National Cooperative Highway Research Program

NCHRP Synthesis 216

Implementation of Technology From Abroad

A Synthesis of Highway Practice

Transportation Research Board
National Research Council

National Cooperative Highway Research Program

Synthesis of Highway Practice 216

Implementation of Technology From Abroad

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Topic Panel

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation Research Board

This synthesis will be of interest to pavement design, materials and testing, traffic, and research engineers and transportation planners. It will also be of interest to chief administrative officers and chief engineers of transportation agencies. This report describes the current implementation by transportation agencies in the United States of technologies that were developed abroad. This report presents several case studies, including mechanically stabilized embankment (MSE) technology, asphalt pavement materials and testing equipment, a tunneling method, moveable barriers, an accelerated loading facility, and a bicycle and pedestrian planning process.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

This report of the Transportation Research Board provides information on the formal and informal processes that have been made by U.S. agencies to employ technologies and methodologies from abroad, including descriptions of both successes and failures and the reasons for implementation problems. Each is described in terms of the identification, introduction, and implementation of the technology. The technologies that are described originated in France, Germany, Austria, Finland, and Australia. Recommendations for future research and the need for management support are included.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the researcher in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

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Information on current practice was provided by many highway and transportation agencies. Their cooperation and assistance were most helpful.

IMPLEMENTATION OF TECHNOLOGY FROM ABROAD

SUMMARY

This synthesis presents current practice related to the employment of foreign transportation technologies and methods in the United States. Nine case studies of implemented technologies illustrate the variety of situations that have made for their success. Results from surveys of the transportation community show the effectiveness of the foreign technology transfer process in three stages: identification, introduction, and implementation.

Since the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the exploration of foreign technologies has grown, manifested by greater support for foreign travel accomplished through study tours, involvement with committees of international organizations, and individual staff exchanges. The participation of high-level industry and state DOT executives in overseas tours brought attention to the advantages of rethinking pavement designs for longer life and lower maintenance costs, as well as making clear the value of foreign tours. The International Technology Scanning Program of the Federal Highway Administration (FHWA) has been increasingly active in this regard.

The case studies presented in this synthesis, which vary in country of origin, type of technology, and nature of the transfer process, were selected to illustrate the diverse ways in which foreign technologies have been introduced into the transportation systems of the United States, and what obstacles had to be overcome in many situations before these innovations could be brought to practice. The studies include both hard- and soft-side technologies, some from private sources, others from public.

The processes for technology transfer are essential stages in implementing foreign technologies and methods. Identification is the first step of this process and is the awareness of a technology by a potential user. A variety of methods are involved in this process and, as the survey results make clear, publications and domestic conferences continue to be the principal resources for information on foreign technology at the technical staff level in public agencies. Group tour respondents ranked travel and tours as effective techniques because they afford the opportunity for firsthand exposure to technologies and methods.

The step of introducing foreign technologies to the United States requires providing potential users with the supporting materials and knowhow needed for making informed implementation decisions. According to survey respondents, the appropriate means can vary according to the technology being introduced. For soft-side applications, seminars and conferences may be adequate, while for hard-side technologies, demonstrations of successful applications are usually necessary, and must often be supplemented by specification and equipment modifications adapted to U.S. and local conditions.

Several U.S. Department of Transportation (USDOT) programs bring foreign technology to the attention of state and local public agencies, and the National Cooperative Highway Research Program (NCHRP) and the Strategic Highway Research Program (SHRP) also have successfully introduced foreign technologies. The Highway Innovation Technology Evaluation Center (HITEC) was set up in 1993 by the private sector (with FHWA start-up funding) specifically to ease the introduction of new highway technology.

Implementing foreign technologies raises issues that many transportation agencies may not yet have faced. Over 20 percent of the state transportation agencies did not respond to

the surveys and approximately one-quarter of state responses reported no foreign technology implementation. Nonetheless, more than 60 examples of implementation were described. About one-half of the examples were pavement related, with stone matrix asphalt (SMA) applications most often mentioned. Other innovations ranged from planning to maintenance activities. Survey recipients noted that demonstrations were the most important approach for setting up the implementation stage.

Successful implementation cases overcame essentially the same kinds of obstacles that blocked implementation in other instances. Such obstacles include language and cultural differences, compatibility of standards and materials, and trade barriers; but heading the list (besides inadequate technical performance) were concerns about the impact of innovations on the status quo. The literature provides evidence of implementation difficulties affecting any innovation, foreign or domestic.

Management support and (necessarily) superior performance of the process or product were most often mentioned with regard to explaining successful implementation. More latitude in procurement practices, permitting life-cycle costing or sole source acquisition, for example, would help to ease implementation. Other issues were the need for adequate demonstrations showing product acceptability, and the adequacy of technical and service support from suppliers and manufacturers. Institutional inertia and resistance to change were also frequently listed as challenges to overcome. A checklist of questions relevant to implementation decisions has been provided.

Many of these issues are being addressed by private sector organizations including the Civil Engineering Research Foundation (CERF) and HITEC, as well as by provisions in national legislation requiring federal action. Yet, if recent initiatives such as NCHRP Project 20-33, "Facilitating The Implementation Of Research Findings" are any indication, more work must still be done to ease the implementation of new technologies.

CHAPTER ONE

INTRODUCTION

The beginning of the 1990s brought a significant change to many aspects of surface transportation technology within the United States. Transportation professionals became increasingly aware of the improved materials and innovative methods employed by foreign countries in their transportation programs. This awareness, which had been growing slowly, accelerated with the activities of the Strategic Highway Research Program (SHRP) in the late 1980s, and was boosted by enactment of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which contained several mandates involving foreign technologies.

Increased awareness of foreign technology led to increased assessment of its potential contributions, and many leaders in all parts of the U.S. surface transportation industry began to conclude that U.S. transportation could benefit from selective importation and implementation of innovative foreign technologies. Among the technologies suggested were such diverse subjects as modified contracting procedures for construction projects, new highway paving techniques, and equipment for high-speed rail corridors.

Some transportation agencies have already accumulated experience in importing foreign innovations, while others are still considering the pros and cons associated with beginning such activities. The purpose of this synthesis is to provide information on the experience of U.S. agencies in importing and employing technologies from abroad.

BACKGROUND

The need to stimulate the use of new methods and technologies in highway activities was highlighted during the 1980s in *Special Report 202: America's Highways: Accelerating the Search for Innovation* (*1*). This report led to the establishment of SHRP, which was one of the first highway programs to formally recognize the values of learning about practices in foreign countries. To facilitate international information exchange, SHRP established an ongoing arrangement for loan staff from foreign highway agencies to work with SHRP management throughout the 5-year program.

Previously, most international information exchange in transportation had occurred through the media of conferences, publications, and individual travel; these approaches, however, could not ensure that all appropriate foreign transportation technologies and methods (FTTM) were recognized and subsequently put to use.

Greater impetus to explore what foreign technology had to offer U.S. transportation systems resulted from ISTEA. Section 6003 of the Act authorized the Secretary of the U.S. Department of Transportation (USDOT) "to engage in activities to inform the domestic highway community of technological innovations abroad . . . . Such activities may include . . . development, monitoring, assessment, and dissemination domestically of information about foreign highway transportation innovations that could significantly improve highway transportation in the United States . . . " (*2*). At the same time, Section 6005 established an Applied Research and Technology Program whose overall purpose is "to facilitate the identification and development of both foreign and domestic technologies, and facilitate the development of new methods for accelerating testing and evaluation of those technologies" (*3*).

Funding levels for these USDOT activities have supported extensive federal efforts in evaluating the potential for U.S. implementation of FTTM, among them the FHWA International Technology Scanning Program. Because of ISTEA, increased funds are also available to other research and development programs, such as those of the state transportation agencies.

The result has been that the identification, introduction, and implementation of foreign transportation technology in the United States is receiving greater attention.

PROBLEM SCOPE

As a body of U.S. experience exists already with the problems of identifying, introducing, and implementing FTTM, this synthesis provides information on the formal and informal processes that have been used by U.S. agencies to employ technologies and methodologies from abroad, with descriptions of both successes and failures. It also seeks to identify subtleties associated with institutional and cultural factors that affect implementation.

This synthesis focuses on experience from the highway and public transportation modes, within which its range extends from administration and planning, through design and construction, to operations and maintenance. It excludes, however, intelligent transportation systems (ITS), although some processes and problems associated with implementing these technologies are briefly addressed.

PROJECT PROCEDURES

Study procedures have primarily included the elements of literature review, surveys, and case studies. Conclusions and recommendations are based on a drawing together of the findings from work in these three areas.

Literature Review

The review of literature helped to define the context in which the implementation of FTTM takes place. Furthermore, the review helped to identify prospective survey recipients and to sharpen the focus of survey instruments. It also aided in the identification of case study prospects.

Surveys

Surveys were useful in assembling the firsthand experiences of the transportation community. Targeted groups included participants in selected international study tours, the designated liaison representatives to the Transportation Research Board (TRB) from state departments of transportation and local transit agencies, and a third group of individuals from a variety of backgrounds who were likely to be involved with FTTM. Appendix A provides a more detailed description of the groups, as well as copies of the survey forms.

Table 1 shows the number of survey forms sent to each group and the number returned. In the group tour list, a 32 percent response rate came from participants representing all relevant employment origins (federal, state, and local transportation agencies; private industry; and associations). Higher rates of return came from the state and transit representatives, while the third, mixed group also had a 32 percent response rate. Overall, the survey recorded a 39 percent rate of return.

Case Studies

A selection of case studies was made to illustrate the diverse ways in which foreign technologies have been introduced into the transportation systems of the United States. Three means were used to identify the examples: personal inquiries and interviews with knowledgeable professionals, the literature review, and replies from the survey returns. The choices for presentation include examples of public and private sector implementation of both proprietary and nonproprietary processes, drawn from the fields of pavement design and construction, traffic operations and planning, and transit activities.

Finally, a list of acronyms is included in Appendix B, and a list of organizations and conferences related to transportation technology is provided in Appendix C.

TABLE 1

SURVEY DISTRIBUTION AND RETURN RATE

Survey Group	Number Sent	Number Returned	Percent
Group Tour Participants	75	24	32
TRB Liaison Representatives			
State	53	38	72
Transit	35	14	40
Subtotal	88	52	59
Others	174	55	32
Total	337	131	39

CHAPTER TWO

CASE STUDIES

OVERVIEW

The nine case studies of foreign technologies presented here differ in countries of origin, types of technology, and the nature of the technology transfer process. Some are from private sources, some from public; some are privately implemented, and others are put to use by public agencies. The examples include hard-side and soft-side technologies.

Most of these technologies come from Europe. Stone matrix asphalt (SMA) pavements originated in Germany and spread through Europe before arriving in the United States. The examples of mechanically stabilized embankment (MSE) technology, NOVACHIP, and some of the test equipment for hot mix asphalt (HMA), came from France. Other HMA test equipment, and the highway capacity analysis method, came from Germany. Two other imported technologies include the New Austrian Tunneling Method (NATM) and the Finnish bicycle and pedestrian planning process. Both the Accelerated Loading Facility (ALF) and the Quickchange Moveable Barrier (QMB) originated in Australia.

The ways in which these technologies were identified by U.S. agencies varied equally. Pavement related technologies were discovered through group tours and conferences. Sources in other cases included a publication from the Organization for Economic Cooperation and Development (OECD) and a trade show. Staff exchanges between the Minnesota Department of Transportation (MnDOT) and the Finnish National Road Administration were yet another mechanism. The first demonstration project of the NATM in the United States took place after a long history of its publication in foreign journals.

Technologies are introduced into the United States by various means. FHWA acquired plans and documentation for the patented equipment of the Australian ALF, funded the purchase of the asphalt test equipment, and initiated the first SMA demonstrations and open houses. NOVACHIP came to the United States when its French owners arranged with U.S. contractors to demonstrate the technological process with equipment and crews brought over from France. The Reinforced Earth Company was set up in the United States to market its MSE products. A private company obtained the Australian QMB through a license agreement and modified it for U.S. application. Germany's highway capacity analysis method was introduced through a research project established to update the Highway Capacity Manual.

Different implementation methods were used for these foreign transportation technologies and methods (FTTM). In the simplest case, the unsignalized intersection capacity procedure was adopted by TRB's Committee on Highway Capacity and Quality of Service and published for use. MnDOT, supported by Finnish exchange staff and consultants, worked cooperatively with a local community to implement the pedestrian and bicycle plans. The moveable barrier system and ALF were constructed in the United States for private sector sales and FHWA research, respectively. The French and German types of asphalt test equipment were purchased and put to regular use in the Colorado Department of Transportation's (CDOT) and Turner-Fairbank Highway Research Center's (TFHRC) material laboratories. NOVACHIP has had applications in several states, paid for by local county construction dollars in one case and by state research or other funds elsewhere. The Reinforced Earth Company's products have been installed through construction contracts in more than 5,000 projects nationwide. The NATM was implemented in Pittsburgh under federal sponsorship, and later in Washington, D.C., through value engineering change proposals (VECPs) submitted by a foreign contractor.

Obstacles had to be overcome in most situations, however, before these foreign technologies could be implemented. The case studies that follow describe these and other characteristics in more detail.

CASE STUDIES

Stone Matrix Asphalt

Product/Process Description

Stone matrix asphalt (SMA) is the term now in use to describe a new formulation or design for asphalt pavements. SMA is described as a gap-graded asphalt mixture containing increased coarse aggregate, mineral filler, and asphalt cement to offset decreased quantities of fine sand. The gap grading is designed to provide a stone-to-stone contact, or skeleton structure, that will not change after initial compaction, thereby producing better resistance to rutting under heavy wheel loads. A stabilizer, either cellulose or mineral fiber, is added to the mix in production to ensure that the asphalt coating on the aggregate is retained during the construction stage. Construction itself presents no special problems; SMA is considered easier to work with than other mixes. The requirement of high quality aggregate (a cubic form is desirable), increased asphalt content, and the addition of the fiber stabilizers typically results in higher costs per ton of SMA than for customary U.S. mixes.

Identification

First developed in the 1960s by paving contractors in Germany, the use of SMA spread to Scandinavia and then to other parts of Europe in subsequent decades. By 1990, usage in Germany was estimated to be nearly 1 million tons (907,000 Mg) per year, and in Sweden, approximately 300,000 tons (272,100 Mg) per year.

The innovative mix design came to the attention of U.S. pavement specialists as a result of the 1990 European Asphalt

Study Tour, a 2-week, six country tour of asphalt pavement related activities in Europe. A team made up of representatives from the American Association of State Highway Officials (AASHTO), FHWA, TRB, SHRP, and the National Asphalt Paving Association (NAPA) observed SMA construction in Germany and Sweden and SMA pavements under traffic in Denmark. Reporting their findings upon return, the team found that "the special-purpose mixture with the greatest promise for use in the United States is SMA" (*4*).

Introduction

At the tour's conclusion, SMA was one of the candidates chosen for initial attention. The Office of Technology Application in FHWA was given the lead to develop a work plan for field tests; follow-up and refine tour information, studies, and evaluations; and establish an advisory committee. In addition to the study tour report, further information on SMA appeared quickly in trade journals and other publications. Joint FHWA-state sponsored Open Houses were arranged to share the SMA technology more widely (see Figure 1). They included exhibits, demonstrations by FHWA mobile laboratories, and observations of SMA production and paving (*5*).

The initial placements of SMA occurred in the summer of 1991 in Georgia, Indiana, Michigan, Missouri, and Wisconsin, usually supported by research and development funding. The advisory committee, now called the Technical Working Group, was formed with members from industry and industry associations, from the National Center for Asphalt Technology, and from FHWA and state DOTs. The group has met two to three times per year to review progress, to extend the outreach of the SMA projects, and to develop guidelines for broader use.

Implementation

From a start in 1991 with five demonstration projects totaling less than 50,000 tons (45,350 Mg) of material placed, the volume of SMA production grew by 1993 to over 500,000 tons (453,500 Mg) in 20 states. SMA projects are now funded with normal construction funds, although some projects may still be classed as experimental. The first five projects are still performing well. In a report to the 1993 TRB Annual Meeting, staff from the Georgia DOT stated that, "The SMA technology

FIGURE 1 FHWA Open House demonstration of stone matrix asphalt (SMA).

may be the best European import we have had in many years" (*6*).

Special Characteristics

The overwhelming acceptance of SMA pavement mixes is a testimonial to the values that can be obtained by awareness of foreign technologies. Several factors probably contributed to the rapidity with which SMA technology was adopted in the United States. First was its identification on the 1990 Study Tour. Second may have been the fact that tour participants were industry and DOT leaders who could push for early action to introduce SMA. Third was the effective leadership of the FHWA Office of Technology Application that, in less than 1 year after the tour, set demonstration projects in place.

Other factors contributing to the broad acceptance are that no large equipment investments or special training are required to start up SMA production and paving operations.

Despite the widespread applications of SMA to date, some technical issues still remain to be addressed and solved. Several research projects have been initiated covering the areas of material selection, mix design, construction methods, and performance prediction.

European Testing Equipment for Hot Mix Asphalt Pavements

Product/Process Description

Several types of laboratory equipment used in Europe for evaluating and designing hot mix asphalt (HMA) pavement materials differ from those commonly used in the United States. Among them are four items developed and used by France's Laboratoire Central des Ponts et Chaussées (LCPC): a mixer, plate compactor, rutting tester, and gyratory compactor. In Germany, a wheel tracking device has been developed for use in evaluating the rutting of pavements.

European tests employing this equipment to forecast the performance of HMA mixtures are considerably more expensive than U.S. test procedures, due to higher equipment costs and the need for physically larger samples and longer testing times. However, there is reason to believe "that the ability of these tools to accurately forecast the performance of a pavement greatly exceeds that of the traditional testing equipment used by many state highway agencies . . . ." (*7*).

Identification

Awareness of the French equipment came about during the 1990 European Asphalt Study Tour. The tour group, which included the Deputy Director of the Colorado Department of Highways (now CDOT), visited LCPC facilities in France, observing the use of equipment and processes for pavement mix design. The trip report discusses the group's findings under "Novel Trip Apparatus" (*4*, p. 101).

Introduction

Following the 1990 tour, participants met to consider technologies on which to focus, and to develop plans for application of their findings. In the area of laboratory equipment, they selected mix design equipment and devices for laboratory compaction and rut testing. FHWA's Turner-Fairbank Highway Research Center (TFHRC) and CDOT were designated to acquire and demonstrate the equipment.

Two sets of the chosen equipment were purchased from the French manufacturer MAP through a Canadian distributor using FHWA research funds (see Figures 2 and 3). The wheel tracking device came from the German supplier, Helmut Wind Machines and Apparatus.

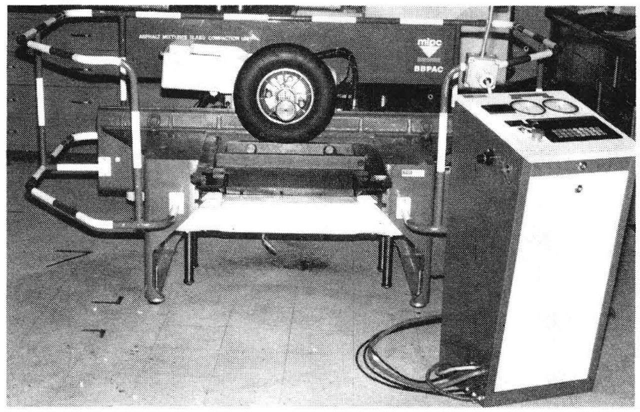

FIGURE 2 French compactor at TFHRC.

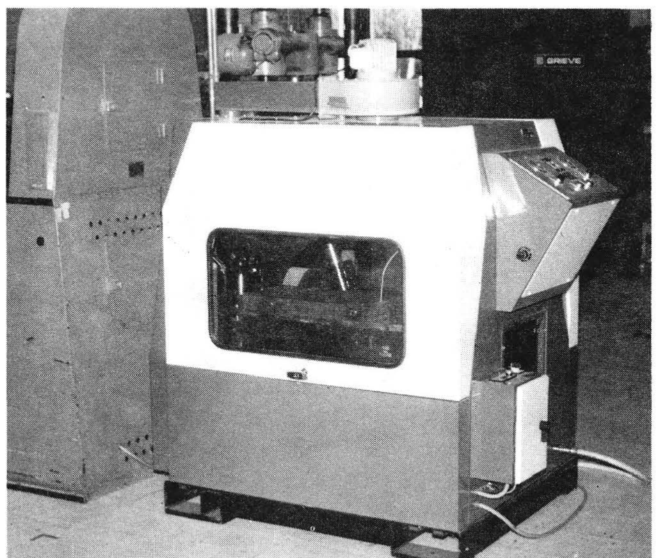

FIGURE 3 French rut tester at TFHRC.

NCHRP Project 20–7, Task 49, "Follow-up on U.S. Asphalt Study Tour of Europe" funded a visit by a CDOT staff engineer to receive training on the LCPC equipment designated for purchase by CDOT and FHWA as a result of the 1990 Asphalt Tour. The engineer also visited a laboratory in Germany to receive training on the Hamburg wheel tracking device.

Implementation

Since its acquisition by CDOT, the laboratory equipment has been employed in demonstration projects to show its

FIGURE 4 NOVACHIP paving equipment.

applicability under U.S. conditions. Demonstration objectives included the following:

- Develop a facility at CDOT to match the facility at TFHRC with the performance related testing equipment.
- Evaluate and define mix design properties that contribute to rutting, stripping, and fatigue characteristics of asphalt concrete pavements.
- Develop field projects and accelerated evaluations for validation of mix design.
- Use the European system to evaluate mix design concepts as developed by other states, SHRP, NCHRP, etc.
- Utilize quality experimental techniques (e.g., database decision making, statistical validations) to determine field validation, laboratory variability, and mix properties improvements.
- Correlate and evaluate mixture design programs as developed by NCHRP and SHRP as they relate to the European system incorporating user/producer participation in the development of the European system.

Several reports have been published. Of particular interest is "I-70, Silverthorne to Copper Mountain: A Case History of the Use of European Testing Equipment," which describes how pavement mix design was modified in the middle of a major project to overcome initial raveling problems (*8*). The effect of the modified mix design, though leading to an increase of $80,000 in project costs as the cost per ton increased from $24 to $25, could lead to a 10-year extension of pavement life and substantial savings.

Work at TFHRC is incorporating the equipment into research projects and evaluating the technologies for their value as research tools. For example, the French Rut Tester has been used in parallel with the Georgia Loaded Wheel Tester, the Gyratory Testing Machine, and triaxial tests to measure the susceptibility of SMA mixtures to rutting. The French Rut Tester has also been part of the test equipment used in research on the relationship of sand characteristics to the rutting susceptibilities of asphalt mixtures. The German wheel tracking device has been used primarily in measuring resistance to moisture damage. The joint venture between FHWA and CDOT is continuing.

Special Characteristics

FHWA's purchase of the European equipment was a direct result of the 1990 European Asphalt Study Tour. While use of the European technology has already been shown to be cost effective, the joint demonstration with TFHRC is still ongoing and under evaluation. One potential result of the project would be the development of design criteria for pavement performance.

NOVACHIP

Product/Process Description

NOVACHIP is a proprietary asphalt paving process developed in France for use on all highway types as an alternative to chipseals, microsurfacing, plant-mix seals, or thin overlays. Hot mix materials with coarse aggregate ranging in size between 0.375 and 0.75 in. (0.95 and 1.91 cm) are laid over a heavy tack coat to restore skid resistance and surface impermeability. The pavement material is laid at high speed in one pass by a specially designed machine that completes all three operations: spreading the tack coat, applying the hot mix asphalt, and smoothing the course (see Figure 4). Rolling is accomplished by a rubber-tired roller and a steel wheel roller acting in tandem.

The process and equipment are patented by SCREG Routes, and marketed through a subsidiary, Societe Internationale Routiere (SIR). Over 4 million m^2 (4.78 million yd^2) have been laid in France, Belgium, and Sweden to date.

Identification

NOVACHIP came to the attention of U.S. engineers during the 1990 European Asphalt Study Tour. Participants inspected a site using this treatment near La Baule, France. Regarding its applicability to U.S. practice, the visit report noted, "May provide alternative maintenance treatment for high-volume interstate and primary routes. Some similarity to chip seals applied with modified asphalt binders in Texas and New Mexico."

Introduction

In 1992, SCREG Routes advertised in U.S. trade magazines for paving contractor partners so that NOVACHIP could be brought into the U.S. market. The company offered to supply equipment and a five-person operating crew for demonstrations if a minimum of 50,000 yd^2 (41,800 m^2) of work could be arranged. A multicolored brochure package, describing the process and including specifications, is available in English.

One contractor in New York, Midland Asphalt Company of Tonawanda, became involved. During the same period, the New York State DOT was introduced to the process by FHWA's Office of Technology Applications. A representative of SCREG Routes visited the DOT and made what was described as a high-quality presentation. Though this did not lead to a project with the DOT, projects were eventually set up with the Departments of Public Works in Wyoming and Niagara Counties of New York, using county highway funds.

Meanwhile, other demonstrations were being arranged in Alabama, Mississippi, and Texas. Staff of the Texas DOT described the introduction of NOVACHIP as a direct result of the Asphalt Tour, in which the Department's Chief Engineer-Director participated. Encouragement from FHWA led to a 100 percent federally funded research study. Presumably, similar arrangements were occurring simultaneously in Alabama and Mississippi, whose chief engineers were also on the Asphalt Tour.

Implementation

The French contractor paved the first test sections in Alabama, Mississippi, and Texas in October 1992. Alabama had one project near Alexander City and a second project, 3 miles long, was placed near Talladega in November. The Mississippi project surface treated 52,580 yd^2 (44,000 m^2) of State Route 12 in Choctaw County. The Texas Transportation Institute is providing 6-month evaluations of the Texas site near New Braunfels, and Auburn University's National Center for Asphalt Technology (NCAT) is evaluating the Alabama projects.

The New York projects were implemented in September 1993 and are being evaluated by the New York State DOT.

Special Characteristics

Informal comments on the demonstration projects from state DOT staffs noted several difficulties, including the following. One comment described the process as "fairly expensive due to the proprietary nature . . . (about three-quarters the cost of 1 in. hot mix);" another was that "while a proprietary process demonstration could be sole-sourced, it would be awfully hard to sole-source a replacement." Other noted difficulties were: "No stateside track record for process" and "Equipment not readily available." At the same time, one positive comment pointed out that representatives from SCREG Routes were willing to travel to meet with highway officials and introduce the concept.

A report from Alabama DOT to the AASHTO Subcommittee on Materials entitled "NOVACHIP—A Cost-Effective Pavement Treatment" (*9*), suggested that the NCAT evaluation is positive concerning construction aspects of the process. On the other hand, a preliminary report from Mississippi, where the process was used as a substitute surface treatment, concluded that "NOVACHIP does not appear to be economically viable compared to the other alternatives available for rehabilitation and routine maintenance operations" (*10*). Because of its recent implementation in the United States, little has been published on NOVACHIP to date. A marketing brochure can be obtained from: Executive Manager, SCREG Routes Group, 1, ave. Eugene Freyssinet, Guyancourt, 78065 St. Quentin-en-Yvelines, France.

Accelerated Loading Facility

Product/Process Description

The Accelerated Loading Facility (ALF) is a mobile, full-scale pavement testing machine used to evaluate pavement performance under heavy wheel loadings, simulating long-term real traffic conditions by providing repeated cycles of wheel loading over a short time period. Its 100-ft long structural frame (see Figure 5) houses a wheel assembly that travels at approximately 11 mph (18 kmph), in contact with the test pavement over a distance of 38 to 45 ft (12 to 14 m). Loads are applied in one direction and tracking can be shifted laterally to simulate actual or selected wear distribution patterns in the traffic lane. The ALF can apply single or dual tire loads ranging from 8,000 to 22,500 lb (3,632 to 10,215 kg) at up to 8,500 applications per day. It incorporates a computer-controlled data acquisition system to monitor environmental, pavement performance, and pavement response data.

A complete description of the machine is given in "Manufacture of Accelerated Loading Facility (ALF)" (*11*), and also in *Transportation Research Record 1060: Pavement Management, Rehabilitation, and Weigh-In-Motion* (*12*).

Identification

Accelerated pavement testing methods were being proposed in the United States as long ago as the 1920s and have been carried out in some forms since then. Mechanical means for conducting them had been developed and used in other countries. An international Pavement Testing Conference, held in March 1984 at TFHRC in McLean, Virginia, produced recommendations that mechanical testing (defined as the accelerated application of simulated wheel loadings) should be incorporated as part of a proposed national pavement testing program.

Development of the technology or the acquisition of existing foreign equipment was necessary to proceed. Two operational devices were then in existence: the Australian ALF and the South African Heavy Vehicle Simulator. The decision was made to acquire the Australian machine, and negotiations between FHWA and the Department of Main Roads of New South Wales led to an agreement in September 1984.

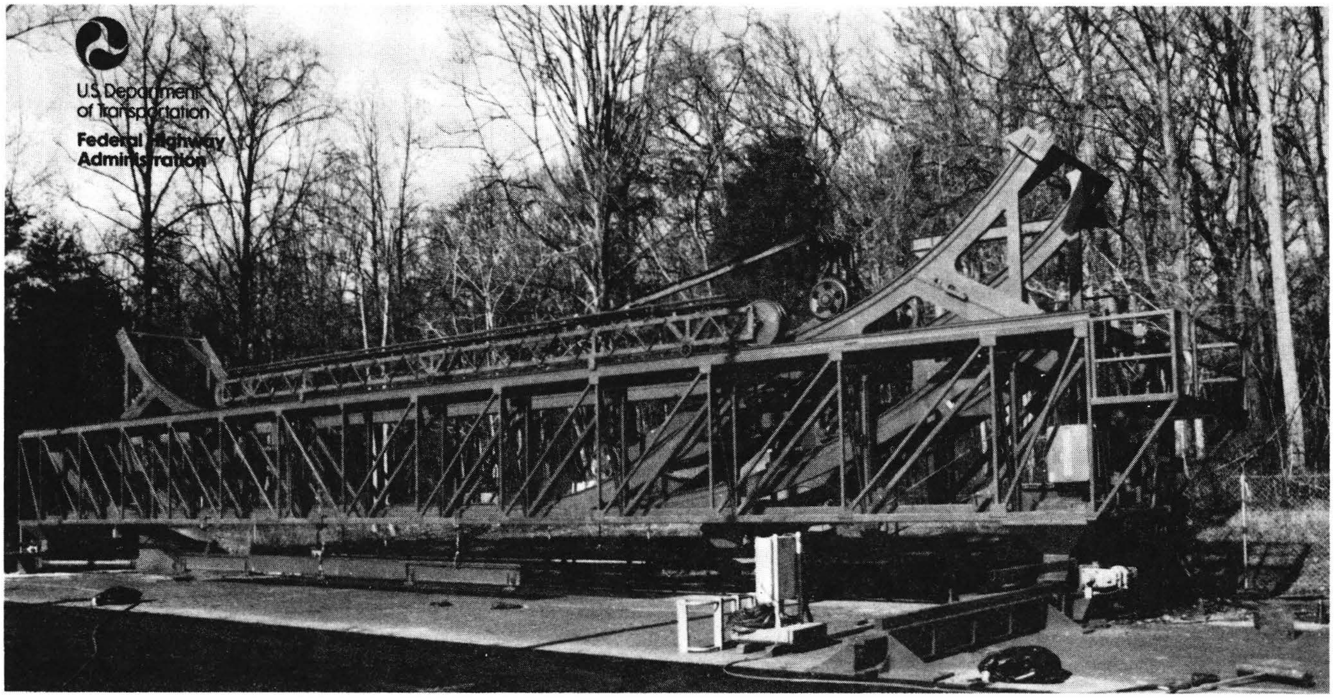

FIGURE 5 Accelerated Loading Facility (ALF) at TFHRC.

Introduction

The 1984 sole source contract called for the Australian agency to provide plans and specifications, technical assistance during fabrication and initial operation, and authorization to construct one ALF in the United States for FHWA (*13*). Once plans were provided, the normal competitive procurement process was used to employ a contractor to modify the plans and build the facility. Necessary changes included conversion from metric to English units and provision of a control system using U.S. components.

Implementation

After the ALF was delivered, the Australian agency entered into an exclusive license agreement allowing FHWA's supplier to produce ALFs in the United States and Canada, with royalties to be paid for all subsequent units constructed. While the ALF was being manufactured, a pavement testing facility site was prepared at TFHRC. After its delivery in August 1986, the ALF operated almost continuously until early 1989. The equipment was then transported to Montana and Wyoming and to the Waterways Experiment Station in Vicksburg, Mississippi for field testing and demonstrations. The ALF was returned to TFHRC in December 1989 for continued research.

In 1992, the ALF was removed to facilitate reconstruction of the Pavement Testing Facility. As that work proceeded, the ALF was refurbished, a new lifting mechanism was installed, and a heating system was added to facilitate shorter testing periods. FHWA also began the procurement process for a second ALF.

Special Characteristics

Procuring the ALF was a government-to-government transaction that involved obtaining U.S. rights to build it because the owners held U.S. patents on the equipment. Added cost elements at that time came from the need to convert plans from metric to English units and to provide the control system. The fabricator (Engineering Incorporated of Hampton, Virginia) holds exclusive rights to build ALFs in the United States and is obligated to pay royalties and report all design modifications to the owners in Australia. Thus, the purchase of a second ALF was done through a negotiated sole source contract.

Quickchange Moveable Barrier

Process/Product Description

The Quickchange Moveable Barrier (QMB) is a two-part system consisting of (1) safety-shaped concrete barrier segments that are linked to form a continuous wall, and (2) a transfer vehicle that lifts and moves the linked wall segments laterally. The conveyor operates on the roadway at speeds up to 5 mph (8 kmph) with a two-person crew, and can shift one mile of barrier in less than 20 minutes. The system can serve as a moveable median barrier for permanent lane reversal or HOV applications, and as a traffic control and worker protection device for work zones on highway construction sites (see Figure 6).

Identification

In 1981, the Australian Government contracted with Quicksteel Pty., Ltd. to design and furnish a curb-height median to control traffic on the Sydney Harbor Bridge. The patented system was seen at an Australian trade show by the president of Barrier Systems Incorporated (BSI), an American company. Initial contacts in 1982 led to a licensing agreement between the Australian manufacturer and BSI. Over the next 2 years, the redesign of the curb into a safety-shaped barrier was

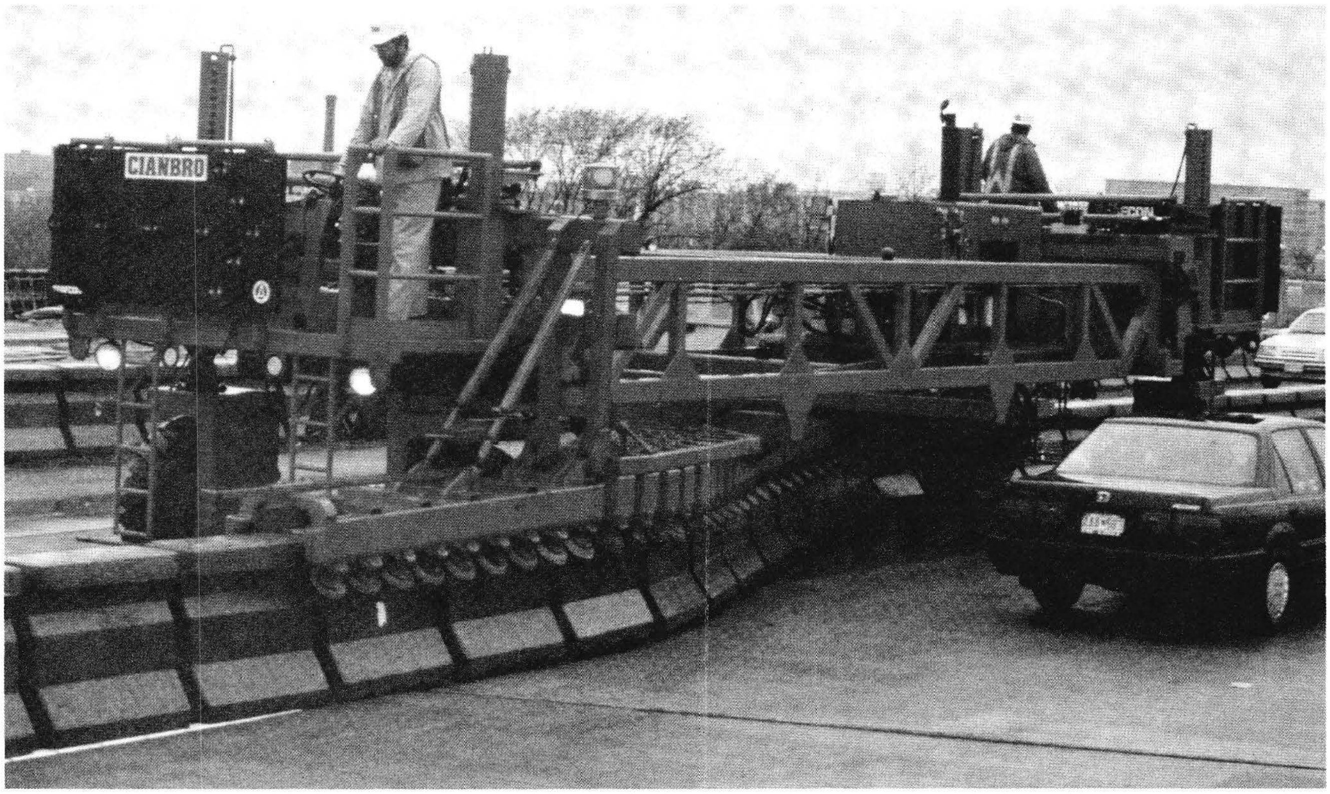

FIGURE 6 Quickchange Moveable Barrier (QMB) System.

conducted jointly by BSI and the Australian manufacturer. Based on consultations with various U.S. state and federal agencies, the new barrier was designed to meet U.S. standards, and the first tests of the transfer vehicle and crash testing of the modified barriers were done in Australia.

Introduction

The initial designs were used in 1985 to build the first U.S. prototype. Crash testing of the prototype at the California Department of Transportation (Caltrans) led to further modifications. By 1986, BSI had built its own test track and run crash tests, including a consultant-managed test series to prove out the final design. After submitting the test findings to FHWA, BSI received approval of the barrier as an experimental feature. Sales efforts then began, formal testing at the Caltrans test track was completed, and in 1987, the first orders for the QMB system were received. BSI now held patents of its own on the design modifications for the QMB, whose research and development expenditures had well exceeded $1 million.

Implementation

The barrier system and transporter can now be either purchased or leased from BSI. By late 1993, more than 70 mi (113 km) of the barrier system were operating in 20 applications across the United States. Seventeen states, Montreal in Canada, and Auckland, New Zealand have used the system. The QMB was cited in 1992 by *Construction Equipment* magazine as one of the 100 most significant new products for highway construction and related industries.

Special Characteristics

The QMB was modified from an original Australian design, and is privately developed and marketed under a licensing agreement. An investment of over $1 million and 5 years in development time were necessary before the first sales occurred. According to a BSI representative, "The chronological history in no way describes the time and effort that goes in, getting from one step to the next. You have to be part 'Riverboat Gambler' and part 'Inmate-at-Bedlam' to put together a project like this" (personal communication, Jon Frank, Vice President, Sales and Director, BSI).

New Austrian Tunneling Method

Product/Process Description

The New Austrian Tunneling Method (NATM) provides an approach to tunneling that results in a technically sound, safe, and economical design for each condition that may occur on a tunnel construction project. Considering the geologic formations surrounding an excavation as both load and load-supporting structures, NATM design and construction typically involves two lining operations: (1) an initial lining using shotcrete, rock bolts, and supplementary components installed shortly after excavation; and (2) an inner lining that increases the safety factor, with waterproofing and a smooth interior surface. Contract documents contain provisions that "involve specifications of construction and support sequences that simplify adaptation of tunneling to changing geological conditions at the site. For purposes of payment . . . it is normal to classify the ground conditions based on anticipated behavior during construction" (*14*).

Identification

Hardly a new method, NATM principles were applied in Europe before World War II. With the advent of shotcrete and new anchoring techniques, NATM became widely used in Europe, Asia, and South America. It has been described frequently in the literature, with many references in the Transportation Research Information Services (TRIS) database. Thus, information on the method has been available to U.S. civil engineers for many years.

Introduction

In 1978–1979, design for the Mount Lebanon Tunnels on Pittsburgh's Light Rail Transit System was underway, when a proposal was drawn up and submitted by the Port Authority of Allegheny County for an alternative design using NATM. Following approval by the USDOT Urban Mass Transportation Administration (UMTA), authorization to proceed with design was given to Law Engineering Testing Company (LETCO) in association with Geoconsult of Salzburg, Austria. In 1983, the NATM option was chosen over the conventional concrete tunnel option by the low bidder and construction of the tunnels began. The project report noted, "The Mount Lebanon Tunnels Demonstration Project using New Austrian Tunneling Method principles was made possible by the U.S. Department of Transportation Urban Mass Transportation Administration's (UMTA) commitment to demonstrating the cost effectiveness of innovative domestic and foreign design and construction technologies" (*14*).

Implementation

The general engineering consulting firm, Parsons Brinckerhoff Gibbs & Hill, Inc., which had served as the base bid designer and coordinator of the design activities, was also construction manager for the project, with LETCO/Geoconsult providing on-site engineering support. The report on the project, published in 1986, "provides evidence that NATM is a tunneling philosophy which produces technically sound, cost competitive designs capable of being bid and constructed within the framework of existing American contracting practice" (*14*).

Since the initial use in Pittsburgh, NATM has been used by the Washington Metropolitan Area Transit Authority (WMATA) in Washington's Metro tunnel construction, being introduced there by value engineering change proposals (VECPs) submitted by foreign contractors. NATM was subsequently permitted as a bid alternative and, in the case of the last rock tunnel for WMATA's Red Line, was the only design in the bid documents.

On the West Coast, the Los Angeles County Metropolitan Transportation Authority considered NATM for station construction as an alternative to cut-and-cover construction, but rejected it when cost estimates showed it to be more expensive.

In a 1994 report to the TRB Committee on Tunnels and Underground Structures, the NATM Subcommittee stated: "Its technical feasibility and reliability firmly established, NATM is now more likely to be evaluated against other tunneling options on a more equitable basis than in the past" (*15*).

Special Characteristics

The NATM concept and reports of its practice had been available for many years, but it was not implemented in the United States until a federally supported demonstration took place. Some years later, the second application came about when VECPs introduced it in Washington, D.C. transit construction. Fifteen years have elapsed since the introduction of the method and the endorsement of TRB's Subcommittee on NATM.

Unsignalized Intersection Capacity

Product/Process Description

TRB *Special Report 209: Highway Capacity Manual—1985* (*16*), is a compilation of procedures for analyzing the capacity of different highway types and operations. Chapter 10, "Unsignalized Intersections," deals with the capacity of intersections controlled with two-way or all-way stop signing. The procedure for two-way stop or yield-controlled locations "is based on evaluating the number of gaps in a major traffic stream available to vehicles crossing or turning through that stream" (*17*, p. 6). Among its other applications, the method is used by local agencies in the review and approval process for new land developments.

Identification

Beginning in 1977, a series of NCHRP projects carried out research directed toward revising the 1965 edition of the Highway Capacity Manual (HCM). The resulting 1985 HCM best describes the identification and selection of several procedures for unsignalized intersection analysis.

> Procedures for the capacity analysis of two-way stop and yield-controlled intersections are based on a German method originally published in 1972 and translated in a 1974 publication of the Organization for Economic Cooperation and Development (OECD). The method has been modified based on a few validation studies in the United States, conducted by the Unsignalized Intersections Subcommittee of the Highway Capacity and Quality of Service Committee of the Transportation Research Board (*16*).

Introduction

The German procedure was first published in the United States in *Transportation Research Circular 212: Interim Materials on Highway Capacity* (*18*), together with analysis procedures for other conditions. The objective of the Circular was to invite comments and encourage research that would validate or improve the proposed methods, which were being considered by the TRB Committee for inclusion in the next HCM. After slight adjustments based on additional research, the German technique was incorporated into Chapter 10 of the new manual.

Implementation

Since 1985, more than 11,000 copies of the HCM have been distributed. Like other parts of the manual, Chapter 10 has been used in the field and has been the subject of ongoing research and discussion. Workshops around the United States have obtained feedback on the procedure. In 1988, an international workshop on the subject at the Ruhr University in Bochum, Germany drew papers from ten countries, establishing an international dialogue among researchers. Later, in 1991, *Transportation Research Circular 373: Interim Materials on Unsignalized Intersection Capacity* described modified procedures for data collection and capacity analyses. In 1993, NCHRP Project 3–46, "Capacity and Level-of-Service at Unsignalized Intersections" was initiated. The research team for this project is made up of individuals representing the University of Idaho, an Oregon consulting firm, the Ruhr University in Germany, and Queensland University of Technology in Australia. Research tasks include a worldwide search for appropriate methodologies and their evaluation.

Special Characteristics

A German method for capacity analysis was identified from an OECD publication through NCHRP research and introduced to the United States by publication in *Transportation Research Circular 212*. Experience and some modifications led to its adoption and publication in the 1985 HCM. Further changes have evolved as a result of international interest and input, and additional research is being carried on by a research team with members from the United States, Germany, and Australia.

Mechanically Stabilized Embankments

Product/Process Description

The expression "mechanically stabilized embankments" describes a family of methods used extensively in transportation and other applications to improve the mechanical properties of earth as a construction material. It involves the use of reinforcing materials that serve, much as reinforcement bars do in concrete, to offset the weakness in tension or shear of the natural material. The result is increased potential for slope stability and for providing walls in narrow rights-of-way. While a variety of techniques are available, three components are basic to most: the earth or backfill material, the reinforcements, and the facing elements.

This case study deals with two methods. The first is Reinforced Earth, a proprietary procedure that has been described as follows: "Structures built of Reinforced Earth consist of alternating layers of granular backfill and reinforcing strips connected to modular precast concrete facing panels" (*19*, p. 2-1).

The second is soil nailing, a generic process, which typically involves the placement of steel rods as passive inclusions in a soil mass to increase shear strength. The exposed surface ends of the rods, or "nails," are connected into the facing element, usually a wall constructed with wire mesh and shotcrete. Figure 7 shows the three stages in the construction process.

Identification

The usage by primitive peoples of bricks and straw, or mud and sticks, is clearly the forerunner of modern engineering technology for reinforcing natural materials. Babylonian ziggurats, which were multistory religious towers, employed bricks and reed matting in such ways over 2,500 years ago (*20*, p. 6). Yet modern applications of soil reinforcement date only from the second half of this century.

A French architect and engineer, Henri Vidal, developed a system in 1963 and patented Terre Armee (Reinforced Earth) in 1966. With growing acceptance and continuing product development, the company has evolved into a worldwide establishment represented in more than 30 countries.

Meanwhile, the first use of soil nailing occurred with its application in 1972 on a railroad construction project in Versailles, France (*21*, p. 5). Research and development spread to Germany in the 1970s, where the technique was used in 1979 on a wall in Stuttgart. Since then, more than 500 soil nail walls have been built in Germany, and the practice has spread to Great Britain and elsewhere, including North America.

Introduction

Reinforced Earth may have been first described to U.S. audiences in "The Principles of Reinforced Earth," published in 1969 in *Highway Research Record 282* (*22*). The method was first employed in the United States when a wall was constructed in 1972 on California State Highway 39 in the San Gabriel Mountains near Los Angeles. Since then, applications in transportation and other construction fields have been numerous in the United States. The Reinforced Earth Company, the sole U.S. licensee, now has offices in ten states besides its corporate headquarters in Northern Virginia.

Soil nailing has been used in the United States mostly to support temporary excavations for buildings. Its first U.S. application in 1976 was on a Portland, Oregon hospital construction project. The first highway application of soil nailing occurred in 1985 on the FHWA Cumberland Gap Tunnel Project in Kentucky, where it was used for a temporary support. Subsequent permanent installations in the late 1980s were made on the same project and in Pennsylvania, California, and Washington. More recently, soil nailing has been used by the state DOTs of New York, Oregon, Texas, and Virginia.

Despite these applications (California has built over 100,000 square feet of soil nailing), acceptance of the concept is far from universal. Partly because of this, and to provide U.S. experts with the latest information on European practice, FHWA assembled a multidisciplinary technical scanning

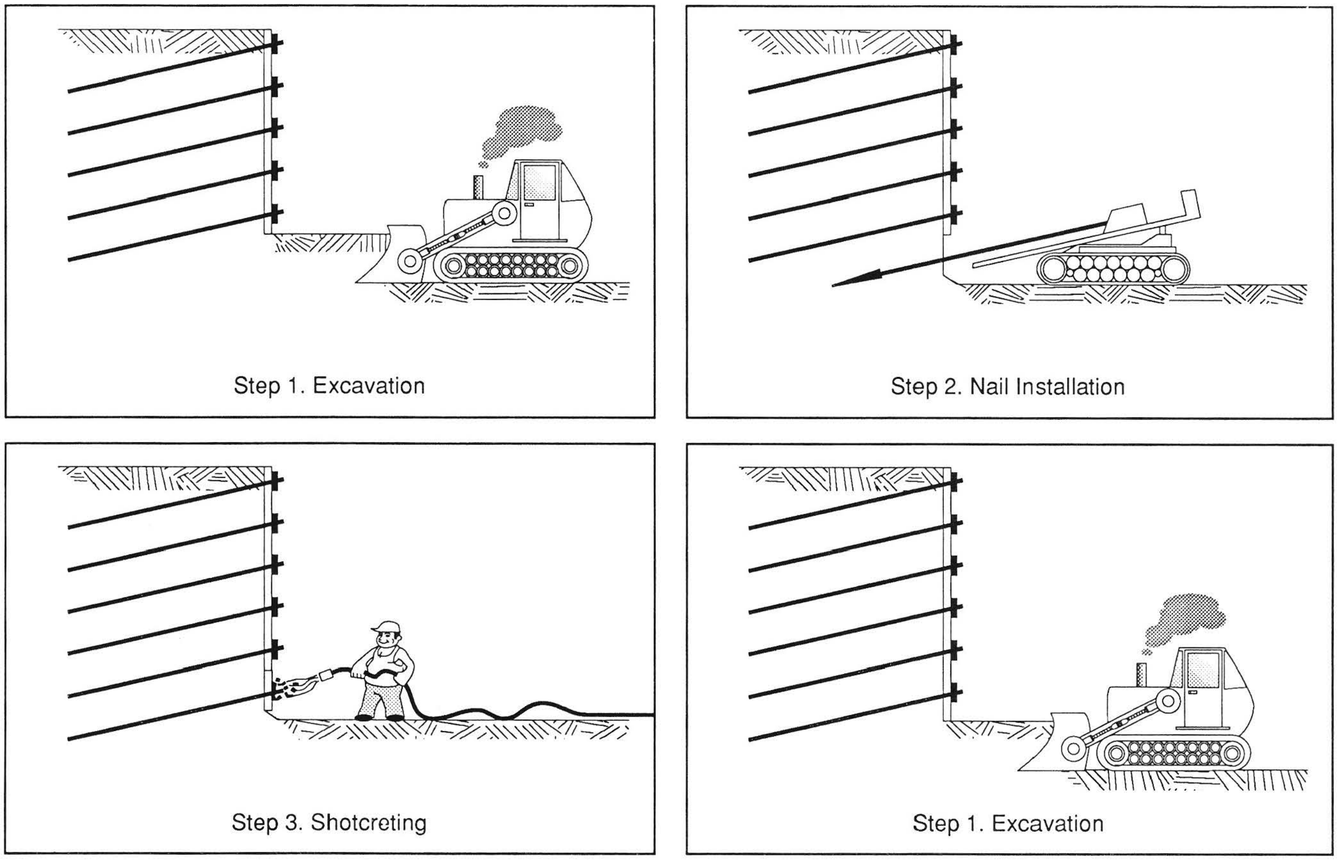

FIGURE 7 Soil nailing construction technology.

team in 1992 for a 3-week tour of three countries. The information thereby obtained on design, construction practices, contracting procedures, and research and development has been published (*21*).

Implementation

"In late 1974, after a 4-year demonstration program, FHWA released Reinforced Earth from its 'experimental category' and approved it as an economical and safe alternate to other earth retaining techniques" (*20*, p. 91). Its use has become widespread and has been extensively reported in trade journals. Technical specifications are available for mechanically stabilized embankments (MSE) and the company describes its services in the following terms:

> Reinforced Earth is an engineered product sold under a firm-price agreement, which includes all company services. The company prepares preliminary feasibility studies and cost estimates, designs the structure, participates in pre-bid and pre-construction conferences, prepares construction plans and specifications, supplies all manufactured components, and provides on-site construction assistance.

On the other hand, the use of soil nailing is not restricted by proprietary issues. Designers can freely specify soil nailing as a construction method and contract awards can be made on the customary low-bid basis. FHWA suggests that, "Alternative bidding including Contractor Design-Build alternates, performance-oriented specifications, and the use of carefully pre-qualified specialty contractors should be encouraged" (*21*, p. ix).

Special Characteristics

Reinforced Earth, a French technology privately developed more than 30 years ago, has been steadily refined and improved as its worldwide use has grown. The Reinforced Earth Company, the U.S. licensee, has successfully marketed its products and zealously guarded against patent infringements by other suppliers of MSE components. A proprietary product provided by a U.S. company with coast-to-coast offices, Reinforced Earth is probably no longer thought of by most potential users as an imported technology.

Soil nailing, on the other hand, is a generic technology that has not yet met with broad U.S. acceptance despite nearly a decade of experience in highway applications. FHWA, which took the lead in past demonstrations and in the arrangement of the 1992 tour, is also carrying out a demonstration project that will include not only more research, testing, and demonstration, but also the preparation of construction specifications, design and construction manuals, inspection manuals, and training programs.

Hutchinson, Minnesota Bicycle and Pedestrian Plan

Product/Process Description

This case is a planning process to develop small community infrastructure that will provide optimum conditions for walking, bicycling, and transit. Techniques being employed call for segregation of different traffic types through combinations of pedestrian zones, bike lanes and paths, "traffic calming" measures, bike parking facilities, and greenway development (see Figure 8). The planning stage, which will take several years, addresses land use and traffic planning coordination and involves the preparation of plans using methods from Finland. The project will also include public education and enforcement related activities to assure public awareness and support for the safety and environmental benefits to be derived.

FIGURE 8 Hutchinson, Minnesota pedestrian planning study sketch.

Identification

The idea for this project probably came from a trip to the United States by a staff member of the Finnish National Road Administration (FinnRA) to attend the 1988 TRB Annual Meeting and then visit several states, one of which was Minnesota. Since then, FinnRA staff have visited Minnesota's Department of Transportation (MnDOT) annually, and one person has been sent over for a 1-year stay. The mutual interests that evolved were fostered in part by the similarities of climate and cultural ties between Minnesota and the Scandinavian countries. The awareness of MnDOT staff about Finnish transportation technology was further enhanced when FHWA funded a 5-week trip to Finland for a transportation planner, who thereby gained firsthand knowledge of Finnish experience.

Introduction

The informal cooperation between MnDOT and FinnRA was formalized in 1991 by an official agreement that provided for staff visits and exchanges, information exchange procedures, and cooperative research programs. Primary subjects of interest have been technology transfer techniques, winter maintenance practices, and planning for pedestrian and bicycle facilities. "The Minnesota Department of Transportation and the Finnish National Road Administration have forged an exciting partnership to create new models for integrating transportation options and enhancing the quality of life in Minnesota communities" (*22*, p. 1).

Implementation

With both staff and technical resources put in place through the international partnership, the next step was to select a community in which to demonstrate methods for diversifying the transportation infrastructure. Hutchinson, a community of 12,000 people 60 mi (97 km) west of Minneapolis with a tradition of environmental interests and strong growth, was chosen because of its optimum conditions and enthusiasm for the project. An agreement was executed in 1993 "to initiate design of a pilot model community for walking, bicycle, and transit—a model of new transportation options and enhanced livability."

Traffic data and videotapes of the city were collected in 1993 for the benefit of the Finnish design team, and the City of Hutchinson began to organize a strong community involvement process. A 2-day seminar in October 1993 brought representatives from MnDOT, FinnRA, the Finnish consultant, and two Finnish communities together with members of the local community and others for information sharing and discussions on goals and procedures for the Hutchinson project.

The seminar showed full awareness of the potential barriers for such technology transfer and the means for overcoming them.

Special Characteristics

The combination of local, state, and national public agencies participating in transportation planning studies for a small community is unusual enough, but is extraordinary when the national agency providing technical expertise is from Finland. The evolution of this project took some years, beginning with staff visits and exchanges between two regions with similar climates and cultural affinities. Not only the formalities of cooperative agreements but also good working relationships between the staffs of Hutchinson, MnDOT, and FinnRA seem to ensure that the ongoing international technology transfer will take place productively.

INSIGHTS FROM THE CASE STUDIES

The nine case studies have revealed a pattern of diverse implementation. Some successes have originated from the foreign private sector, some from the public. Some have been transferred into the private sector in the United States, while others have gone to the public sector.

Difficulties and delays accompanied the private sector candidates for implementation. These were overcome by persistence in the moveable barrier case, and apparently by aggressive marketing in the cases of NOVACHIP and The Reinforced Earth Company. In these cases, only the expectation of profitable markets could have sustained the preliminary efforts necessary to introduce the products.

National public agencies such as FHWA or the Federal Transit Administration (FTA), with legislative mandates and extensive resources, are perhaps better positioned to overcome obstacles. They are better able to expedite implementation through demonstrations, as in the cases of SMA, soil nailing, or the Pittsburgh NATM tunnel project

NATM's implementation in Washington, coming about through a VECP, was a more unusual situation.

At the state level, where interest in FTTM seems highly variable from state to state, other influences may drive the international technology transfer mechanism. In the case of MnDOT's transfer of planning and technologies from Scandinavian countries, cultural ties as well as shared experience seem to have facilitated the exchanges. Additionally, however, as will be seen in the next chapter, MnDOT has internal activities that strengthen the acceptance of innovation. Colorado's partnership with FHWA in demonstrating the HMA test equipment may have resulted from the participation of a staff member in the 1990 European Asphalt Study Tour.

Overall, the case studies suggest that foreign technologies were implemented because management decided that the benefits of these technologies would outweigh the potential time and effort required to overcome any obstacles to implementation.

CHAPTER THREE

IDENTIFICATION OF FOREIGN TRANSPORTATION TECHNOLOGIES AND METHODS

Technology transfer processes are essential stages in implementing foreign transportation technology. Identification, the first step in technology transfer as defined here, begins with awareness of a technology by a potential user. If implementation is to result, the awareness further includes a judgment that the newly discovered technology may offer one or more of the following: solutions for existing or anticipated problems, improved performance, or reduced costs.

Separating the identification stage from the subsequent one of introduction is perhaps arbitrary. Take the case of a foreign entrepreneur attending a U.S. conference and making a presentation about a proprietary product or process employed in his own country. He is expecting eventually to market it also in the United States. From the viewpoint of the entrepreneur, the conference presentation might seem an act of product introduction. Yet from the viewpoint of the U.S. conference audience, hearing about a potentially useful foreign technology for the first time, the presentation is better described for them as the step of identification.

Numerous players and techniques are involved in identifying foreign transportation technologies and methods (FTTM). Largely as a result of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the federal transportation agencies have held the dominant role. Other public agencies at the state and local level, such as transportation agencies and technology transfer (T^2) centers, are involved. In the academic world, university transportation education and research centers are also contributors. In the private sector, international engineering firms, the contracting industry, professional engineering societies, and associations all call attention to emerging innovations, whether foreign or domestic.

The purpose of this chapter is to describe the organizations that have a role in FTTM identification and the various means of identification they employ.

THE ROLE OF PUBLIC ORGANIZATIONS

In the public sector, many programs and activities generate or support the publications, conferences, and tours that spread awareness about foreign transportation technologies and methods. Probably the most important among these are several USDOT initiatives mandated in the ISTEA legislation.

Federal Initiatives

FHWA's International Technology Scanning Program is active in the following areas relating to foreign technology imports: reconnaissance and team visits overseas, technical cooperation and exchange, and technical information management (*24*). The first activity assembles teams of federal, state, academic, and private sector experts and sends them overseas to investigate selected topics. Second, technical cooperation and exchange activities include participation in international committees, working groups, and conferences, as well as the exchange of staff experts for in-depth investigations. FHWA now has increased involvement with leading international organizations concerned with highways, such as the International Road Federation (IRF), the Permanent International Association of Road Congresses (PIARC), and the Organization for Economic Cooperation and Development (OECD). Third, under technical information management, research has been undertaken to develop recommendations for improving the acquisition and dissemination of foreign technical materials related to transportation.

Beyond these activities, FHWA encourages the application of new technologies (whether foreign or domestic) through the Local Technology Assistance Program (LTAP). This expansion of the previously existing Rural Technical Assistance Program serves to connect new technology vendors and local agencies that might benefit from the technology. Through more than 50 T^2 centers, whose activities were summarized in "LTAP Accomplishments and Successes—1991" (*25*), LTAP information reaches 38,000 local governments. An important link in this process is the T^2 clearinghouse operated under contract to FHWA by the American Public Works Association.

Combining the activities of LTAP and international technology transfer, FHWA established in 1993 an international regional T^2 center in Finland in cooperation with the Finnish National Road Administration (FinnRA). One of its functions is to gather and transmit information on regional technologies to the U.S. transportation community through FHWA, the state DOTs, and LTAP T^2 centers.

Other National Activities

Two Washington, D.C. organizations, which are generally regarded as public institutions because all or most of their support comes from public funds, have a history of identifying foreign technologies for potential use in the United States. The American Association of State Highway and Transportation Officials (AASHTO) has been a leader, for example, in cosponsoring, arranging support for, and disseminating findings from overseas tours. The Transportation Research Board (TRB) has facilitated information exchange for decades through the Transportation Research Information Services (TRIS), conferences, committees, and publications.

State and Local Governments

With clearly lesser roles in identifying foreign technology, state and local governments have assisted through such activities as research, conference sponsorship, staff exchanges, and T^2 centers. Strong cultural ties to Scandinavia, for instance, have contributed to a variety of interactions between the Minnesota Department of Transportation (MnDOT) and the national road administrations of Finland, Norway, and Sweden. When the state of Arkansas initiated a policy of encouraging foreign businesses to establish new operations there, the Arkansas Department of Transportation took advantage of the opportunities presented for evaluating new foreign technologies related to transportation.

Several years ago, the organization of the Heavy Vehicle Electronic License Plate (HELP) Program and Crescent Study by six Western states provided opportunities to test and evaluate a number of foreign products related to Weigh-In-Motion (WIM) and Automatic Vehicle Classification (AVC) technologies.

Survey Comments on Organization Roles

Some indication of activities in identifying FTTM was obtained from the survey results. One set of survey responses was sorted into replies from universities (12), transportation agencies (13), associations (7), private industry (8), and T^2 centers (15). Transportation agencies in this case represented mainly toll facility operators, and the industry group contained both consultants and contractors.

On the question of whether their organizations played a role in identifying FTTM, university responses were equally divided between "Yes" and "No," while the toll facility operators and private organizations gave a 74 percent "Yes" response. Only 40 percent of the T^2 agencies responded affirmatively, however, and none claimed that the role was a significant one.

PRIVATE SECTOR ACTIVITIES

The private sector contributes to the identification of foreign technologies in many of the same ways as the public sector. Associations provide publications, organize conferences, and co-sponsor tours with public agencies. A different mechanism, used by manufacturers, is marketing.

Marketing

Although an essential for foreign companies with products to sell in the United States, neither the surveys nor the literature review produced much information on the role of private sector marketing in identifying foreign transportation technology and methods. Several case study inquiries resulted in brochures being provided. One example, obtained from a Canadian distributor of European equipment, was a high-quality multicolored publication that had the drawback of being written in French. Nevertheless, effective marketing has been carried out by the suppliers of NOVACHIP, the Quickchange Moveable Barrier (QMB), and the Reinforced Earth technologies described earlier. Techniques followed by foreign manufacturers or their U.S. representatives include advertising and placing articles in trade and other journals. Sales calls on potential customers constitute the other widely practiced approach.

As with conferences, the survey findings were mixed on the role of marketing with regard to product identification. Nearly two-thirds of the state and transit representatives reported that marketing had served this purpose, less so for transit agency responses than for state agencies. The response from group tour members varied according to their employment. Industry related respondents listed marketing as an identifier mechanism nearly as often as group tours, while association responses and public agency participants noted it rarely.

Association Activities

Apart from marketing, the private sector probably contributes most to the identification of FTTM through the activities of many associations. Three recently established organizations are briefly described because of their potential influence on the application of foreign transportation innovations. They are the Intelligent Transportation Society of America (ITS AMERICA) (formerly the Intelligent Vehicle-Highway Society of America (IVHS AMERICA)), the Civil Engineering Research Foundation (CERF), and the Highway Innovative Technology Evaluation Center (HITEC).

ITS AMERICA

ITS AMERICA is a non-profit educational and scientific society that encourages development and deployment of advanced surface transportation systems. Its approximately 450 members are organizations and firms in the transportation, communications, and electronics industries; federal, state, regional, and local government agencies; academic institutions; and societies and professional associations in related fields. The USDOT has designated ITS AMERICA as an official Federal Advisory Committee, of which at least three of its activities serve or potentially serve in the identification of FTTM. First, in alliance with European, Japanese, U.S., and other international intelligent transportation systems (ITS) leaders, the Committee has begun a series of World Congresses, the first of which took place in Paris in late 1994. The next World Congress is scheduled for November 1995 in Japan. Second, in 1991, it developed and has since operated the International ITS Information Clearinghouse, which "exchanges technical, safety and procurement information among organizations and people involved in IVHS research and development and acts as repository for the information" (*26*). Third, its monthly newsletter *ITS AMERICA* (*27*) reports to its members on meetings, and reviews items such as the first-year results of the Crescent System operation, a program that owes much to the contributions of foreign technologies.

Civil Engineering Research Foundation

As stated in its descriptive brochure, "The Civil Engineering Research Foundation (CERF), an independent, 501(c)3 organization, was created by the American Society of Civil Engineers (ASCE) and began operation in 1989 to advance the civil engineering profession through research. CERF's mission is to bring together diverse groups within the civil engineering community to create industry-coordinated and directed R&D programs. As an *industry-guided* research organization, CERF serves as a critical catalyst to help the design and construction industry and the civil engineering profession expedite the transfer of research results into practice through cooperative national programs" (*28*).

Many CERF activities oriented to bringing research into practice apply to foreign technologies. CERF co-sponsorship of a 1993 study tour to Europe was noted earlier. One of its goals was "to learn how to apply European technology transfer techniques for promoting innovations and implementing advanced technologies in the United States." Thus, even technology transfer is a foreign process being considered for importation. CERF is planning a 1995 International Symposium that will provide a forum for the free exchange of research results from around the world. In its report "High-Performance Construction Materials—An Essential Program for America and Its Infrastructure," the need for transfer of foreign technology is made clear:

> Research and development programs aimed at developing high-performance construction materials and systems have been established in other countries the ... national program will ensure that available knowledge about foreign programs and their results is obtained and disseminated (*29*).

The potential of CERF with regard to FTTM identification has been enhanced by its establishment of HITEC, described next.

Highway Innovative Technology Evaluation Center

In 1991, FHWA had conducted a development study for a national center to evaluate innovative highway technology. This led to a 1992 workshop co-sponsored by FHWA, AASHTO, TRB, and CERF, which reviewed and refined the conceptual plan. The result was the founding of the Highway Innovative Technology Evaluation Center (HITEC) within CERF in 1993 under a $3 million cooperative agreement with FHWA. HITEC's function has been described as

> A nationally recognized service center and clearinghouse for implementing highway innovation; one that will serve as a focal point for evaluating new innovative technologies and help to expedite their transfer into practice. By providing impartial evaluations of technologies where no industry standards exist, HITEC hopes to enhance the incentives for private industry to invest in highway oriented research and development, and for state and local governments to implement more quickly innovative products in the highway system (*30*).

Serving as a central point of screening and evaluating new technology, HITEC will have a lead role in carrying out ISTEA objectives related to advanced technology.

INTERNATIONAL ORGANIZATIONS

Given the new support for U.S. professionals participating in committees and meetings of organizations like the PIARC and OECD, the contribution of such organizations to U.S. awareness of foreign technology cannot help but grow. Their role in this regard, through publications and conferences, was identified by some survey respondents. One relevant OECD activity is the International Road Research Documentation system, a database of publication abstracts on current international research.

Private international organizations aid in information exchange. Best known to U.S. transportation professionals are two organizations headquartered in Washington, D.C.: the International Road Federation (IRF) and the International Bridge, Tunnel and Turnpike Association (IBTTA). IRF devotes 70 percent of its activities to international, regional, and executive conferences, and manages a videotape program with distribution to 82 countries including the United States. IRF also supports a fellowship program bringing foreign students for U.S. university graduate studies. IBTTA, with an annual budget of approximately $1 million, conducts research, compiles statistics, and reports on legislative actions affecting transportation worldwide.

Another example is the Union Internationale des Transports Publics (UITP) (*31*), headquartered in Belgium. Its 1,700 members represent more than 60 countries and focus on mass transit issues and other aspects of urban mobility.

Other foreign resources for identifying innovative technologies are national transportation research centers, such as the following:

- Australian Road Research Board (ARRB)
- Centre de Recherches Routieres (CRR) (Belgium)
- Laboratoire Central des Ponts et Chaussées (LCPC) (France)
- Institute for Road Safety Research (SWOV) (Netherlands)
- Swedish Road and Traffic Research Institute (VTI)
- Transport Research Laboratory (TRL) (United Kingdom).

In addition to their research and development interests, the centers are concerned with information dissemination. TRL has also supported British industry in overseas marketing in recent years, particularly with respect to SCOOT, a traffic signal control system that was initially developed by TRL staff.

IDENTIFICATION METHODS

Looking at the techniques employed by the various organizations helps to illustrate their roles. Furthermore, the survey responses on identification techniques suggest the relative effectiveness of different mechanisms in identifying foreign technologies.

Publications

The most likely access for transportation professionals to information on new technologies is through the great number of regularly published technical and trade journals. Not to be entirely ignored, however, is the influence of the general media: television, newspapers, weekly news magazines, and other periodicals. Insofar as special transportation features done by these information channels are likely to get the attention of legislators and other community leaders, they can influence—favorably or unfavorably—the climate for funding of innovative technology applications.

More relevant to industry professionals are the technical and business trade journals such as *ENR—Engineering News Record, Mass Transit, Public Works*, and *Roads and Bridges*. Foreign trade publications, especially those published in English and distributed in the United States, can be good sources for identifying potentially useful foreign technology, e.g., *Traffic Engineering and Control*. Periodicals from associations, including *World Highways* from IRF, or *Routes/Roads* published by PIARC, offer similar benefits.

Publications from professional societies, such as *Civil Engineering* (American Society of Civil Engineers (ASCE)) and *ITE Journal* (Institute of Transportation Engineers (ITE)), are widely read sources of information about new products and processes. Furthermore, the Division Journals of ASCE are another information source. A recent database search on the New Austrian Tunneling Method (NATM) showed, for example, that a 1973 journal of ASCE's Construction Division was the earliest listed U.S. reference on the subject. Association publications are important outlets. Examples of periodicals from other sources include TRB's *TR News* and FHWA's *Public Roads*.

Newsletters also convey information on innovative foreign technologies. One such is "Public Innovations Abroad," published by the International Center of the Academy for State and Local Government to promote the international exchange of practical experience in dealing with common problems at the state, county, and city levels of government. Transportation related news from this source also appears under "International Transportation Observer" in the *AASHTO Quarterly* (*32*).

The importance of publications is indicated by the responses from the three survey groups. TRB's representatives from state DOTs and transit agencies reported publications more frequently (78 percent) than any other mechanism as a means of bringing FTTM to the attention of agency staffs. Similar results came from associations, universities, T^2 centers, and toll facility operators. Group tour participants listed publications less frequently than tours and conferences as means for identifying foreign technology.

Conferences

Both domestic and international conferences are playing a larger role than they did several years ago in increasing awareness of foreign technologies. Conferences can identify new technology not only through technical presentations but by exhibits and demonstrations as well. Two examples of domestic and international conferences are described below.

The National Traffic Data Acquisition Technology Conference and Expo, held in 1990 at Austin, Texas, provided its 250 attendees (10 percent of whom came from foreign countries) with sessions that included presentations by several foreign manufacturers (*33*). Part of the program was a series of 18 demonstrations of Weigh-in-Motion (WIM) and traffic classification systems installed under actual working conditions. At least four of the 12 exhibitors showed products of foreign origin. This conference, hosted by the Texas State Department of Highways and Public Transportation (now TxDOT), was co-sponsored by the American Society for Testing and Materials, Texas A&M University, University of Texas, and FHWA.

International conferences, whether held in the United States or elsewhere, clearly provide opportunities to spread awareness of foreign technology. The Third International Symposium on Snow Removal and Ice Control, held at Minneapolis in 1992, was conducted by TRB with FHWA support and in cooperation with five other organizations: MnDOT, AASHTO, PIARC, Standing International Road Weather Commission, and U.S. Army Cold Regions Research and Engineering Laboratory. While the total attendance was similar in number to the 1990 Texas meeting, one-half of the participants came from outside North America, and 20 countries were represented. Sessions included 33 presentations (among the program total of 56) from 10 foreign countries.

Conferences have an outreach far beyond the meeting rooms. The Snow Removal and Ice Control conference had two sets of publications distributed. A two-volume set of preprints was prepared for the meeting, and a later collection of 34 peer-reviewed papers appeared in *Transportation Research Record 1387* (*34*) as the conference "Proceedings." Typically, conference proceedings from annual or other meetings of technical societies can be purchased by members and nonmembers.

A different form of proceedings was "Transportation Technology Transfer: A Global Enterprise" (*35*). This report, prepared by the University of Florida Transportation Research Center for the USDOT in cooperation with OECD, summarized two seminars held in Orlando, Florida and Seville, Spain. Order forms supplied with the report enable readers to obtain other reports and videotapes related to the seminars.

Videotapes are increasingly popular dissemination tools and have been used for identifying FTTM. For example, a 16-minute tape describing Michigan's demonstration of European concrete pavement technology on I-75 in Detroit was released concurrently with the 1993 AASHTO meeting.

Current survey results provided mixed indicators of conference values in identifying FTTM. While 71 percent of state DOT representatives said that domestic conferences had brought FTTM to the attention of their staffs, the figure for transit agency representatives was much lower (only 38 percent). Lower still was the percentage for both groups regarding international conferences (only 17 percent). These figures likely reflect the constraints on state and local agency budgets for travel support. Group tour participants rated conferences more useful than publications, with participants from associations rating international conferences as the most effective means of identifying FTTM. Among the third or "mixed" group surveyed, 50 percent of those organizations that reported a role in FTTM identification said that conferences had been one of the mechanisms employed. However, only one-half of these had used exhibits in conjunction with conferences.

The results suggest that conferences are rated more highly than publications by those who have the opportunity to attend them.

Travel and Tours

With ISTEA emphasis on searching out foreign transportation technology to apply to domestic problems, group and individual travel activities have likely increased. The availability of publications reporting on such travel has certainly grown, examples of which include "European Asphalt Study Tour" (*4*), "Report on the 1992 U.S. Tour of European Concrete Highways" (*36*), and "FHWA Tour for Geotechnology—Soil Nailing" (*21*). Tour reports appear in other publications, for example, "Paving The Way," in *TR News* (*37*), and "Study Team Visits European Highways and Infrastructures" in *Research & Technology Transporter* (*38*). The latter briefly describes travel arranged by CERF and the National Science Foundation. Group tour sponsors may issue news releases to report the findings of such tours.

Tour reports may also be prepared by participants for the benefit of their employers. "IVHS in Japan" (*39*) describes, for the New York City Department of Transportation, the 1992 tour sponsored by the Institute of Transportation Engineers (ITE), with support from FHWA. An article on this tour also appeared in *ITE Journal* (*40*). "Automatic Vehicle Location/Control and Traffic Signal Preemption—Lessons From Europe" (*41*) was prepared for the Chicago Transit Authority by its Communications Implementation Task Force to describe European site visits on a trip supported by FTA.

Because of their remoteness from most developed countries, Australians have long favored individual tours to observe foreign practice. One unpublished report on this type of travel, "Traffic Management and Safety in Europe and North America 1988—A Study Tour," ran to over 250 pages. Results from this sort of trip can require careful assessment.

> To cover the most with the least, agencies often adopt a "Marco Polo" strategy in which an individual envoy attempts to explore the widest possible array of marvels, many of which the envoy cannot critically assess. The traveller returns with a thick book of tales, but any discoveries made through these explorations must be skeptically examined to ensure their validity and relevance back home (*42*).

In the survey responses, the individual foreign tour was reported less frequently than group tours as a method for identifying foreign technology. Among state and transit representatives, less than 25 percent said that individual travel was a means of bringing FTTM to staff attention, while 25 percent said that group tours had served this way. Not surprisingly, the group tour participants gave group tours their highest ranking. For those who have the opportunity to travel, first hand exposure to foreign technologies is the best way to identify them.

Staff Exchanges

Useful means of increasing awareness of FTTM are the exchange of personnel between nations, or providing staff on a loan basis. MnDOT has benefitted from staff exchange agreements with Scandinavian countries in planning and other areas. Staff exchanges with Finland led to the bicycle and pedestrian planning project in Hutchinson, described in the case studies. Placing FHWA personnel for up to 1 year in foreign agencies has been a part of FHWA response to ISTEA requirements.

The benefits of such exchanges were noted in a SHRP article: "Twenty-five professionals from 12 nations have spent a year or more as SHRP loaned staff. This has made an enormous contribution to the expertise and management of the program." The article went on: "Thirty-two nations have appointed SHRP coordinators. They have distributed SHRP findings to their nations' agencies and have alerted us to related work that we were not familiar with, and to alternative ways of doing things that we might not have discovered" (*42*).

Research

Research programs are one more source for revealing foreign technologies applicable to U.S. transportation needs. NCHRP Project 3–38(1), "Assessment of Advanced Technologies for Relieving Urban Congestion," reviewed and assessed domestic and foreign technologies, thus serving an identification role. Another NCHRP project, "Highway Research and Technology—International Information Sharing," was set up as a resource to facilitate several activities: the participation of U.S. representatives in PIARC activities, participation of U.S. professionals in study tours, visits by foreign specialists to the United States, and participation in an international newsletter to report on relevant research and development abroad. A third NCHRP project, "Facilitating the Implementation of Research Findings," also has potential for aiding FTTM applications in the United States.

A somewhat similar project under the Transit Cooperative Research Program (TCRP) was administered by TRB for the FTA. The project, "International Transit Study Program," has initial objectives of facilitating foreign travel by transit industry professionals, but focuses on professional development rather than on technology.

CHAPTER FOUR

INTRODUCTION OF FOREIGN TRANSPORTATION TECHNOLOGIES AND METHODS

The stage of introduction in technology transfer is defined here as the process by which a potential user of a foreign technology acquires the knowledge and materials necessary to make an informed decision on whether or not to implement that technology. The step may include the preceding one of identification, but it implies action by a supplier or sponsor to set the scene for implementation.

Continuing the analogy drawn earlier about a foreign manufacturer making a conference presentation to increase U.S. awareness of a product to be marketed in the United States, introduction might comprise subsequent demonstrations of equipment or processes, provision of specification information, preliminary consideration of licensing agreements, personnel training needs, and so on.

Introduction of foreign technology, therefore, may take different forms and involve different kinds of agencies. The purpose of this chapter is to outline current practice, as reported in the literature and by respondents to the surveys.

TECHNOLOGY INTRODUCTION AS SEEN BY RESPONDENTS

The survey of TRB state and transit representatives was designed to obtain the views of technology users or recipients, i.e., those to whom new processes were being introduced. As such, their responses were expected to reveal a mostly "bottom up" view of foreign technology transfer. Group tour participants, who were typically organization leaders in the transportation community, were expected to provide more of a "top down" view. The third group, representing a mix of organization types, were expected to be "activists" in the introduction role, and were asked what introductory activities their organizations had carried out. Summaries of the three sets of responses follow.

TRB State and Transit Representatives

Forty-eight replies from the liaison representatives to TRB from state DOTs and local transit agencies indicated the bottom up view. Table 2 summarizes their responses. Demonstrations were named most frequently, whether they were provided by the private sector or by public agencies. The uses of advertising, exhibits, and sales calls were mentioned less frequently but approximately equally. Joint venture approaches were rarely mentioned as a means of introducing foreign transportation technologies and methods (FTTM).

There were many comments relating to what introductory procedures were appropriate to what kind of technology. Generally, the comments suggested that each technology must be examined separately to determine the appropriate technology transfer strategy. New theories and technologies can be described in technical journals, while new products and methods require demonstrations and exhibits. For publications introducing new technologies, comparative studies with sound experimental design produce the highest credibility. Some replies indicated that introducing a new technology requires documented success in other states.

TABLE 2

EFFECTIVE MEANS OF FTTM INTRODUCTION*

Means Provided By	Percent of Respondents Naming Means
Public Sector	
Demonstrations	58
Publications	40
Sponsorship	33
Other	6
Private Sector	
Demonstrations	52
Sales calls	44
Exhibits	40
Advertising	37
Licensing agreements	8
Joint Venture	19

*From surveys of TRB state and transit agency representatives.

Several comments emphasized cost considerations in that introductory material should contain elements of cost benefit, performance, and value engineering.

Comments directed mostly to construction and paving issues suggested that demonstration projects are essential, particularly where contractors are heavily involved or affected, or where performance will be affected by local materials or conditions. Among the suggested prerequisites were complete specifications and procedures for design, testing, and application.

Group Tour Participants

Generally, the responses from 22 group tour participants mirrored those shown in Table 2. Proportionally more comments came from this top down group than from the state and transit representatives. Demonstrations were most frequently cited (by two-thirds), followed by sales calls and advertising. Comments concerning demonstrations included the following:

demonstrations are essential to show how machinery, equipment, or instruments work and how they are superior to present technology; demonstrations are for hard-side technologies, and conferences and seminars for soft-side; and demonstration projects and hands-on training are for technologies that require end-users to change their methods for performing a particular task.

Other comments tended to deal with broader issues including the fact that it may be even more difficult for foreign technology to get into the public sector than it is for U.S. technology. It was pointed out that where risks are relatively high, only joint partnerships will work, as most private companies cannot or will not afford to assume the financial risk. Another issue was that the procurement process for new technology frequently has to be vendor-specific or selection-based, and cannot always be handled in an open-bid process.

The Presumed Activists in Technology Introduction

This last group of 55 respondents was asked if their organizations had a role in introducing foreign technologies, and if they had sponsored or carried out demonstrations, training, or report distribution with respect to FTTM. The results are shown in Table 3.

In the entire group, only 40 percent reported that their organizations were involved in introducing foreign technologies, with involvement ranging from a high of 88 percent for the consultant/industry respondents to a low of only 13 percent for technology transfer (T^2) centers. The types of activities carried out are also shown in Table 3. Report distribution is most common, with 13 mentions, followed by demonstrations with nine, and training with six. Videotape production or distribution was also mentioned by five organizations as an introductory device.

PRIVATE SECTOR ACTIVITIES

The case studies and the literature review gave more detail than the surveys on private sector activities in introducing foreign technology. Beyond creating an initial product awareness, suppliers of foreign technology need to generate confidence and provide the information that will enable a potential user to decide about implementing the product or process. Demonstrations, translations of text material, metric to English measurement conversions, hardware adaptations, specification modifications, operator instructions, and training may all be required.

The report, "High-Performance Construction Materials and Systems—An Essential Program for America and Its Infrastructure" (*29*), reveals that other industries suffer from similar difficulties in moving innovations into practice. The Civil Engineering Research Foundation (CERF) proposes a national program to address the problems. Regarding new materials technology, it states

> The present program therefore gives serious attention to technology transfer and removal or reduction of barriers to exploitation of new or improved materials technologies. The activities to be carried out under the heading of technology transfer include the development of an integrated knowledge system, identification of relevant foreign developments, technical education, information dissemination, new product evaluation, life cycle costing, the contract/bid system, reductions of barriers to transfer of technology to practice, tort liability, and prototype evaluation projects (*29*, p. 16).

Focusing on the highway industry, the Highway Innovative Technology Evaluation Center (HITEC) has been set up as a national evaluation center. Among its missions, HITEC hopes to "create less time and expense for market introduction than could be achieved through agency-by-agency evaluations" (*43*). HITEC's Action Plan calls for technical panels "working with innovators, private companies and public entities . . . to plan and implement the necessary real world evaluations to demonstrate to the highway user community *how* the product or service performs, *where* it would be applicable, and *what* benefits it will provide, if utilized" (*30*). The Action Plan continues, "Through a 'consensus-based' approach and pooled funding mechanisms, the traditional risks of introducing new products will be shared more equitably, thus encouraging more investment in both researching new ideas and introducing new products" (*30*). Potentially useful foreign technologies could benefit from this program.

PUBLIC SECTOR ROLES

While one contribution of the public sector to introduction of FTTM could be through support of HITEC, the public sector role involves many other activities.

TABLE 3
INTRODUCTORY ACTIVITY BY ORGANIZATION TYPE

			Activities		
Organization Type	Number of Responses	Percent of Total	Demonstrations	Training	Reports
Consultants and industry	7	88	3	1	7
Toll or highway agency	6	46	3	2	3
University transportation centers	5	42	3	2	1
Associations	2	29	–	–	1
Technology transfer centers	2	13	–	–	1
Total	22	40	9	6	13

Federal Role

The federal government initiated technology transfer in the highway field about 100 years ago, when "good road trains" carried equipment and experts around the country to build demonstration highways (*44*). Similar activities go on today, e.g., the stone matrix asphalt (SMA) Open Houses.

FHWA's Office of Technology Applications, which was responsible for the SMA Open Houses, is also responsible for the Local Technical Assistance Program (LTAP). In this program, state T^2 centers share technology with local governments, publish and distribute newsletters, conduct self-evaluation programs, provide training, and cooperate on demonstration projects. Though the survey returns showed little current interest by T^2 centers in foreign technology, the international regional T^2 centers set up through FHWA's Office of International Programs will circulate information in the future through these LTAP channels.

Research activities in the FHWA Office of Research and Development at Turner-Fairbank Highway Research Center (TFHRC), as shown in the case studies, further contribute to the introduction of foreign technology.

Finally, through support of national research programs administered by TRB and the provision of experimental grants to state and local agencies, FHWA and FTA both advance the introduction of foreign technology.

Other National Programs

SHRP aided the importation of foreign technology early on. Three testing devices for use in the long-term pavement-performance study came from overseas: " . . . a pavement-surface monitoring device developed in Japan, a falling-weight pavement-deflection measuring device developed in Europe, and an Accelerated Loading Facility (ALF) developed in Australia" (*45*, p. 14). The *SHRP Product Catalog* lists several other devices or procedures with origins in Australia, Denmark, Norway, and Spain. While neither endorsing nor guaranteeing their effectiveness, the Catalog describes the items as "competent and useful products deemed worthy of consideration by highway agencies" (*46*).

The Office of Technology Evaluation and Assessment in the National Institute of Standards and Technology has a program sponsored by the U.S. Department of Energy to promote entrepreneurial technology having energy payoffs, as some transportation technologies do. However, its typical projects are mainly in the development stage rather than being ready for market introduction.

State DOT and Transit Agency Activities

While the federal role in SMA demonstrations was described earlier, more than one dozen states have been involved with SMA demonstration projects following the 1990 European Asphalt Study Tour and subsequent FHWA Open Houses. These demonstration projects result from combinations of DOT staff interest, AASHTO "championing," and FHWA support. They serve to introduce the new pavement technology, evaluate it, and encourage its widespread application.

Survey returns from state DOTs indicated varying interest in trying new technology. Some reported a dozen or so examples of FTTM applications, others reported none, and one response suggested technology would be tried if its success were demonstrated elsewhere—a conflict of interest if all DOTs felt the same way.

The methods of introduction at the state level are diverse. Some instances might be described as collaborative efforts with manufacturers, as in Connecticut's acquisition of technology to document pavement conditions and video technology for information systems. A formal product evaluation procedure is used: "Following successful trial evaluations, new products (or processes or methodologies) must be brought into use through special provisions and changes in specifications, if they are not already covered/allowed by current specifications." Washington State DOT's implementation of soil nail retaining walls was attributed to its introduction through a combination of publications, individual foreign travel, and private sector marketing.

The Chicago Transit Authority aggressively pursued foreign technology in its search for Automatic Vehicle Location and Control (AVLC) systems. Authority staff reviewed foreign journal articles, followed up on journal advertising, made foreign tours, and surveyed operators worldwide. When they eventually requested proposals, according to the survey return, "Three of four bids now being considered for an AVLC system rely on foreign technology (and the RFP [request for proposal] itself calls for some technology not previously implemented in the United States)."

A different approach for introducing foreign technology was described by Washington Metropolitan Area Transit Authority (WMATA). Value engineering change proposals (VECPs) were received from contractors in connection with tunnel and concrete bridge construction contracts. WMATA commented in its survey response: "Contractor-sponsored VECPs provide new technologies at savings, an attractive way to implement new technologies without sacrificing function." The agency's response continued: "Very thorough technical analyses of proposed methods of construction and of the final products were accomplished prior to implementation."

Other Introductory Activities

Research programs at universities are another means of introducing foreign technology. Research at the University of California at Berkeley is making an Australian software package for capacity analysis of two-lane rural highways more user-friendly, which will facilitate its use in the United States. Several university responses described other research to adapt or evaluate foreign technologies, often with sponsorship from state DOTs. The survey return from Purdue University said: "We conduct research for Indiana DOT . . . . For example, INDOT is interested in finding remedies against rutting. One project is going to look into a German device and adapt it to U.S. conditions." The University of Nevada return mentioned work on "Hot In-Place Recycling Technology" developed by a Canadian manufacturer. A respondent from the University of Minnesota reported "an active partnership with Finland" and a demonstration of Finnish bicycle/pedestrian systems in Hutchinson, Minnesota. The University of South Dakota return stated that: "We are working with DOT to place some experimental test sections of SMA in South Dakota." These examples illustrate the diversity both in technologies and in the methods of introducing them that can be found across the country.

JOINT VENTURES

Joint ventures of private organizations and public agencies were expected to be a means of introducing and implementing FTTM. However, the survey returns gave little evidence of this, with only one reply suggesting that they would be useful where private organizations were unable or unwilling to incur high risks.

A situation that might be considered a joint venture was the FHWA-supported Heavy Vehicle Electronic License Plate (HELP) Program, begun in the 1980s as a research project involving several states and other agencies. Concerned with heavy vehicle management, HELP focused on testing Weigh-In-Motion (WIM) and Automatic Vehicle Classification (AVC) technologies, and providing a test-bed for equipment manufacturers, some of which were foreign.

CHAPTER FIVE

IMPLEMENTATION OF FOREIGN TRANSPORTATION TECHNOLOGIES AND METHODS

This chapter examines the survey findings and the literature to identify those elements that lead to successful implementation, or result in either a lack of implementation or its failure. The survey results are presented first, followed by findings from the literature. The chapter closes with a summary of those elements that appear most likely to facilitate the implementation of foreign technologies.

SURVEY FINDINGS ON IMPLEMENTATION

A review of the returns showed that some respondents described a technology as being implemented when it was merely being demonstrated or evaluated in the field. The following discussion may be generous, as a result, in describing the extent of foreign technology implementation in U.S. practice. The term implementation as used here includes accomplishment of a demonstration. It does not necessarily mean that a public agency has accepted and committed funds to the ongoing use of a product or process.

Organization Roles in Technology Implementation

Survey recipients were asked about the roles of their organizations in implementing foreign technologies. The involvement varies by type of organization.

According to responses obtained from FHWA personnel who participated in group tours, FHWA's role is limited by the fact that it controls only 6 percent of the nation's highway mileage. The agency's implementation role was consequently described mainly as one of supplying packages for demonstrations and technical staff support for advisory groups. However, FHWA's Turner-Fairbank Highway Research Center (TFHRC) is the user of the Accelerated Loading Facility (ALF) and European asphalt test equipment described earlier in the case studies.

Almost all state highway and local transit agency replies reported an implementation role, although it was sometimes clearly one of demonstration and evaluation. Several comments noted that foreign technologies were handled in the same way as domestically developed technical innovations.

Industry initiatives in foreign technology were described by contractors in various ways, for instance, developing a polymer-modified asphalt cement, being licensed to use foreign patented processes, and using new construction technology for underground work. One consultant noted that the international activities of his agency's staff made them aware of foreign techniques that were then applied to projects in the United States.

Although not generally concerned with implementation, some associations have supported demonstration projects by FHWA and state DOTs. The association role has typically been one of introduction, in presenting seminars and conferences, and supporting task force activities.

Several university responses cited an implementation role, as did one-third of the technology transfer (T^2) centers. The actual activities described, though, were mainly introductory in nature. One university research program reported the purchase of foreign technology for its internal use.

Examples of Implemented Technologies

A total of 62 implemented products and processes were named in the survey returns. Most respondents identified only one technology, and only one-third of the technologies received more than one mention. The return from the Arkansas DOT, presumably because a state policy encourages foreign investment in all types of industry, listed eight foreign materials or processes that had been implemented.

Listed in Table 4 are the materials, equipment, and processes associated with pavements that accounted for nearly one-half of the total. Table 5 lists the other reported technologies, which range from noise-attenuating walls to bicycle and pedestrian planning procedures. Documentation or evaluation reports were said to be available for approximately 50 percent of the 62 implemented projects.

Reasons for Success

Table 6 summarizes the reasons given to explain successful implementation. The factors that stood out, and the only ones cited more than once, were top management support and superior product performance.

Indicating the values of international staff exchanges, the reason given for successful implementation of an Australian compaction measuring device was that "The inventor was a visiting scholar at Purdue."

A summary of reported obstacles encountered and overcome in implementation, and the frequency with which they were mentioned, is given in Table 7. The obstacles are characterized as administrative, technical, and political or institutional issues. Under administrative obstacles, procurement difficulties were most often mentioned, but were not always elaborated upon. They included problems with the normal low-bid purchase process and restrictions on sole source purchasing. Restrictions against specifying proprietary products were similar constraints. Only once was management disinterest listed as an obstacle.

TABLE 4

EXAMPLES OF IMPLEMENTED PAVEMENT-RELATED FOREIGN TECHNOLOGIES*

MATERIALS	EQUIPMENT	PROCESSES
Ralumac	Asphalt cement test equipment	NOVACHIP
Verglimit	Hydromill	Novophalt
Styrelf	Accelerated loading facility	Drainable base
Asphalt stabilizer	Australian compaction device	Asphalt recycling
Paveset	Pavement roughness measuring device	Stone matrix asphalt
Accorex	Portland cement concrete rapid test	Asphalt cement mix
Plusride	Soil test	Chipseal
Ethyl propylene monomer	Dutch cone penetrometer	Porous mix
Etan plasticizer	Vane shear test	Thick portland cement concrete pavement
	Falling weight deflectometer	

*From survey responses.

TABLE 5

EXAMPLES OF IMPLEMENTED FOREIGN TECHNOLOGIES OTHER THAN PAVEMENT-RELATED*

MATERIALS	EQUIPMENT	PROCESSES
Hilti HVA	Fare handling	Roundabout design
Silane	PASCO road reconnaissance	Bike trail
Sound attenuation walls	Video information	Bicycle and pedestrian planning
Bellpro traffic paint	Weigh-in-motion	Inventory software
EPS foam (soil stabilizer)	Automatic vehicle identification	Traffic control software
Plastic pipe	Traffic detector technology	Highway capacity model
	Bridge expansion joints	Snow and control
	Traffic control hardware	Transit service route methodology
	Cruise control system	Automatic vehicle location and control system
	Electronic toll collection	
	Moveable barrier	
	Von roll monorail	
	Rail fastener	
	Riflex rail	

*From survey responses

Under technical obstacles, language barriers and lack of technical data were mentioned most frequently. Costs were next, presumably cases where foreign technologies were initially more expensive than other available solutions. Various difficulties were described including adapting to local conditions, voltage and frequency conversions, metrication, special materials, and the need for special provisions or modified specifications. Least mentioned were problems of equipment delivery, parts availability, and the staff time required to accomplish implementation.

The only political obstacles named were Buy America requirements (cited in two transit agency responses) and several others grouped under inertia. These included resistance from local suppliers and reluctance to change. These may be more cultural than political obstacles, but they were cited several times with variations.

The issues identified above were those that were encountered and overcome on the way to successful implementation. The next section identifies those obstacles that were reported to have blocked implementation or led to its failure.

TABLE 6

REASONS GIVEN FOR SUCCESSFUL IMPLEMENTATION

Administrative	Technical
Management support (5)*	Superior performance (4)
Good promotion	Involve personnel
Public/private support	Close attention to project
Risk/cost sharing	Proper analysis/evaluation
Travel support	Cost effective
	Good manuals
	Only technology available
	Good technical support

*Number indicates frequency of mention. All others are (1).

Obstacles That Prevented Successful Implementation

When survey recipients were asked to identify administrative, technical, and political obstacles that had prevented implementation or precluded its success, 63 percent of the returns reported no instances of administrative or technical obstacles, and 79 percent reported no political obstacles that blocked implementation. Comments from the remainder are summarized below.

Administrative Obstacles

Contracting procedures were the most frequently named obstacles of this type. They included rules and regulations

TABLE 7

TYPES OF OBSTACLES OVERCOME IN SUCCESSFUL IMPLEMENTATION CASES

Administrative	Technical	Political
Procurement (5)*	Language barrier (5)	Inertia (6)
Proprietary products (2)	Lack of technical data (5)	Buy America (2)
Travel restrictions (2)	Cost (3)	
Sole source	Adapting to local conditions (3)	
Currency rate	Voltage/frequency differences (3)	
Fluctuation	Specifications (3)	
Management disinterest	Special materials(2)	
	Parts availability	
	Metrication	
	Staff time	

*Number indicates frequency of mention.

requiring advertising and bidding except for small quantities, low-bid laws, and the difficulties of sole source contracts. Equally mentioned were problems related to patents and proprietary products.

Liability issues were noted several times, with one reply stating, "Some foreign manufacturers will not supply to the United States because of liability." Other reported difficulties were the inability to use performance specifications or to require warranties, as used in Europe.

Comparison of these replies with the list of obstacles that were overcome by successful implementers (Table 6) showed that the leading obstacles in both groups were procurement practices and proprietary products. The two sets were essentially comparable in all respects except that liability concerns were listed only by the unsuccessful implementers.

Technical Obstacles

Reported obstacles of this kind were numerous, but no one problem dominated. Most frequently listed was higher first costs associated with improved designs. Personnel training needs, capital investment for equipment, parts availability, and the need for documented success were each named by several respondents.

Parts availability and staff training issues were dominant concerns in the unsuccessful cases, while they were rarely identified by the successful group. The obstacles of language barriers and inadequate technical data, which were reportedly overcome in the successful cases, were not frequently mentioned by the unsuccessful implementers. Cost concerns were about equal for the two groups.

Political Obstacles

This class of obstacles drew relatively few comments. The need for leadership and issues of jurisdictional coordination were each noted twice as problems. Several state agency replies noted contractor related issues such as reluctance to change technology. While supplier resistance was mentioned only once among the successful group of implementers, many comments came from unsuccessful implementers about the impacts of foreign technologies on contractors, suppliers, and the local economy. This was the most marked distinction between the successful and unsuccessful groups.

IMPLEMENTATION ISSUES IN THE LITERATURE REVIEW

The review of technology transfer literature suggests that the difficulties that can occur in completing this last step of technology transfer have their roots not only in the highway or construction industries, but in society as a whole. Innovations, per se, threaten the status quo. They are resisted, therefore, by those whose interests seem best served by maintaining the status quo.

Furthermore, innovators face risks. First is the possibility of non-acceptance; second, in the United States, is the risk of tort liability. A 1992 article in *Civil Engineering* notes, "Tort liability has created a crisis in the U.S. and has become a strong disincentive to the introduction of new innovation into practice" (*47*). The risk of liability associated with new technology, the article suggests, may be why research and development investment by U.S. construction firms is only one-fifteenth that of Japanese firms.

Within the construction field, present institutional arrangements also impede the acceptance of innovations. A *TR News* article reports, "If U.S. bridge design and construction teams are going to innovate in analytical and construction techniques (or be more effective at adopting innovations that originate elsewhere), adjustments are needed in the ways that clients, legal counselors, insurance carriers, contractors, and engineers conduct their professional and business activities (*48*). This article notes further that the importation of European innovative bridge technology has been impeded by "the U.S. construction industry's structure, which clearly allotted the responsibilities and functions for design and for construction to two different services groups."

In the highway field, slow acceptance of new private sector technology has been attributed to various factors. *NCHRP Synthesis of Highway Practice 149: Partnerships for Innovation: Private Sector Contributions to Innovation in the Highway Industry* names the following (*45*):

- Market characteristics in a public highway program involving many agencies,

- Issues of risk versus reward potential,
- The character of procurement practices,
- The effect of prescriptive specifications and low-bid requirements versus performance specifications, and
- Geographic and other variables affecting material specifications and precluding product standardization.

Comments in an evaluation of legal constraints affecting implementation of intelligent transportation systems (ITS) may have some applicability to foreign technology transfers in other transportation areas also. Tort liability is a problem in areas such as advanced vehicle control systems, but fears of such constraints are not borne out by experience in other ITS activities. The report recommends research on whether the standard setting proceedings of the National Highway Traffic Safety Administration have desirable or undesirable effects on ITS innovations in the United States. More generally, "FHWA and IVHS AMERICA [now ITS AMERICA] should sponsor or encourage research into whether American products liability law and procedure is in fact depressing rates of IVHS innovation in the United States compared to Japan and Europe" (*49*, p. 431).

Clearly, foreign technologies face all the problems affecting the introduction of domestic innovations and more.

IMPROVING THE PROSPECTS FOR IMPLEMENTATION

Findings from both surveys and literature show how the climate is improving in the encouragement of transportation innovations generally, and with regard to the deployment of foreign technology in particular.

Survey Findings

Survey recipients were asked what issues most needed addressing to facilitate successful applications of foreign technologies. Table 8 summarizes the comments received under the same headings of administrative, technical, and political/institutional issues used earlier. Some comments were difficult to classify because of their brevity. For example, depending on the amplification offered, cost comments were assigned to the administrative category if they related to procurement issues, but to the technical group if they were cost effectiveness related. Within the administrative category, the term procurement includes not only one-word comments using the term but also comments on sole source, low-bid, warranty, and related issues. The result is that Table 8 can only suggest, by the frequency with which items are mentioned, what are the major issues to address in facilitating implementation of foreign technologies.

Administrative Issues

Changes in procurement practices led all other items as the principal concern of respondents. Concerns over liability and risk (whether on the part of the user or the supplier of FTTM was usually unspecified) were frequently mentioned. Travel or travel fund restrictions were identified several times, as were problems in obtaining approvals or funding by state or federal agencies.

Technical Issues

A need to address technical issues came up more frequently (78 times) than either administrative (54) or political (43) concerns. The need for demonstrated applicability of the technologies, to be achieved through tests and evaluations, was most frequently noted. For example, products must be clearly appropriate or clearly superior. The adequacy of technical assistance to facilitate deployment was next most frequently listed. This area includes documentation, specifications, technical support, training materials, and staff training. Several returns mentioned the need for staff skill levels adequate to identify, understand, and evaluate a technology, and to train personnel in its use. A major issue for many respondents was achieving compatibility of standards, materials, methods, and measurements (e.g., metrication problems). Eliminating language and terminology barriers was often cited. Greater awareness of FTTM, cost or cost effectiveness, and assuring local support

TABLE 8

ISSUES TO ADDRESS IN FACILITATING FUTURE IMPLEMENTATION OF FTTM

Issues by Type with Frequency of Mention					
Administrative		Technical		Political	
Procurement practices	(20)	Demonstrated acceptability	(16)	Reluctance to change	(13)
Patents and proprietary products	(11)	Technical assistance	(14)	Not invented here	(8)
Liability and risk	(11)	Compatibility	(13)	Cultural difference	(5)
		Language	(11)		
Travel restrictions	(6)	Awareness	(9)	Cooperation and coordination	(5)
Funding and approvals	(6)	Costs	(9)	Buy America	(5)
		Local support	(6)	Leadership	(4)
				Trade barriers	(3)

from suppliers and manufacturers for parts and services were other needs to facilitate implementation.

Political and Institutional Issues

Overcoming reluctance to change, meaning the inertia or active resistance of user agencies, contractors and suppliers of equipment to the application of FTTM, was the issue most needing to be addressed. A related problem, the "not invented here" syndrome, was also mentioned. Receiving occasional attention were the issues of cultural differences (whose nature or impacts were never described), cooperation and coordination problems (either between jurisdictions or between public and private organizations), Buy America provisions, and the need for leadership or "champions." Least mentioned was the issue of overcoming trade barriers that either prevent imports or drive up their costs.

Other Evidence

Evidence of an improving situation for implementing FTTM can be found in the literature and other sources. "Transportation Technology Transfer: A Global Enterprise" (*35*, p.41) points out that the Intermodal Surface Transportation Efficiency Act (ISTEA) addresses some barriers to implementation by making it possible to use performance specifications on federal-aid projects and to enter into design-build contract arrangements. Furthermore, ISTEA requires the USDOT to seek out FTTM and to disseminate information on them.

Improved access to international bibliographical databases will result from the compact disk (CD-ROM) packaging of three current sources. The Organization for Economic Cooperation and Development's (OECD) International Road Research Documentation database is being combined with the TRANSDOC file of the European Conference of Ministers of Transport and TRB's TRIS database into a new product, TRANSPORT, containing more transportation information than is available in any single source.

The Civil Engineering Research Foundation's (CERF) proposed national program to facilitate the use of high-performance materials in construction (CONMAT) includes provisions for developing standards and software for life-cycle cost calculations, and emphasizes that "Contract/bid procedures must not be allowed to stifle innovation or impede transfer of new technologies such as are expected to emerge from this national program" (*29*, p. 18).

The report on the 1992 European Concrete Pavement Tour offers recommendations for concrete pavement design and construction that could have applicability to other technologies. The report urges the following (*36*):

- Increased government and industry cooperative research,
- A focal point for collecting and disseminating information,
- Demonstration projects,
- Training programs for public agency and contractor staffs, and
- The encouragement of "closer interaction among highway agency engineers, consultants, researchers, industry, and contractors."

Demonstrated acceptability of technologies, a need indicated by the surveys, may be satisfied in part through the programs of the Highway Innovative Technology Evaluation Center (HITEC), which will also address other needs pertinent to foreign technologies. As noted in one HITEC brochure, "By providing impartial evaluations of technologies where no industry standards exist, HITEC hopes to enhance the incentives for private industry to invest in highway oriented research and development, and for state and local governments to implement more quickly innovative products in the highway system" (*30*).

Overcoming institutional reluctance to change has been the subject of management research on a broad industrial front. Investigation of several cases where innovations were introduced showed that shocks, in the form of external forces or changes in internal leadership, are needed to overcome institutional inertia and stimulate innovation (*50*, p. 123). Furthermore, in successful cases, "Hands-on top management involvement occurs throughout the innovation period; several levels of management removed from the innovation itself are directly involved in all major decisions" (*50*, p. 634).

The Research and Strategic Initiatives Division of MnDOT exemplifies one way in which public agencies can create a climate for acceptance of innovation. Created in 1992, the Division's mission statement is as follows:

> The Research and Strategic Initiatives Division (RSI) inspires MnDOT to pioneer new ways of thinking and acting by challenging the agency to continuously improve its ability to anticipate and create transportation's future and make strategic investments that meet customer's needs.

The last piece of evidence that prospects for implementing innovations are improving is the research statement for NCHRP Project 20-33, "Facilitating the Implementation of Research Findings," which has these objectives: (1) identify and evaluate the significant factors that influence the implementation of research findings, (2) determine ways to improve technology transfer and facilitate interagency and public-private cooperation in applying research results in surface transportation, and (3) recommend strategies to create an environment conducive to innovation and timely application of research findings in surface transportation. If these objectives are achieved, applications of foreign innovations in the United States will be facilitated along with all others.

A CHECKLIST FOR IMPLEMENTATION

First-time applications of foreign transportation technologies and methods may be quite readily accomplished with funding from either research sources or demonstration grants. Such approaches may circumvent administrative constraints on new procedures that might otherwise apply. Setting up routine use of foreign technologies in ongoing construction or other programs may face more difficult hurdles, however. Answering the following checklist would be helpful when incorporating and implementing foreign technologies in public agency programs is considered.

- Are there any legal difficulties or regulatory prohibitions in contracting procedures that preclude implementation? Is a low-bid award process the only possible procedure? Are there restrictions against use of proprietary products? Can sole source purchases be made? Is life-cycle costing an acceptable option?
- Is top management supportive of the introduction of new technologies? If resistance to change on the part of industry or local groups is evident in outside pressures on the agency, can it be overcome?
- Can special provisions and specifications (such as performance specifications) be prepared so that the technology can be appropriately selected?
- Do demonstrations, locally or elsewhere, show conclusively that the technology performs acceptably?
- Is needed documentation (e.g., specifications and training materials) adequately translated into English language and measurements so that implementation is facilitated?
- Must personnel skills be developed or other expertise be made available before implementation can occur?
- Are the appropriate materials or equipment available locally to support the implementation?
- Is the technology supplier capable of providing ongoing support as needed in technical data, training, equipment maintenance, and parts availability?

CHAPTER SIX

CONCLUSIONS

Each part of the project—the surveys, literature review, and case studies—contributed to findings on the state of the practice with respect to implementation of foreign transportation technology. The conclusions reached from the information so derived are presented here.

CONCLUSIONS

The conclusions are grouped under the steps of identification, introduction, and implementation used throughout the report, and a fourth heading of management support. In general, the climate for implementing foreign technologies has greatly improved since the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), and there is broad supportive activity in both the public and private sectors. Nevertheless, the fact that a major research project to find better ways of implementing research findings has been funded indicates problems still exist for the acceptance of technology innovations, whether foreign or domestic.

Identification

All techniques currently employed to identify foreign technologies are useful, but they also have limitations. Publications reach the widest audience but have no impact in terms of conveying firsthand information. Staff exchange programs probably have the greatest impact of firsthand experience but on the narrowest audience. Conferences and group tours fall somewhere between in terms of outreach and impact.

The success of the 1990 European Asphalt Study Tour, measured by the demonstrations and use of new technology it generated, was probably due to the fact that it provided firsthand awareness to leaders, of both industry and public agencies, who then stimulated the introduction of innovations within their organizations. Growing experience with tours has shown that the makeup of each tour group is a vital element in its subsequent impacts on technology adoption. The concept of tours has become so well regarded and utilized that some concerns are being voiced about the need for more coordination of them among tour sponsors, for the benefit of countries visited as well as with a view to their cost effectiveness.

The dissemination of information is expanding. The capability of the Local Technology Assistance Program (LTAP) and other organizations (i.e., TRB's Transportation Research Information Services (TRIS)) to bring information on innovations to the state and local levels has been enhanced. While the technology transfer (T^2) centers presently do not typically focus on foreign technologies, the emerging international technology transfer activity will feed into LTAP and will likely improve that situation.

Introduction

A requirement for winning converts to foreign innovations is demonstrating the worth of the product or process. The FHWA Open Houses and the occasional demonstration, such as the Mount Lebanon Tunnels project or the first soil nailing project, are effective but expensive stimuli. Others are likely to be needed. Such costly demonstrations warrant national sponsorship, especially when the technology values will not be revealed for several years, as in the case of the 1993 concrete pavement demonstration in Michigan.

The advent of the Highway Innovative Technology Evaluation Center's (HITEC) programs further promises to alleviate some of the impediments to introducing new technology.

Implementation

Foreign technologies face more obstacles than domestic ones including contracting procedures, language or compatibility in measurement, and other factors. But the obstacles to their application seen by some observers, apparently less willing to change the status quo, are not insurmountable to those who are interested in innovation. Aspects of the procurement process, and the realities of (or misconceptions about) tort liability that impede innovation are being addressed. The results will help foreign as well as domestic technologies.

Management Support

Leadership is key to improved climates for foreign technology in state and local transportation agencies. In private industry, leadership by national organizations such as associations can help to overcome inertia. Overcoming reluctance to change practices, either within a DOT or local contracting industry, requires motivated management and staff. Special units established within public agencies may best facilitate the acceptance of innovation.

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APPENDIX A

SURVEY FORMS

The nature of this synthesis obviously dictated who would be surveyed on the subject of foreign transportation technologies and methods (FTTM) implementation. Because a number of overseas study tours have been conducted in recent years, tour group participants were a prospective source. Other individuals in state DOTs and local transit agencies were selected because their positions would likely make them knowledgeable about innovations and their implementation. They were the designated state and transit agency representatives to the Transportation Research Board. Several other target groups were chosen because of their possible experience, including university transportation centers, state-level technology transfer organizations, selected transportation industry associations, a number of engineering consultants, and a small group of toll facility operators.

The group tour survey form was sent to participants who had been on five different tours:

(1) 1990 European Asphalt Study Tour
(2) 1991 ITE European IVHS Tour
(3) 1992 European Concrete Pavement Tour
(4) 1992 ITE Japan Tour
(5) 1993 Soil Nailing Tour.

The form asked for comments on the effectiveness of different means for identifying prospective FTTM, introducing them to the United States, and implementing them. The form asked whether specific technologies had been implemented as a result of tours and what kinds of obstacles were encountered. Finally, it invited comments on what difficulties must be overcome to facilitate U.S. implementation of FTTM. Copies of this and other forms are provided in this Appendix.

Essentially, the same questions were asked of the state DOT and transit agency representatives. These representatives were also asked to describe any examples of successful implementation and to list reasons explaining their success.

The survey form for the third group, which represented a mix of organization types, differed by initially asking about the roles of their organizations in identification, introduction, and implementation of FTTM. Recipients were then asked to describe what methods had been used to increase awareness of their members or clients, to cite examples, and to discuss how they were concerned with introduction and implementation. Like the others, they too were invited to comment on activities leading to successful implementation and on obstacles to be overcome.

NCHRP PROJECT 20–5, SYNTHESIS TOPIC 24–11

"IMPLEMENTATION OF TECHNOLOGIES FROM ABROAD"

SURVEY FORM

(TRB State and Transit Representatives)

Name of Respondent or Future Contact: ______________________________

Organization: ____________________ Telephone: (   ) __________

PART ONE— IDENTIFICATION OF FOREIGN TRANSPORTATION TECHNOLOGY

A. Which of the following identification techniques have brought foreign transportation technology and methods (FTTM) to the attention of your organization's staff?

1. Publications of Professional Societies or Associations _____
2. Conferences _____ Domestic _____ International _____
3. Individual foreign travel _____
4. Sponsored group travel _____
5. Private sector marketing _____
6. Other (please describe) ______________________________

B. If any have led to consideration or implementation of FTTM projects by your organization, please provide details: ______________________________

____

PART TWO—INTRODUCTION OF FTTM INTO THE UNITED STATES

A. When FTTM of potential value have been identified, which processes of introducing them into the U.S.A. have been effective?

1. Private sector: advertising ___, exhibits ___, sales calls ___, license agreements ___, demonstrations ___.
2. Public sector: sponsorship___, demonstrations ___, publication distribution, ___, other ___.
3. Joint private/public ventures ___.

B. If the nature of the technology affects the processes employed, please indicate your views on suitable procedures for selected technologies. ______________________________

____

____

PART THREE—IMPLEMENTATION OF FOREIGN TRANSPORTATION TECHNOLOGY

A. What role has your organization played in implementing FTTM? Please describe.

____

____

B. Please list any examples of successful implementation by your organization. _____

____

____

C. Have formal evaluations been made? _____ Are they documented and available?_____ Please describe. ______________________________

____

D. What obstacles had to be overcome, or what special reasons, if any, explain the success?

____

____

E. Has your organization encountered obstacles that have prevented implementation of FTTM or precluded their success? If so, please describe:

Administrative (e.g., contracting, liability, patents) ______________________

____

Technical (e.g., capital, operating and maintenance costs, staff needs and training)

____

____

Political (e.g., leadership or other impedances, jurisdictional coordination, other)

____

____

PART FIVE—PROSPECTS FOR IMPLEMENTATION OF FOREIGN TECHNOLOGY

A. In your view, is it important to demonstrate successful implementation of FTTM?

____

____

B. What approaches seem most likely to produce successful implementation of FTTM by public agencies?

In identification methods ______________________

____

In technology transfer to U.S.A ______________________

____

In implementation ______________________

____

C. What difficulties must be overcome to facilitate U.S. implementation of foreign transportation technologies? ______________________

____

____

____

THANK YOU VERY MUCH FOR YOUR PARTICIPATION IN THIS SURVEY. YOUR RESPONSE WILL BE EXTREMELY USEFUL IN THIS SYNTHESIS.

PLEASE RETURN COMPLETED FORM TO THE FOLLOWING ADDRESS:

David Witheford
11423 Purple Beech Drive
Reston, Va. 22091

OR FAX TO:

Sally Liff, TRB
1–(202)–334–2003

NCHRP PROJECT 20–5, SYNTHESIS TOPIC 24–11

"IMPLEMENTATION OF TECHNOLOGIES FROM ABROAD"

SURVEY FORM
(Group Tour Participants)

Name of Respondent or Future Contact: ____________________

Organization: ____________ Telephone: ( ) ________

PART ONE— IDENTIFICATION OF FOREIGN TRANSPORTATION TECHNOLOGY

A. How would you rank the following methods for identifying foreign transportation technology and methods (FTTM) that may have potential value in the U.S. practice?

1. Publications of Professional Societies or Associations ____
2. Conferences ____ Domestic ____ International ____
3. Individual foreign travel ____
4. Sponsored group travel ____
5. Private sector marketing ____
6. Other (please describe) ____________

B. Please cite examples of the above if they have led to implementation of FTTM by your organization. ____________

PART TWO—INTRODUCTION OF FTTM INTO THE UNITED STATES

A. Which processes for introducing FTTM into the U.S.A. have been effective in your experience?

1. Private sector: advertising ____, exhibits____, sales calls ____, license agreements ____, demonstrations ____ .
2. Public sector: sponsorship____, demonstrations ____, publication distribution ____, other ____.
3. Joint private/public ventures ____.

B. If the nature of the technology affects the methods employed, please indicate your views on suitable procedures for selected technologies. ____________

PART THREE—IMPLEMENTATION OF FOREIGN TRANSPORTATION TECHNOLOGY

A. Does your organization have a role in implementing FTTM? If so, please describe. ____________

B. Please list any examples of successful implementation by your organization that originated:
(a) out of your group tour. ____________
or
(b) by some other means ____________

C. Have formal evaluations been made?____ Are they documented and available?____
Please describe. ____________

D. What obstacles had to be overcome, or what special reasons, if any, explain the success? ____________

E. Has your organization encountered obstacles that have prevented implementation of FTTM or precluded their success? If so, please describe:

Administrative (e.g., contracting, liability, patents) ______

______

Technical (e.g., capital, operating and maintenance costs, staff needs and training)

______

______

Political (e.g., leadership or other impedances, jurisdictional coordination, other)

______

______

PART FIVE—PROSPECTS FOR IMPLEMENTATION OF FOREIGN TECHNOLOGY

A. In your view, is it important to demonstrate successful implementation of FTTM?

______

______

B. What approaches seem most likely to produce successful implementation of FTTM by public agencies?

In identification methods ______

______

In technology transfer to U.S.A ______

______

In implementation ______

______

C. What difficulties must be overcome to facilitate U.S. implementation of foreign transportation technologies? ______

______

______

______

THANK YOU VERY MUCH FOR YOUR PARTICIPATION IN THIS SURVEY.
YOUR RESPONSE WILL BE EXTREMELY USEFUL IN THIS SYNTHESIS.

PLEASE RETURN COMPLETED FORM TO THE FOLLOWING ADDRESS:

David Witheford
11423 Purple Beech Drive
Reston, Va. 22091

OR FAX TO:

Sally Liff, TRB
1–(202)–334–2003
Reston, Va. 22091

NCHRP PROJECT 20–5, SYNTHESIS TOPIC 24–11

"IMPLEMENTATION OF TECHNOLOGIES FROM ABROAD"

SURVEY FORM

Name of Respondent or Future Contact: ______________________________

Organization: ____________________ Telephone: ( ) __________

PART ONE—ORGANIZATION ROLE

A. Has your organization been involved with the following activities related to foreign transportation technology and methods?
   1. Identification of candidate technologies for introduction into the U.S.A? Yes___ No___.
   2. Their introduction into the U.S.A? Yes___ No ___.
   3. Their implementation in the the U.S.A.? Yes___ No ___.
   (PLEASE CONTINUE IF YES TO ANY OF THE ABOVE)

B. Is such involvement a significant part of your currnet activities? Yes ___ No ___. Please comment below: ______________________________

____

C. Will future involvement likely increase ___decrease___ ? In what way __________

____

____

PART TWO—IDENTIFICATION OF FOREIGN TRANSPORTATION TECHNOLOGY

A. Which of the following processes have been used by your organization to increase awareness of foreign transportation technology (FTT) by U.S. members/clients?
   1. Publications: Journal papers ___ , Advertising___ , Special announcements ___ , Newsletters ___.
   2. Conferences: International ___, Domestic ___, Exhibits___, Proceedings ___.
   3. Group tours ___.
   4. Staff activities: Tours___ , Research ___ , Other ___.
   5. Other (please describe): ______________________________

____

B. Please list examples, provide references or personal contacts for our followup if needed.

____

____

____

PART THREE—INTRODUCTION OF TECHNOLOGY INTO THE U.S.A.

A. Has your organization sponsored or conducted any of the following means of bringing FTT into the U.S.A.?
   1. Demonstrations ___.
   2. Training Sessions ___.
   3. Technical report distribution ___.
   4. Other (e.g., Videotape production)___.

A. How is your organization concerned with FTT implementation? __________

____

____

B. Can you cite examples of successful implementation? Please list here or on supplmental sheet. ______________________________

____

____

C. Have formal evaluations been made? ___Are they documented and available? Please describe.

D. What special reasons, if any, explain the success?

E. Please cite examples where implementation did not occur or was less than successful.

F. What reasons may explain these cases? (e.g., patent or licensing agreements, contracting procedures, risk or liability issues, costs and fund sources, political or leadership impedances, jurisdictional coordination needs, etc.)

PLEASE RETURN COMPLETED FROM TO THE FOLLOWING ADDRESS:

David Witheford
11423 Purple Beech Drive
Reston, Va. 22091

PART FIVE—PROSPECTS FOR FOREIGN TECHNOLOGY TRANSFER

A. What approaches seem most likely to produce successful implementation of FTT?

1. In technology identification
2. In introduction to U.S.A.
3. In implementation

B. What difficulties must be overcome to facilitate U.S. implementation of foreign transportation technologies?

THANK YOU VERY MUCH FOR YOUR PARTICIPATION IN THIS SURVEY. YOUR RESPONSE WILL BE EXTREMELY USEFU IN THIS SYNTHESIS.

OR FAX TO:

Sally Liff, TRB
1–(202)–334–2003

APPENDIX B

LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
ALF	Accelerated Loading Facility
AVC	Automatic Vehicle Classification
ASCE	American Society of Civil Engineers
AVLC	Automatic Vehicle Location and Control
BSI	Barrier Systems Incorporated
CDOT	Colorado Department of Transportation
CERF	Civil Engineering Research Foundation
DOT	Department of Transportation
FHWA	Federal Highway Administration
FinnRA	Finnish National Road Administration
FTA	Federal Transit Administration
FTTM	Foreign Transportation Technologies and Methods
HITEC	Highway Innovative Technology Evaluation Center
HCM	Highway Capacity Manual
HELP	Heavy Vehicle Electronic License Plate
HMA	Hot Mix Asphalt
IBTTA	International Bridge, Tunnel and Turnpike Association
IRF	International Road Federation
ISTEA	Intermodal Surface Transportation Efficiency Act
ITE	Institute of Transportation Officials
ITS	Intelligent Transportation Systems
IVHS	Intelligent Vehicle/Highway Systems
LCPC	Laboratoire Central des Ponts et Chaussées
LETCO	Law Engineering Testing Company
LTAP	Local Technology Assistance Program
MnDOT	Minnesota Department of Transportation
MSE	Mechnically Stabilized Embankment
NATM	New Austrian Tunneling Method
NCAT	National Center for Asphalt Technology
NCHRP	National Cooperative Highway Research Program
OECD	Organization for Economic Cooperation and Development
PIARC	Permanent International Association of Road Congresses
QMB	Quickchange Moveable Barrier
SHRP	Strategic Highway Research Program
SIR	Societe Internationale Routiere
SMA	Stone Matrix Asphalt (originally Split Mastic Asphalt)
SWOV	Netherlands Institute for Road Safety Research
T^2	Technology Transfer
TCRP	Transit Cooperative Research Program
TFHRC	Turner-Fairbank Highway Research Center
TRB	Transportation Research Board
TRL	Transport Research Laboratory
TRIS	Transportation Research Information Services
UITP	Union Internationale des Transport Publics
UMTA	Urban Mass Transportation Administration
USDOT	United States Department of Transportation
VECP	Value Engineering Change Proposal
WIM	Weigh-In-Motion
WMATA	Washington Metropolitan Area Transit Authority

APPENDIX C

SELECTED FOREIGN ORGANIZATIONS AND INTERNATIONAL CONFERENCES RELATED TO TRANSPORTATION TECHNOLOGY

ORGANIZATIONS

Australian Road Research Board
P.O. Box 156, Nunawading
Victoria, Australia

Centre de Recherches Routieres
Boulevard de la Woluwe 42
Brussels B-1200, Belgium

CSIR—Division of Roads &
Transport Technology
P.O. Box 395
Pretoria 0001, South Africa

Finnish National Road Organization
P.O. Box 33, SF-00521
Helsinki 52, Finland

India Roads Congress
Jamnagar House
Shahjahan Road
New Delhi-110011, India

International Bridge, Tunnel and
Turnpike Association
2120 L Street NW, Suite 305
Washington, D.C., 20037, U.S.A.

Institute de Recherches des Transports
BP34 Centre de Documentation
F94114 Arcueil Cedex, France

Institute for Road Safety Research (SWOV)
P.O. Box 170, 2260 AD
Leidschendam, The Netherlands

International Road Federation
525 School St. SW, Suite 302
Washington, D.C. 20024, U.S.A.

Japan Road Association
Shoyu-Kaikan 7th Floor, 3-3-1
Kasumigaseki/Chiyoda-Ku
Tokyo 100, Japan

Laboratoire Central des Ponts et Chaussees
BP19, 44340 Bouguenais
France

Organization for Economic Cooperation
and Development
94,Rue Chardon Lagache
Paris 75016, France

Permanent International Association of
Road Congresses
27 Rue Guenegaud
Paris 75006, France

PTRC Education and Research Services, Ltd
Glenthorne House, Hammersmith Grove,
London W6OLG, England

Swedish Road and Traffic Research Institute
S-581 01, Linkoping
Sweden

Transport Research Laboratory
Crowthorne, Berkshire, RG11 6AU
England

Transport Canada
Place de Ville Tower C 29A, 330
Sparks Street, Ottawa, Ontario
K1A 0N5, Canada

Transport Association of Canada
2323 St. Laurent Blvd., Ottawa, Ontario
K1G 4K6, Canada

ORGANIZATIONS THAT SPONSOR MAJOR ANNUAL OR PERIODIC INTERNATIONAL TRANSPORTATION CONFERENCES

American Society of Civil Engineers (ASCE)
Australian Road Research Board
International Bridge, Tunnel and Turnpike Association (IBTTA)
International Road Federation (IRF)
Institute of Transportation Engineers (ITE)
Permanent International Association of Road Congresses (PIARC)
Organization for Economic Cooperation and Development (OECD)
ITS AMERICA
Transportation Research Board (TRB)

THE TRANSPORTATION RESEARCH BOARD is a unit of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. It evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society. The Board's purpose is to stimulate research concerning the nature and performance of transportation systems, to disseminate information that the research produces, and to encourage the application of appropriate research findings. The Board's program is carried out by more than 270 committees, task forces, and panels composed of more than 3,300 administrators, engineers, social scientists, attorneys, educators, and others concerned with transportation; they serve without compensation. The program is supported by state transportation and highway departments, the modal administrations of the U.S. Department of Transportation, the Association of American Railroads, the National Highway Traffic Safety Administration, and other organizations and individuals interested in the development of transportation.

The National Academy of Sciences is a nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce Alberts is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encouraging education and research, and recognizes the superior achievements of engineers. Dr. Robert M. White is president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences, by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Kenneth I. Shine is president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce Alberts and Dr. Robert M. White are chairman and vice chairman, respectively, of the National Research Council.

Transportation Research Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

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