U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: PAVEMENT MANAGEMENT SYSTEM

Date: 9/28/88
Initiated by: AAS-200

AC No: 150/5380-7
Change:

1. PURPOSE. This advisory circular (AC) presents the concepts of a Pavement Management System, discusses the essential components of such a system, and outlines how it can be used in making cost-effective decisions regarding pavement maintenance and rehabilitation.

2. APPLICATION. The guidelines contained herein are recommended by the Federal Aviation Administration for use when considering implementation of a pavement management system.

3. BACKGROUND.

a. Historically, most agencies have made decisions regarding maintenance and rehabilitation based on experience rather than using documented data. This approach did not allow the agency to evaluate the cost-effectiveness of alternative maintenance and repair strategies and led to an inefficient use of funds.

b. Every agency must decide how to allocate its available funds most effectively. Many agencies use the "ad hoc" approach, whereby the staff applies the maintenance and repair procedure that their experience indicates is the best solution. This approach usually results in the repeated application of a select few alternatives and does not necessarily select the best or most economical option. The "existing condition" approach is also used. Here, the pavement network is first evaluated by means of various condition indicators. Based on an analysis of these indicators, maintenance and repair alternatives are selected. However, life-cycle cost comparisons of the alternatives are not considered. This approach selects the maintenance and repair procedures that relate to the deficiencies in the pavement, but the choice may not be the most cost-effective method based on life-cycle costing.

c. Since these approaches worked well, they became part of the standard operating procedure in some agencies. Today, however, with limited money to spend on maintenance and rehabilitation and new technology providing more options for repair, these established procedures do not answer some basic questions. For example, what if funds are available to do only half the overlays that the procedure indicates is necessary in a particular year? Should some pavements be overlaid to the proper thickness while the remainder receive no overlay? Should the thickness be reduced and a thin overlay be placed on all pavements? It is evident that decisions made today will have an effect on the pavements condition in future years. The question then becomes which course of action to take and the immediate and future consequences of such action.

4. NEW DECISIONMAKING PROCESS.

a. The question can best be answered on the basis of the predicted effects of each action. For example, if a thin overlay is placed on all pavements there will be an immediate improvement to all the pavements. However, due to rapid deterioration there will probably be a need for further rehabilitation in a short period of time. If some of these same pavements need work again next year, in addition to other pavement in need of work, the overall condition of the pavement network will deteriorate. Alternatively, if the full thickness overlay is placed only on selected pavements, they will not need rehabilitation for many years. During each of these years it may be possible to overlay some of the remaining pavements so that ultimately the number of pavements needing rehabilitation may decrease. However, those pavements that have not been overlaid will continue lo deteriorate under this strategy, and the overall pavement condition will probably be worse during the first few years than under the first strategy.

In order to determine which of these actions is preferable, we must be able to predict the future consequences of the various scenarios. For example, we must know the life span of a thick overlay , say 4-inches, versus a thin 2-inch overlay. We should also have a knowledge of the rate of deterioration of pavements, with and without maintenance, and a good understanding of the causes of current pavement deterioration.

b, These predictions may be' made using "engineering judgment'* in the decisionmaking process. However, if the consequences are predicted using a predetermined methodology, it will be possible to analyze previous predictions and to improve on the prediction procedure over a period of time.

c. One such methodology is a Pavement Management System (PMS). The idea of a pavement management system is to improve on the decisionmaking process, expand its scope, allow for feedback based on decisions made, and to ensure that consistent decisions are made throughout an organization.

5. PAVEMENT MANAGEMENT SYSTEM (PMS). A pavement management system provides a consistent objective and systematic procedure for setting priorities and schedules, allocating resources, and budgeting for pavement maintenance and rehabilitation. It can also quantify information and provide specific recommendations for actions required to maintain a pavement network at an acceptable level of service while minimizing the cost of maintenance and rehabilitation.

A PMS is not a "black box" solution but is a tool for helping the engineer, budget director, and management to do a better job in making cost-effective decisions regarding pavement maintenance and rehabilitation.

a. Concepts of a Pavement Management System. A PMS not only evaluates the present condition of a pavement but predicts its future condition through the use of a pavement condition indicator. By projecting the rate of deterioration, a life-cycle cost analysis can be performed for various alternatives, and the optimal time of application of the best alternative is determined.

Such a decision is critical in order to avoid higher maintenance and repair (M&R) costs at a later date. Figure 1 illustrates how a pavement generally deteriorates and the relative cost of rehabilitation at various times throughout its life. Note that during the first 75 percent of a pavements' life, it performs relatively well. After that, however, it begins to deteriorate rapidly. The number of years a pavement stays in "good" condition depends on how well it is maintained. Numerous studies have shown that the ratio of total annual costs between maintaining a good pavement and periodically rehabilitating a poor pavement is in the order of 1 to 4 or 5.

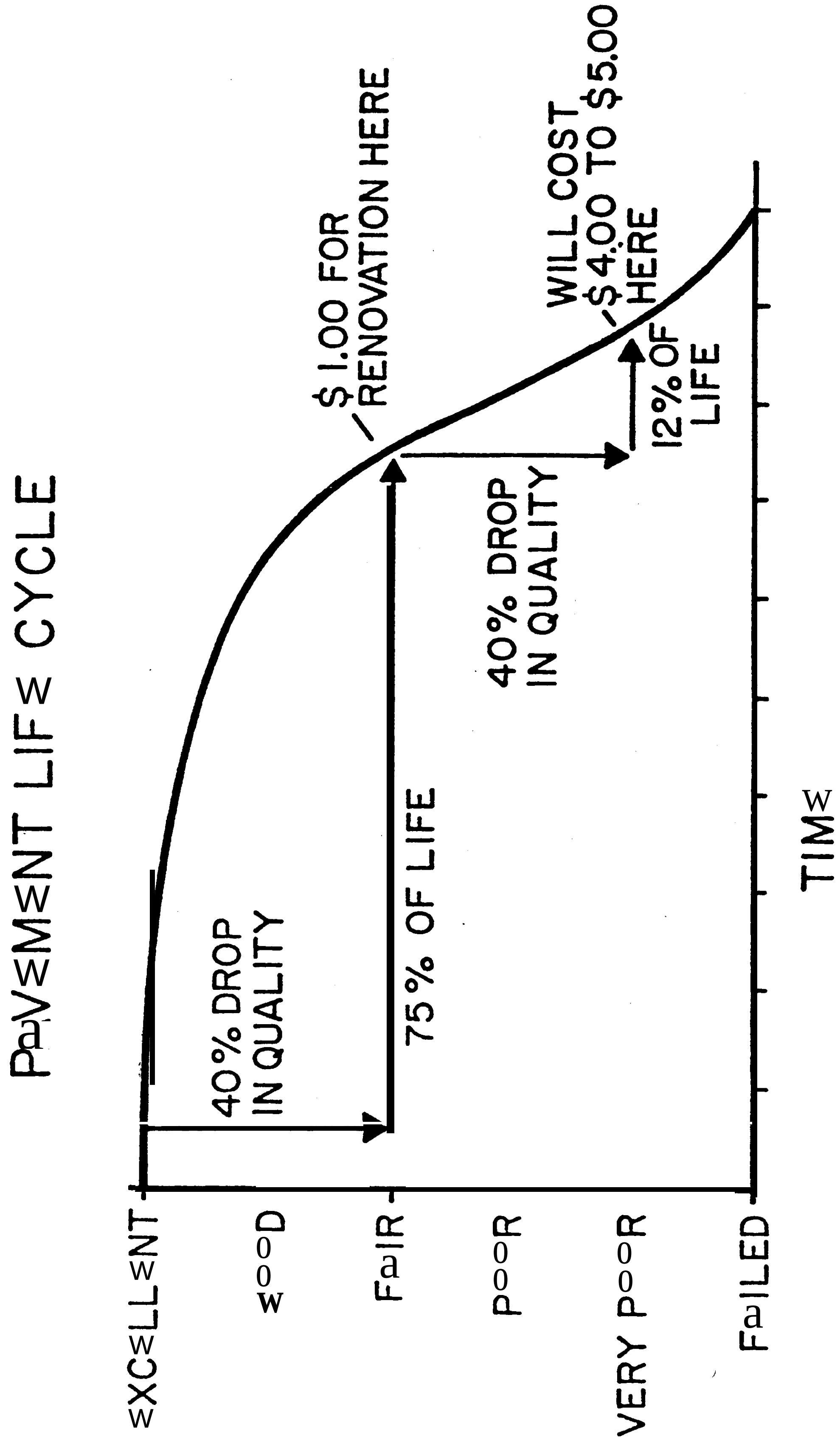
Figure 1 also shows that the optimum time for major rehabilitation Is just as a pavement's rate of deterioration begins to increase. Maintenance and rehabilitation solutions would be more easily managed if pavements exhibited a clear sign at this point, but this is not the case. The shape of the deterioration curve, and therefore the optimal maintenance and repair points, vary considerably within a pavement network A pavement experiencing a sudden increase in operations or aircraft loading will have a tendency to deteriorate more rapidly than a pavement deteriorating from environmental causes. In addition, there are no obvious visual signs at this time. A pavement deteriorating from environmental damage may have a number of cracks that need filling but still be structurally sound. Conversely, this same pavement may be in the early stages of load damage deterioration which can only be detected with proper testing.

Since there is no "positive signal" as to when a pavement reaches the 75 percent deterioration point, we depend on a PMS to help us target our resources to this optimum rehabilitation point. This can be accomplished through the use of a pavement condition rating system which will predict future conditions and indicate whether the distress is load or environmentally related.

b. Cost Effective Solutions. Information on pavement deterioration, by itself, is not sufficient to answer questions involved in selecting cost-effective maintenance and repair strategies. For example, should a pavement be sealcoated, recycled, or resurfaced? This type of decision requires information on the cost of various maintenance and repair procedures and their effectiveness. Effectiveness in this case means:

The proposed solution is targeted toward the source of the deficiency and will improve' the pavement's condition rating.

The pavement will stay in this improved condition for several years to optimally recover the cost of the solution.



Typical Pavement Condition Life Cycle (Reprinted from APWA Reporter, November 1983)

A pavement management system will enable a user to store information in a data base and use the system's programs to determine the most cost-effective solution to these questions.

6. COMPONENTS OF A PAVEMENT MANAGEMENT SYSTEM. In order to take full advantage of a pavement management system, information must be collected and periodically updated, decision criteria must be established, alternative strategies must be identified, predictions of the performance and costs of alternative strategies must be made, and optimization procedures that consider the entire pavement life cycle must be developed.

A system for accomplishing these objectives must generally include:

A systematic means for collecting and storing information.

An objective and repeatable system for evaluating pavement condition.

Procedures for identifying alternative strategies.

Procedures for predicting the performance and costs of alternative strategies.

Procedures for identifying the optimum alternative.

A discussion of the essential components of a PMS follows.

a. Data Base. There are several elements critical to making good pavement maintenance and, repair decisions; pavement structure, maintenance history, including costs, traffic data, and information on the condition of a pavement. This data can be stored in a system's data base.

(1) Pavement 'Structure. A key to analyzing problems and designing solutions is a knowledge of when the pavement was originally built, the structural compositions (material and thickness), and subsequent overlays, rehabilitation, etc. "As built" records should provide this information. If they are not available or if records are suspect, it will be necessary to take test cores in the existing pavement.

(2) Maintenance History. A history of maintenance performed and its associated costs provide valuable information on the effectiveness of various maintenance procedures on flexible and rigid pavements. The cost of each maintenance procedure is necessary when performing a life-cycle cost analysis.

(3) Traffic Data, The number of operations and type of aircraft using the pavement are necessary when analyzing probable causes of deterioration and when considering rehabilitation procedures.

(4) Pavement Condition. A basic component of any pavement management system is the ability to track a pavement's deterioration and determine the cause of the deterioration. This requires an evaluation process that is objective, systematic, and repeatable. A pavement condition rating system that is based on the quantity, severity, and type of distress is a rating of the surface condition of a pavement performance with implications of structural performance. Condition rating data collected periodically will track the performance of a pavement.

b. Alternative Strategies. In order to compare alternative solutions to a particular problem, the system must contain a list of feasible actions related to the pavement condition. These alternative strategies should take into consideration such factors as pavement condition, rate of deterioration, causes of distress, previous maintenance, and current and future traffic.

c. Performance and Costs of Alternatives. Based on the results of identifying alternative strategies, the system must be able to predict the future performance of a pavement for the various alternatives and perform an economic analysis to compare the costs of all alternatives (life-cycle costing).

d. Optimization. In order to select the alternative that satisfies cost and performance constraints, a procedure that evaluates several alternative solutions to a specific set of conditions is needed.

7. MICRO-PAVER.

a. Background. A pavement management system that has been used on airport pavement networks al the state and local level is Micro-PAVER. This system, which operates on a microcomputer, was developed by the U.S. Army Construction Engineering Research Laboratory under contract to the Federal Aviation Administration.

The program allows for storage of pavement condition history, nondestructive testing data, 'and construction and maintenance history, including cost data. This data base provides many capabilities including evaluation of current conditions, prediction of future conditions, identification of maintenance and rehabilitation needs, inspection scheduling, economic analysis, and budget planning. Micro-PAVER not only evaluates the present condition of the pavement using the pavement condition index (PCI) described in Appendix A of AC 150/5380-6, Guidelines and Procedures for Maintenance of Airport Pavements but can also predict its future condition. The PCI is a numerical indicator that reflects the structural integrity and surface operational condition of a pavement. It is based on an objective measurement of distress type, severity, and quantity. By projecting the rate of deterioration, a life-cycle cost analysis can be performed for various maintenance and rehabilitation alternatives. Not only is the best alternative selected but the optimal time of application is also determined.

b. Management Levels. Once a data base has been established, Micro-PAVER can be used to assist in making pavement management decisions. Managing a pavement system effectively requires decisionmaking at two levels:

(1) Network level. At the network level in which decisions are made regarding the management of an entire pavement network. For example, at the local level, all the pavements on an airport, and at the state level, all the pavements on each of the airports in the state system.

(2) Project level. At the project level, decisions are made regarding the selection of the most cost-effective maintenance and rehabilitation alternative for a pavement identified as a candidate for work at the network level.

8. NETWORK LEVEL.

a. In network level management, questions are answered concerning short and long range budget needs, the overall condition of the network, both currently and in the future, and identification of pavements for consideration at the project level.

b. In addition to providing an automated inventory of pavements being managed, Micro-PAVER provides a series of programs which access the data base and produce customized reports. These reports help the user make decisions regarding inspection scheduling, identification of pavements for rehabilitation, budget forecasting, identification of routine maintenance projects, evaluation of current condition, and prediction of future condition.

c. Condition prediction is used as the basis for developing inspection schedules and identifying pavements requiring maintenance or rehabilitation. Once pavements requiring future work have been identified, a budget for the current year and for several years into the future can be developed. By using an agency's prioritization scheme, maintenance policy, and maintenance and rehabilitation costs and comparing the budget to the actual funds available for the current year, a list of potential projects is produced. This list becomes the link with project level management.

9. PROJECT LEVEL. In project level management, decisions are made regarding the most cost-effective maintenance and rehabilitation alternative for the pavements identified in the network analysis. At this level each of these pavements should have a detailed condition survey. In addition, nondestructive and/or destructive tests should be made to determine the pavements load-carrying capacity.

Roughness and friction measurements may be useful for project development. Roughness measurements may be useful when there is evidence of roughness, usually in the form of frequent pilot complaints. Roughness measurement is of more value when the pavement is in very good condition with little or no distress. If reconstruction is imminent, roughness measurements of the existing pavement may not be of any value. Friction measurements, on the other hand, should be made on a periodic basis to measure the textural properties of the pavement and determine the amount of deterioration that has occurred. Nondestructive test data, friction measurements, roughness measurements. and drainage information may all be entered into the data base. This information is used to identify feasible alternatives that can correct existing deficiencies. The various alternatives identified, including no action, are then compared on a life-cycle cost basis. The results, combined with budget and management constraints, produce the current year's maintenance and repair (M&R) program.

10. REPORT GENERATION AND USAGE. Micro-PAVER can assist in the 'decisionmaking process through the use of several standard reports. Each report can be customized to include only the pavements and/or conditions of interest and can be generated to represent various budget/condition scenarios. The use of each report is briefly outlined below.

a. Inventory Report. This report is a listing of all pavements in a network and contains information such as surface type, location, area, and pavement function, i.e.; runway, taxiway, apron.

b. Inspection Scheduling Report. This report allows the user to schedule inspections for the next 5 years based on a pavements minimum acceptable PCI condition level and rate of deterioration.

c. PCI Frequency Report. This report provides the user with an indication of overall network condition, based on the PCI scale, for the current or future years. The projected condition can be used to assist in planning future maintenance and repair needs and to inform management of present and future conditions. Since the PCI extrapolation used presumes no major repairs have occurred between the last inspection and prediction dates, the user can see the impact on the overall network condition of performing no major repairs.

d. Budget Planning Report. This report allows the user to produce 5-year projected budgets required to maintain the pavement network above a user-specified condition level. The user is required to input three forms of data; (1) minimum PCI values for each pavement type (2) average unit repair costs based on surface type and PCI ranges, (3) the inflation rate during the analysis period. The report predicts for each pavement selected the year in which the minimum PCI will be reached and calculates the cost of repair.

e. Network Maintenance Report. This report uses the agency's maintenance policy which is stored in the data base and applies it to the distresses identified in the latest PCI survey. This report can be used to estimate both the type and cost of routine maintenance for the development of an annual work plan.

f. Economic Analysis Report. This report can be used to help select the most cost-effective alterna-. tive for a pavement repair. For each feasible alternative, the user must input initial costs, periodic maintenance costs, one-time future maintenance costs, interest rates, and discount rates. The program performs a life-cycle cost analysis and provides the user with an equivalent uniform annual cost per square yard. The program allows the user to vary interest rates, repair costs, and timing so that their effect on alternatives can be analyzed.

11. MICRO-PAVER SOFTWARE. The Micro-PAVER Program can be operated on an IBM-compatible personal computer having a hard disk with 20 mega-bytes storage capacity and 640K random access memory (RAM). Version 2.0, or greater, of MS-DOS is the operating system required.

The Micro-PAVER software package, together with a user's guide, may be obtained from a distribution center. currently, there are three distribution centers, with each center responsible for establishing individual fees for distribution and providing updates and corrections as they become available. The fees vary according to the service provided to the user (training, implementation assistance, user's group membership, etc.), but range between $300 and $500 per year. Users should contact each center and determine which one will best suit their needs. The location of the centers is contained in AC 150/5000-6, Micro-PAVER, Pavement Management System.

Additional information concerning Micro-PAVER is contained in report number DOT/FAA/PM-87/8, Micro-PAVER, Concept and Development Airport Pavement Management System, dated July 1987.

12. OTHER PAVEMENT MANAGEMENT SYSTEMS. Pavement management systems other than Micro-PAVER are used by consulting engineer firms that provide pavement evaluation and management services. The software programs used by these firms are not in the public domain and therefore cannot be purchased for use by an individual or an agency.

13. BENEFITS OF A PAVEMENT MANAGEMENT SYSTEM. Some of the benefits to be gained from implementation of a PMS include:

a. provides an objective and consistent evaluation of the condition of a network of pavements.

b. provides a systematic and documentable engineering basis for determining maintenance and rehabilitation needs.

c. identifies budget requirements necessary to maintain pavements at various levels of serviceability.

d. provides documentation on the present and future condition of the pavements in a network.

e. determines life-cycle costs for various M&R alternatives.

f. identifies the impact on the pavement network as a result of performing no major repairs.

Raymond T. Uhl
for Leonard E. Mudd
Director, Office of Airport Standards