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16. Abstract

This report discusses the procedure used to implement a new Flexible Pavement Design System into the Texas Highway Department pavement design operations. A step by step account is given of the work undertaken in implementation. This includes developing, trying, and revising the system. At the present stage design personnel from 10 of 26 Districts in the State have been trained in the fundamentals of using the system and are now putting the system to use.

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IMPLEMENTATION OF A COMPLEX DESIGN SYSTEM

by

Larry J. Buttler
and
Hugo E. Orellana

Research Report No. 123-20

"A System Analysis of Pavement Design
And Research Implementation"

Research Project 1-8-69-123

conducted

in cooperation with the
U.S. Department of Transportation
Federal Highway Administration

by the

The Roadway Design Section of
The Highway Design Division
Texas Highway Department

Texas Transportation Institute
Texas A&M University

Center for Highway Research
The University of Texas at Austin

June 1973

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation. Reference to specific makes or models of computer equipment is made for identification purposes only and does not imply endorsement by the sponsors of this report.

LIST OF REPORTS

Report No. 123-1, "A Systems Approach Applied to Pavement Design and Research," by W. Ronald Hudson, B. Frank McCullough, F. H. Scrivner, and James L. Brown, describes a long-range comprehensive research program to develop a pavement systems analysis and presents a working systems model for the design of flexible pavements.

Report No. 123-2, "A Recommended Texas Highway Department Pavement Design System Users Manual," by James L. Brown, Larry J. Buttler, and Hugo E. Orellana, is a manual of instructions to Texas Highway Department personnel for obtaining and processing data for flexible pavement design system.

Report No. 123-3, "Characterization of the Swelling Clay Parameter Used in the Pavement Design System," by Arthur W. Witt, III, and B. Frank McCullough, describes the results of a study of the swelling clay parameter used in pavement design system.

Report No. 123-4, "Developing A Pavement Feedback Data System," by R. C. G. Haas, describes the initial planning and development of a pavement feedback data system.

Report No. 123-5, "A Systems Analysis of Rigid Pavement Design," by Ramesh K. Kher, W. R. Hudson, and B. F. McCullough, describes the development of a working systems model for the design of rigid pavements.

Report No. 123-6, "Calculation of the Elastic Moduli of a Two Layer Pavement System from Measured Surface Deflections," by F. H. Scrivner, C. H. Michalak, and W. M. Moore, describes a computer program which will serve as a subsystem of a future Flexible Pavement System founded on linear elastic theory.

Report No. 123-6A, "Calculation of the Elastic Moduli of a Two Layer Pavement System from Measured Surface Deflections, Part II," by Frank H. Scrivner, Chester H. Michalak, and William M. Moore, is a supplement to Report No. 123-6 and describes the effect of a change in the specified location of one of the deflection points.

Report No. 123-7, "Annual Report on Important 1970-71 Pavement Research Needs," by B. Frank McCullough, James L. Brown, W. Ronald Hudson, and F. H. Scrivner, describes a list of priority research items based on findings from use of the pavement design system.

Report No. 123-8, "A Sensitivity Analysis of Flexible Pavement System FPS2," by Ramesh K. Kher, B. Frank McCullough, and W. Ronald Hudson, describes the overall importance of this sytem, the relative importance of the variables of the system and recommendations for efficient use of the computer program.

Report No. 123-9, "Skid Resistance Considerations in the Flexible Pavement Design System," by David C. Steitle and B. Frank McCullough, describes skid resistance consideration in the Flexible Pavement System based on the testing

of aggregates in the laboratory to predict field performance and presents a nomograph for the field engineer to use to eliminate aggregates which would not provide adequate skid resistance performance, April 1972.

Report No. 123-10, "Flexible Pavement System - Second Generation, Incorporating Fatigue and Stochastic Concepts," by Surendra Prakash Jain, B Frank McCullough and W. Ronadl Hudson, describes the development of new structural design models for the design of flexible pavement which will replace the empirical relationship used at present in flexible pavement systems to simulate the transformation between the input variables and performance of a pavement, January 1972.

Report No. 123-11, "Flexible Pavement System Computer Program Documentation," by Dale L. Schafer, provides documentation and an easily updated documentation system for the computer program FPS-9.

Report No. 123-12, "A Pavement Feedback Data System," by Oren G. Strom, W. Ronald Hudson, and James L. Brown, defines a data system to acquire, store, and analyze performance feedback data from in-service flexible pavements, May 1972.

Report No. 123-13, "Benefit Analysis for Pavement Design System," by Frank McFarland, presents a method for relating motorist's costs to the pavement serviceability index and a discussion of several different methods of economic analysis.

Report No. 123-14, "Prediction of Low-Temperature and Thermal-Fatigue Cracking in Flexible Pavements," by Mohamed Y. Shahin and B. Frank McCullough, describes a design system for predicting temperature cracking in asphalt concrete surfaces, August 1972.

Report No. 123-15, "FPS-11 Flexible Pavement System Computer Program Documentation," by Hugo E. Orellana, gives the documentation of the computer program FPS-11, October 1972.

Report No. 123-16, "Fatigue and Stress Analysis Concepts for Modifying the Rigid Pavement Design System," by Piti Yimprasert and B. Frank McCullough, describes the fatigue of concrete and stress analyses of rigid pavement, October 1972.

Report No. 123-17, "The Optimization of a Flexible Pavement System Using Linear Elasticity," by Danny Y. Lu, Chia Shun Shih and Frank H. Scrivner, describes the integration of the current Flexible Pavement System computer program and Shell Oil Company's program BISTRO, for elastic layered systems, with special emphasis on economy of computation and evaluation of structural feasibility of materials, March 1973.

Report No. 123-18, "Probabilistic Design Concepts Applied to Flexible Pavement System Design," by Michael I. Darter and W. Ronald Hudson, describes the development and implementation of the probabilistic design approach and its incorporation into the Texas flexible pavement design system for new construction and asphalt concrete overlay, May 1973.

Report No. 123-20, "Implementation of a Complex Design System," by Larry J. Buttler and Hugo E. Orellana, describes the procedure used to implement a new Flexible Pavement Design System in the Texas Highway Department pavement design operations, June 1973.

PREFACE

This is the twentieth of a series of reports issued under Research Study 1-8-69-123, "A Systems Analysis of Pavement Design and Research Implementation." This study is being conducted jointly by principal investigators and their staffs in three agencies -- The Texas Highway Department at Austin, The Center for Highway Research at Austin, and The Texas Transportation Institute at College Station, as a part of the cooperative research program with the Department of Transportation, Federal Highway Administration.

Included herein is the procedure used to implement a new Flexible Pavement Design System into the Texas Highway Department pavement design operations.

SUMMARY

This report documents the attempts to-date at implementation of research results developed under Project 123, "A System Analysis of Pavement Design and Research Implementation." The task undertaken was to incorporate the first generation of a Flexible Pavement Design System into the Texas Highway Department's design operations. Some effort has been made in this report to point out the success or failure of each work item undertaken in implementation.

INTRODUCTION

The Texas Highway Department administers an extensive research program which includes approximately 50 projects at an annual cost near two million dollars. The success of a research project depends on implementation of results. George E. Rice, (Ref. 1) in his report, stated that "Implementation is the key to evaluation of a research system. Time, effort, and money are wasted when research findings are not put to use in some manner." Project 123, "A Systems Analysis of Pavement Design and Research Implementation" assumed this philosophy from the onset. This project was started to organize highway pavement research findings in a systematic manner and to implement the results that are pertinent to Texas needs.

This report documents Project 123's attempts to-date at implementation of research results. The task undertaken was to incorporate the first generation of a Flexible Pavement Design System into the Texas Highway Department's design operations. Some effort has been made in this report to point out the success or failure of each work item undertaken in implementation. This is done to aid the reader in his planning of research implementation, but he should always keep in mind that the steps taken are not necessarily considered to have been the ideal approach to implementation.

BACKGROUND

Approval for work on Research Project 123, "The Development of a Feasible Approach to Systematic Pavement Design and Research," was made by the Federal Highway Administration in November 1968, and the project was officially started in December. In April 1969, after only four months of work, a proposal for continuation of the program was submitted as required. In this proposal, the title of the project was changed to "A Systems Analysis of Pavement Design and Research Implementation" because the project staff was convinced that it was possible to carry out such a systems analysis and implement the system within the Highway Department. This conviction resulted from concerted study of the overall problem.

In February 1969, the project staff met to formulate a recommended work plan for implementing the pavement design system within the Texas Highway Department. This work plan was later submitted as an appendix to the Research Study Renewal for fiscal year 1969-1970, under the title "A Proposal for Implementing Pavement Design Research to the Chief Engineer of Highway Design - Texas Highway Department." In the proposal, it was suggested that a Pavement Design Section, within the Highway Design Division, begin functioning with a working staff. This new section would work with the Research Area Advisory Committee for Pavement Design, serving as a research sponsor and providing technical direction for pavement design and research. The Pavement Design Section was staffed in February 1971, to perform the above plus additional functions within the Highway Department. These include review of all pavement designs and development of policies, procedures, standards and specifications for pavement design. However, a majority of the effort of this section is devoted to working with the remaining Project 123 staff at implementing the Flexible Pavement Design System.

CHRONOLOGY OF IMPLEMENTATION

The following is a list of steps taken in the trial implementation by the Texas Highway Department.

1. Modification and Further Development of the FPS Computer Programs
2. Writing of the User's Manual
3. Introduction and Selling of the FPS System
4. Training of Design Personnel
5. Revising the System
6. Additional Training of Design Personnel

Figure 1 is a bar graph showing the approximate periods during which these items were accomplished. In this section each step will be discussed in the order shown. Some of the work in several of the steps was conducted simultaneoulsy; but, basically each step is an individual item of work which can be separated from the others for the purpose of this discussion.

1. Modification and Further Development of the FPS Computer Programs

Utilization of a computer to handle the vast amount of computations necessary for comparison of alternate materials and optimization of designs was essential. The first FPS program was developed by Research Project 32, "Extension of AASHO Road Test Results" (Ref. 2, 3, and 4). This program and two subsidiary programs (Ref. 5) developed by previous research were modified and incorporated into the Flexible Pavement Design System. The three programs formed the computational package for the design system. They were successful from the standpoint of performing the required calculations with reasonable computer time when used with proper constraints. It should be emphasized that these programs are constantly being revised as better subsystems are developed by research or experience.

2. Writing of the User's Manual

Implementation of a new system can be more successfully accomplished with the use of a handy simplified set of written instructions to be used as a reference. Such a set of instructions and explanations was conceptualized as a "User's Manual" which would be written in a language that would be understandable to design engineers with a minimum of additional instructions and study.

Specifically, this manual was written to provide instructions to the Texas Highway Department operating personnel for collecting and processing of data for use in the THD Flexible Pavement Design System. This manual had to be written by someone who was not only familiar with the proposed pavement design system, but also familiar with the way that data is collected and used by THD pavement designers. To gain the experience needed to write this manual, the project staff first conducted a sensitivity analysis and familiarization study (Ref. 6) of the programs involved. Next, the System was used in an actual trial application within the Highway Department. Then the actual writing of the manual began.

a. Sensitivity Analysis and Familiarization with Programs. The sensitivity analysis gave the staff members a feel for the sensitivity of the outputs to the FPS program input variables. At the same time minor errors in the program were found and corrected. Most importantly, the sensitivity study gave the researchers a working knowledge of the program

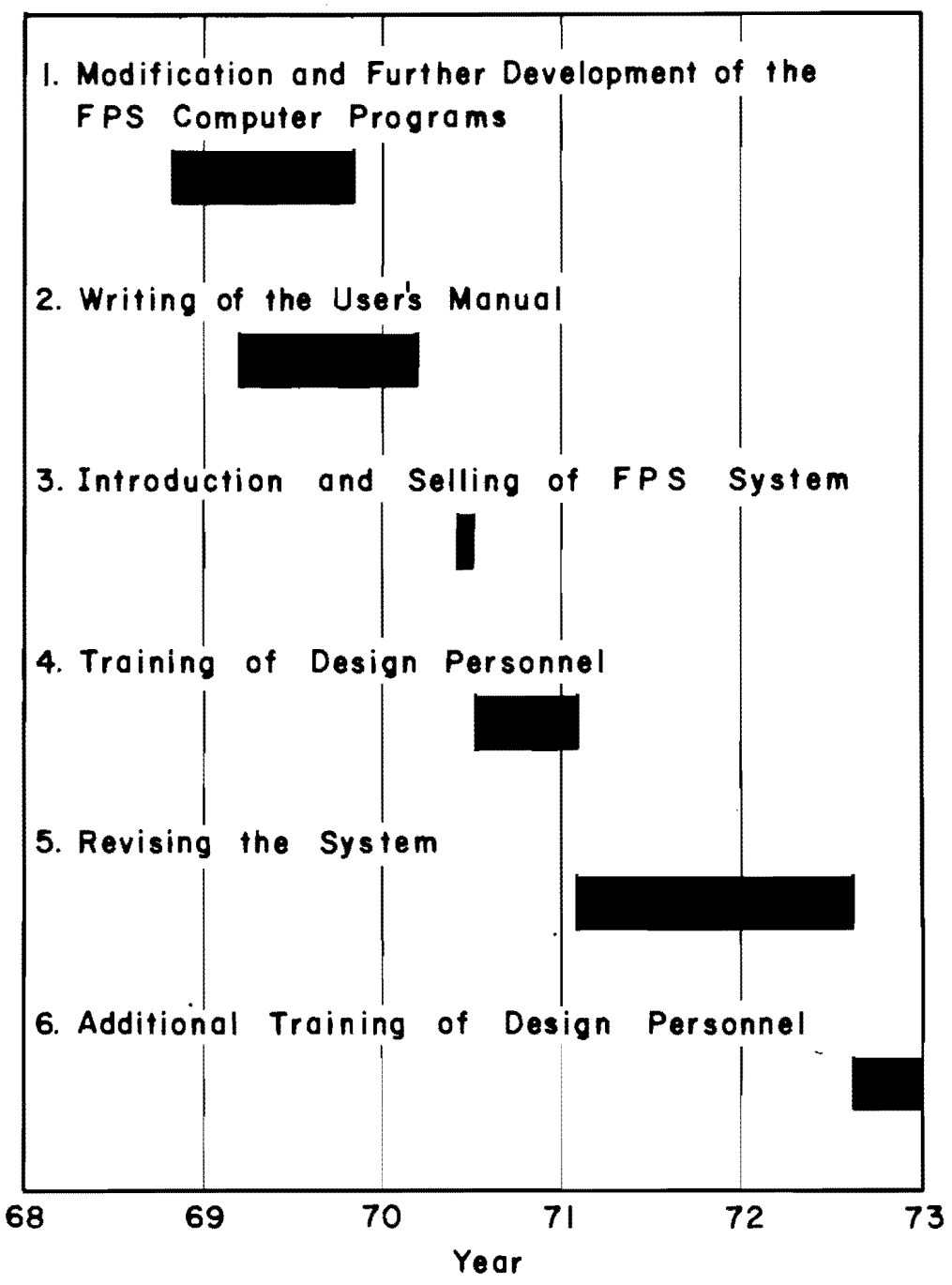

Figure 1 TIME-TABLE FOR WORK IN IMPLEMENTATION

which better enabled the staff members to apply the FPS program to an actual design problem. For example, it was found that some of the variables could be ignored and that others which were difficult to quantify could be estimated to a satisfactory accuracy without exhaustive efforts. It identified the most critical variables, thus enabling the designer to spend his time collecting data more profitably.

In addition to the formal analysis, many additional computer runs were made on the FPS program by staff members of all three agencies to familiarize themselves with the program. It is felt that this was a necessary step in implementation. It is estimated that an equivalent of 100 minutes of computer time on the IBM 370 computer was used. Approximately one man year was spent running the FPS program and writing the report, and another man year was spent in the familiarization study of the Stiffness Coefficient Program and how it can be used in the System. The Profile Analysis Program did not require a significant effort because it was a simple statistical operation with which the staff was familiar.

b. First Application of the System. It is considered essential that conceptual ideas be put to actual test as early in the development stage as feasible in order to make needed changes and prevent a large expenditure of time on impractical ideas. In the present instance the project staff assisted by District 19 personnel of the Highway Department designed the pavement structure for a section of US 59 South of Texarkana, Texas. The trial design required the measurement of deflections and collection of data for costs, maintenance, seal coats, traffic, etc. These data were analyzed and prepared for use in the computer programs of the design system. The computer outputs were used as an aid in choosing a design strategy.

Many difficulties were encountered in coding the FPS program to represent the actual conditions in the field. The main difficulty was that the program had been developed to design a pavement on a new location while the design problem at hand was reconstruction of an existing pavement. Many more computer runs were made to gain experience and confidence in the program solutions than were necessary to design the pavement. Approximately a half-man year was used in obtaining inputs and coding the problems. It is felt that the working of an actual problem was a necessary step before a user manual could be written.

c. Actual Writing of the User's Manual. With the experience of applying the system to a real problem, writing of a user manual was the next step. As stated before, this manual provides instructions to the Highway Department for collecting and processing data for use in the THD Flexible Pavement Design System.

Since the system was new to the user, the "User's Manual" (Ref. 7) gave suggested ways of collecting each input variable. Coding instructions and code sheets for each of the three computer programs in the system were provided. Figure 2 is a typical input form. As an example of how much attention to details must be given it is noted on this form that decimal points have been placed at logical places to help prevent coding errors. For instance it is known the input cost per compacted cubic yard for paving materials will be between 0 and $99.00, so only five coding blanks with the decimal place were provided. This simplification and detail may

TEXAS HIGHWAY DEPARTMENT
FLEXIBLE PAVEMENT DESIGN SYSTEM
FPS - 11

PAVING MATERIAL INFORMATION

Item	Description	Card columns
10.0	Card type	1 0 (cols. 1, 2)
10.1	Layer designation number	4
10.2	Letter code of material	8
10.3	Name of material	12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
10.4	In-place cost/comp. - C.Y. ($)	31 32 33 34 35 (● at 33)
10.5	Stiffness coefficient	40 41 42 43 (● at 41)
10.6	Min. allowable thickness of initial const. (inches)	47 48 49 50 51 (● at 49)
10.7	Max. allowable thickness of initial const. (inches)	55 56 57 58 59 (● at 57)
10.8	Material's salvage value as % of original cost	62 63 64 65
10.9	Check	80

Figure 2 TYPICAL INPUT FORM

seem unimportant to most researchers; however, it was found to be necessary in order to reduce coding errors which may result in non-valid and costly computer runs.

Developing useful code sheets, writing the manual, making minor modifications of the three programs and doing the research to develop inputs not previously available were major efforts. It is estimated that two man years went into the writing of the manual. Computer and printing cost were minor.

As will be pointed out later under the heading "Revising the System" the writing of this manual has been an iterative process. It was found necessary to revise the manual due to revisions in the system. Use of the first manual revealed the need for loose leaf pages so that future revisions would be simplified.

3. Introducing and Selling of the FPS System

Introducing a new design concept to replace an existing method is fraught with problems. It is necessary to acquaint the prospective users with the new system and "advertise" it in such a way that they will want to try it. At the same time it should not be "oversold" since it is still in the developmental stage and requires limited use rather than wholesale implementation.

Research Report 123-1, "A Systems Approach Applied to Pavement Design and Research" (Ref. 8), was a background document providing the framework for future work within the project. This report illustrated how a pavement design system could be developed by coordinated research. A working FPS model was presented (to show that the approach was feasible for flexible pavements) in a one-day introductory session held at District 14 (Austin) Conference Room on May 5, 1970. A total of 37 people attended which included representatives from the following:

1. Highway Design Division
2. Construction Division
3. Secondary Roads Division
4. Maintenance Operations Division
5. Automation Division
6. District 14
7. Center for Highway Research
8. Texas Transportation Institute
9. FHWA

A satisfactory response was received at this meeting, but (except for District 14 personnel) none of those attending would be using such a system. The primary benefit from this meeting was the experience gained in presenting the program to a group and in acquainting the affected Divisions in the Austin office with the progress of the research. On May 28, 1970, a similar meeting was held in the big Hearing Room of the main THD Building in Austin with approximately 75 persons representing all Districts attending. In each of these two meetings a summary of Research Report 123-1 was given and several example problems were shown of the Flexible Pavement Design System. This gave a brief evaluation of the many variables involved and the complexity of the system. It was emphasized at these meeting that considerable effort would be necessary to give it a trial use.

At these meetings it was pointed out that volunteer Districts were needed to try the system and that each volunteering District would be required to furnish personnel who could work on design problems on a part-time basis for several months after attending a three day design school. These personnel would also be required to attend a workshop after the design problems were completed to furnish feedback to the researchers and to provide the other Districts an illustration of different design projects.

To conduct this type of meeting considerable effort was necessary; not to mention the effort involved in preparing Report 123-1. It was felt that a meeting of this type was necessary to sell the new Flexible Pavement Design System, but possibly a mistake was made in overselling the system. Too many people were invited to these meetings and not enough emphasis was placed on the fact that the Design System was new, untried, and umproven. The Design Engineers did not understand that the first users would in fact be researchers providing inputs for immediate revision of the system.

In short, enthusiasm should be generated only as is justified by the product available; and care should be taken to not over-sell a new design system while it is in the developmental stage.

4. Training of Design Personnel

Training of personnel was a two-fold process with the first being a design school and the second the working of actual problems in the field.

Thirteen of the twenty-six Districts volunteered to try the system. Because of the amount of effort required by each participant and limited personnel and funds available for instructors, only five Districts were selected to try the system. Districts 2, 5, 14, 17 and 19, whose locations are shown on Figure 3, were chosen. These particular Districts were selected to obtain a variety of environment, materials, and traffic conditions. The school was held July 21 thru 23, 1970. Approximately thirty Engineers attended. The Materials, Design, Construction, and Research disciplines were represented.

Research Report 123-2 (the User's Manual) was used as a basic textbook. The school included sessions on collecting and processing design data. Sample problems were coded and computer solutions were obtained. Another session included interpretation of the "best" output results and selection of a design strategy from the various alternatives generated by the FPS Program. Some evaluation of the output was made, but since mostly hypothetical data was used as input no valid comparison with actual conditions could be made. The future work of the participants in the school was discussed. Each District was to select a project for design, set up a data measurement and collection scheme, and run the program in the design system. This would enable the designers and researchers to compare the new system with presently used design methods.

It is hard to evaluate the success of this type training. For the Texas Highway Department with pavement designers being so decentralized, it is felt that this type of school is an efficient way to train personnel. A better evaluation of the success in training can be made by studying the problems encountered in working of the design problems.

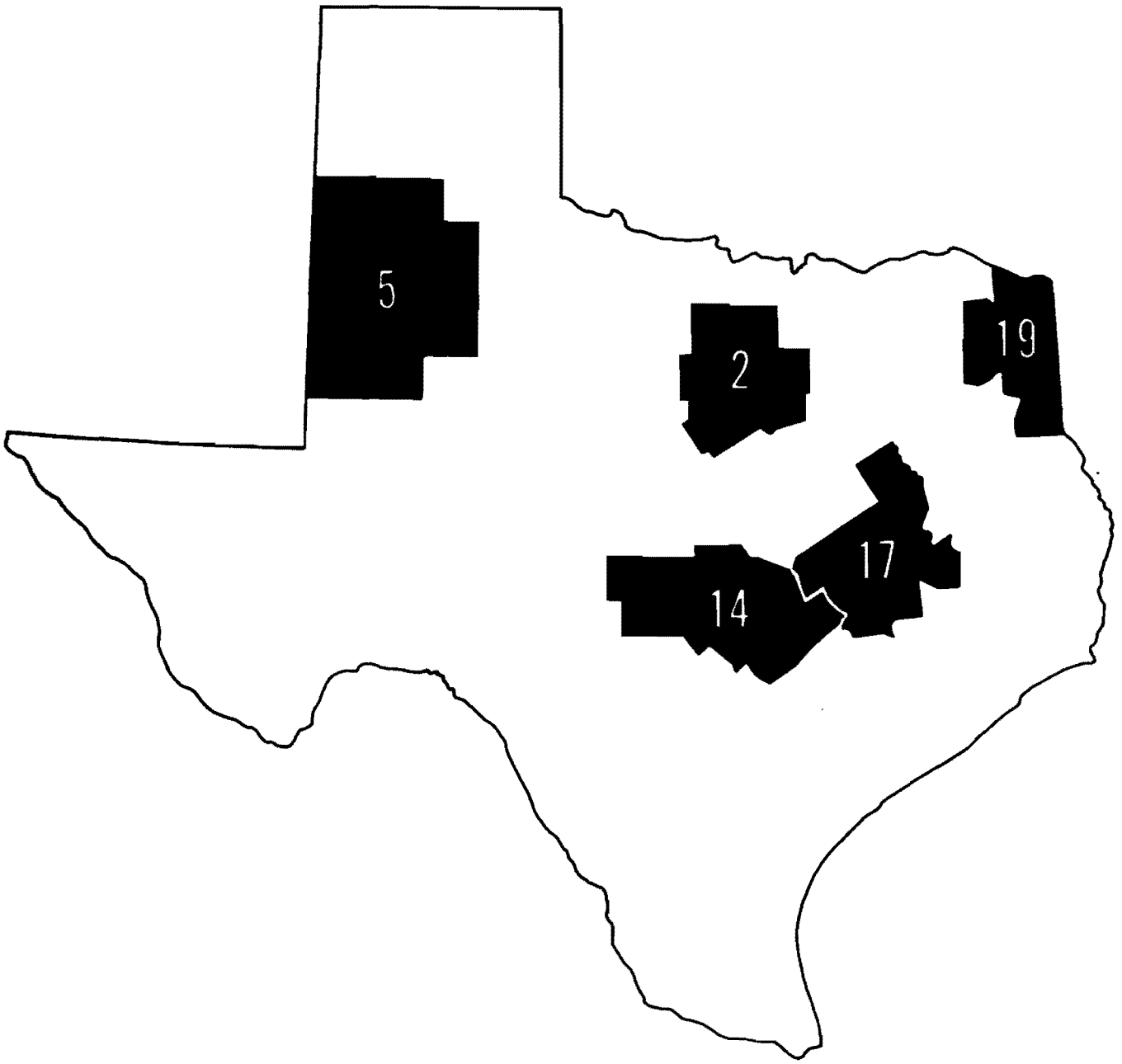

Figure 3 DISTRICTS PARTICIPATING

During the trial period, two Districts designed one project each, one District 3 projects, another 5, and another 20. Since only one design project was required, it is believed this extra work reflects the enthusiasm and interest in the system. A significant effort was given by each District and certainly sufficient use was made to present a fair appraisal of the merits and needs of the system. As was anticipated, it was necessary for a member of the project staff from the Highway Department to visit each District to assist with sampling plans for field measurements. It was also necessary for the project staff to proof code sheets before submitting each program for computations. Even after this proofing numerous problems failed to run because of minor coding errors.

Where the manual did not detail specific ways to establish input values for variables unfamiliar to the pavement designer, the values used in the example problems in the manual were generally used. It had been hoped that the District Pavement Designers would search their files, take field measurements or make independent estimates to establish these values. Examples of such inputs are maintenance data, detour speed data, and salvage value data. This type of information, in general, is hard or costly to establish. To expect practical pavement designers to do this work without specific recommended procedures appears unrealistic. Researchers will have to provide more specific ways of obtaining these inputs.

The next step would be the critical examination of each of the problems and a comparison of the results with what the pavement designers would have used under existing design methods and judgement. This could have been done in several ways, but the most productive appeared to be the holding of a workshop so that all interested parties could examine and discuss the results. This leads into the next phase of implementation, "Revising the System," where the need for revision shown at the "Feedback Workshop" will be discussed.

5. Revising the System

On January 12 thru 14, 1971, a "Feedback Workshop" was held. Attending were both the researchers that had developed the system and those designers who had tried it. The designers discussed faults of the system and the difficulty they had. The main fault was that the overall thickness of the pavement structure always appeared to be too thin. Another problem recognized by some of the Districts was that the swelling clay model and many parts of the system were only crude approximations.

Revisions suggested by the workshop were not thought to be small items of work, but the time required to complete these revisions was underestimated. It was thought that the revisons could be made in three months, but the work took approximately eleven months. This included rerunning of the trial problems during the last month. The time element is mentioned here to indicate the problems involved in making apparently minor changes in the design system. One of the reasons for this was that the program had not been adequately documented to facilitate these revisions.

The Workshop served its purpose well in defining the weakest points of the design system and it layed the ground work for revising the system. While making these revisions, it was found desirable to incorporate other improvements in the system which could be made easily. The result was program FPS-11. The revisions are discussed in detail in Report 123-15 by Orellana (Ref. 9). Briefly the revisions were as follows:

a. Addition of Reliability Calculations
b. A New Swelling Clay Model
c. A New Overlay Model in the Flexible Pavement Design Mode
d. Addition of an ACP Overlay Design Mode
e. Deletion of Seal Coat Considerations from the Program
f. Program Changes to Save Computer Time
g. A More Logical Output Format

These revisions required not only a large amount of programming time, but included considerable work in selecting the applicable models and quantifying some of the constants and inputs. In addition, the "User's Manual" was revised to include the above changes and was printed in loose leaf form and bound in a three ring binder for ease of future updates.

Revisions should be thorough, but as rapid as possible in the present case the long period of inactivity while revisions were being made resulted in a decline of enthusiasm on the part of some of the Districts and some degree of skepticism from Administrators. If more personnel had been available it would have been expedient to work with the Districts and keep them informed of the status of the revisions being made.

Revisions to the system will continue as improved subsystems are developed and as feedback from both users and data collected dictate. If the user is affected by the changes, the Designer's Manual will be updated.

6. Additional Training of Design Personnel

The success of the first design school, the feedback workshop and promising results of the revisions prompted the research staff to choose five additional Districts to train. From the original volunteers to try the system Districts 1, 8, 11, 15 and 21 were choosen. These represent Districts with headquarters in Paris, Abilene, Lufkin, San Antonio, and Pharr, respectively. The original five Districts (2, 5, 14, 17 and 19) were also invited to send participants for a refresher course and an explanation of the revisions. Figure 4 shows the location of these ten Districts. A school was held June 27, through June 29, 1972. Approximately 35 people attended the entire time.

The revised "Texas Highway Department, Flexible Pavement Designer's Manual, Part 1" was used as a textbook for the school. Mr. James L. Brown was the instructor at the school with short lectures given by Dr. B. F. McCullough of the Center for Highway Research at the University of Texas and Dr. Robert L. Lytton of the Texas Transportation Institute at Texas A & M University.

The participants of the school were divided into five work groups. Each group designed several fictitious pavements using the FPS Program during the course of the school and made an oral report about a design worked by the group.

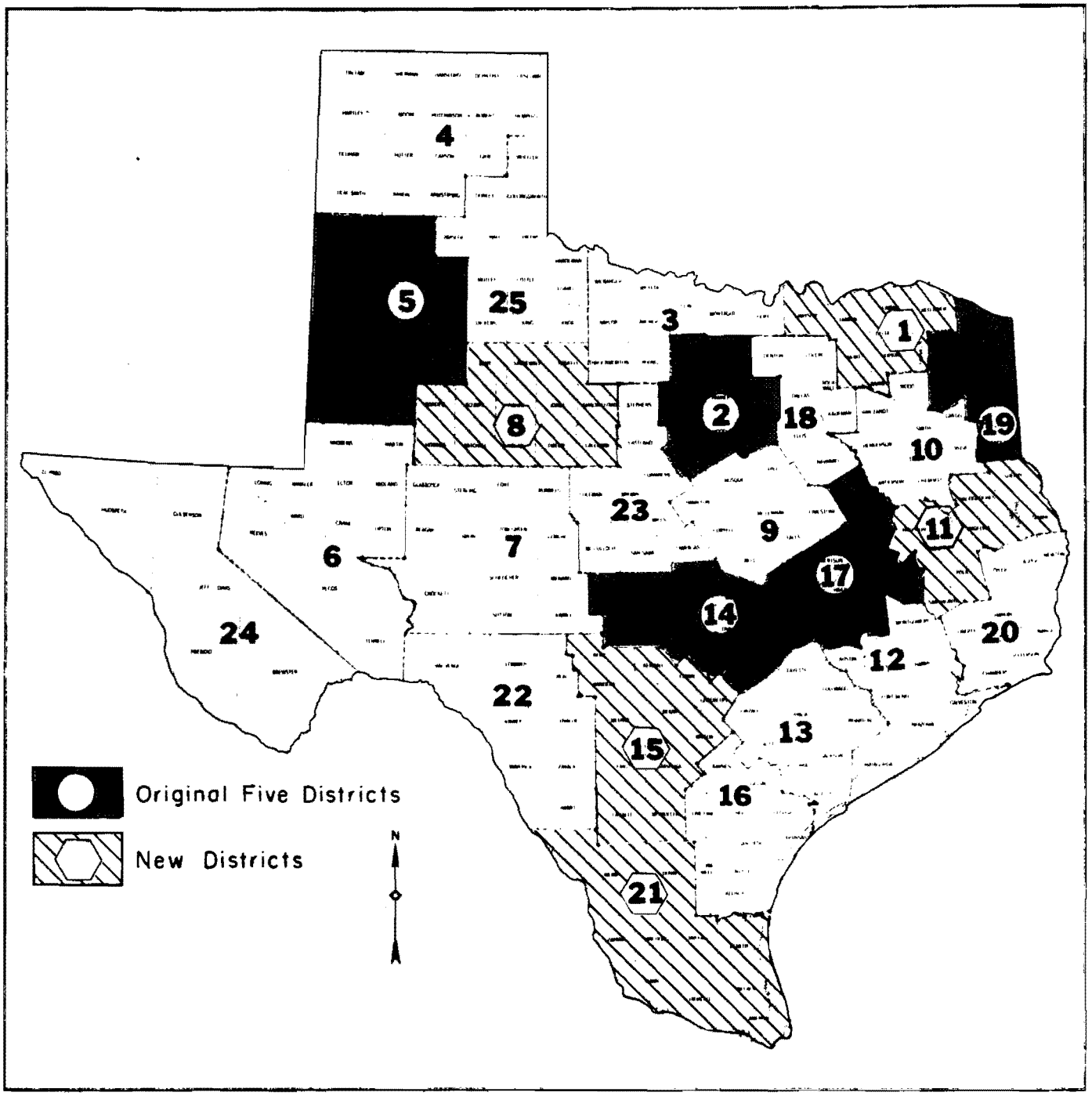

Figure 4 THE TEN PARTICIPATING DISTRICTS

No attempt was made to explain the mathematical details of the program. A general concept was given of the entire system. Each major subsystem in the program was discussed briefly. Changes in the program were discussed briefly for the benefit of the Districts who were already using the system. The major portion of the time was spent working problems and discussing how to collect and input data for the FPS Program. Reference reports where supplied to each District so that the detailed background of the system would be available if needed or desired. A great deal of enthusiasm appeared to be generated at this school and the rate of implementation by these 10 Districts may be a function of the ability of the personnel of the Pavement Design Section to furnish guidance as needed in securing input data and assistance in using the system.

Rapid implementation also dictates a need for completion and implementation of the Pavement Feedback Data System (Ref. 10). One of the most important pay offs of the systems approach to pavement design is conceived to be the increased ability of pavement management. This feature of the system as well as the ability to make future improvements is dependent on the use of a workable computerized filing and retrieval system. The feedback from this school points out that the structural and performance models used in this system and the implementation of a feedback data system should have first priority in the work list for improving the system. However, it is felt that the program in its present form will be of sufficient benefit to designers to warrant its continued implementation and use.

SUMMARY AND RECOMMENDATIONS

This report discussed the trial and error procedure used to implement a new Flexible Pavement Design System into the Texas Highway Department pavement design operations. A step by step account has been given of the work undertaken in implementation. This included developing, trying, and revising the system to the present stage where design personnel from 10 of the 26 Districts in the state have been trained in the fundamentals of using the system and are now trying to use it. The success of this trial will depend mainly on the efforts made by these designers using the system.

The next step in implementation will be in building a Pavement Feedback Data System (PFDS). It is felt that this next step will be most important toward making the total Pavement Design System a useful tool for pavement management.

Based on the researchers experience gained in this implementation the following points are recommended for consideration before implementing any complex design system.

1. When a system is first being introduced to users or administrators extreme care should be taken to explain what stage of development the system is in. Most of the people assume when they are introduced to a complex system with computer programs that the system is in its final state.

2. Manuals should be developed to cover every operation not previously encountered by the user and the manual should be printed for easy revision.

3. When computer code sheets are involved every effort should be taken to make them blunder proof. If the user is not a programmer, the code sheets should be developed so that little knowledge of computer programming is needed.

4. All computer programs should be thoroughly documented for easy revision.

References

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