducing an idea to practice. Anyone who thinks otherwise is only misleading himself. . ." (1). Research efforts cannot long survive without some promise of implementation of their findings.

Millions of dollars are spent each year by both federal and state governments to finance highway research. These expenditures can only be justified if the findings are put into practice. The ratio of potential benefit to cost of research is perhaps 10 to 1 (2); and, in fact, great savings are available in merely reducing the time lag between actual research and implementation of its findings. Highway agencies must use research findings—primarily to change practice.

"Practice" includes those methods and procedures used to plan, design, construct, and maintain highways. They are represented by the "media of practice"—plans, specifications, standards, policy and procedure memoranda, handbooks, manuals, etc. (Fig. 1)—wherein changes must be made in order to change existing practice. Although the primary use of research results is to change practice, there are others. For example, research results can verify the validity of current practice, change the starting point or direction of planned research, or even cancel research.

Many highway agencies, the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and others involved in research have long been aware of the need to implement research findings as soon as possible after conclusion of research work and have been actively engaged in efforts to meet this need. Nevertheless, implementation problems remain.

IMPLEMENTATION PROBLEMS

It has been stated that all worthwhile research results eventually get into practice. Two queries inherent in this statement are: (1) What does worthwhile mean?; and (2) How long is eventually?

A researcher usually believes that all research he has conducted is worthwhile. A practitioner, however, has to evaluate the validity of research findings and, further, has to weigh the benefits of applying findings against many other factors. These factors include:

- *Increased costs.* A new technique, material, or procedure may provide a better end product but at an increased cost that may not be justified.

- *Construction and manufacturing problems.* Research is usually conducted under controlled conditions that may be difficult to reproduce or apply in ordinary production or construction circumstances.

- *Management and training problems.* The difficulties involved in overcoming a resistance to change or retraining a large staff may offset the benefits of implementing research results.

- *Maintenance problems.* A new product or material must be considered in terms of the frequency and cost of maintenance as well as the possible need for special equipment and training to perform maintenance.

Some agencies are not able to implement research results as fast as others. Delays in implementation can be attributed to a number of causes. The research evaluation procedure takes time. Or, procedures for evaluation and implementation may not be formalized, which can cause additional delays. Some states have a "wait-and-see" attitude wherein they wait until an adjacent state has accumulated experience with a new product or material before trying it themselves. Sometimes the people having authority to make changes are unaware of research results or even of the need for changes. In spite of all these delays, changes are eventually made.

Reporting Results

The incentive to *do* research is greater than the incentive to *report* research—especially in the language and detail such that findings can be implemented. Much time and tedious work is required to report research findings and, once a report is published, the risk of its refutation is sobering to all researchers.

As difficult as it may be to get a researcher to report positive findings, it is even more difficult to get him to report negative findings. Negative findings are all too often swept under the rug as though they are an incrimination of a researcher's ability. Much valuable research is negative. Negative results delineate limits of performance outside of which a procedure, product, or material becomes uneconomical, undesirable, or unacceptable. For this reason, negative findings are often more valuable than positive results.

Distribution of Reports

One major distribution problem is the routing of too much information. Personnel can become so overwhelmed with reports that they develop a tolerance and are prone either to pass reports on without thoughtful review or to stockpile them with good intentions of reviewing them later.

Distribution fails if it is not made to the proper people and in a timely fashion. Not always do those who are best able to evaluate and get research findings into practice even receive reports, much less receive them on time.

In some instances agencies do not receive reports. This problem occurs among states, within and among federal agencies, and among federal agencies and states.

Understandable Reports

Personnel cite lack of time as a basic reason for their failure to read research reports or notices of research findings. Reports that are concisely written in understandable language allow more reports to be read in whatever small amount of time may be available.

Another cause is that a preponderance of research reports are written in highly technical terms by researchers who often use mathematical techniques, computer programs, and principles so new or so complicated that they may be difficult for others to comprehend. On the other hand, researchers may not be familiar with specific highway problems and related terminology.

ORGANIZATION FOR RESEARCH IMPLEMENTATION

Several approaches are used by highway agencies to facilitate research implementation. For many years the typical agency research organization has had as its ultimate goal the implementation of research findings. More recently established are implementation groups, specification committees, and product evaluation groups whose primary purpose is that of getting research findings into the media of practice. In addition, a variety of schemes have been used to encourage wider in-house review of research performed by others, technical reports, and new product information.

Research Organization

In many cases, a leading role in research findings implementation is fulfilled by the research organization. This organization may include such groups as a research committee, a research advisory council, a research coordinating committee, and research panels. Each of these groups should be aware of implementation requirements for projects, beginning with the research planning stage and continuing through the conduct and conclusion of the research until implementation of the findings is achieved. In most agencies a research engineer is an active member of each group and therefore plays a major role in implementing research results.

The research organization assists implementation efforts for a number of reasons:

- Its groups include representation from those areas which will benefit by the research as well as representatives from the practitioners who will use or administer the research findings.
- The broad spectrum of interests represented in these groups assures research awareness throughout the highway department.
- Cross-referencing of individual group action is assured because the research engineer provides liaison with every group.

- The division of responsibilities among groups is compatible with individual interests and capabilities.

- The amount of attention to research and implementation of valid findings is in good balance with other responsibilities of a state highway department.

Management

The AASHTO Special Committee on Utilization of Research pointed to an unnecessary and undesirable time lag between completion of the research and the utilization of findings from that research. The Committee concluded that the lag was caused by a "missing link" between research and operations. The missing link *might* be a "new breed of professional generalist" who has a background in research and who would be responsible for getting proven research findings into use (3).

But whatever the nature of the missing link, its function must be to connect research and operations. Operations starts with management. Morf (4) proposes seven principles for research management:

1. We must adopt a strategy that will recognize the gap between research and practice as the "vital link" and do everything possible to close or minimize this gap from the "first gasp on."
2. . . . we should forget the idea cherished by so many researchers that if they could only break through the resistance or the inattentiveness and lethargy of the practicing engineers. . . . Practicing engineers responsible for the more than \$12 billion Highway Programs in the United States are alert and eager to adopt changes that are persuasively presented as offering substantial improvements in practice.
3. In order to change engineering practice, changes must be made in the media of engineering practice . . . the handbooks, the manuals, the standards of design, and standard specifications that are fundamental to all engineering activities.
4. The aiming point of applied research program management should be on the relevant media of practice and the means by which they are supported or changed. These changes are made by people highly regarded in their profession who are usually representative of organizations of engineers in practice. . . . Such people must be involved or associated with applied research efforts in an advisory capacity from the very beginning.
5. . . . we should not delude ourselves . . . (that some) . . . generalist as yet unknown, untrained, and perhaps unborn . . . can stand with one foot in the camp of research and the other in practice no matter how wide the separations created or tolerated by management. . . . Good management from the "first gasp" will strive to make this gap so small that ordinary human beings alive, and well, and functioning today can span it.
6. . . . in closing the gap, we should recognize the strengths of the researcher and the strengths of the practicing engineer. The researcher, by reason of his studies, can be presumed to have a more complete knowledge of the historical record, the complexities, the limitations, and the pitfalls of the facts of his field. The practicing engineer adds the strength of value judgments and the relationships between the narrow field of research with the broader considerations that govern a total application or design. Good research program management will bring the researcher in

closest communication with the practicing engineers so that their separate strengths will each support the other.

7. . . . the application of research results should not be

regarded as separate from applied research, but rather as fulfillment of applied research. As such, the funding of research and application should be consistently balanced and from the same source in the same program.



Figure 1. Examples of the media of practice.

IMPLEMENTATION TECHNIQUES AND METHODS

Highway agency management and research administrators agree that improvement has been made in getting research findings into use. Implementation techniques are varied and the number of people actually involved in the implementation process range from a few individuals to one or more committees. Although the effectiveness of the various methods is difficult to determine, it is possible to identify several elements of successful implementation efforts.

IMPLEMENTATION IN THE RESEARCH PLANNING PHASE

Implementation of potential findings is actually begun at the time a research project is defined. The probability of getting research findings into practice is increased when the research is aimed at problems that are important and potentially solvable. The sponsor of the research will have definite views on how the research findings should be used and their effect on existing practice. In addition, the research proposal may require the researchers to specifically state how the research findings can be used and how they might be implemented. For example, the National Cooperative Highway Research Program (NCHRP) "Information and Instructions for Preparing Proposals" states that proposals **will not be accepted** if the research plan does not include a section captioned "Applicability of Results to Highway Practice." In most agencies the research proposal is not approved or authorized until the responsible administrators have been convinced of the need for improved or changed practice and have reason to believe that the proposed research will fulfill that need.

There is general agreement within highway agencies that efforts to implement research results are enhanced by the appointment of practitioners to research committees, advisory panels, and other groups that plan and monitor research.

Get the Right People Involved. At the very beginning, involve knowledgeable engineers who are successful and effective in the appropriate field to discuss the research. In-house, the engineers should be selected from those units that are responsible for administering the activity. These people will be able to supply valuable ideas and help focus the research effort on the most acute problems. In addition, it gives the researcher the first opportunity to sell his research to the user. Every modern textbook on personnel management points out the advantages of group participation, particularly when initiating new procedures. This is certainly true in highway research, where the full cooperation of operational people is a necessity (5).

Participation by individuals who will eventually use research findings increases the probability of a timely application of new practices and techniques. In many cases their involvement eliminates an intermediate training or evaluation phase. Another benefit is the lessening of resistance to change on the part of other practitioners when

one of their associates has some role in developing a new procedure.

Many researchers and practitioners agree that failure to provide for the implementation effort in the research contract delays implementation. It is desirable that some portion of the research funding be reserved for the preparation of draft specifications or guidelines and the field testing or demonstration as well, if applicable.

IMPLEMENTATION IN THE CONDUCT OF RESEARCH

Persons responsible for monitoring research in progress should keep its over-all objectives in focus and be aware of the problems associated with implementing its findings. It is not always necessary to wait for the completion of research and subsequent publication of a report to start using the findings. It has been pointed out that research can produce information that can be put to use before a study is completed. However, projects have terminated early because it became obvious that their findings would not be useful (6). It is important that members of the advisory panel have sufficient experience to make such determinations at the earliest, most practical time.

DEVELOPMENT

In many cases, for a variety of reasons, the formal research output must be developed further before full-scale implementation can begin. Often more widespread testing, real-world trials, equipment designs, manufacturing details, operator manuals, and integration with other procedures and equipment are required. Unless accomplished in the research, these tasks constitute an important development phase. Development work is critical to the implementation decision because it answers such questions as: Can the result be economically produced? Is there a practical application for the results? What are the impacts on existing conditions?

DISSEMINATION OF RESULTS

Clearly Written Reports

The highway researcher seldom implements his own findings. He must communicate his findings to others. The user must be able to understand the researcher's report and recognize its value before attempting to put the findings into use. If the user has not devoted time to the research, its applicability may not be apparent to him. The report must be orderly, direct, and written so that the practitioner can understand the findings well enough to implement them.

If research findings are to be put into use, they must be phrased in the language of practitioners. Moreover, the research should be based on techniques and methods that are well known to practitioners. For example, methods should be based on standard tests rather than unrecognized ones perhaps more convenient for the researcher.

The following comments by highway officials indicate their concern with readable and usable reports:

The direct application of research findings to improve operations in a particular field is generally difficult, since the published articles often are written in complex, technical language that is difficult to interpret at the working level. Also, many of the research projects do not present definite conclusions that are applicable to field operations (6).

The researcher and the highway designer generally have quite different educational and experience backgrounds, in addition to different objectives. Many research reports, therefore, fail to succeed in spanning the gap between a research finding and the solution to a practical problem. Some reports are written for other researchers and not for the highway designer (6).

A Research Report is an "Implementation Tool." Research reports are too often written for "the ears" of other researchers rather than for the engineer. Most engineers are not interested in the volumes of data and the clever research methods employed. They want to know the *significance* of research findings and how to apply them. At the very front of the report, there should be an abstract or a concise summary, a list of conclusions, and recommendations. The operating engineer has neither the time nor the inclination to dig out information applicable to his work which is buried under "mountains" of detail (or "mountains" of words burying insufficient detail) (5).

Distribution Techniques

As discussed in Chapter One, achieving proper distribution of research reports is a problem. One method to alleviate this problem is to prepare research digests or summaries for general distribution. Persons interested in additional information can then request a copy of the full report. This practice is followed in several states. For example, Figure 2 presents an order blank used to request reports listed in the digest of the Texas Highway Department. The Department notes that requests have increased considerably during the past few years. Two factors should be considered when assessing the relative values of digests, summaries, and reviews. One is the quantity and quality of the material. Some documents are little more than lists of report titles. Others give complete entries with the more important details noted and may show an agency evaluation. The second factor is the time lag between publication of the report and the circulation of the digest. One digest lists reports as early as the month after they are published; another contains material published more than a year earlier and some portions are more than two years old.

Another method, considered effective by several states, routes reports or notices of research to persons having interest in their subject matter with instructions to read and comment.

Although the effectiveness of a system or combination of systems depends on the personnel involved, some routine, systematic distribution procedure should be followed.

Information Services

Computerized information services provide fast, concise monitoring of international research results to highway engineers. Perhaps the oldest and best known of these is the HRB Highway Research Information Service (HRIS). Others are the National Technical Information Service (NTIS), Transportation Research Activities Information Service (TRAIS), Transportation Noise Research Information Service (TNRIS), Maritime Research Information Service (MRIS), Railroad Research Information Service (RRIS), and the Current Research Information Service (CRIS) of the Department of Agriculture.

HRIS

HRIS is an automated information storage and retrieval system developed by the Highway Research Board with financial support from state highway and transportation departments, as well as the Federal Highway Administration and the Urban Mass Transportation Administration of the U.S. Department of Transportation. This service permits transportation administrators, engineers, and researchers rapid access to worldwide information about current highway-, transit-, and urban-related research and the results of completed research.

Input for HRIS comes from over 4,000 domestic and foreign sources. Major contributors are the Board itself and the U.S. Department of Transportation, as well as other information services with which the Board maintains exchange agreements. Such agreements are in force with the Smithsonian Science Information Exchange, the National Safety Council, the Roads and Transportation Association of Canada, the Road Research Institute of Brazil, the International Road Federation, and—through direct cooperation with the British Transport and Road Research Laboratory—the English language center of the International Road Research Documentation network.

Considering that HRIS has more than 52,000 references currently stored on computer tapes and that 10,000 new items are added annually, HRIS maintains one of the most complete collections of information on transportation research available anywhere.

The HRIS file can be searched for information in response to a specific inquiry. The search can be done manually or by use of a computer. The output consists of abstracts of articles and reports, and summaries of ongoing research supplemented by documents, reference lists, or other material supplied through the professional resources of the Board.

HRIS can also provide to individuals or organizations a selective monthly listing based on their specific information needs. Information is categorized into 34 established subject areas (Fig. 3). A more specific current awareness service based on combinations of key words or index terms can be provided.

Publications include *Highway Research in Progress* (HRIP) and *HRIS Abstracts*. HRIP, published annually, contains summaries of ongoing and recently completed highway transportation research projects. *HRIS Abstracts*, a quarterly publication, contains informative abstracts of

ORDER BLANK

Research Digest 72-5B Reports

I would like to review the report(s) checked below on a loan basis:

Item No. (✓)	Title
1	Demonstration Of A Test-Driver Technique To Assess The Effects Of Roadway Geometrics And Development On Speed Selection (Ohio) (EES 326B)
2	A Study Of Testing Variance In Size Distribution Analysis Of Coarse Aggregate (Ohio) (HWY #72-09)
3	Evaluation Of Raised Pavement Markers (Louisiana) (Report No. 60)
4	The Effect Of Water On The Resilient Modulus Of Asphalt Treated Mixes (Calif.)
5	Development Of A Traffic Accident Analysis System (Georgia #7109)
6	"Techniques For Reducing Roadway Occupancy During Routine Maintenance Activities" (NCHRP #14-2)
7	Studded Tire Fact Sheets (DOT - Ontario)
8	Highlights AASHO Policy On Urban Highways (FHWA) (Mississippi)
9	Water Supply And Waste Disposal Series (D.O.T) (Report 72R-1065-1)
10	Environmental Litigation In 1971 (D.O.T. #135)
11	An Experimental Concrete Road 38 Years Old: Condition and Performance of Sections of A.316 Great Chertsey Road (TRRL 317)
12	Research For A Road Safety Campaign-Accident Studies For Advertising Formulation (TRRL Report LR 432)
13	A Preliminary Report On An On-The-Spot Survey Of Accidents (TRRL Report LR 434)
14	Future Research On Bituminous Materials At The Road Research Laboratory (TRRL Report LR 442)
15	Reports Presented At The 1972 AASHO Regional Meeting Of The Operating Sub-Committee On Roadway Design (Circle: A B C D E F G)
16	Papers From The W.A.S.H.O. Meeting, June 8, 1972 (Circle: A B C D E F G H I)

Send this form to the following address:

Texas Highway Department
 Research and Development Committee
 R. L. Lewis, Chairman
 File D-8 Research
 Austin, Texas 78701

Your District _____
 Number _____

Your Division _____
 Name _____

Attention _____

Date of Request _____

journal articles, research reports and technical papers, and announcements of bibliographies. Both publications contain HRIS selections from the U.S. and foreign countries. All summaries and abstracts are in English.

HRIS contributors and subscribers can help improve service by:

- Reporting highway research in progress.
- Updating information submitted.
- Submitting reports and abstracts of completed research.
- Using the service.

One highway researcher has commented:

Published research reports are of prime value to us. Of special usefulness to the search of this field is the Highway Research Board's new computer-based Highway Research Information Service.

We have found that even if a research project performed by others does not contain the complete solution to our problem, it saves us a great deal of work by offering new information and usually at least a partial solution (6).

NTIS

The U.S. Commerce Department's National Technical Information Service (NTIS) is the central source for the public sale of Government-sponsored research and development reports and other Government analyses prepared by federal agencies, their contractors, or grantees. NTIS offers a computer-generated custom bibliographic search of abstracts of federally sponsored documents published since 1964. Copies of the full texts of most of the original reports, in either hard copy or microfiche, are offered for sale directly from NTIS.

Other Information Services

The TNRIS, MRIS, and RRIS, developed along the lines of HRIS, provide services similar to those of HRIS in transportation noise, maritime, and railroad research information. Several other information services in the Federal Government may have specific information of use to highway agencies (7).

On-Line Information Retrieval

The Transportation Research Activities Information Service (TRAIS) is an on-line information retrieval system for current research projects. TR AIS was developed by HRB for the Department of Transportation (DOT) in-house management information system and is maintained by DOT's Transportation System Center, Cambridge, Massachusetts. It uses a computer retrieval system developed and operated by Battelle's Columbus Laboratories. Currently all ongoing research funded by DOT is in the TR AIS system and plans are under way to include the entire HPR and NCHRP programs.

Use of TR AIS is simple. Once a user establishes an account, he need only dial into the system via ordinary

Subject Area Group		Subject Areas
Group Letter	Area Number	Name
A	11	Transportation Administration
	12	Personnel Management
	13	Land Acquisition
	14	Transportation Finance
	15	Transportation Economics
	70	Legal Studies
	81	Urban Transportation Administration
	82	Urban Community Values
	83	Urban Land Use
	84	Urban Transportation Systems
B	90	Highway Research, General
	51	Highway Safety
C	52	Road User Characteristics
	53	Traffic Control and Operations
	54	Traffic Flow
	55	Traffic Measurements
D	21	Photogrammetry
	22	Highway Design
	24	Roadside Development
	25	Pavement Design
E	26	Pavement Performance
	23	Highway Drainage
F	27	Bridge Design
	31	Bituminous Materials & Mixes
G	32	Cement and Concrete
	33	Construction
	34	General Materials
	35	Mineral Aggregates
	40	Maintenance, General
H	41	Construction & Maintenance Equipment
	61	Exploration-Classification, Soils
	62	Foundations, Soils
	63	Mechanics, Earth Mass
	64	Soil Science

Figure 3. HRIS current awareness service subject area groups.

telephone lines to make his request. Appropriate project titles and resumes are displayed on a cathode ray tube or they can be printed by the terminal at the user's location. If a printed copy of many resumes is desired, the user signals the Battelle computer to print the resumes, which are subsequently mailed to him.

Highway Libraries

Many highway and transportation agencies have their own clearinghouse and library for research reports and notices, and other pertinent literature. The type of clearinghouse-library maintained depends on an agency's needs. It can either be a central library or fragmented libraries. In either event, there should be a central control. In a few agencies this responsibility was left to random individuals and documents became lost because the employee responsible changed jobs, terminated, or retired.

Several libraries prepare bibliographies on specific subject areas either as a matter of course or on request. The HRB library and the U.S. Department of Transportation library have been helpful in preparing these bibliographies. Reports and other documents that are not available from local libraries may be obtained from the U.S. Department of Transportation library through an inter-library loan.

Seminars and Conferences

Several states periodically conduct seminars, which are similar to HRB meetings. Examples are the California Street and Highway Conference, the Ohio Highway Engineering Conference, and the Virginia Highway Conference. The objectives of these seminars are:

- To present research findings to administrators, practitioners, and other interested persons (such as suppliers).
- To require researchers to evaluate the applicability of their research periodically and to formulate understandable reports.

Because practitioners attend the seminar, the reporting researchers will be especially mindful of them in the preparation of their presentations.

In-house research is a prime source of reports for seminars, as well as research being conducted outside. In the event an outside researcher cannot attend a seminar and present his paper, a research engineer and his staff might assume the responsibility for the presentation. Some agencies make multiple copies of the papers and associated materials, such as movies and slides, specifically for loan to other agencies.

The attendance and participation of nonhighway people (such as government officials; representatives from suppliers, manufacturers, and contractors; and university faculty) can contribute toward research efforts and toward getting research findings into practice.

... There is an additional factor present in meetings and conferences that is not available in reports. This is the opportunity to be in the presence of the individuals responsible for the research or commenting in a discussion. Many times the "heart of the problem" is exposed in discussion but sidetracked in written reports (6).

National and international conferences are also excellent means for communicating the findings of research. Agency representatives attending such conferences can report on conference discussions and presentations at agency-sponsored workshops and seminars.

Highway Research Board

Each year members of the HRB Technical Activities Staff (TAS) visit highway agencies, engineering colleges, and related industries throughout the nation. The purpose of these trips is to correlate highway research. The HRB, by means of staff visits, functions as a circulatory system to disseminate information. Research findings, wherever generated, are circulated through the HRB system and channeled to those who can put them to use. Some agencies telephone or write to an appropriate staff member at the time their question arises rather than wait for his regular visit. This serves two purposes: (1) the agency receives immediate available information in response to its inquiry, and (2) the TAS is alerted to specific problems.

The Board's Annual and Summer Meetings provide a forum for presentation of research findings to the practitioners who are ultimately responsible for changing the media of practice. Preprints of papers presented at the Annual Meeting are distributed to each highway agency,

and most of the papers from both meetings are published in HRB publications.

The results of NCHRP research projects are disseminated by publication of reports. However, significant findings that appear during the conduct of research can be published in an NCHRP Research Results Digest and distributed immediately. Also, after a research project is completed, copies of its report in final draft form are available in limited numbers on a loan basis prior to formal publication of the report.

EVALUATION

Administrators and practitioners have expressed concern about the validity of research findings.

... the first step in implementation is an evaluation of the research work—does the work support and validate the findings and conclusions that have been drawn? What are the limitations imposed upon the findings by the research—can the findings be applied directly to conditions as they exist in our regular practice or do they have to be extended through further development to cover these conditions? (8)

The next step in the evaluation process is an analysis of the "trade-offs." The analysis, often difficult to perform, generally follows the course illustrated in Figure 4. Additional expertise from a wide range of sources within an agency, or even action at high levels of state government, might be needed to properly perform an analysis.

... an evaluation has to be made as to whether or not it is feasible, both economically and engineering-wise, to implement the finding. What problems will be solved or improved, what new problems may be created, what are the benefits, and what may be the repercussions? (8)

Analysis can indicate that certain research findings should not be implemented because the trade-offs are deemed unfavorable. That is, the improvements offered would not justify additional monetary expenditures or other problems created in the various aspects of practice—construction, manufacturing, management, maintenance, or training. For instance, an analysis might indicate that implementation could result in the loss of one trade-off of such paramount importance (as environmental protection or personnel safety) as to outweigh all other considerations and nullify implementation.

Evaluation Methods

Agency evaluation methods are numerous. One method is to specifically charge a research implementation committee or other group with the evaluation of research findings. In-house research can be evaluated during the conduct of the research by the entire group or by assigned members of the group. Research reports received by the agency from others can be evaluated jointly, separately, or can be assigned to an individual with particular interest or knowledge for evaluation and subsequent reporting to the group (Fig. 5).

In some cases, an ad hoc group is appointed to evaluate a research report and to assist in preparing special provisions, standards, specifications, and the like. This group

usually works with or reports to a parent committee or an appropriate divisional head.

Research findings can be evaluated and implemented by an alert individual who recognizes them as a solution to an existing problem. In this instance little, if any, change in the media of practice is required as use is made of the specifications and procedures developed by others.

The extent to which evaluation is carried varies also. Some methods may involve in-depth research and detailed preparation by in-house personnel. Others may consist of a brief study and, in some cases, a field test. An example of a detailed and well-planned evaluation and implementation effort is included as Appendix A. In this case, however, publication of the guidelines was not achieved until two years after the start of the evaluation procedure. In contrast, another state agency was able to implement a lime stabilization procedure in a relatively short period of time. Research findings from other state highway agencies and technical literature on the subject were utilized to design a test strip at a problem site on an ongoing construction project. Preliminary study of the strip by the responsible project and headquarters staff satisfied them as to the adequacy of the treatment. They then developed special provisions, issued change orders, and consummated a supplementary agreement—all within a few months.

Product Evaluation

Product evaluation is the check-testing of products to determine whether they meet agency requirements or manufacturer's claims (Fig. 6). In the past, agencies generally have been hesitant to identify products that performed poorly, the major concern being initiation of legal action by manufacturers against the state. However, proliferation of products is forcing agencies to institute programs for product evaluation. Appendix B outlines one such program. Those agencies having successfully used a product evaluation program maintain that the possibility of a suit is merely a "paper tiger."

Without some form of product evaluation, agencies are susceptible to misrepresented products. For example, the manufacturer of a product may donate his product and possibly even pay for the cost of its use in a check-test program in State X. However, before any test results are published, this manufacturer may have advertised his product in other states as being in use in State X. If the product fails, the testing agency of State X, embarrassed about being duped, may not reveal negative test results and expose an inadequate product. Thus, misrepresentation of this product can be perpetrated elsewhere.

Reporting product evaluation on a national scale is a desirable goal and the current exchange of information on a regional basis is a sound first step toward this goal. A second step has been initiated by the AASHTO Operating Subcommittee on Materials. This subcommittee, with administrative support from the FHWA, maintains a list of products that have been tested and pertinent test information for each product. The information names the state performing the tests, notes the purpose of the tests, indicates

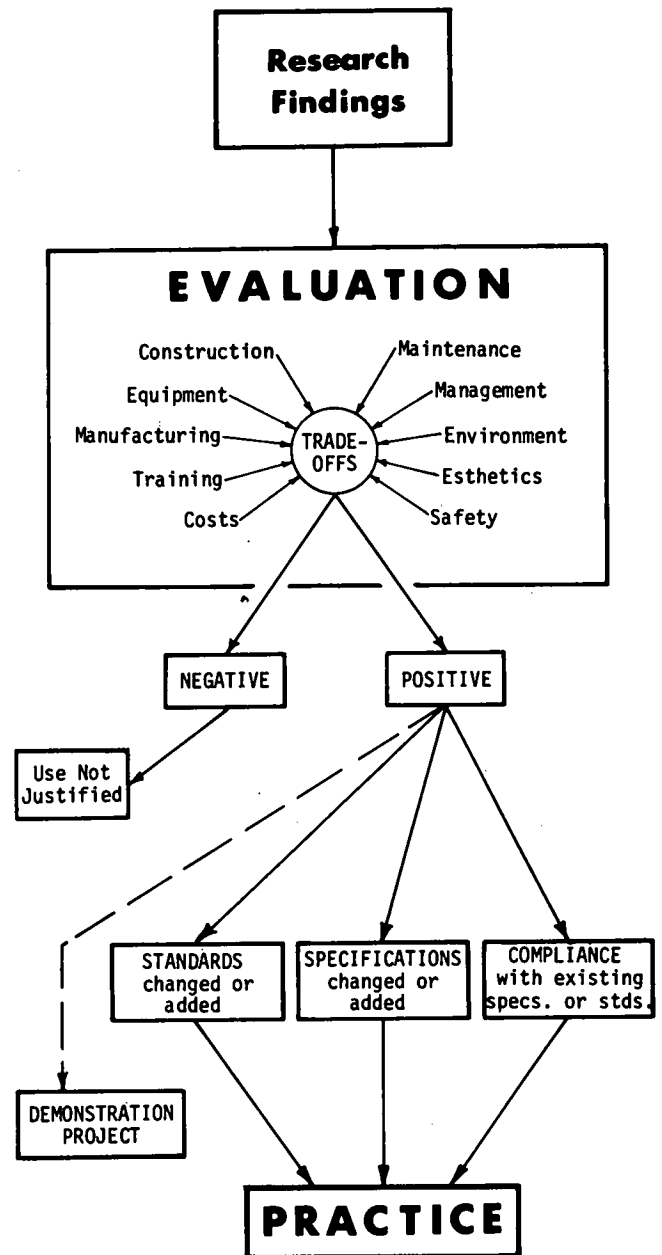


Figure 4. Evaluating research findings.

product acceptance or rejection, and mentions whether the product is still being tested. Agencies that have further interest in one of these products can contact the testing agency directly.

PROMOTION

Workshops

Workshops are a direct means for promoting research findings. These usually involve division and district personnel and may include field men, who are most directly responsible for success or failure of implementation. For example, one state research engineer conducted a successful workshop on quality control. Key field men from the districts

REPORT
OF
COMMITTEE ON
IMPLEMENTATION OF RESEARCH

QUARTERLY MEETING 7/10/73

SOURCE DOCUMENT: California Division of Highways research report, "Evaluation of Minor Improvements--Grooved Pavements"

Data showed 45 motorcycle accidents before grooving and 46 after grooving despite an increase in the number of motorcycles during recent years. Apparently grooves are not dangerous to motorcycle operation. Thirty-four lane miles of grooving were studied.

Grooving reduced wet pavement accidents on the studied sections from 535 accidents to 158. Dry pavement accidents increased 15%, and the conclusion was that grooving does not affect dry pavement one way or the other.

Grooves are being cut 1/8" deep; they last 10 years in concrete, and 5 years in brittle AC pavements. Not much data from the five asphalt projects.

Stopping distances from 40 mph were about 50 feet less on grooved wet pavement than on ungrooved wet pavement. Grooving also tended to make skids controllable.

Grooving should be performed on no less than 500' lengths. For most pavements a satisfactory groove pattern would be 1/10", 1/8" deep, and spaced on 3/4" centers. However, this study was conducted in California, where percentage of studded tires is very low.

Although little grooving is expected in Colorado, this information might help decide if it would be helpful. Maintenance engineers might benefit in case certain sections are found to have low skid resistance. Research engineers will benefit in being able to recommend remedial treatments.

RECOMMENDATION: General interest to District Engineers.

* * * * *

SOURCE DOCUMENT: California Division of Highways research report, "Coatings and Pavement Marking Materials 1960-1972 Interim Report"

Figure 5. Portion of a report by a research implementation committee.

were brought together for three days. In addition to discussing the most recent research (the expressed reason for the workshop), they reviewed general background information helpful to understanding research reports. Topics included:

- The necessity of quality control.
- Theory of random numbers, in testing and sampling.
- Examples of quality control.
- Quality control costs as opposed to no quality control.

Visual Aids

Visual aids—slides, movies, videotapes—often are used to promote research findings. Videotape is employed where the use of the information is short-term or where immediate viewing of the subject matter is needed. For long-term or extended use, film is usually less expensive. For instance, Iowa has produced a film that summarizes several years of research on roadside maintenance. California and Texas have produced films showing improved equipment and

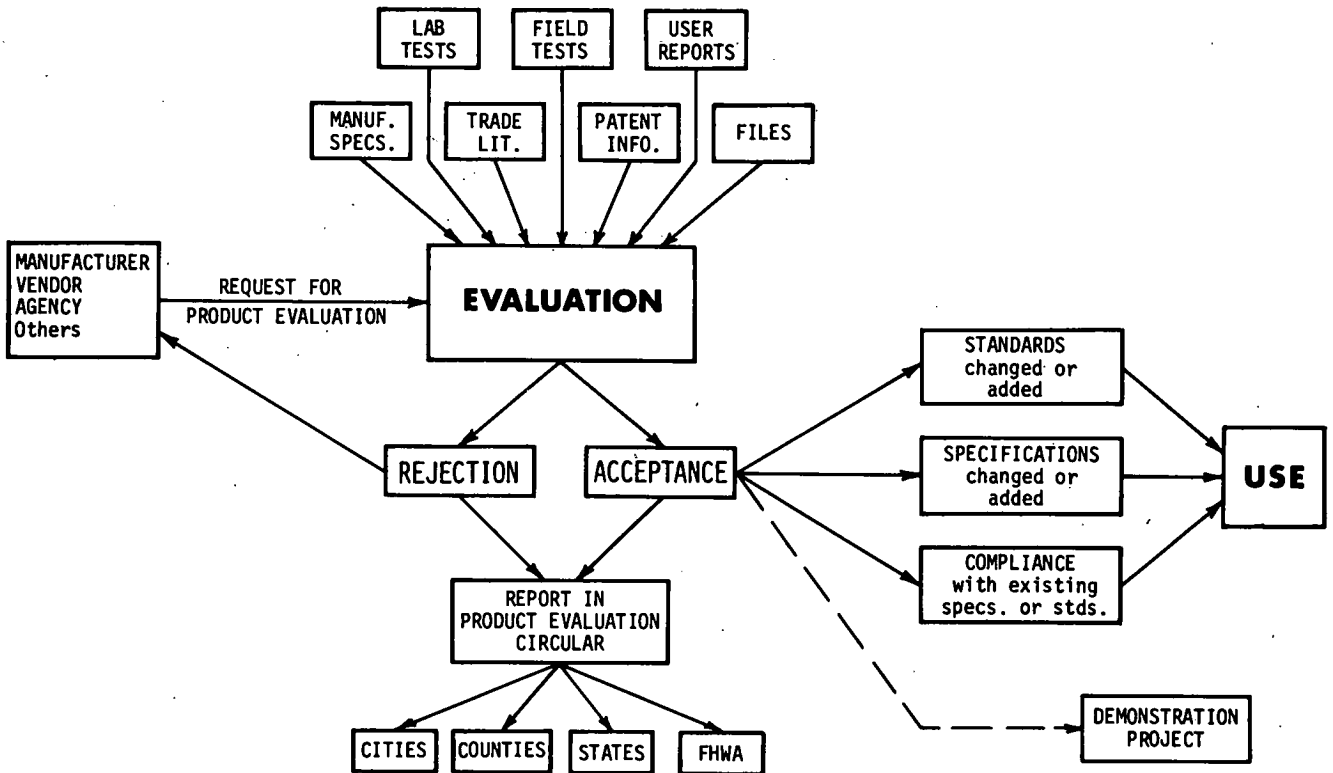


Figure 6. Product evaluation procedure.

techniques for handling traffic during maintenance on free-ways. Other states have produced similar films.

In many cases visual aids are produced in conjunction with the research project. For example, Table 1 lists films that were produced as part of NCHRP research projects and which are available on a loan basis. The HRB also has other films available for loan and these are listed in the *Highway Research News* from time to time. The FHWA will lend its films, listed in the publication "FHWA Motion Pictures," to other government agencies upon request to the Photographic Section, FHWA, Washington, D.C. 20591.

Demonstration Projects

Squanto *showed* the Pilgrims how to plant corn. The Pilgrims survived. Had Squanto written them a set of instructions, the outcome may have been quite different. Undoubtedly the most effective teaching device is demonstration. As an example, manufacturer demonstrations of electronically controlled paving machines resulted in overwhelming and almost immediate acceptance of the machines. Advertisements of such complex devices are not likely to have elicited the same response.

Costs of demonstrations can be substantially reduced by scheduling the demonstration as a part of actual work. In those cases where the cost of demonstration teams is too great, movies or videotape can be substituted. One disadvantage of a filmed demonstration is that, although the

essentials of the demonstration are retained, the opportunity for participation is lost.

Highway agencies' demonstration efforts, whether for one individual or a group, have been particularly successful in introducing new techniques of materials testing and construction. Many states have advantageously requested FHWA demonstration teams to present new or improved techniques (see Chapter Three).

Field Testing

Many highway agencies recognize that the validity of research findings cannot always be proven in the laboratory. When laboratory data indicate that the research may have positive benefits, the next step in implementation may be field testing.

Expand the laboratory. In planning a modern highway research facility we try to provide sufficient space and equipment for the researcher. In addition to this carefully planned area, we must add the highway itself to our "laboratory." After data analysis and evaluation, the implementation or field trial period provides the researcher with an invaluable opportunity to sell his product to the field men as well as the designers (5).

Timely field testing may be a part of the research effort, it may be included in an active project, or it might be a combination of both. In every case, the researcher should be available to provide guidance, to answer questions, to evaluate the performance, and to assist with modifications. Field personnel often require special training in order to take part in the testing.

TABLE 1
FILMS AVAILABLE FROM NCHRP *

TITLE	TIME (MIN)	SUBJECT	REPORT OR PROJECT	PRODUCED BY
Relief for Tired Streets	20	Urban traffic engineering.	Rep. 113	Edwards & Kelcey
Lights Out	18	Crash tests of various breakaway bases for luminaire supports.	Rep. 77	The Texas A&M Univ.
Guardrail Performance and Design	10	Crash tests of various guardrail and median barrier designs.	Rep. 54, 115, 118, 129	Southwest Research Inst.
Pavement Marking Materials	2	Operation of a machine that manufactures and installs new marker directly on the pavement.	Rep. 45, 85	Southwest Research Inst.
Safety at Freeway Exits	10	Improving traffic operations at exit gore areas.	Proj. 3-17	The Pennsylvania State Univ.

* Send requests to: Program Director, National Cooperative Highway Research Program, Highway Research Board, 2101 Constitution Ave., N.W., Washington, D.C. 20418.

CHANGING THE MEDIA OF PRACTICE

Highway Agencies

It is widely recognized that a substantial amount of research findings cannot be used by highway agencies until the media of practice have been changed. This involves addition, deletion, or change in specifications, standards, procedures, policies, and the like.

Some agencies assign to a standing committee or a specific unit the task of continuously updating and redrafting existing specifications and standards. The chairman often confers with appropriate division heads and members of the research organization to ensure compatibility between the research findings and the new specifications.

Other agencies designate specific individuals to work on a temporary or intermittent basis with an ad hoc or task group to revise specifications and standards. An objection to this approach is that it often keeps individuals from working on their primary assignment.

In some agencies the research unit or the research team prepares drafts of proposed revisions or additions that are required to implement findings. In this event, the task may be included in the research contract.

It is an often overlooked fact that the media of practice may be changed by executive fiat. In highway agencies, heads of most engineering units keep abreast of new developments and closely follow the activities of national groups sharing common interests. Many of these individuals can implement changes with a minimum of agency review.

National Organizations

Several organizations with nationwide membership (AASHTO, ASTM, ACI, etc.) are active in changing the media of practice. Each of these organizations has a broad committee structure where research findings can be discussed and then applied to writing or revising standards and specifications. An advantage of these organizations is the widely varied backgrounds of the committee members that enable different viewpoints to be heard. Another advantage is the fact that many agencies' specifications refer to AASHTO or ASTM standards. Thus, when the standards are changed the agencies' specifications also are changed.

Trade Groups

Trade groups, such as The Asphalt Institute, Portland Cement Association, and American Institute of Steel Construction, operate in a manner similar to that of the national organizations. However, they usually exhibit a somewhat narrower viewpoint because each group represents a specific industry and usually addresses itself only to problems within its industry and those in areas that might overlap. The standards and specifications that they produce are usually in the form of guidelines, which may or may not be of use to highway agencies.

Professional Associations

Professional associations (ASCE, ITE, NSPE, etc.) generally are not as active in writing standards and specifications. However, their publications and journals enable practitioners to learn of specifications published by others and also aid in the dissemination of research results.

FOLLOW-UP

Implementation of research findings can be disappointing to both the researcher and the practitioner when no formal follow-up is conducted. Poor communication between the researcher and the practitioner can lead to the use of incorrect procedures or to incorrect use of valid procedures

and materials. The follow-up effort ascertains that the original objectives are being fulfilled as intended by the researcher and the specification writer. In some cases additional training or support equipment may be necessary, or a specification may require modifications in order to be realistic.

CHAPTER THREE

FEDERAL HIGHWAY ADMINISTRATION IMPLEMENTATION PROGRAM

The Federal Highway Administration's Federally Coordinated Program of Research and Development in Highway Transportation (FCP) provides for a comprehensive and cooperative state-federal approach to research implementation (9). Direction for the national implementation program is provided by the FHWA Implementation Division, Office of Development.

The basic plan for the implementation program is contained in Category VI of the FCP, which provides for developing and transferring the results of research into practice (i.e., bridging the gap between research and operations). The objective of FCP Category VI is to stimulate and expand the application and practical use of those items resulting from all highway research and development.

IMPLEMENTATION ENVIRONMENT

To achieve its objective, the program emphasizes the development of an environment that is conducive to cooperative nationally coordinated implementation efforts by FHWA, state highway agencies, and other highway organizations. It also emphasizes systematic management of the research and assessment of the success of implementation, including the benefits realized. Some objectives to strive for in developing this environment are to:

1. Obtain the interest for full cooperation and support of top management in both state and federal organizations.
2. Involve practicing engineers in research and development processes to ensure firstly that research is addressing real-world problems; and, secondly, at such time as it becomes apparent that usable research results will be produced, that implementers can translate the results into user form and then take the necessary steps to implement the results on a widespread basis.
3. Ensure that sufficient funds are provided for the necessary implementation, field test, and evaluation phases of a research project to be sure that results are ready for the practicing engineer to apply with confidence.
4. Provide solutions to the real problems of practicing engineers.

5. Present research findings in a form or language that can be readily understood and immediately used by the practicing engineer. Often a research report does not meet this objective, and a special user package must be prepared.

6. Provide educational programs so that practicing engineers can better understand the benefits to be derived from adopting new technology.

7. Provide a management framework that is flexible, avoids duplication of effort, minimizes coordination requirements, is responsive to needs, and does not involve a lot of red tape.

To meet these objectives and goals, a management plan was developed by the Implementation Division to form the basis for a coordinated, comprehensive, and cooperative approach to implementation. It provides a role for other FHWA offices and for state highway agencies. The plan relates existing programs, such as experimental projects and demonstration projects, to newer implementation activities in identification, planning, packaging, and promotion.

The plan considers the interrelationships necessarily required of research, management, and operating personnel in the FHWA, the states, other government agencies, the HRB, and nongovernment highway organizations that are involved in highway-related research implementation processes. Although primarily a state-federal cooperative effort, spin-off may benefit other users, such as counties, municipalities, producers, and federal agencies other than those directly concerned.

IMPLEMENTATION PROCESS

FHWA has developed a six-stage process for implementation activities as a part of its management plan for FCP Category VI. This process describes the typical procedures that are followed with individual implementation efforts and provides a framework for organizing, managing, and performing implementation activities. The six-stage implementation process consists of item identification, planning, packaging, promotion, evaluation, and adoption.

Identification

The identification process screens and reviews past and current results of research and development to determine their relative importance and to evaluate their potential for implementation. The identification process answers two basic questions: Were the research results implemented or recommended for implementation by the sponsoring organization? How useful and important are these results to other agencies?

The plan attempts to establish an organized approach to identification. The principal mechanism for identifying implementable results from state highway agency R&D programs is an Implementation Data Report Form submitted to the FHWA by the states. The Offices of Research and Development prepare implementation recommendations for FHWA research programs and the NCHRP. The Implementation Division, in cooperation with the Office of Research and the FHWA operating offices, assesses the implementation potential of the submissions and recommendations.

Planning

Once an item has been identified and judged to have potential, it enters the planning stage. The planners outline the action required in order to achieve effective implementation of the item. They determine the sequence of action, how best to conduct it and to what degree, and assign responsibility.

This may be a very simple and rapid task for some items. Others might require a detailed and complex strategy, particularly when additional work is required for the "packaging" and "promotion" stages. The important thing is to prepare a plan scaled to the effort that is needed and to the importance of the item.

Packaging

When implementation of new technology is encouraged or recommended, interaction between the research and the operations personnel provides a key element in the development of a package of user-oriented material. The package is a complete "how-to-do-it" kit that instructs the potential user of the manner in which it can be effected immediately.

The formal research report often is not suitable as an operating tool with which to apply new technology. The report must be translated into field orders, manuals, specifications or standards, graphs, data tables, and other similar documents. Training materials, films, and other explanatory and educational documents may also be needed to assist in the implementation. Generally, a combination of these preparations, assemblies and translations (the number and complexity of which depend on the need) constitutes the "user package." There is no standard formula. Just as the Implementation Division is responsible for preparing packages planned for FHWA programs, state highway agencies are encouraged to prepare user packages for items produced from their own research programs and particularly those in practice within their state. The mechanism used by a state to implement its own results may guide

others to implement the same results. A special implementation activity has been established in the Federal-Aid Planning and Research Program to assist states in funding their work. As user packages are received by the Implementation Division, it promotes nationwide application of these items to appropriate users.

Promotion

Promotion is the "action stage of implementation." Depending upon the strategy developed in the planning stage, promotion is conveyed to potential users by one or more state-federal channels. The principal promotion channels are:

- Films, slides, publications, and workshops—especially effective in stimulating implementation of user packages.
- Organizations, such as AASHTO and ASTM.

Also effective are the Experimental Projects and Demonstration Projects Programs of the FHWA and the educational and training programs of the National Highway Institute, all three of which are discussed in more detail later herein.

Another channel is a series of announcements called Implementation Division Alerts (IDA's). The IDA's are intended to provide advance notification of significant products of research that are nearly ready for a major implementation effort. They include sufficient information to allow the initiation of preliminary planning and strategy on the implementation approach that will be used within a region on the item highlighted.

Evaluation

Throughout the implementation process, evaluation plays an important role. There are two points, however, at which it is most critical. One is between the "identification" and "planning" stages when an implementation advisory group in the FHWA field office or in the Washington headquarters decides whether an item is ready for implementation. The second critical point is after implementation has been tried in one place or many places, and its value is determined.

Identification and documentation of measurable benefits and accomplishments resulting from the application of research results are the most important evaluation goals. Documentation is extremely important to the research implementation program and the over-all highway program for two reasons. In conjunction with the user package, it is a most effective tool for encouraging implementation by others. It is also the most visible evidence of the values of research and development programs to present to the public, as well as to highway administrators and program sponsors.

Adoption

Adoption is the final stage of the implementation process wherein a research item becomes an integral part of a standard procedure or practice. In some cases, its status of adoption develops over a period of time and without

benefit of any formal action. In others, its status is made official by a formal order, specification, or standard that confirms its adoption.

EXPERIMENTAL PROJECTS PROGRAM

The Office of Engineering and Traffic Operations has primary responsibility for administration of the Experimental Projects Program within the FHWA. From its inception, this state-federal program has tested and evaluated new or promising research features of high priority for use in highway construction. It also has the authority to place proprietary and patented products in actual highway construction projects, both major and minor, for evaluation purposes. Prior to 1968, nearly all its experimental projects were initiated by state highway agencies. Since that time, the scope of the initial program was expanded to include two programs serving national and regional interests in a more immediate fashion. These programs are the National Experimental and Evaluation Program and the Regional Evaluation Action Program.

National Experimental and Evaluation Program (NEEP)

The National Experimental and Evaluation Program (NEEP), designed to benefit all highway engineers, was established in 1968 and is dedicated to a unified national effort to evaluate promising results of highway research or new products, methods, or procedures for highway application. It was hoped that NEEP would also accelerate the accumulation of significant findings in the implementation process. The current goal, for most NEEP projects under way, is to obtain answers to specific problems within 18 months to two years.

An FHWA technical advisory committee conducts preliminary evaluations for NEEP. The committee issues for each project a prospectus stating its test and evaluation parameters to the national FHWA field offices. An attached memorandum encourages one or more states in each region to participate in the evaluation by establishing an experimental project of an extent to be limited by prospectus guidelines. Once states undertake participation in such projects, they issue quarterly status reports to their appropriate FHWA field office, which then forwards the reports to the Office of Highway Operations for national coordination. In the meantime, the technical advisory committee has also analyzed the status reports. The Office of Highway Operations subsequently compiles for each NEEP project a final summary report, which includes project conclusions and recommendations, with the assistance of the technical advisory committee and other appropriate FHWA offices. The summary reports are then distributed to all the states so that each can profit from the national evaluation regardless of whether or not it actively participated in the experimental project.

Regional Evaluation Action Program (REAP)

A less publicized effort to evaluate the results of research is the Regional Evaluation Action Program (REAP). REAP, similar in framework and purpose to those of

NEEP, affords an avenue by which a regional office can promote evaluation of new construction methods, materials, equipment, practices, and implementable research items on a regional level.

DEMONSTRATION PROJECTS PROGRAM

The Demonstration Projects Program, established in January 1969, has as its main objectives to:

- Promote the utilization of research and development results to application in the fields of management, location, design, construction, maintenance, and operations of highways to prove their effectiveness for general adoption and use.
- Provide special training opportunities associated with the program for Federal Highway Administration and state engineers.

Although most highway operational personnel realize the importance and value of digesting research reports, this program recognizes that it is difficult for personnel to find the time and organize the manpower needed to analyze research results and translate them into practice. The Federal Highway Administration (originally the Office of Road Inquiry, subsequently the Bureau of Public Roads) has accumulated experience in demonstration projects that date back to 1893. The FHWA Region 15 Demonstration Projects Division has reestablished and expanded the demonstration activities to help accelerate the adoption and utilization of research results in operational highway programs.

The Demonstration Projects are offered as a service to the states for little or no cost, with a minimum of conditions, and with no pressure to adopt the demonstrated products—the demonstrations must do the selling job. This program has been widely accepted and is praised by highway officials. Its success has been reflected in an increased level of funding provided for this work.

The FHWA Region 15 Demonstration Projects Division is responsible for planning, coordinating, and directing the execution of the program. Proposed projects are analyzed and prospectuses developed for review by a coordinating committee, which includes representatives of such FHWA offices as:

- Engineering
- Traffic Operations
- Research
- Highway Planning
- Highway Safety
- Highway Operations
- Development
- Environmental Policy
- Motor Carrier Safety

The committee maintains coordination and communications with other offices to ensure that demonstration projects are consistent with current programs. It reviews and approves proposed projects, approves work plans, approves project managers, reviews progress, and approves final reports.

A technical advisory committee is formed for each dem-

onstration project to provide expert technical advice on project details. These advisors, from all interested FHWA offices as well as other interested and related organizations, assist project managers to develop a project work plan, monitor the project, and report the results.

During the past three years, three distinct types of demonstration methods have emerged. The most common type has been the field demonstration of advanced location, design, and construction engineering procedures. A second type is the physical construction of demonstration installations with the Region 15 capabilities. A third is construction by state highway departments with Demonstration Projects support.

The popularity of the Demonstration Projects, within both the FHWA and state highway departments, is because the program:

- Selects timely projects that offer solutions for immediate and real problems of highway agencies.
- Forms coordinating and technical committees with knowledgeable and interested personnel.
- Assigns operational responsibility to a single subunit.
- Appoints project managers and field coordinators for each project.
- Prepares a skillful program of demonstration.
- Ordinarily takes the demonstration to the highway agency.
- Uses a soft-sell technique backed up with additional assistance, if requested.

Movies, slide presentations, conferences, workshops, and personal on-the-job demonstrations have been used to reach more than 6,000 engineers from the FHWA, state highway departments, and other organizations on active projects to date. The positive actions that have been taken

by highway agencies after observing or taking part in these activities are too numerous to list; however, it should be noted that some agencies have established similar steps to implement their own and other research findings.

THE NATIONAL HIGHWAY INSTITUTE

One stumbling block in the way of implementing research findings has been the problems associated with training personnel in new methodology and procedures. The Federal-Aid Highway Act of 1970 established the National Highway Institute to “. . . concentrate on providing skills and knowledge necessary for coping with the rapid growth of technology and the broadening social and environmental involvement of highway transportation” (10).

The functions of the Institute are:

1. Continuously ascertain and inventory training needs and resources and coordinate activities in these areas for federal, state, and local highway employees.
2. Assist the states in highway-related education and training.
3. Perform other training administrative functions as required to fulfill its role.

The primary function of Institute programs is to aid personnel in highway agencies to “utilize new knowledge in their work.” It is suggested that these “programs might be, in effect, the third link in the chain of:

- (a) Research—the finding of new knowledge,
- (b) Development—the field testing and packaging or assembly of new knowledge into usable form, and
- (c) Application—through communications, the implementation of new knowledge by getting it into the minds of persons who can use it.”

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

Highway agencies have exhibited progress in the implementation of research findings, particularly in cases where research has been completed within agencies or under their direction. The implementation of research performed by others suffers, at best, a time lag. A definite need exists to improve techniques for utilizing research done by others.

Top management of each agency has the responsibility to actively support agency research efforts with emphasis on implementation. Conversely, other levels of management and operating personnel are responsible for apprising top management of the status of all research and implementation efforts.

Planning for implementation of the findings should be

a part of initial research planning. Early consideration of implementation helps to ensure that research is directed toward a real problem and that it will provide useful information for the user.

If implementation is to take place in an orderly and timely manner, the “right” people must be involved with the actual research and also the implementation of its findings. In most cases the right people would be a mix of professionals who have strong interests in the research. A member or members of the organization that will make use of the research findings should be involved at all stages from initial planning through changing the media of practice.

Consideration should be given to including provisions in

each research contract for the preparation of draft guides, policies, standards, and specifications that implement research findings. Also, it may be desirable to fund workshops, seminars, demonstration projects, and training sessions as an extension of research efforts.

The conduct of a research project should be monitored continuously to recognize beneficial findings that can be implemented early and to ensure that the end results will be implementable. Potential users and those responsible for changing the media of practice should participate in the monitoring task.

Research reports should be prepared promptly and written in the language of the user. When possible, they should include draft specifications or procedures that would facilitate early implementation of findings.

The routing of research reports or notices of research findings unfortunately has not always been timely, to the right people, or complete. Each agency should develop a system for receiving, cataloging, and routing reports. The routing method should be tailored to the agency's needs. Whenever possible, the material should be reviewed by individuals having interest in the subject in addition to those having responsibility in the area. After reading the report, a reviewer should recommend whether or not the agency should implement the research results. All such recommendations should be reviewed by an appropriate staff member or committee.

Conferences, seminars, and workshops are excellent means of informing management and personnel of research results. They permit group participation and face-to-face discussion between researcher and user.

Communications within and among highway agencies continue to be a serious problem. Retirements, deaths, transfers, and promotions continuously change the staff of all agencies, making personal contact more difficult. Organized channels for inter-agency communication among staff members having like responsibilities should be improved.

Agencies should recognize the advantages of lending or exchanging personnel as a part of the training or retraining that is needed to put a new method or procedure into practice. This utilizes individuals having the most experience or interest.

Visits or field trips by key agency personnel to projects of interest in other states have played a role in stimulating acceptance of new materials, techniques, and equipment.

The loan of personnel among states might even be considered.

Cooperation with trade associations, industry, and other groups with a common interest in new or improved products, materials, methods, and such has been successful. The services and technical knowledge available through these groups can be most useful when planning for and carrying out training or retraining.

Demonstration projects continue to be well received. This method of implementation serves a dual purpose. It demonstrates to a potential user the validity of a new item and it provides instruction in its use.

The results of research cannot always be accepted and used. A system for evaluation is a part of the implementation process that should carry over into practice. Timely evaluation is a major factor in both early implementation of findings or abandonment of unfruitful research.

The AASHTO-FHWA effort to publish product evaluation data must have the support of each highway agency. To be effective, agencies must report the results of their own evaluations and make use of the evaluations reported by others.

Research findings are not fully implemented until they are reflected in specifications, standards, plans, manuals, guides, handbooks, or other media of practice. The researcher should work with those who are responsible for implementation to change the media of practice.

To get research findings into practice, several principles should be observed:

- Research planning must include consideration for implementation of findings.
- A research planning team must include potential users.
- Research must be monitored to enable timely use of its findings and its modification or termination, if warranted.
- Research reports must be written promptly and in the language of the user.
- Reports should be distributed to appropriate persons within and without each agency.
- Negative results also should be reported and disseminated.
- Evaluation of research and its findings must be made before deciding whether or not findings should be implemented.
- Procedures must be available for getting research findings into the media of practice.

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APPENDIX A

EXAMPLE OF A PROCEDURE USED TO IMPLEMENT RESEARCH RESULTS

APPLICATION OF IHR-76, LIME STABILIZATION OF SOILS, TO ILLINOIS DESIGN PRACTICE

The lime stabilization project (IHR-76) was undertaken to develop laboratory tests that can be used to evaluate lime-soil mixtures and, by means of laboratory and field studies, to obtain sufficient information so that specifications can be developed for lime stabilization.

Extensive laboratory testing was conducted to investigate the factors influencing lime stabilization of soils. These factors included lime reactivity, and the effects of the type, the amount, and the curing conditions of lime on typical Illinois soils.

Documenting the appropriateness of lime stabilization, the project evaluated the engineering properties of lime-soil mixtures and the required service conditions. This effort culminated in the development of a mixture design process for determining the proper lime content for adequate soil stabilization.

The process of implementation of the research findings into practice covered a two-year period, which terminated one year after the formal completion of the research project. This process involved four phases:

- (1) Development of specifications for lime-stabilized and lime-modified soils.
- (2) Development of design coefficients for lime-soil mixtures.
- (3) Development of guidelines for the use of lime-soil stabilization.
- (4) Development of a policy memorandum concerning mixture design for lime-soil mixtures.

The development of specifications for lime-stabilized and lime-modified soils was initiated by the Bureau of Research and Development. Preliminary specifications were written and submitted to the Bureau of Design and the IHR-76 Project Supervisor. Comments received from the Project Supervisor were forwarded to the Bureau of Design for consideration in the preparation of interim specifications. Interim specifications were then circulated by the Bureau of Design to the Bureaus of Research and Development and Materials and to the IHR-76 Project Supervisor. These specifications were then the subject of a joint conference of the two Bureaus and the project supervisor in which they developed the specifications' final format. Revised speci-

cations were then prepared and submitted to the Division's Specification Committee for formal approval.

The initial work on design coefficients for lime-soil mixtures was accomplished by the IHR-76 Project Supervisor. This work was submitted to the Bureau of Research and Development where considerable effort was expended to refine the preliminary effort. Upon completion of Research and Development's effort, a conference was scheduled with the Bureaus of Design and Materials, and the IHR-76 Project Supervisor. This conference resulted in the approval of design coefficients that were subsequently submitted to the Federal Highway Administration in the form of a formal report.

As the efforts on the specification and design-coefficients phases neared completion, work was initiated on developing a set of guidelines for the use of lime stabilization to be circulated among practicing engineers. Some work initially was accomplished by engineers of the Bureaus of Materials and Design, but the work was completed by the Research

and Development staff. The resulting guidelines were submitted to the Bureaus of Design, Materials, and Local Roads and Streets for review and comment. Following this, final guidelines were prepared for distribution.

The remaining phase, concerning a mixture design process, was largely accomplished by the IHR-76 research staff, and the resulting research report was published under the project. However, the Bureau of Materials was required to develop a policy statement on mixture design, which took a form similar to that of an ASTM specification.

In addition to these efforts, a program that concerned lime stabilization of soils was included in an Annual Highway Engineering Conference. At this program, the engineers involved in the implementation process and the Project Supervisor discussed the use of lime and the developed specifications, design coefficients, and mixture design process. This presentation disseminated the developed information not only to the Department's personnel, but also to attending county, city, and consulting engineers.

APPENDIX B

HIGHWAY PRODUCT EVALUATION: ILLINOIS *

A product evaluation system to improve and accelerate the flow of new products, materials, and processes into practice has been in successful use by the Illinois Division of Highways for several years. This is accomplished through a Products Evaluation Unit that is a part of the Bureau of Research and Development. The system principally serves as a clearinghouse wherein the proposals of manufacturers, producers, and others promoting new items for highway use can be reviewed and given proper consideration (Fig. B-1). Following its review and evaluation, the proposal is then recommended for one of the following actions:

- Immediate adoption.
- Field or laboratory investigation.
- Additional background study by Division of Highways.
- Full-scale research.
- Reference to vendor for additional information.
- Rejection.

The main task of the evaluation unit is to make preliminary decisions as to whether or not the item appears to be capable of meeting an existing or anticipated need and whether or not it is of a type and of sufficient importance

* Based on: BURKE, J. E., "The Illinois System of Evaluating New Highway Products, Materials and Processes." *Hwy. Res. News*, No. 27 (Spring 1967) pp. 52-55.

to warrant the attention of the Development Council. The unit must also obtain sufficient information to allow a reasonable evaluation.

Each product proposal undergoes a screening process in the Bureau of Research and Development. Here a judgment is made whether or not a product warrants consideration by the Development Council. A product can be rejected without consideration by the Council when obviously its potential use will be minor, it does not appear to fill any particular need, or it is not competitive. An item of very specialized use or for use in only one bureau is referred for study directly to the bureau whose need it fills.

Before each Council meeting, the members receive information on new products to be introduced. Members consider each product from the viewpoint of their respective bureau interests as well as from the viewpoint of the division.

When the Council recommends that a proposal be accepted for immediate adoption, the recommendation is relayed to the chief engineer for approval. The agency responsible for preparing the specification or otherwise initiating use is notified.

When a proposal is rejected, the vendor is informed and given the reasons for rejection. The "Products Evaluation

Circular" provides information on the status of all proposals.

In the event the Council recommends that field installation be made to evaluate the product, the Products Evaluation staff designs the field trials, monitors placement, col-

lects and analyzes the data, and prepares the necessary reports.

The product material and process evaluation system now in use has evoked numerous favorable comments from both Division of Highways engineers and vendors.

PRELIMINARY INFORMATION FOR PRODUCT EVALUATION

Trade name _____ Date _____

Manufacturer _____

Address _____ Patented- No ___ Yes ___ Applied for ___
City State Zip Code

Representative _____

Address _____ Phone No. _____
City State Zip Code Area Call

Product identification _____

Recommended use - Primary _____

Recommended uses - Alternate _____

Outstanding features or advantages claimed _____

Material composition _____

Material specifications furnished by Mfr.?- Yes ___ No ___ Copy attached- Yes ___ No ___
To be mailed _____

Plan drawing, picture, or sketch furnished by Mfr.? Yes ___ No ___
Copy attached- Yes ___ No ___ To be mailed _____

Meets requirements of following specifications: AASHO _____ ASTM _____
Fed. Spec. _____ Others _____

Approved for proposed use by highway authorities or other agencies in the following
states: _____

Are they using it?- Yes ___ No ___ Trial _____

Are instructions or directions for installation, application or use available?- _____
Yes ___ No ___

Copy attached?- Yes ___ No ___ To be mailed _____

Figure B-1. Form for product evaluation.

Will demonstration be provided? _____

Are educational courses or movies available?- Yes ___ No ___

Availability: Seasonal ___ Non-seasonal ___ Delivery at site _____ after receipt of order. Are quantities limited?- Yes ___ No ___

Will free sample be furnished?- Yes ___ No ___ Will laboratory analysis be furnished?- _____
Yes ___ No ___

Approximate cost _____

If proprietary, what are royalty costs and on what basis are they collected? _____

New on market?- Yes ___ No ___ It was in 19___. Alternate for what existing product?- _____

Is product guaranteed?- Yes ___ No ___ Conditions _____

Copy attached _____

Background description of Company and its product _____

Who recommended that the Division of Highways be contacted? _____

Who directed you to the Bureau of Research and Development? _____

Has another office of the Division of Highways been contacted?- Yes ___ No ___ Which?-

Additional information _____

Interview by _____

Title _____

Bureau or District _____

Person furnishing information _____

Title _____

Published reports of the
NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Highway Research Board
 National Academy of Sciences
 2101 Constitution Avenue
 Washington, D.C. 20418

Rep.

No. Title

- * A Critical Review of Literature Treating Methods of Identifying Aggregates Subject to Destructive Volume Change When Frozen in Concrete and a Proposed Program of Research—Intermediate Report (Proj. 4-3(2)), 81 p., \$1.80
- 1 Evaluation of Methods of Replacement of Deteriorated Concrete in Structures (Proj. 6-8), 56 p., \$2.80
- 2 An Introduction to Guidelines for Satellite Studies of Pavement Performance (Proj. 1-1), 19 p., \$1.80
- 2A Guidelines for Satellite Studies of Pavement Performance, 85 p.+9 figs., 26 tables, 4 app., \$3.00
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No. Title

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* Highway Research Board Special Report 80.

<i>Rep. No.</i>	<i>Title</i>		
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