TEXAS HIGHWAY DEPARTMENT PAVEMENT MANAGEMENT SYSTEM

James L. Brown, Texas Highway Department

This paper describes a conceptual version of a pavement management system to assist in making pavement decisions that will result in users getting better services for their expenditures. These decisions are made about programming, designing, constructing, and maintaining pavements. A description is given of the conceptual system and the present working system.

•THE TEXAS Highway Department is developing and implementing a pavement management system. Initial attempts to use the AASHO Road Test results to develop a better pavement design method (1) led to a working pavement design system (2), which led to this pavement management system concept.

The primary decision stages in the pavement management process are programming (preliminary design), design (plans, estimates, specifications), construction, operation (traffic, environment, maintenance), and retirement (abandon, salvage, rebuild). The purpose of the pavement management system is to provide information to decision-makers during these 5 stages so that decisions result in either satisfactory service at a lesser cost or the best service with available resources (3). The systems methodology includes identifying the decisions that must be made and the information that is required for them, supplying these data to the decision-makers in a timely and useful form, and monitoring the process to measure success and improve shortcomings.

In Texas, we started with the intention of improving our design procedure, and that effort evolved into developing a pavement management system. Basically, we ran into the following situations: Design decisions were frequently controlled by programming or budgeting constraints; and pavement performance (which we were trying to predict in design) is often affected by construction, environmental, or maintenance inputs to the pavement. We found that a pavement design methodology must consider budget constraints and the construction, maintenance, and natural environment the pavement will encounter. Failure to do so results in the pavement not being built as designed or not performing as predicted (4).

CONCEPTUAL PAVEMENT MANAGEMENT SYSTEM

Conceptually, our system contains the following key elements: design analysis package, pavement feedback data system, and personnel and equipment.

Design Analysis Package

Ultimately, our system should contain a group of pavement design computer programs consisting of a pavement design system, a pavement rehabilitation system, and special analysis routines. The pavement design system will compare all alternate pavement types—thin-surfaced flexible pavements, deep-strength asphaltic pavements, plain concrete pavements, continuously reinforced concrete pavements, and even some of the newer reinforcement systems such as prestressed pavements. The system will assist the decision-maker to select the proper pavement type for a given project and then to design that pavement.

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The pavement rehabilitation system may be a special case of the pavement design system, adding input about the existing pavement and its performance (5). I see a need to receive and analyze the opinions or judgments of local maintenance and engineering personnel about future performance (6).

The special analysis routines are computer programs such as stress analysis routines or fatigue analysis systems or other costly programs that will be used to investigate special conditions. Outputs from these analyses probably will be used to place constraints on the general pavement design system usage or to develop statewide standards. Generally, use of these routines on a project-to-project basis is prohibitive because of computer costs, materials characterizations, and personnel training.

Pavement Feedback Data System

The correct jargon may be pavement management information system instead of pavement feedback data system, which we adopted (7, 8). Whatever the name, important considerations include the data, the storage and retrieval software, and the data analysis and reports software. Also, the management of the system including data editing, methods of purging the files of redundant data, and general maintenance of the files should be considered. The data must answer the following questions:

1. What is the pavement? That is, what is the typical section?
2. Where is it located on the highway network?
3. When was it built?
4. What traffic is traversing it?
5. How is it performing?
6. What maintenance is being applied to it?

We have spent considerable energy studying storage and retrieval software and know that, before it can be designed, we will have to answer certain questions such as the following:

1. What are the data?
2. How will they be used?
3. How frequently will they be accessed?
4. When and how will they be acquired?
5. What are the available hardware and software that can be used?

We have concluded that the Texas Highway Department has ample computer facilities to process (store and retrieve) efficiently the pavement data that we can afford to acquire.

Our pavement management system must supply data to decision-makers in a timely and useful manner. Our feedback data system must contain analysis routines to reduce the raw data to useful statistics, and timely reports must be generated from the processed data. The data system will have to anticipate what reports will be needed so that a minimum of programming will be required to generate them. In other words, the data system will have to contain analysis routines and a report generator.

Managing the information system so that it continues to meet the needs of the users is perhaps the most difficult part of the data system. Recognition that management is an essential element and planning for it in the early stages will help to overcome this difficulty.

Personnel and Equipment

A most difficult problem in establishing our pavement management system lies in the personnel area. This problem becomes clearly evident if one examines our existing organization for pavement design. We have 26 rather autonomous districts, responsible for design, construction, and maintenance of the highways within their areas. Each district generally has 7 or 8 permanent resident engineer's offices that prepare plans and supervise construction for their areas. The following process generally describes the procedures used to make pavement management decisions.

Preliminary design decisions, including selection of pavement type, are usually made at the district headquarters by either the district engineer, assistant district engineer, or district design engineer. Detailed pavement design decisions including location of material sources, final thickness design, and plan preparation are most frequently made by the resident engineer with input from the district laboratory regarding available materials. Construction is then usually supervised by that same resident engineer's office, but may be assigned to another office. Routine and minor maintenance is handled by maintenance crews under the supervision of maintenance foremen; there are 7 or 8 maintenance sections per district. Major maintenance decisions involving overlays or reconstruction are usually made by the resident engineer

The expertise used in making decisions is engineering judgment gained from experience with the materials, traffic, and environment (9). Our difficult task, then, lies in identifying the personnel making the decisions and supplementing that experience (or expertise) with additional information. This additional information might be the results of theoretical analyses or the results of empirical measurements. Whatever, we will have to train the people to use the data, which will basically be new to them.

The operators of the system, that is, the people who collect and process the data, also have to be considered: equipment operators, researchers to use the data in improving models, and a manager to ensure that the system is responsive to the users' needs.

The equipment includes skid- and texture-measuring devices, deflection-measuring devices, roughness-measuring equipment, the computer (including terminals located in district offices), and whatever special laboratory equipment is required for material characterization. Special equipment for pavement distress surveys will also be required on high-capacity, high-speed freeways such as those in Houston, Dallas, Fort Worth, and San Antonio. We have given a cursory examination to aerial photography and photologging as possibilities for this equipment. We are certain that selecting the equipment and preparing manuals for its calibration, operation, and control are major tasks.

PRESENT STATUS OF DEVELOPMENT AND IMPLEMENTATION

Design Analysis Package

We have operational and in some usage a flexible pavement design system (10). Its objective is to minimize the present value of total cost for a satisfactory pavement service. The designer specifies a minimum serviceability level, a desired reliability, an analysis period, a minimum time to the first overlay, and a minimum time between future overlays. Costs considered include initial construction cost and the construction cost of future overlays. One important additional feature is the consideration of the serviceability loss due to the presence of swelling clays.

Some personnel from 10 districts have been trained in using this system (11). Their usage represents roughly 50 percent of the flexible pavement designed in those 10 districts. Fifty percent of 40 percent of the districts is 20 percent coverage of the state.

Implementation of our rigid pavement design system (RPS) is presenting some elusive problems (12). The designers who have used it generally feel that they have no design problems except for perhaps 1 or 2 factors. They may be uncertain about, for example thickness of pavement or subbase type or joint spacing. The RPS developers believe that pavement designers have many problems including the selection of the type and thickness of rigid pavement, type and thickness of subbase, and proper amounts and spacing for reinforcement.

I am not completely convinced that our RPS offers a good solution to either recognized or unrecognized problems of designers, nor am I convinced that the designers recognize or admit to nearly all of the problems they have. I am convinced that the solution lies in having the developers work closely with the users so that the needs and problems of each are recognized.

We have operational an asphaltic concrete overlay mode only (13, 14). It utilizes Dynaflect deflection measurements on the existing road, and we could add, without too much difficulty, the traffic the existing road has carried and its present serviceability as inputs.

Pavement Feedback Data System

Our pavement management information system is still just an idea with the exception of skid information. In several districts we are collecting on a periodic basis skid measurements and surface construction materials information. These data are stored and retrieved in a data system (15). Those engineers who have studied the pavement management system being considered in Texas feel that the biggest payoff will come from implementation of the feedback data system; yet, it will require the largest effort.

Personnel and Equipment

The organization of personnel and the assignment of responsibilities have not proceeded much beyond the conceptual stage mentioned earlier. We have attempted to identify those existing tasks that can be considered part of our pavement management system, and in addition we have identified some completely new ones. These include primarily measuring pavement performance and putting all of the operations together in the system, i.e., managing the system. We have many ongoing tasks ranging from pavement design to data collection in our road life studies by existing personnel. These tasks and people must be identified and included in the system.

Our largest equipment problem involves getting a workable, repeatable fleet of roughness-measuring devices to handle a 70,000-mile network inventory.

SUMMARY AND CONCLUSIONS

1. A pavement management system is not merely a pavement design system. In fact, a typical structural design analysis will frequently be overridden by the realism of financial constraints.
2. Decisions about pavements are based primarily on experience. This experience must be recognized and supplemented, not replaced.
3. Throughout all phases, from development to implementation, the user of the system must be involved. Otherwise, the system will probably not respond to the needs of the user, or possibly the user cannot recognize the responses and apply them to his or her needs.
4. In many respects the pavement management system must be custom-designed for an organization.

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