A SYSTEMS APPROACH APPLIED TO PAVEMENT DESIGN AND RESEARCH

SUMMARY REPORT 123-1 (S)

SUMMARY OF
RESEARCH REPORT 123-1

PROJECT 1-8-69-123

COOPERATIVE HIGHWAY RESEARCH PROGRAM
WITH U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
BUREAU OF PUBLIC ROADS

TEXAS HIGHWAY DEPARTMENT

CENTER FOR HIGHWAY RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

TEXAS TRANSPORTATION INSTITUTE
TEXAS A&M UNIVERSITY

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Foreword

This is a brief summary of Research Report No. 123-1, the first in a series of reports emanating from Research Project 1-8-69-123, entitled "A System Analysis of Pavement Design and Research Implementation." This project is part of the Cooperative Highway Research Program and represents the combined efforts of the Center for Highway Research at The University of Texas at Austin, the Texas Transportation Institute at Texas A&M University, and the Texas Highway Department, in cooperation with the U. S. Department of Transportation Federal Highway Administration.

Introduction

The complex nature of highway pavements and the demands placed on them by traffic and environment have resulted in a piecemeal and incomplete design methodology. It has become apparent from analysis of the problem that realistic analyses of pavement design and management problems can be obtained only by looking at the total pavement system, i.e., through systems analysis. It is also evident that this approach should involve a team effort of interested research agencies and sponsors. The report describes such an approach and presents a working systems model.

History of Project Development

A study (Project 2-8-62-32) was initiated in Texas in 1962 to "extend the AASHO Road Test results." This study, which terminated in 1968, resulted in the computerized flexible pavement design system and forms the basis for the systems model used in the report. The overall findings of Project 32 point out that an adequate pavement design method could not be generated by applying the traditional piecemeal approach to the problem. After seven years of concerted effort at "extending the AASHO Road Test" in Texas, the research staff in cooperation with the Texas Highway Department came to the conclusion that it was necessary to develop a more coordinated approach to pavement analysis and design than had been anticipated at the beginning of the project.

In 1967, NCHRP began a research contract (Project 1-10) with the general objective to provide the type of basic information required to adapt the information obtained on the AASHO Road Test to local environments. That project emphasized the importance of organizing the problem with a systems approach and developed a framework for pavement systems analysis.

For several years the Pavement Research Advisory Committee and Research Section of the Texas Highway Department had grappled with the problem of developing a coordinated research program which could be used to vigorously prosecute the task of developing required solutions to priority pavement problems.

With this background knowledge, the staff of the three agencies developed a coordinated long term program of pavement research and design. The project was started in December 1968 with the following long range goals:

(1) to develop a rational design and management system for all pavement types and
(2) to develop this system such that new research knowledge can be easily and efficiently incorporated as it becomes available and in turn to establish the necessary communication and information channels.

Analysis of the Research Problem

A pavement design system is made up of not only a particular set of mathematical models or graphs as has often been assumed in the past, but also includes an implementation plan, equipment, and personnel necessary to implement the system. The plan of attack involves the organization of the entire system, the flow of information within the system, and the arrangement of the computer programs which provide possible solutions. Too often in the past, the narrow concept of design has been used to refer to picking a pavement thickness off a chart and writing it on a set of proposed plans. This method will not suffice for high-speed, high-volume, modern highways and transportation facilities.

In approaching the problem of creating the best pavement design system, it is logical to use the systems analysis method. The basic outline of the

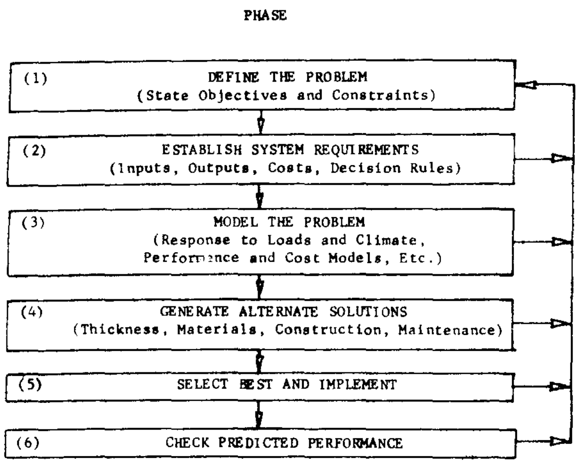

Fig 1. Major phases of the systems analysis method.

method as applied here is shown in Fig 1, the most important concept being that as the problem is more fully understood it must be redefined in the light of the improved information. Therefore, the results of new research may be continually incorporated into the system.

The Working Systems Model

The report presents a working systems model for the design of flexible pavements designated as FPS. The basic models used in the system were obtained from Project 32-11, which was the outgrowth of the attempt to apply the AASHO Road Test results to Texas conditions. More than 50 physical inputs and constraints are used in the model and the output is a set of recommended pavement design strategies based on the net present work of the lowest total cost.

A pavement cross section including overlays for a two-layer design is shown in Fig 2. Its predicted performance is shown in Fig 3. This design represents the minimum total cost design for a two layer pavement structure. Total cost consists of initial construction, maintenance, overlay, seal coat, etc. For these combinations of materials as many as 52 designs were considered for the two layered system. The designer could examine as many of these designs as he wishes. From these the pavement designer and/or administrator may select his design. This approach gives him considerable expanded scope and flexibility in exploring design options and a better chance of achieving the best possible design. Thus the engineer experiences no loss of the normal decision-making power, but rather acquires superior information for making a decision.

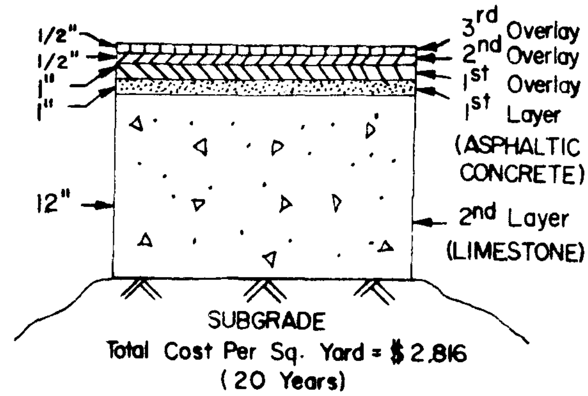

Fig 2. Cross section including overlays for optimum two-layer design.

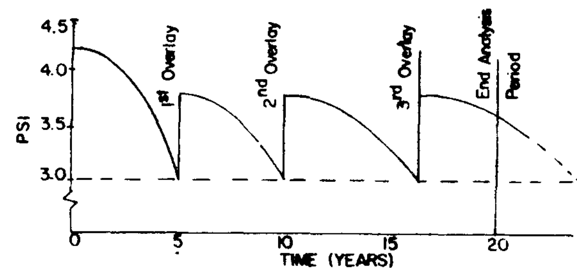

Fig 3. Predicted serviceability history for two-layer design example.

Composition of the Pavement Design System

The total system consists of software (computer programs), hardware (computer and Dynaflect), organization, information, and research management subsystems. The function of each of these parts and their role in the design system are defined in the report.

Implementation of the Pavement Design System

The ultimate value of research is its implementation into the daily operations of the Highway Department. The report recommends guidelines for infusing the pavement design system into the organizational operations of the Texas Highway Department.

The ultimate objective of the project is to develop a complete design system that encompasses all the parameters and variables that affect pavement design, construction, and performance. To attain this will require time and effort. The present design system is far from ideal, but if the Department waits until the complete system is developed at some distant future time, then the payoff of the research investment will be postponed until that future time. Furthermore, its full achievement is not possible without applied usage since the feedback loop is necessary for ascertaining if the system simulates the real design problem adequately. Only through a step function of continual improvement can the ideal system be developed.

Evaluating the Utility of a Systems Based Design

The utility of the approach is examined by a discussion of four factors which if satisfied would indicate that the pavement design system concept is useful to the Texas Highway Department in its normal operations. The report concludes that the pavement design system meets the tests of operationality, rationality, acceptability, and revisability. Thus the implementation of the pavement design systems approach within the Texas Highway Department is feasible.

Recommendations

Based on the findings in the project thus far the report recommends that an appropriate implementation procedure be initiated by the Texas Highway Department in the near future to assist in putting FPS into practice. It is only through use of the system for design and construction that the necessary feedback information can be developed to complete the cycle and begin subsequent improvements. It is also recommended that Texas Highway Department engineers be encouraged to support the project with their time, effort, and facilities when called upon through the proper administrative procedures of the Highway Department.

The full text of Research Report 123-1 can be obtained from R. L. Lewis, Chairman, Research and Development Committee, Texas Highway Department, File D-8 Research, 11th and Brazos Streets, Austin, Texas 78701 (512/475-2971).

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KEY WORDS: systems analysis, systems engineering, design, pavements, flexible pavements, pavement structure, optimization, pavement design, performance, analysis, research management, Texas Highway Department, Center for Highway Research, Texas Transportation Institute, computer program.