Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-97/1461-1F		

4. Title and Subtitle	5. Report Date
DATA INTEGRATION FOR PAVEMENT RESEARCH	November 1996
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Thomas J. Freeman, P.E. and Dr. Roger E. Smith, P.E.	Research Report 1461-1F

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135	11. Contract or Grant No. Study No. 0-1461

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Texas Department of Transportation Research and Technology Transfer Office P. O. Box 5080 Austin, Texas 78763-5080	Final: December 1994 - July 1996
	14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.
Research Study Title: Data Integration for Pavement Research

16. Abstract

The Texas Department of Transportation (TxDOT) has conducted numerous formal pavement research projects. In addition, many districts have conducted less formal, but often very important, evaluations of new materials, new treatments, and new techniques. In some of these activities, special sections of pavement were constructed. After the project was finished or the person responsible changed positions, information for the test section was lost.

When a research project is initiated, those in charge of conducting the research almost always begin by reviewing related research. In the past, information on previous research sections may not have been available in a medium that could be retrieved, or the information may not have been available at all. This study was designed to develop a plan for identifying in-service pavement sections that are being used for research and to store the information in a medium that will be accessible to those interested in reviewing previous research related to their work.

17. Key Words	18. Distribution Statement
Pavement Database, Pavement Research, Data Storage	No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	34	

DATA INTEGRATION FOR PAVEMENT RESEARCH

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Research Report 1461-1F
Research Study Number 0-1461
Research Study Title: Data Integration for Pavement Research

Sponsored by the
Texas Department of Transportation
In Cooperation with
U.S. Department of Transportation,
Federal Highway Administration

November 1996

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IMPLEMENTATION RECOMMENDATIONS

This report describes the feasibility of developing a research database where data would be stored on previous test sections around the state. When researching a particular maintenance or construction technique, the TxDOT employee or researcher could search this database for in-service examples.

This project would benefit TxDOT by ensuring that once test sections are constructed, the data collection effort would continue and research knowledge would be retained. This effort would also support and augment the Flexible and Rigid Pavement Databases by adding specific research sections. Having a database of research test sections would also support network and project level pavement management. Proposed rehabilitation techniques would have their performance documented in the database which would help with project justification. This research would also be a contribution to the integration of highway management systems required by ISTEA. We strongly encourage the development of this database.

The results of this study will be to propose a change in the submission of TxDOT reports. In addition to the standard final report, a diskette containing separate files for the abstract, key words, executive summary, and data files will be required. Future projects should require that a search of the integrated database be conducted as part of the literature search. To fully implement the monitoring of district projects, it will be necessary to modify training for district personnel.

ACTION ITEMS

1.0 Develop Data Entry Screens

1.1 Develop data entry screens and fields to allow entry of the header information to identify the specific research study to which the section is related. This would include the title of the study, project number, the contact person responsible for the study, a list of written reports available about the work, a series of key words that designate the types of items included in the research, and a description of the type of data available on this pavement research section.

1.2 Develop data entry screens and fields to allow entry for each of the standard inspection formats.

1.3 Develop data entry screens and fields to allow entry of the project specific data, laboratory, field, material data collection, and the location of other data.

2.0 Pavement research sections should be designated in PMIS to identify these sections so that they are not lost or covered accidently, and so that they can be identified for inspection more often, if necessary.

3.0 A search engine, on the mainframe, will need to be developed to access the data in the header files in order to limit the data selected. This search engine will also need to access PMIS and layer files.

4.0 Change the submission of TxDOT reports. In addition to the standard final report, a diskette containing separate files for the header information, abstract, key words, executive summary, and data files will be required. Future projects should require that a search of the integrated database be conducted as part of the literature search. To fully implement the monitoring of district projects, it will be necessary to include training for district personnel.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. The engineer in charge of the project was Thomas J. Freeman, PE# 062-044540 IL.

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SUMMARY

Each year TxDOT conducts in excess of thirty research projects and numerous special studies in the districts. In completing these projects, researchers or TxDOT personnel build test sections, conduct laboratory tests, collect and analyze data, and write research reports. The data collection effort of the research is often more expensive than the data analysis. When related research is performed, similar research studies are reviewed, if they are known, but too often the previously built test sections have become lost, inadvertently overlaid or rehabilitated, or data collection efforts stopped with the end of the original project. The data is often only presented in summarized form as part of the final report, and the basic data is not available to other researchers. The result is that the data must be collected again and knowledge is not retained.

The main objective of this study is to determine the feasibility of establishing a single, organized repository for all pavement-related data generated by TxDOT and TxDOT funded research projects. We have determined that this is feasible and have developed a plan for the database structure and proposed retrieval interface.

A pavement research database would be a collection of data that includes information of importance to TxDOT in conducting special studies about pavements. We are proposing a series of data formats that would be used in conjunction with the current designation of PMIS research section. When a pavement research section is designated, either as a new construction or as a collection of existing sections, information will be assembled and a series of data fields will be completed for the section to identify the specific research study to which the section is related. This would include the title of the study, project number, the contact person responsible for the study, a list of written reports available about the work, a series of key words that designate the types of items included in the research, and a description of the type of data available on this pavement research section.

CHAPTER 1. BACKGROUND AND OBJECTIVES

BACKGROUND

The Texas Department of Transportation (TxDOT) has conducted numerous formal pavement research projects. In addition, many districts have conducted less formal, but often very important, evaluations of new materials, new treatments, and new techniques. In some of these activities, special sections of pavement were constructed. After the project was finished or the person responsible changed positions, information for the test section was lost.

When a research project is initiated, those in charge of conducting the research almost always begin by reviewing related research. In the past, information on previous research sections may not have been available in a medium that could be retrieved, or the information may not have been available at all. This study was designed to develop a plan for identifying in-service pavement sections that are being used for research and to store the information in a medium that will be accessible to those interested in reviewing previous research related to their work.

TxDOT personnel who want to try a new material, technique, or treatment may use this database as a resource to review and determine if others within TxDOT have already tried that material, technique, or treatment. It will also provide information to researchers on previous research in a particular area including information about the number, type, and amount of data available to support the research.

OBJECTIVES

The main objective of this study is to determine the feasibility of establishing a single, organized repository for all pavement-related data generated by TxDOT and TxDOT funded research projects. We have determined that this is feasible and have developed a plan for the database structure and proposed retrieval interface.

In order to accomplish this objective, we have determined the steps needed to support the development of an integrated database:

- determining, in general, what data will be stored in the database,
- identifying the requirements of candidate sections including data collection and monitoring,
- listing procedures for determining whether a section is included,
- developing the integration with PMIS,
- determining the location of layer and traffic information,
- determining the information should be included and in what format the output should be,
- determining whether recently completed projects can be included, and
- evaluating the alternatives for data storage and retrieval.

In addition, changes will need to be made to future research projects to ensure compatibility with the database. A requirement would be made that data from selected funded projects would be turned over in standardized, electronic form with the final report. This data would be checked, copied, archived, and abstracted at a central location.

GENERAL

A pavement research database would be a collection of data that includes information of importance to TxDOT in conducting special studies about pavements. When the TxDOT Pavement Management Information System (PMIS) was developed, several different methods for defining sections were included. One method recommended for inclusion was the definition of a research section. This project plans to make use of this ability in PMIS to designate pavement research sections to help develop a pavement research database.

We are proposing a series of data formats to be used in conjunction with the current designation of PMIS research section. When a pavement research section is designated, information will be assembled and a series of data fields will be completed for the section to identify the specific research study to which the section is related. This would include the title of the study, project number, the contact person responsible for the study, a list of written reports available about the work, a series of key words that designate the types of items included in the research, and a description of the type of data available on this pavement research section.

COLLECTING BACKGROUND INFORMATION

In this task we gathered and assimilated the background information and made contacts with the FHWA regarding the status of databases in other states. The literature search was not productive. Most of the titles dealt with the development of pavement management (37%), traffic (15%), or the SHRP (Strategic Highway Research Program) database (13%).

We spoke with Mr. Frank Botelho of the FHWA about databases in other states. Although the ISTEA regulations encourage the development of performance-related databases, Mr. Botelho says that none currently exist. He was very interested in the results of this research project.

CHAPTER 2. DATABASE DESCRIPTION

LEVELS

A pavement research database must be carefully defined. If too little data is included, it will be of little value. However, if it requires too much data, TxDOT may not be able to keep the data current because of the cost. This has led to the concept of developing different levels for storing data depending on the importance of the study and the cost of collecting the data.

A global database currently exists in the form of the management sections in the existing PMIS database. However, there is relatively limited data about the thousands of sections in the PMIS database, which limits the amount of analysis that can be completed. For instance, there is no information about the thickness of the base materials, nor is there information about the material types in the base. Therefore, the data can only be used to develop general relationships, such as a comparison of how thick asphalt pavements perform compared to Portland cement concrete pavements, or how thin asphalt pavements perform in South Texas compared to how they perform in East Texas.

To facilitate development of pavement research sections, we propose to develop various levels. These levels are differentiated based on the data collected and stored. This will allow the storage of data from simple to complex without unduly complicating the current PMIS database structure. We propose a database with three levels, the proposed levels are as follows:

LEVEL 1 - Basic Data

A list of test sections arranged by category of treatment. This level identifies sections in the data base that have treatments that the department or researches need to evaluate over time, but special data is not collected. Examples that could be considered are:

Cold Mix Recycling
RAP in Black Base
Granular Overlay of Crack and Seated JCP
Horizontal Drilling to Install Transverse Drains
Granular Overlay and Stabilization of FM Roads
Lime/Fly Ash Stabilization

Header Data Includes:

District	Highway	CSJ
Contact Person	Report Number	Date Constructed
TRM Start	TRM Stop	Treatment Category
Data Collection Category	Brief Description of Treatment	
Data Available		

LEVEL 2 - Performance Data

All data from Level 1, and additional information that are generally standard data.

Examples include:

Distress Survey Prior to Construction[1]	
Yearly PMIS or Yearly Inspection Data	
Layer Data from Layer Database	Construction Information
Admixture Content	Are Specs Available (Y/N)
Other Data	

LEVEL 3 - Laboratory and Project Specific Data

All data from Level 1, and other data that are in a format that is non-standard for the current TxDOT data.

Examples include:

Laboratory Test Data	Non-standard Performance Data
SHRP Type Data	Location of Data Not Stored in the Database
Data Not Yet Defined	

When users query the database, they would start with the Level 1 data to determine if appropriate test sections and data exist. Then, if more specific data are required, a Level 2 report of the sections identified in the Level 1 search can be performed. Depending on the purpose of

[1]The concept of collecting data prior to treatment or construction needs to be instituted throughout all new TxDOT pavement test sections. The performance of a treatment is dependant on many factors, many of which can be measured after construction. However, too many times the pre-construction condition is not collected, and two pavements which have otherwise similar characteristics perform differently due to one being in relatively better or worse condition.

the investigation, specific test sections can be queried at Level 3, or requests for a report of test sections which have data in a specific table can be made.

CATEGORIES OF DATA COLLECTION

Different types of test sections will be monitored with different types of condition surveys ranging from the standard PMIS inspection where categories of extent are estimated, to a full SHRP level inspection where all distresses are mapped and measured, to data from a project specific inspection where a specific inspection is performed. An example of this last type of inspection would be conducting a Sand-Patch test on chip seals to determine macro texture. The type of condition inspection performed will be an important part of the Level 2 data. The types of inspections are categorized below.

Standard PMIS Condition Data

This type of section would use the condition data as it is currently collected in the normal PMIS data collection process. However, it would have special data attached to the section. As an example, consider a research project to determine the performance of rigid pavements that have been rehabilitated with a break and seat and overlay compared to the performance of rigid pavements rehabilitated with a standard asphalt concrete overlay. This would normally include an evaluation of how the condition of several sections of pavement rehabilitated with each treatment change over some period of time.

The TxDOT PMIS currently collects information on distress on half-mile sections, roughness on tenth-mile sections, and deflection on half-mile sections. All of these start at standard points and progress through the length of the road in a county or district. The data is collected on a standard schedule annually or biennially. If the standard PMIS data gives adequate information to define difference in performance, the data currently being collected by TxDOT can be used to determine the difference in performance. If the research test sections are standard construction sections, then they will generally be long enough that these data collection intervals will be adequate to define the condition of both methods of treatment.

The thickness of the various layers, strength of the subgrade, level of traffic loadings, environmental conditions, and construction could all affect how well each treatment would perform. However, the current database does not include information about the pavement layers and subgrade. To effectively analyze the performance, information affecting the performance, such as layer information, would need to be collected and stored in the database.

Since considerable work was invested in conceptual development of an automated roadlife file, we propose to use that structure for storing layer data in the research database. The research identification data would include information stating that pavement layer data are available for that section.

To summarize, this type of section would use the standard condition data collected during the normal PMIS data collection activities to determine the change in condition over time of the various sections. There is no need for special data on condition information in this type of section. Additional data on pavement layers would need to be collected and stored in the research database. The person analyzing the data would know what additional data are present because the identifying information indicates what additional data is available. That layer data would be available in a standard format accessible to the interested party. Whether it would be in the same database as PMIS data or in another accessible database has not yet been determined.

PMIS Data on Short Sections, Collected at Non-Standard Intervals

Some specially constructed sections are relatively short. This means that the condition data collected using the standard PMIS procedures would not be appropriate since the research sections could be shorter than the PMIS data collection section or the research sections could be located partly in two different standard data collection sections. If the PMIS definitions of condition are adequate, then the standard distress, roughness, and deflection definitions and data collection approaches could be used, except that the location and length of the data collection would be different.

In other situations, the PMIS data is adequate except that it needs to be collected more often (i.e., semiannually). The deflection data might need to be collected at 50- or 100-meter intervals rather than the standard PMIS interval. The deflection data might need to be collected

in both the wheel path and the center of the lane, or possibly the deflection data is needed in all lanes rather than the outside lane.

This would require a special data collection and data entry effort. The PMIS data definitions would be used, but a walking distress survey might be conducted for the entire short research section. The data would need to be stored in a condition data file separate from the standard PMIS data file. However, the format of the data storage file could be copied from the current PMIS data structure. The section would probably have additional data on the pavement layers as described above. Condition data might be collected at time or distance intervals different from those used in the standard PMIS process.

To summarize, this type of section would use the standard PMIS condition data definitions and collection techniques, except for location, length, and timing of data collection. A special data collection effort would be required. The data would be stored in a special research database structure; however, that data structure would basically be a duplicate of the existing PMIS condition data structure. The person analyzing the data would know that the additional data are present because the identifying information would indicate what additional data are available.

This type of section could be used with the Mobile Load Simulator (MLS) test sections to ensure the data could be used to correlate with the data collected in the PMIS database.

Standard SHRP Data Collection on Short Sections

The Strategic Highway Research Program (SHRP) Long Term Pavement Performance (LTPP) program developed a standard method for collecting condition data on 152 m (500-foot) long test sections. The definitions of condition are somewhat different from those used in the TxDOT PMIS. Because these were developed for research, the data collection procedures are much more intense than those used in the TxDOT PMIS, including mapping all cracks each time the condition data is collected and extensive deflection testing in wheel paths and between wheel paths. The current methodology requires that all measures of condition be collected by equipment or from film. These procedures are currently recognized as a standard method of collecting data for research activities. The data structures for the condition data are available and

could be used to develop database formats for research sections being evaluated with the SHRP procedures.

This level of data collection would not only require a special data collection, special equipment, and entry effort, it would require that those collecting the data be trained in the SHRP LTPP data collection procedures. In addition, the crack maps will need to be stored in a designated location. The data structure should provide information to the analyzer about where these are physically located and the time the measurements are conducted. The timing of data collection intervals might vary from those used in the TxDOT PMIS process. Additional information on pavement layers may also be stored.

To summarize, for this type of section the standard SHRP data collection procedures would be used. Special data collection efforts would be required. The data would be stored in a data structure based on that currently used by FHWA and TRB to store SHRP condition information. The person analyzing the data would know that SHRP condition information is available because the identifying information would indicate what additional data are available.

It is doubtful that TxDOT would complete such a full SHRP evaluation. However, there are more than a hundred SHRP test sections in Texas. It would be possible to develop a data structure that would store selected data currently being collected by the FHWA SHRP contractors. That data could then be imported into the TxDOT research database for use directly by TxDOT and research personnel.

Modified SHRP Data Collection

This procedure would be the same as described for standard SHRP, except that some of the standard SHRP procedures might not be followed. For instance, crack maps would not be required; distress might be collected manually; rutting might be measured manually using a string line or rut gage; or rutting might be collected using the TxDOT rut bar equipment instead of the SHRP equipment. The research sections might not be exactly 152 m (500 feet) long. The data structure for the standard SHRP sections would be used for the modified SHRP as much as possible, or as much as needed. However, a method to identify those procedures that are different from the standard SHRP methods would need to be designated.

To summarize, for this type of section the SHRP data collection procedures would be used with some modification. Special data collection efforts would be required. The data would be stored in a data structure developed based on that currently used by FHWA and TRB to store SHRP condition information. The person analyzing the data would know that SHRP condition information is available because the identifying information would indicate what additional data are available. The data structure would identify the data elements that were collected by a procedure different from the standard SHRP methods with a reference to the differences.

This type of section might be appropriate for MLS test sections. It is currently used for the TxDOT SMERP (Supplemental Maintenance Effectiveness Research Program) sites.

Project Specific Data Collection

In some cases neither the TxDOT PMIS nor the SHRP condition definitions will be adequate to define the performance of a section of pavement with a special treatment, and such data should be stored in the research database, if possible. For instance, neither the TxDOT PMIS nor the SHRP method would give information on the amount of aggregate lost from a seal coat. The researchers propose that a generic database be developed in which the definition of the measures, quantities, severities, and units are designated. The structure would be based on the same principles used for the SHRP data, but the person entering the data must also enter the definitions in a specially designated database structure.

It is assumed that this section with project specific data would also have either the PMIS or the SHRP data. The project specific data would supplement the standard definitions. If the data cannot be stored in this type of database, the data storage structure should allow the inclusion of information that describes what data were collected and where it is stored.

To summarize, for this type of section project specific data collection would be allowed. It would supplement data collected by either the modified PMIS or SHRP procedures. Special data collection efforts would be required. The data would be stored in an open data structure based on that currently used by FHWA and TRB to store SHRP condition information. The person analyzing the data would know that the standard and project specific condition information is available because the identifying information would indicate what additional data

are available. The data structure would identify the data elements that were collected but could not be stored in the database.

Laboratory, Field, and Material Data Collection

It is proposed that the layer data stored in the research database have fields that would tell those analyzing the data whether there is other data available about that pavement layer. This could include laboratory data (such as Texas Triaxial Test Results), field data (such as multi-depth deflectometer data), or material property data (such as the source of a reclaimed material), or results of ground penetrating radar surveys.

We propose that a standard data structure be developed for each standard TxDOT pavement material related test procedure. We propose to work with the Materials and Test Division to develop standard data structures for each standard test.

We propose to work with TxDOT and other research organizations in the state to identify additional field test and material information that should be stored. This would include information on data structures.

In research, non-standard tests are often used. If the data will fit into one of the standard test formats, then it can be stored in those data structures. We propose that the data structure include a method of identifying data that is in the same format as the standard test, although the test was not conducted in accordance with standard TxDOT procedures. It should also include a comment field to tell those using the data who to contact to determine what is non-standard about the data.

For those sections where the non-standard test data will not fit the data structure, the researchers propose that information be provided to those analyzing the data as to what type of data were collected and where the results of those tests are stored.

To summarize, the storage of this type of data would be connected to pavement layer information. The pavement layer database structure would identify the availability of this additional data about the materials in that pavement layer. Data structures for standard laboratory data, selected field tests, and selected layer information would be developed. The data structure would identify the data elements that were collected by a procedure different from the

standard methods with a reference to the differences. A method to identify that non-standard data is available and the location of that data would also be included in the database. These types of information would often be used with the MLS test sections.

REQUIRED CHARACTERISTICS OF A RESEARCH SECTION

Although some TxDOT personnel expressed the opinion that all pavements in the state are research sections, the research sections to be included here are sections that are meant to have more extensive data collection and monitoring than a routine treatment would have.

The required data for a section to become a part of the research database is the header information which details the district, highway, location, type of research, data available, etc., layer data from the pavement layer data base, and data items that will have an impact on the performance of that section. The data that will affect the performance of that research section will vary for each type if study, but can be stored in standardized formats.

Whether a PMIS section or a research section is included in the research database should be determined by a subcommittee of TxDOT personnel. Identifying a section as a part of the research database is a commitment to continuing the performance data collection for an extended period of time and should be in support of the long range plan. In addition, this subcommittee will determine the additional data and format of the data to be collected. The researchers recommend that RMC-6, Pavements, develop a subcommittee under their direction that would be responsible for completing the activities identified herein for the TxDOT committee to oversee the Research Database activities. The RMC is already established, and it has representatives from the department as well as advisors from the research community who work with TxDOT. The responsibilities of this subcommittee would include;

1. Determine Which Sections Should Be Included. The committee should determine which sections should be included, the data to collect, and the frequency to collect with respect to both time and spatial spacing. They should work with the RMC to ensure that either the department or researchers are collecting the data in the method desired. They should decide when data collection activities would cease, and they should work with the RMC to ensure that the data are analyzed at appropriate times by appropriate researchers if it is an ongoing effort. They should decide if additional data storage elements should be added to the database.

2. Qualify Test Sections for Inclusion in the Research Data Base. Test sections should be included if they are of general interest, use materials or techniques that have the potential to be used by TxDOT, and meet general criteria for the type and amount of data to be collected.

3. Determine Minimum Data Collection. Some minimum set of data must be collected on all test sections. This data and some of the additional data have been identified in this report. However, additional data must be collected, based on the type of work to be performed. Asphalt content and gradation are important for HMAC test sections, but not for crack sealing.

4. Ensure Data Collection Activities are Conducted. Many of these test sections will require that other groups within TxDOT perform work in support of this data base, including distress surveys and laboratory testing. The support of this committee should help smooth this process.

5. Spread the Word. In order to be effective, this data base must contain valuable data and be used. This subcommittee should be responsible for ensuring that others are made aware of this potential resource.

Pavement sections should only be designated as research sections when they are part of a specific study instigated by the department, or by a district, and approved by the proposed subcommittee of RMC-6. These sections will often originally be a part of a specific research study. However, they may be sections that the department or district wishes to track to develop performance equations or to compare to other types of sections.

In-service sections can be designated as research sections; however, the required data must be available for those sections. They must be designated as part of an experimental, or sampling, design to develop the required performance equations or comparisons with other in-service sections.

The researchers recommend that a "control" be developed for all special studies, including those being completed by department personnel. The purpose of "control" sections is to provide a base-line to which the performance of experimental sections can be compared. A control section is a portion of the road where no treatment is applied, or, where an untreated area is not feasible as in an overlay or reconstruction, a standard treatment is placed. For example, to study the effects of an additive in hot mix overlays, a portion of the road should be constructed without the additive or with the standard additive. For a chip seal study, a portion

of the road could be left untreated or treated with an AC or emulsion chip seal. The inclusion of a control section will allow the comparison of the revised treatment to the performance of a procedure that is well understood. The control section should be monitored in exactly the same way as the treated section and all data collected for the treatment to be studied should also be collected for the control section.

DATA ACCESS AND RETRIEVAL

A search engine, on the mainframe, will need to be developed to access the data in the header files in order to limit the data selected. This search engine will also need to access PMIS and layer files. Originally, we thought that the search could be done on the microcomputer, but until more districts routinely download PMIS data, this will not be possible. An example of a proposed search is included in the Appendix.

PROPOSED CHANGES IN REPORT SUBMITTAL

Before the end of a research project, projects that have the potential to become a part of the research database should be submitted by the project director to the TxDOT team that determines what projects are included in the research database. If a project is so designated, in addition to the standard final report, a diskette containing separate files for the header information, abstract, key words, executive summary, and data files will be required. Future projects should require that a search of the integrated database be conducted as part of the literature search. To fully implement the monitoring of projects developed by an individual district, it will be necessary to modify training for district personnel to complete the required information.

CHAPTER 3. CONCLUSIONS

A pavement research database is needed and feasible, but it must be carefully defined. In order to make it useable and valuable, some standardization is required.

We propose a database with three levels to facilitate the investigation and retrieval of the different types of test sections and to guide the user through the increasing detail of the database. By maintaining a level containing basic data, database searches will be faster and can be specifically tailored since results can be retrieved quickly. Once sections are selected, the user would be led through the rest of the data. Since condition data can be collected in a variety of format, the types of surveys conducted most often will be standardized and others will be stored as project specific surveys.

Database Levels

Level 1 - Basic Data Containing Header Data
Level 2 - Performance Data
Level 3 - Laboratory and Project Specific Data

Categories of Condition Data

Standard PMIS Condition Data
PMIS Data on Short Sections of Collected at Non-Standard Intervals
Standard SHRP Data Collection on Short Sections
Modified SHRP Condition Survey
Project Specific Data
Laboratory, Field, and Material Data

We feel that this database layout will lead to a powerful, easy-to-use database that will help researchers and district and division personnel to be more aware of existing test sections. This awareness should lead to fewer test sections being abandoned or covered up. Future enhancements should include a field in the PMIS database identifying an area which contains a test section, so that these test sections are not accidently covered up.

APPENDIX A:
EXAMPLE QUERIES FROM TRIAL DATABASE

In order to integrate the data and store it in a centralized location where it is accessible to researchers and district and division personnel, a research database should be developed as a part of the existing PMIS database. Since the PMIS database contains much of the same data, having this as a subset of the PMIS data would reduce storage and memory requirements and increase speed of retrieval. By including information such as the name of the researchers, the kind of research, the keywords, the date when the research was completed, results, etc., a keyword search can be done which will select the research projects which have been carried out and which match the keyword search. By giving more and more specific search words, the result of the search can be narrowed down to a few research projects. The researcher can then access the database and retrieve data on those projects that have the appropriate information. This will help the researcher avoid the trouble of having to search all TxDOT reports to locate the data that might be helpful.

A sample keyword search was performed using Microsoft Access™. A table was created where the data was stored under different project headings. Some keywords were given to each project. A form was created with various "push buttons" for the various keywords. The user has the option of choosing one or more of the keywords and running the query to get the names of the project reports.

Suppose the user is interested in the research data available on seal coats and overlays. The user would select seal coat and overlay as the keywords and run a query. When the query is run, names of various research reports having the specified keywords will be displayed. In order to reduce the number of reports matching the query, more keywords can be chosen and the query rerun. Once the search is made, the user can go into the database to pull out data on those projects.

A query was also written on a table which contained data on FY96. The table had 8650 records. A specific county number and a visual inspection date were selected and a search was done to find the number of matching records. In this case 21 records were selected. The same

query was run again with one more specification, the PMIS highway system. Out of the 21 matching records for the earlier query, 16 were selected for having the specified PMIS highway system. The query was run again and again with more specifications, until one record was selected which met all the specifications. Similarly, queries can be run on different research reports. The keywords can be set up as specifications and the required information can be obtained instead of going through the whole database.

DATABASE SEARCH EXAMPLE

Search for matching records in the table for the specified conditions.

First, the search is made for particular values of County-Number and Visual-date.

```
SELECT DISTINCTROW D17FY96.[COUNTY-NBR], D17FY96.[VISUAL-DATE]
FROM D17FY96 WHERE ((D17FY96.[COUNTY-NBR]=21) AND
(D17FY96.[VISUAL-DATE]>#09/1/95#));
```

364 matching records of the available 8650 records are selected.

Then one more condition, a particular PMIS-HIGHWAY-SYSTEM is specified.

```
SELECT DISTINCTROW D17FY96.[COUNTY-NBR], D17FY96.[VISUAL-DATE],
D17FY96.[PMIS-HIGHWAY-SYSTEM] FROM D17FY96
WHERE ((D17FY96.[COUNTY-NBR]=21) AND (D17FY96.[VISUAL-DATE]>#09/1/95#)
AND (D17FY96.[PMIS-HIGHWAY-SYSTEM]="br"));
```

16 matching conditions are selected.

Again one more condition, a maintenance cost is specified.

```
SELECT DISTINCTROW D17FY96.[COUNTY-NBR],
D17FY96.[PMIS-HIGHWAY-SYSTEM], D17FY96.[MAINTENANCE-COST-AMT],
D17FY96.[VISUAL-DATE] FROM D17FY96
WHERE ((D17FY96.[COUNTY-NBR]=21) AND
(D17FY96.[PMIS-HIGHWAY-SYSTEM]="br") AND
(D17FY96.[MAINTENANCE-COST-AMT]=54) AND
(D17FY96.[VISUAL-DATE]>#09/1/95#));
```

6 matching records are selected.

Another condition, distress score is specified.

```
SELECT DISTINCTROW D17FY96.[COUNTY-NBR],
D17FY96.[PMIS-HIGHWAY-SYSTEM], D17FY96.[MAINTENANCE-COST-AMT],
D17FY96.[VISUAL-DATE], D17FY96.[DISTRESS-SCORE]FROM D17FY96
WHERE ((D17FY96.[COUNTY-NBR]=21) AND
(D17FY96.[PMIS-HIGHWAY-SYSTEM]="br") AND
(D17FY96.[MAINTENANCE-COST-AMT]=54) AND
(D17FY96.[VISUAL-DATE]>#09/1/95#) AND (D17FY96.[DISTRESS-SCORE]>50));
```

4 matching records are selected.

Yet another condition, the condition score is specified.

```
SELECT DISTINCTROW D17FY96.[COUNTY-NBR],
D17FY96.[PMIS-HIGHWAY-SYSTEM], D17FY96.[MAINTENANCE-COST-AMT],
D17FY96.[VISUAL-DATE], D17FY96.[DISTRESS-SCORE],
D17FY96.[CONDITION-SCORE] FROM D17FY96
WHERE ((D17FY96.[COUNTY-NBR]=21) AND
(D17FY96.[PMIS-HIGHWAY-SYSTEM]="br") AND
(D17FY96.[MAINTENANCE-COST-AMT]=54) AND
(D17FY96.[VISUAL-DATE]>#09/1/95#) AND (D17FY96.[DISTRESS-SCORE]>50) AND
(D17FY96.[CONDITION-SCORE]<70));
```

Thus, by giving a number of conditions or constraints, the number of matching records can be drastically reduced resulting in records which properly match the requirements of the user. Once the search is done, the user can go into the database and pull out information on the selected records.