Ten Years of Research Implementation and Technology Transfer for Local Agencies in Minnesota

E. L. SKOK, Jr., G. S. BODOCZY, and P. J. DIETHELM

ABSTRACT

The Minnesota Local Road Research Board has sponsored a Research Implementation Project for the past 10 years to help put research into practice for city and county engineers and other administrators of low-volume roads. The project was developed by (a) establishing an advisory panel or committee, (b) developing a prospectus that included goals and guidelines, (c) engaging a consultant, (d) presenting proposals including subject background to the advisory panel, and (e) ranking the projects selected by the panel in priority order. Implementation of each project included (a) obtaining an idea from the panel or staff, (b) gathering background information, and (c) developing an implementation plan that might include some or all of the following: slide tapes or videotapes, technical advisories, and memos. Implementation packages have been developed for pavement management (surface condition, rideability, calculation of equivalent 18,000-lb single axle loads, pavement strength, and a summary presentation); water quality; sprinkle treatments; load effects on pavements; statistics for end-result specifications; pavement recycling; use of geotextiles in road construction; research summaries; snow and ice control; and bituminous pavement repair techniques. Presentations and publications on these subjects have been made available around the state and throughout the country. The project staff has also been working with the various technology transfer centers in the upper midwest to help distribute more research information.

From the beginning there has been concern about how the new ideas and materials that result from research can be put to use. Researchers themselves usually are familiar with the materials they are working with and assume that practitioners will easily see the benefits of the new concepts or materials and immediately carry through with their application. Unfortunately, because of lack of time, interest, or follow-through for verification, many worthwhile new ideas are not used as soon as they could be. This problem exists in the transportation field as it does in many other fields of technology.

In Minnesota the Local Road Research Board saw a need for this step in the application of research to practice for local roads. They therefore set up a project to accomplish this. This research implementation project has now been operating for more than 10 years and has used many different approaches to developing new concepts and procedures:

1. To make local city and county engineers aware of a rating scheme for bituminous pavement surfaces, a slide show was developed and presented at seminars around the state. After the presentations, those attending the seminars practiced rating the surface condition of some local pavements. This same approach was used for rating the rideability and strength of pavements. Many users have documented large monetary savings by avoiding unnecessary work using this rating scheme.
2. Sprinkle treatment of bituminous pavements is an interesting method of obtaining a good surface. This procedure was suggested and developed as a demonstration project by the FHWA (1). Information on this procedure was gathered in Minnesota and sent to all city and county engineers by memo to generate interest in this process.
3. To make Minnesota local engineers aware of and able to design using geotextiles, an expert, the late T. Allen Haliburton, was asked to teach some seminars around the state. Then demonstration projects were set up and monitored. Research implementation pamphlets called "The Research Implementation Series" have been developed to briefly present the concepts of geotextile technology and how geotextiles can be designed into various types of projects. Situations in which geotextiles can be used as an economic alternative are also presented. Such pamphlets are advertised as available and are sent to anyone who wants them.
4. In 1980 10-ton routes were proposed in many locations around the state of Minnesota. There were even some proposals to have all routes increased in rated capacity to 10-ton routes. The staff of the Research Implementation Project were asked to gather information on this for the city and county engineers. A slide-tape presentation was developed and shown to technical, nontechnical, and political groups not only around Minnesota and in this country but internationally. This slide tape is an example of how relatively new technology can be disseminated in useful form to let the public know what the effect of higher axle loads would be. For such diverse audiences, extreme care must be exercised to make presentations as nontechnical as possible.

These are a few examples of how research has been implemented in Minnesota during the past 10 years with the Research Implementation Project. In this paper are discussed the development of the project,

E.L. Skok, Midwest Pavement Management, Inc., 1404 Concordia Avenue, St. Paul, Minn. 55104. G.S. Bodoczy and P.J. Diethelm, Minnesota Department of Transportation, Transportation Building, John Ireland Boulevard, St. Paul, Minn. 55155.

how it is funded, how it is administered, and the steps that are necessary to carry out an effective research implementation program. Above all, it is shown that the cooperation of many people from experts to laborers is required to effectively implement new topics and materials.

MINNESOTA LOCAL ROAD RESEARCH BOARD

Minnesota has had a Local Road Research Board for more than 25 years. This group has funded more than 50 useful projects and conducted and administered these through the Office of Research and Development of the Minnesota Department of Transportation (previously the Minnesota Highway Department). These projects cover many aspects of road design, construction, and maintenance.

Lukanen and Skok (2) have compiled a compendium of reports on projects funded by the Minnesota Local Road Research Board (LRRB). Also included are annotations and the implementation status of each project. The information contained in this work is of interest and use to Minnesota's local roads engineers. The topics covered include

1. Bridges,
2. Ice removal and salt,
3. Literature and research reviews,
4. Load capacity,
5. Miscellaneous,
6. Pavements,
7. Quality control and laboratory tests,
8. Specifications and standards,
9. Subgrade and base materials,
10. Surface treatments and crack sealing,
11. Trench studies, and
12. Vegetation and erosion control.

The Minnesota LRRB was formed in 1960 by the Minnesota Legislature and is funded with up to 1/4 of 1 percent of all municipal and county state-aid funds. This amounts to about $300,000 per year at present funding levels. Research is administered through the Office of Research and Development of the Minnesota DOT. Some research is conducted by that office and other projects are carried out by other public and private research agencies. As can be seen (2), through the years much good research has been completed, reported, and used by most state and local agencies in Minnesota. Much of this work has also been used in other states. Minnesota has also received the benefit of work done in the other states through similar exchanges of information. This work can be shared by the states through such forums as the Transportation Research Board (TRB), the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), the American Society of Civil Engineers (ASCE), the American Concrete Institute (ACI), the Association of Asphalt Paving Technologists (AAPT), the American Public Works Association (APWA), and the National Association of County Engineers (NACE). By participating in these organizations and attending meetings, researchers and practicing engineers can exchange ideas and interact with people doing design, construction, and maintenance work on roads. The people conducting the research must know what the real problems are before the work is started and, when the research is completed, the results must be presented in such a way as to be most usable to the practicing engineer.

The Minnesota LRRB helps in the first function by recommending and funding projects. In 1974 the Minnesota LRRB decided to sponsor a research implementation project (Investigation 645) so that new research work and concepts developed here and elsewhere could be made more directly usable by local and state agencies.

ADMINISTRATION OF THE MINNESOTA RESEARCH IMPLEMENTATION PROJECT

Research implementation and technology transfer have been helped by the Minnesota LRRB, which has initiated a project specifically aimed at implementation of research findings. The project was organized as follows:

1. An advisory panel was established and appointed by the Chairman of the LRRB. This panel consists of two county engineers, two engineers working for municipalities, a Minnesota DOT state-aid engineer, and two staff engineers from the Office of Research and Development.
2. The advisory panel was used to develop a project prospectus that included a definition of goals and some general guidelines for conducting the project.
3. A consultant was engaged to conduct the research implementation. The initial contractor was St. Paul Technical Vocational Institute. It was believed that an educational institution would be appropriate for this because they had access to audiovisual equipment and staff members would have expertise in various functions needed for the individual implementation packages. The consultant, after some study, developed a proposed set of implementations based on the advice of the project advisory panel. The project has been conducted by a private consultant (Midwest Pavement Management, Inc.) for the past 3 years.
4. The implementation proposals included subject background, technical subject, and proposed method of presentation. In some cases during the 10-year period, memos were sent to all city and county engineers to inquire what subjects they were interested in.
5. The project advisory panel then made a final selection of implementations and ranked the project activities in priority order for the staff.

SUMMARY OF IMPLEMENTATION

Many subjects and research activities have been covered during the course of this project. The form of the presentations has ranged from memos to city and county engineers to slide-tape shows, videotapes, and workshops with demonstrations. In this section the various research areas are summarized along with the type of implementation packages developed for each subject. In some cases there have been a number of different presentations made on the same subject to encourage use of the concepts.

Process

The implementation process has taken many forms. In some cases memos have been sent out informing local engineers of some new concept or material available. The feedback has then been analyzed.

The general implementation process has usually taken the following five steps:

1. An idea for a topic is presented. Ideas have come from many sources. The most important has been the project panel. Ideas have also been obtained from contact with Minnesota DOT and local engineers. Reports and attendance at national meetings are also

sources of useful new concepts. Project personnel also attend many local meetings so that they can find out from local engineers what types of problems they need solved or what new materials they are using or work they are doing that might be of interest to others. Being available to individual local engineers is an important step in implementation.

2. After ideas are generated, background information is gathered. This can be obtained by making a synthesis of publications, journals, or research reports on the subject. In some cases reports and other presentations have already been developed and only have to be modified for Minnesota conditions. An important part of this step is to contact a resource person who is an expert on the subject. Resource people have been Minnesota DOT employees such as Roger Olson, Richard Wolters, Dennis Luoto, and Rudy Ford; industry people such as Timothy O'Connell and Roy Boone; and national experts such as T.A. Haliburton (deceased), David Anderson, Herbert Southgate, and John Barron.

3. After the background material and resources are gathered, an implementation plan is developed. Various methods are considered. In some cases memos are sent out asking if there is more information available and if the subject is of general interest. If there is significant interest, a workshop may be set up. The workshop includes experts to discuss and give up-to-date background material on the topic. For instance, T.A. Haliburton and John Barron have come from Oklahoma to present a condensed version of a short course that was prepared for the FHWA. The short course was discovered in discussions at a planning committee meeting for the Third International Conference on Low-Volume Roads.

4. Visual aids including slide tapes, videotapes, or other types of training aids may be developed. At the workshops general applications are usually presented, whereas, for implementation in Minnesota, examples are developed that conformed to local uses and materials.

Technical advisories have been prepared to disseminate information on subjects that are considered particularly useful and implementable. These items and announcements have been sent to all city and county engineers in the state. Questionnaires have been included to find out how many have been using the new concepts.

5. The tying together of methods and the sequence of implementation are not always the same. How they have been carried out depends on the subject matter covered; how far the given subject has been developed; and, to some extent, what packages may be in existence from other sources.

For most of the subjects some type of presentation has been developed; these are listed in the Appendix. These are sent to each district state-aid engineer or made available through the Minnesota DOT Research Office. The marketing of these is done through meetings, announcements, and personal contact. Project personnel are available to local engineers for discussions on how best to use the new ideas, and engineers are also referred to local experts who can best help with the work. Eventually, project personnel will mostly refer local engineers to appropriate experts in the field for advice about proper use of a new procedure. However, periodic updating may be necessary.

The marketing strategy for each of the packages relies on contact with potential users of the information. This includes sending memos and announcements; attending city, county, and speciality conferences; and making presentations to make people aware of the research implementation effort and let them know what is available.

Implementation Packages

Since the Research Implementation Project started, there have been a number of packages developed. There have also been many informal and personal contacts made as part of the project. The major areas of effort have been in pavement management, water quality, sprinkle treatments, load effects on pavements, pavement recycling, geotextiles in road construction, end-result statistically based specifications, Minnesota research summaries, snow and ice control, and bituminous pavement repair techniques. Each of these areas has been approached in a different way, and the audience for each has been different. For instance, the research summaries are mostly for the engineers, whereas the snow and ice control slide tapes are for snowplow operators. In this section the packages are summarized and the methods used for presenting and selling the concepts are discussed.

Pavement Management

Slide shows with scripts were developed for surface condition rating of a pavement system, determination of the rideability of a pavement, calculation of the traffic factor (N18) on a pavement section for design purposes, and determination of the strength of a pavement section using the Benkelman beam device.

For the surface condition rating system a booklet was developed to illustrate the various conditions to be rated and the slide presentation was put into a slide-tape format. The slide show was originally developed in 1975 and was updated to the slide-tape show in 1983. This procedure has been used by some engineers in the area for determining when a pavement needs surfacing, whether it be a seal coat or overlay. The slide set was presented in workshops 10 times around Minnesota. The presentation was supplemented by practice rating sessions for the city and county engineers and maintenance people. More than 300 people attended these sessions.

The rideability slide set describes the use of the present serviceability rating for determining the rideability of pavement sections. Methods were presented whereby local agencies could determine the rideability with a panel or by measuring it using either the PCA roadmeter or the Maysmeter. This slide series was also presented in seminars around the state.

A slide set describing a method for predicting and calculating the load effect of traffic on a pavement section was developed. The equivalent load concept is presented and methods of estimating total traffic, truck distribution, and weight distribution of trucks in Minnesota are presented. A worksheet is used for making calculations and some problems are worked out during the seminars to help local engineers make the calculations.

Methods of determining the strength of pavements using the Benkelman beam deflection test in Minnesota were presented in the slide series on pavement strength. The Benkelman beam was the device available to measure the strength of a pavement section in 1976. The proper method of running the Benkelman beam test was presented along with the method developed by the Minnesota DOT to determine the allowable loading for a pavement section during the critical spring period. The appropriate factors to use to convert deflections during any period of the year to the critical spring deflections were presented along with temperature corrections and other factors necessary to appropriately determine pavement strength.

These four factors, surface condition, rideability, traffic, and strength, were combined in a summary report that was made available to all city and county engineers around the state. Examples were presented to show how city and county engineers could use the information to make appropriate decisions about when maintenance is required on their pavements and what maintenance procedure would be most appropriate for a pavement with particular conditions and traffic level. This set of slide shows and seminars was the primary effort of the Research Implementation Project staff for the first 2 1/2 to 3 years of the project. This early (1976) synthesis of relevant information was the first pavement management effort in Minnesota.

Water Quality

Water quality was of concern to both the Minnesota DOT staff engineers and to the city and county engineers in the mid to late 1970s because of increasing concern with the environment. Various references were obtained on the latest procedures and rules to follow for assuring continued good water quality during and after construction of both state and local roads. A memo was developed to alert local engineers to some of the newest developments in this area. The memo also gave a list of expert people to contact for help in evaluating these conditions.

Use of Sprinkle Treatments

In 1976 and 1977 the FHWA had developed as one of its demonstration projects the use of sprinkle treatments of aggregates on asphalt pavements. A number of sprinkle treatment installations had been made in Virginia, in Iowa, and in other states. This is a method of applying a high-quality rock to a soft asphalt surface and rolling the rock into the surface. A high-quality, skid-resistant surface results without using the high-quality rock throughout the total asphalt mix. Information and specifications were gathered and put into a memo on sprinkle treatments, which was distributed to the city and county engineers of Minnesota. An offer was made to help design and construct some pavements using this procedure. There was not a great deal of interest in this subject in Minnesota because in most areas good aggregate is available.

Load Effects on Pavement

One of the primary problems that Minnesota city and county engineers have with their pavements is determining what the allowable load capacity should be for a given route. In Minnesota this has been studied for almost 40 years using the flexible pavement design procedure, the plate load test, the Benkelman beam test, the Road Rater, and the falling weight deflectometer. These devices have not been available to the city and county engineers until lately. There were two projects that came under the general category of load effects on pavements.

One of these was brought about by Northern States Power Co. (NSP) because they wished to move some 375,000-lb. transformers over roadways between North Branch, Minnesota, and a location 5 mi to the south. As part of the research implementation work, an evaluation was made of the pavement proposed for the moves on the basis of surface condition, rideability, and structure. The structure was evaluated in terms of its condition and strength was measured with the Benkelman beam deflection device.

NSP rented a trailer with 92 wheels that had a hydraulically controlled suspension system. This suspension system kept an equal weight on each wheel and thus kept the individual loads within design limits. However, the total stress bulb under the large load was greater than for most loads. Evaluation of the pavement section and condition after the move showed that there was no measurable deterioration of the roadway due to the move of the five 375,000-lb transformers. This information was documented with slides and in report form and made available to the city and county engineers. It was presented at a number of conferences around the state.

In 1980 proposals were being made to increase the allowable load limit on single axles of trucks to 10 tons (20,000 lb). The effect of this increase would not necessarily show up as a dramatic decrease in serviceability or increase in cracking and rutting of pavements, especially on low-volume roads, but there would be a fatigue effect over a period of time. A slide-tape show was developed to bring out what some of the consequences would be of increasing allowable axle loads. This slide-tape show presented the equivalent load concept as a fatigue effect on pavement sections. The slide tape was developed so that city and county engineers could present it to truckers, city councils, legislators, and so forth, to point out the decrease in pavement life that would occur if the axle loads were increased. This slide-tape show was presented at many town councils and the state legislature. It has been distributed to all nine districts of Minnesota DOT and to many state DOTs around the country. It has also been translated into Spanish and used by the World Bank.

A publication was put together based on the slide-tape show on load effects on pavements. This report was also distributed to all city and county engineers in the state of Minnesota and to selected other engineers throughout the country.

Pavement Recycling

Pavement recycling has been used successfully in Minnesota since 1978. The first hot mix recycling research project was performed in 1976 in Maplewood. Minnesota DOT and many of the cities and counties have used the concept of recycling as an alternative to pavement rehabilitation since about that time. Hot recycling especially has become a good, usable tool for the stabilization of base courses. Many of the city and county engineers were not aware of how this procedure and concept could be used. Therefore, a slide-tape show was developed for showing at the state-aid engineers' meetings. This makes the city and county engineers aware of the recycling specification available from Minnesota DOT. It also warns the local engineers that proper design and construction procedures must be followed. A recycling job must be watched more carefully than a job using only new materials. The important parts of Minnesota DOT recycling specification 2332 were presented and it was indicated that this could be used as an alternative to standard reconstruction or stabilization procedures. A reference file has also been developed so that the project staff can respond to city and county engineers if they have problems with hot recycling projects.

In the past 3 years the concept of cold recycling has been developed. Cold recycling can be done essentially as base stabilization by grinding up the in-place material and spraying liquid asphalt emulsion or some other appropriate asphalt material into the recycled material. This procedure, along with crack and pothole repair, was covered in a bitumi-

nous repair workshop held in April 1984. Local staff put on the workshop and other experts were brought in from Canada, Pennsylvania, and other parts of the United States to present the updated procedures that are currently being used for each of these three processes. At the workshop the attendees were asked if they would be interested in participating in a demonstration project in the field. Allen Goodman, the Lake County engineer, stated that he would like to work further on this project. After some developmental work, pavement sections near Knife River were selected for cold recycling. A BROS reclaimer machine was used to grind up and mix asphalt emulsion into the existing ground-up pavement structure. This was a cooperative effort among Lake County, Minnesota DOT, Koch Asphalt Co., and the Research Implementation Project staff. This project showed that the cold recycling concept can be used for low-volume road applications. The project was done in August 1984 and is performing quite well considering the type of construction used. In 1985 more cold recycling projects were done in Winona and Sibley Counties, Minnesota.

A research implementation series publication is planned to review the concept of cold recycling and how it can be economically used in Minnesota. Some drawbacks and precautions are also presented so that city and county engineers will have a good idea of both what can and what cannot be done with cold recycling.

Geotextiles in Road Construction

During the past 10 years there have been many projects done around the country using engineering fabrics or geotextiles to aid in the construction of road and other embankment-type construction. Geotextiles have been valuable in helping stabilize very weak subgrade soils such as those in swamp and beach areas. They also work well as a separation layer between granular materials and fine-grained soils. They can be used in erosion control as silt fences and have been used with some mixed success as interlayers in pavement sections. Many engineers saw the application of geotextiles as a save-all procedure under just about any conditions. Manufacturers also saw geotextiles as solutions to just about any type of construction problem. Geotextiles had worked well beyond the imagination on some projects with little analysis or documentation of properties or construction conditions. The U.S. Army Corps of Engineers and the FHWA cooperated to categorize the use of geotextiles and document what types of geotextiles are appropriate for given applications.

A manual was written by the late T. Allen Haliburton et al. (3). He and his associates wrote a complete manual on the design and construction of projects with geotextiles. They developed slides and set up a 4-day school for presentation of this material to engineers throughout the country. This project, sponsored by the FHWA, was done for the purpose of presenting the most up-to-date material on geotextile technology. In 1981 geotextile technology was one subject that the Research Implementation Project advisory panel thought was critical and, therefore, the project staff began looking for ways to make this information available directly to Minnesota engineers. The FHWA was contacted and gave permission to have the geotextiles manual (3) reprinted and distributed to all of the city and county engineers in Minnesota. Haliburton was contacted and, in the winter and spring of 1982, presented four 2-day schools in Minnesota. These were in Brooklyn Park, Mankato, Brainerd, and Maplewood.

At these schools slides were used to supplement Haliburton's presentation and discussion and there were some problems actually worked out by the attendees. A total of 240 people attended these workshops.

Questionnaires were handed out at the workshops and the attendees were asked how they could most effectively use the concepts that were presented. They were asked if they would be willing to put in some trial geotextile sections in their own county or city areas. A number of them responded positively, and many people believed that follow-up workshops, in which more specific design information could be presented, should be held. The original workshops in Minnesota were 2-day condensations of the 4-day workshop that had been developed for the FHWA. Many of the design problems that were to have been worked by the attendees were omitted due to lack of time. Haliburton passed away in the fall of 1982 and, therefore, one of his associates, John Barron, was contacted to put on a number of schools that would include design examples using geotextiles. Four schools were again put on, two in the Twin Cities area, one in Marshall, and one in Park Rapids. At these schools much of the same general material was summarized and then there was time available for the attendees to work out some design problems. A total of 180 people attended these four workshop sessions.

Minnesota DOT had been using geotextiles in various types of construction for a number of years. These applications included stabilization of embankments, erosion control, and pavement interlayers. A number of counties decided to try the various applications of geotextiles. There follow a few examples of these.

1. Wright County constructed a road in a swamp section using geotextiles as stabilization. This was done in 1977 and is an example of successful use of geotextiles in Minnesota. This project had been well documented by the Wright County Engineering Department and was discussed in a paper at the 1983 TRB Low-Volume Road Conference. Similar projects were also built in Cass County and Pine County. These projects have been well documented by the respective county engineering departments and are used as examples of how to properly use geotextiles for embankment construction.
2. St. Louis County has been using geotextiles as separation layers between clay-type soils and granular base materials. Installations of these have been in service now for more than 5 years. Areas of frost boils and soft spots have been successfully rehabilitated with these procedures.
3. As mentioned, Minnesota DOT has two projects in which they are evaluating the use of geotextiles as pavement interlayers. So far these have met with mixed success and a well-documented design procedure has not been developed. This continues to be studied and materials such as geogrids may be available in the near future for this use.

Implementation of the use of geotextiles in Minnesota has been carried out for this project by reviewing as much literature as possible on the subject and talking with experts within Minnesota, such as Graham R. Ford of the Soils and Geology Section, and some local suppliers. National experts were contacted to help generate more interest and to educate Minnesota engineers about what geotextiles can and cannot do and how to design engineering structures. Installations were encouraged and documented after the schools were completed. Research Implementation Series publications have covered the various applications of geotextiles and how to property set up and use them. As more information becomes available on this subject, the staff of the Research Implemen-

tation Project will try to document and make available this more up-to-date design and construction information.

End-Result Statistically Based Specifications

In 1977 the Minnesota DOT started using statistically based specifications. The FHWA sponsored the development of a short course at the Pennsylvania State University to help practicing engineers and technicians see how to apply statistics to the materials used for highway construction. This 2 1/2-day short course was taught in each of the nine districts of Minnesota DOT. It was available to all interested Minnesota DOT, city, and county engineers and technicians. A total of 180 people participated. The workbook developed under the sponsorship of FHWA (4) was distributed to each of the attendees.

Minnesota Research Summaries

The Research Implementation Project panel believed that it would be useful to have a listing of all research projects that had been conducted over the years by the Office of Research and Development at Minnesota DOT. There have been projects sponsored directly by Minnesota DOT, the LRRB, or the FHWA and in cooperation with other states and national organizations. These projects were classified as investigations, special studies, and local documentations. In some cases the findings have been fully implemented and in others only partly. In some cases the projects have not received much attention since they were completed. Occasionally new products and projects have been proposed when there had been similar work done in the not-too-recent past. Therefore a listing of projects including a statement on how they had been implemented was considered useful. Two of the three planned research implementation summaries have been completed.

The first research review (2) covers the implementation status of research projects that have been sponsored wholly or in part by the Minnesota LRRB since 1959. These projects cover a wide variety of subjects including geometric standards, pavement design and evaluation, materials evaluation, and roadside turf establishment. Much of the information from these projects has been of value to all city and county engineers as well as Minnesota DOT engineers and industry. In addition to a statement indicating how each of the projects is being implemented, recommendations are included regarding further implementation. As more implementation or changes in the status of the projects occur, updated pages will be prepared and distributed. For particularly significant projects, a Research Implementation Series pamphlet is produced. The projects have been put in the categories of bridges, ice removal and salt, literature and research reviews, load capacity, miscellaneous, pavements, quality control and laboratory tests, specifications and standards, subgrade and base materials, surface treatments and crack sealing, trench studies, vegetation, and erosion control.

A second implementation review publication (5) has been completed and includes a listing and review of all investigations conducted by the Office of Research and Development. Some of these were sponsored by Minnesota DOT and some by the FHWA.

A third compendium of research and implementation summaries is planned to cover the various special studies that have been conducted by the Office of Research and Development.

Snow and Ice Control

The project implementation panel believed that the subject of snow and ice control is of great interest to all city and county engineers and maintenance personnel, and that there had been much new information and many new procedures developed on this subject in the past few years. Also, there have been many retirements of maintenance personnel and it would be good to have some type of videotape or other presentation available to show new personnel. The project staff contacted Pat Chandler, retired maintenance engineer from the Golden Valley Minnesota DOT district office, who gave technical assistance and coordinated presentations on snow and ice control. With the cooperation of the maintenance sections of both the Oakdale (District 9) and the Golden Valley (District 5) offices of Minnesota DOT, videotapes were prepared on truck preparation, snowplow attachment, and the general concepts of snowplowing.

The presentation on truck preparation shows the proper check-out procedure that each driver should go through daily before using the truck. The snowplow attachment videotape shows the attachment procedure used on Minnesota DOT Type-33 trucks. In this way the attachment procedure can be shown without having to have a truck available.

The general videotape, entitled "The Snowfighters," describes general snow removal techniques and the importance of the job. It can be shown to new employees to make them aware of the great importance of the job and some general procedures that will help them carry the job out properly. Making this videotape required much time to obtain good shots of actual snow removal operations in the field.

It is hoped that by preparing these videotapes the research implementation staff has encouraged the training section of Minnesota DOT and the various other sections to develop similar training aids and other publications to help train in-service and new employees.

Bituminous Pavement Repair Techniques

One of the great needs of the past few years has been to develop and use proper techniques for repairing pavements. There have been more than 100,000 mi of pavements constructed in Minnesota during the past 50 to 60 years, and to keep these in serviceable condition will require continual maintenance and rehabilitation work. It has been found that the most economical way to maintain a pavement is to make the repair as permanent as possible so that a particular location does not have to be repaired repeatedly. If pavements are deteriorating during the cold wet seasons, it is not always possible to go through the proper procedures and more emergency-type measures must be used. Repairs made under emergency conditions should be replaced with more permanent repairs during the summer season.

Work in this field was reviewed by the project staff and it was decided to sponsor a pavement repair conference at which local experts and others from around the country would be asked to present some state-of-the-art knowledge on this subject. In April 1984 a conference was held in St. Paul. The conference covered the latest information on pothole repair techniques, crack repair and filling methods, and seal coat and surface treatment procedures. The Office of Research and Development participated in this conference by making the attendees aware of projects that have been conducted by Minnesota DOT along with the status of these projects. There were 135 attendees at this conference including county

engineers, city engineers, and maintenance supervisors.

As a follow-up to this conference it was believed that workshops should be presented at which there could be demonstrations of the procedures presented. In 1985 five workshops were developed and presented. At these workshops Minnesota DOT engineers reviewed projects and procedures that are appropriate for crack, pothole, and surface repair. Local crews and some manufacturers provided equipment and materials to conduct field demonstrations of the procedures. There were between 45 and 55 attendees at each of these workshops, which were held at Marshall, Normandale Community College in Bloomington (2), Detroit Lakes, and Virginia. The benefits of these workshops have been ascertained from the evaluation sheets. Just about all subjects were well received. Workshops like these make it possible for people to get together and have presentations and discussions on the various aspects of proposed new techniques.

A slide show on causes of and proper repair techniques for potholes was prepared by the Pennsylvania DOT. This show has been adopted to cover Minnesota conditions and has been distributed around Minnesota.

Each of these projects has required the cooperation of many people, in particular the staff of the Office of Research and Development of Minnesota DOT. These include Gabriel Bodoczy, Roger Olson, Ronald Cassellius, Donald Caswell, and Ronald Canner.

As can be seen from the review of the projects conducted for the Research Implementation Study, there have been various procedures used. These procedures have been categorized as

1. Research Implementation Series (RIS),
2. Slide show (SS),
3. Slide tape (ST),
4. Research Implementation publication (RIP),
5. Videotape (VT),
6. Memo (M),
7. Workshop (WS),
8. Seminar (SM), and
9. Demonstration project (DP).

The following listing shows which of these procedures or methods were used for the implementation subjects.

Pavement management	
Surface condition rating	SS, ST, RIP, SM
Traffic--18,000-lb single axle equivalent load calculation	SS, RIP, SM
Rideability	SS, RIP, SM
Pavement strength	SS, RIP, SM
Summary presentation	SS, RIP, SM
Water quality	M
Sprinkle treatment	M
Statistically based specifications	RIP, WS
Load effects	
Transformer moves	RIP, DP
Truck effects on pavements	ST, RIP, SM
Recycling	ST, RIP, SM, WS, DP
Use of fabrics in road construction	M, SM, WS, DP, RIS
Minnesota research summaries	RIP (3)
Snow and ice control	M, VT
Pavement repair and maintenance	VT, SM, WS, DP

As can be seen from this list, the subject and available information dictate the type of research implementation package to use for a particular topic.

Interaction with Technology Transfer Centers

The FHWA has sponsored technology transfer centers, which have as part of their operation research implementation work throughout the country. In the upper Midwest, centers are located at the North Dakota State University in Fargo, the University of Wisconsin in Madison, and Iowa State University in Ames. The center at North Dakota State University has as part of its responsibility serving the state of Minnesota. The purpose of these technology transfer centers is to convey new technology to the county, city, and township engineers and other people responsible for the design and maintenance of transportation systems. The technology transfer centers have, in addition to research implementation, the task of training maintenance and other highway personnel. They are involved with the setting up and distribution of slide-tape shows and videotapes, conducting workshops, and publishing newsletters. The staff of the Minnesota Research Implementation Project has cooperated with the North Dakota State University staff in putting on a transportation conference in Fargo. Other areas of cooperation are also being developed.

SUMMARY

Minnesota has had a Research Implementation Project for more than 10 years. During this 10-year period the project has resulted in many research implementation packages. The written reports and various other presentations are listed in the Appendix of this paper. As can be seen from the Appendix and the previous list, there are many different approaches that can be taken to developing research implementation packages. The one chosen depends on the audience to be served and the subject matter being considered.

The Minnesota LRRB, which was created in 1959, has sponsored many research projects for local application in Minnesota since that time. The Research Implementation Project has been administered by an advisory panel appointed by the chairman of the Minnesota LRRB. The steps required to conduct the project and develop research implementation packages are

1. Establish an advisory panel;
2. Develop a project prospectus including a definition of the goals of the project and some general guidelines for conducting the project;
3. Engage a consultant to conduct the research implementation; the consultant, after some study, should develop a proposed set of implementations to present to the advisory panel;
4. Present proposals including subject background and technical support to the advisory panel; and
5. Select implementation packages by ranking the project activities in priority order for the staff.

The implementation packages have consisted of slides, narrations, slide shows, slide tapes, publications, videotapes, memos, workshops, seminars, and demonstration projects. The 10 or more implementation areas that have been worked on are discussed in this paper and various forms of implementation have been used within each of the general areas as deemed appropriate. The implementation process has generally included the following steps:

1. Obtaining an idea from the panel or staff;
2. Gathering background information; and
3. Developing an implementation plan that can include some or all of the following: (a) visual

aids such as slide tapes or video tapes, (b) technical advisories, and (c) memos.

The 10 areas are pavement management, water quality, sprinkle treatments of asphalt pavements, statistics for end-result specifications, load effects on pavements, pavement recycling, use of geotextiles in road construction, Minnesota research summaries, snow and ice control, and bituminous pavement repair techniques. Presentations and publications on these various activities have been presented around the state and are being used by many local city and county engineers throughout Minnesota. Some have been distributed around the country as well as internationally.

The project staff is now cooperating with the technology transfer centers sponsored by the FHWA to help further develop and disseminate implementation packages.

REFERENCES

1. C.L. Huisman and L. Zearley. Evaluation of 1977 Iowa Asphaltic Concrete Sprinkle Treatments. FHWA, U.S. Department of Transportation, June 1978.
2. E.O. Lukanen and E.L. Skok, Jr. Research Review, Vol. 1: The Implementation Status of Local Road Research Board Projects. Investigation 645. Research Implementation Publication, Minnesota Department of Transportation, St. Paul, July 1983.
3. T.A. Haliburton, J.D. Lawmaster, and V.C. McGuffey. Use of Engineering Fabrics in Transportation Related Applications. Office of Development, FHWA, U.S. Department of Transportation, Dec. 1981.
4. J.H. Willenbrock. A Manual for Statistical Quality Control of Highway Construction. National Highway Institute, FHWA, U.S. Department of Transportation, Jan. 1976.
5. M.M. Marti, E.O. Lukanen, and E.L. Skok, Jr. Research Review, Vol. II: The Implementation Status of Local Road Research Board Projects. Investigation 645. Research Implementation Publication, Minnesota Department of Transportation, St. Paul, Feb. 1985.

APPENDIX--PUBLICATIONS AND PRESENTATIONS OF THE RESEARCH IMPLEMENTATION PROJECT

Publications

1. Surface Condition Rating System
2. Rideability
3. Calculation of Equivalent 18,000-lb Axle Loads
4. Determination of Strength with the Benkelman Beam Deflection Test
5. Summary Report on Measurement of Pavement Conditions and Evaluation Techniques
6. Statistical Calculations for Highway Material End-Results Specifications
7. Load Effects on Highway Pavements
8. Use of Nonspecification Fine Aggregate Asphalt Hot Mix Materials--Research Implementation Series No. 1
9. Research Review, Vol. 1: Minnesota LRRB Projects
10. Research Review, Vol. 2: Minnesota DOT Investigation Report Summaries
11. Research Review, Vol. 3: Summary of Special Reports
12. Summary of Geotextile Usage--Minnesota Research Implementation Series No. 2
13. Use of Geotextiles for Roadway Embankment Construction--Minnesota Research Implementation Series No. 3
14. Use of Geotextiles as Separation Layers--Minnesota Research Implementation Series No. 4

Audiovisual Presentations

1. Surface Condition Rating System: slide show with written narration
2. Rideability: slide show with written narration
3. Calculation of Equivalent 18,000-lb Single Axle Loads: slide show with written narration
4. Measurement of Strength with the Benkelman Beam Deflection Test: slide show with written narration
5. Summary of Pavement Conditions: slide show and report
6. Load Effects on Highway Pavements: slide-tape show
7. The Use of Recycled Materials in Minnesota: slide-tape show
8. Surface Condition Rating System: slide-tape show
9. Pothole Repair Techniques: slide-tape show
10. Inspection of Minnesota DOT Type-33 Truck: videotape
11. Attachment of Standard Minnesota DOT Snowplow: videotape
12. The Snowfighters--A General Guide for Snowplowing: videotape

Publication of this paper sponsored by Committee on Conduct of Research.