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of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: AIRPORT PAVEMENT MANAGEMENT PROGRAM

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Initiated by: AAS-100

Change:

1. PURPOSE OF THIS ADVISORY CIRCULAR.

This advisory circular (AC) discusses the Airport Pavement Management System (APMS) concept, its essential components, and how it can be used to make cost-effective decisions about pavement maintenance and rehabilitation.

2. WHAT THIS AC CANCELS.

This AC cancels AC 150/5380-7, Pavement Management System, dated September 28, 1988.

3. WHO THIS AC AFFECTS.

This AC is intended for the airport operators, engineers, and maintenance personnel responsible for implementing an airport pavement management system.

4. COMMENTS OR SUGGESTIONS.

Send comments or suggestions for improving this AC to—

Manager, Airport Engineering Division
Federal Aviation Administration
ATTN: AAS-100
800 Independence Avenue SW
Washington DC 20591

5. COPIES OF THIS AC.

The Office of Airport Safety and Standards makes its ACs available online at http://www.faa.gov/airports_airtraffic/airports/resources/advisory_circulars/.

David L. Bennett
Director, Office of Airport Safety and Standards

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1.0 BACKGROUND.

a. Historically, most airport sponsors have made decisions about pavement maintenance and rehabilitation (M&R) based on immediate need or experience rather than long-term planning or documented data. This approach did not allow the airport sponsors to evaluate the cost effectiveness of alternative maintenance and repair strategies, and it led to an inefficient use of funds.

b. Every airport sponsor must decide how to allocate its available funds most effectively. Typically, this is done using one of the following methods:

(1). Many airport sponsors use an “ad hoc” approach, whereby the staff applies the maintenance and repair procedure that their experience indicates is the best solution for the immediate problem. This approach usually results in the repeated application of a select few alternatives and may not lead to the selection of a preferred rehabilitation strategy that considers pavement performance and a life-cycle cost (LCC) analysis.

(2). 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. This method does not take into account life-cycle cost comparisons of the alternatives because decisions are based solely on the current condition of the pavement. This approach selects the maintenance and repair procedures that relate to the current 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 reasonably well in the past, they became part of the standard operating procedure in some agencies. Today, however, with limited money to spend on maintenance and rehabilitation and new technologies 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 are necessary in a particular year? Should some pavements be overlaid to the proper thickness while the remaining pavements receive no overlay? Should the thickness be reduced and a thin overlay placed on all pavements? It is evident that decisions made today will have an effect on the pavements’ condition in future years. The question must then become, which course of action should be taken and what are the immediate and future consequences of such decisions.

2.0 NEW DECISION-MAKING PROCESS.

a. The selection of the best course of action can be determined based on the predicted effects of each action. For example, by placing a thin overlay on all pavements, there will be an immediate improvement to all the pavements. However, due to rapid deterioration of the overlays, there will probably be a need for further rehabilitation in a short period of time. If, in addition to other pavements needing work, some of the overlaid pavements need rehabilitation action again next year, the overall condition of the pavement network will eventually deteriorate. Alternatively, if a few selected pavements receive the full thickness overlay, they will not need rehabilitation for many years. During subsequent years, remaining pavements can then receive full thickness overlays, so the number of pavements needing rehabilitation will ultimately decrease. With this strategy, however, overall pavement condition will be worse in the short term

because those pavements that have not been overlaid will continue to deteriorate until they are rehabilitated.

In order to determine which of these actions is preferable, we must be able to predict the future consequences of the various scenarios. This requires an understanding of the life span of a thick (e.g., 4-inch) versus thin (2-inch) overlay. Practitioners should also have a good understanding of the rate of pavement deterioration, with and without maintenance, and the causes of current pavement deterioration, such as environmental conditions or pavement loading conditions.

b. Predicting consequences of rehabilitation scenarios requires using “engineering judgment” in the decision-making process. However, if the consequences are predicted using a predetermined methodology, it becomes possible to analyze previous predictions and improve on the prediction procedure over a period of time—regardless of management or staff turnover.

c. One such methodology is an Airport Pavement Management System (APMS), which can improve on the decision-making process, expand its scope, allow for feedback based on choices made, and ensure that consistent decisions are made throughout an organization.

3.0 AIRPORT PAVEMENT MANAGEMENT SYSTEM (APMS).

An APMS—as identified in Appendix 1 of AC 150/5380-6, Guidelines and Procedures for Maintenance of Airport Pavements—provides a consistent, objective, and systematic procedure for establishing facility policies, 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. Theory Behind an Airport Pavement Management System. An APMS not only evaluates the present condition of a pavement, but also 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 made for various alternatives. This analysis will help determine the optimal time for applying the best alternative. Such a decision is necessary to avoid higher maintenance and repair costs in the future. Figure 1 illustrates how a pavement generally deteriorates and the relative cost of rehabilitation at various times throughout its life. A pavement generally performs well for the majority of its life, after which it reaches a “critical condition” and begins to deteriorate rapidly. Several studies have shown that maintaining a pavement in good condition versus periodically rehabilitating a pavement in poor condition is four to five times less expensive. The number of years a pavement stays in “good” condition before rapidly deteriorating depends on several factors, including construction type and quality, pavement use, climate, and maintenance.

Figure 1 also shows that the ideal time for major rehabilitation is just as a pavement’s rate of deterioration begins to increase. Maintenance and rehabilitation solutions would be easy to plan if pavements exhibited clear signs they had reached this point, but unfortunately, they do not. 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 solely from environmental causes. A pavement deteriorating from environmental

damage may have a number of cracks that need filling but still remain structurally sound. Conversely, this same pavement may be in the early stages of load damage deterioration, which can only be detected with proper testing.

Because it is difficult to determine when a pavement has reached the critical condition, an APMS can help identify the optimal rehabilitation point and help decision-makers target available resources where they will be most effective. The APMS can do this by making use of data from a pavement condition rating system that will predict future conditions and indicate whether the distress is load or environmentally related.

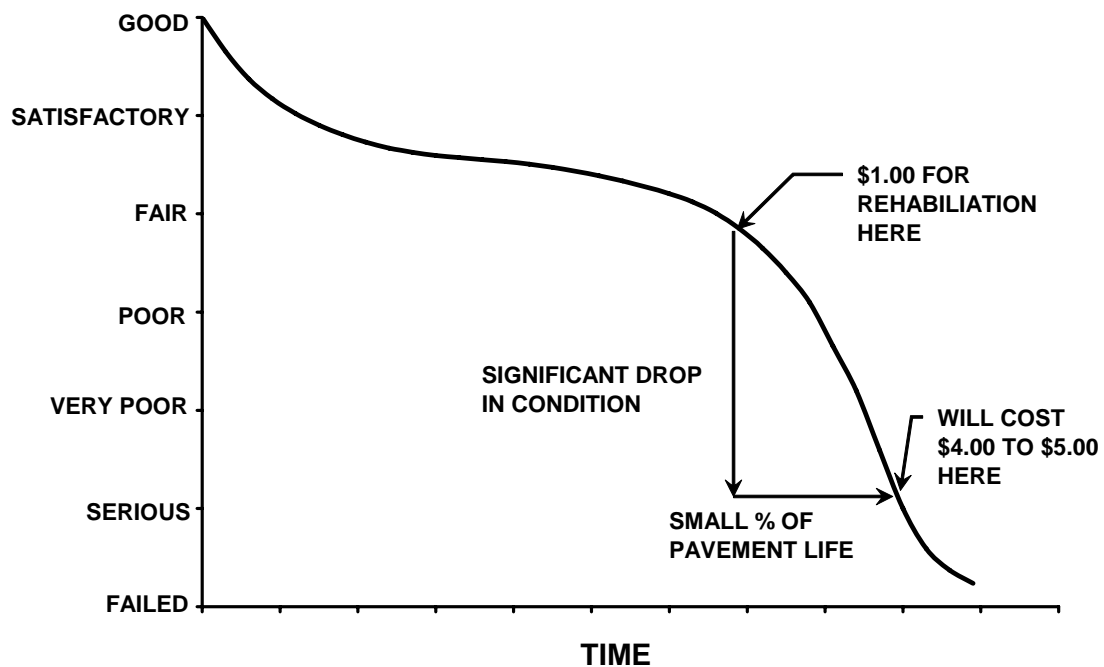


FIGURE 1. Typical Pavement Condition Life Cycle (Springer 2005)

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 sealed, 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 targets 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.

A pavement management system will enable a user to store pavement condition and maintenance information in a database and use the program's resources to determine the most cost-effective solution for pavement maintenance issues.

3.1 BENEFITS OF AN AIRPORT PAVEMENT MANAGEMENT SYSTEM.

An APMS can provide several benefits, including—

- Providing an objective and consistent evaluation of the condition of a network of pavements.
- Providing a systematic and documentable engineering basis for determining maintenance and rehabilitation needs.
- Identifying budget requirements necessary to maintain pavements at various levels of serviceability.
- Providing documentation on the present and future condition of the pavements in a network.
- Determining life-cycle costs for various maintenance and rehabilitation alternatives.
- Identifying the impact on the pavement network as a result of performing no major repairs.

3.2 COMPONENTS OF AN AIRPORT PAVEMENT MANAGEMENT SYSTEM.

In order to take full advantage of a pavement management system, pavement condition information must be collected and periodically updated. Alternative rehabilitation strategies must be identified along with decision criteria and maintenance policy that will determine which rehabilitation procedures are employed. Further, the pavement management system must contain models for prediction of performance, cost of alternate strategies, and optimization procedures that consider the entire pavement life cycle.

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 predicting future pavement condition.
- Procedures for modeling pavement performance (both past and future condition).
- Procedures for determining the consequence on pavement condition and life-cycle costing for a given M&R budget.

- Procedures for determining budget requirements to meet management objectives, such as maintaining a minimum condition.
- Procedures for formulating and prioritizing M&R projects. A project normally consists of multiple pavement sections and may include different M&R actions for different sections.

The essential components of a pavement management system include—

a. Database. 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 an APMS database.

(1). Pavement Structure. Knowing when the pavement was originally built, the structural composition (material and thickness), and subsequent overlays, rehabilitation, etc., is key to analyzing problems and designing solutions. “As built” records should provide this information. If they are not available or if records are suspect, it will be necessary to core the existing pavement to establish the thickness and composition of the structural layers.

(2). Maintenance History. A history of maintenance performed and its associated costs will 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. Data about the number of operations and type of aircraft using the pavement is necessary when analyzing probable causes of deterioration and when considering alternate M&R procedures.

(4). Pavement Condition Data. A fundamental component of any pavement management system is the ability to track pavement condition. This requires an evaluation process that is objective, systematic, and repeatable. A pavement condition rating system—such as the pavement condition index (PCI) rating system described in *ASTM D 5340, Standard Test Method for Airport Pavement Condition Index Surveys* (and discussed below), provides a rating of the surface condition of a pavement with implications of structural performance. Periodically collecting condition data is essential for tracking pavement performance, modeling pavement performance, and determining when to schedule M&R.

b. System Capabilities.

(1). Predicting Future Pavement Condition. A pavement management system must be capable of predicting future pavement condition. Condition predictions are necessary in developing optimum, multi-year M&R plans.

(2). Determining Optimum M&R Plans for a Given Budget. An APMS should be capable of producing an optimum M&R plan that identifies where and when M&R is required and approximately how much it will cost. This data will assist in setting priorities that fit predetermined M&R budgets.

(3). Determining Budget Requirements to Meet Management Objectives. An APMS should be capable of determining the budget requirements for meeting specified management objectives. Typical management objectives include maintaining pavements above a specified condition and eliminating major M&R requirements over a specified number of years.

(4). Facilitating the Formulation and Prioritization of M&R Projects. In addition to developing optimum M&R plans at the section level, an APMS should facilitate the formulation and prioritization of M&R projects. Engineering judgment, however, remains a key component in transforming the optimum M&R plans into practical executable projects.

4.0 MICRO PAVER™ AND OTHER COMMERCIAL PMS SOFTWARE.

When developing an APMS, airports can make use of several existing software options. Micro Paver™ is a pavement management system (PMS) application being used by airport pavement networks at the state and local level. The U.S. Army Construction Engineering Research Laboratory under contract to the Federal Aviation Administration developed this computer program. The program has been continually updated by the FAA, Federal Highway Administration, U.S. Corp of Engineers, U.S. Air Force, U.S. Navy, and other authorities to meet the needs of current users. In addition, various consulting firms have developed similar software using the concept originally developed in Micro Paver™.

PMS software allows for storage of pavement condition history, nondestructive testing data, and construction and maintenance history, including cost data. It 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. PMS software not only evaluates the present condition of the pavement using the PCI system described in *ASTM D 5340*, but can also predict its future condition.

Note: 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 M&R alternatives. Not only can the best alternative be selected, but the optimal time of application can also be determined.

4.1 MANAGEMENT LEVELS.

Once an APMS has been established, PMS software can be used to assist in making pavement management decisions. Managing a pavement system effectively requires decision-making at two levels:

a. Network-Level Management. In network-level management, questions are answered about short-term and long-term budget needs, the overall condition of the network (currently and in the future), and pavements to be considered at the project level. Decisions are made about the management of an entire pavement network. At a local level, this might comprise all the pavements on an airport, and at a state level, all the pavements in the state airport system.

(1). Using PMS Software at the Network Level. In addition to providing an automated tool for storing information about specific pavements, PMS software provides a series

of routines that access the database and produce customized or user-defined reports. These reports can help the user make decisions about inspection scheduling, pavements needing rehabilitation, budget forecasting, routine maintenance projects, current pavement conditions, and future condition predictions.

(2). Condition Prediction. 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 M&R costs and then comparing the budget to the actual funds available for the current year, the software produces a list of potential projects. This list becomes the link into project-level management.

b. Project-Level Management. In project-level management, decisions are made about the most cost-effective M&R alternative for the pavements identified in the network analysis. At this level, each specified pavement should have a detailed condition survey. In addition, nondestructive and/or destructive tests should be made to determine the pavement's load-carrying capacity. Roughness and friction measurements may be useful for project development.

(1). Roughness. Roughness measurements can be helpful when there is evidence of roughness, usually in the form of frequent pilot complaints. Roughness measurement is of greater value when the pavement is in very good condition with little or no distress. It has less value if reconstruction is imminent.

(2). Friction. 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. AC 150/5320-12, *Measurement, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces*, provides recommendations for friction measurements.

(3). Using PMS Software at the Project Level. PMS software can use a number of engineering measurements to quantify a pavement's condition. Nondestructive test data, friction measurements, roughness measurements, and drainage information may be entered into the APMS database. 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 program.

4.2 REPORT GENERATION AND USAGE.

Micro PaverTM and other PMS software can assist in the decision-making process by allowing the user to run several standard reports. Standard and customized reporting functions vary among PMS software packages. The recommended minimum set of reports and the use of each report is outlined below. PMS software should allow the user to customize the reports to include only the pavements and/or conditions of interest and to generate various budget/condition scenarios.

- a. Inventory Report.** This report lists 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 based on minimum acceptable condition levels and rates of deterioration.
- c. Pavement Condition Report.** This report provides the user with a tabulation of pavement condition for the current or future years. The report should provide the condition of individual pavement sections and the overall network condition. The projected condition can be used to assist in planning future maintenance and repair needs and to inform management of present and future conditions.
- d. Budget Planning Report.** This report allows the user to project the budgets required to maintain the pavement network above a user-specified condition level. For each pavement selected, the report predicts the year in which the minimum condition or PCI will be reached and calculates the cost of repair. To obtain this report, the user must input three forms of data:
- (1). Minimum pavement condition (often PCI) for each pavement type,
 - (2). Average unit repair costs based on surface type and PCI ranges, and
 - (3). Inflation rate during the analysis period.
- e. Network Maintenance Report.** This report uses the agency's maintenance strategy, which is stored in the database, 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 assist the user in selecting the most cost-effective alternative 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 a means of comparing the effectiveness of the various repair alternatives. The program should allow the user to vary interest rates, repair costs, and timing so their effect on alternatives can be analyzed.

4.3 SOURCES OF PMS SOFTWARE.

- a. Micro Paver™.** The Micro Paver™ software package may be obtained from an authorized distribution center. Currently, there are two 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, user guides, implementation assistance, user's group membership, etc.). Users should contact each center and determine which one will best suit their needs. The location of the distribution centers, user manuals, and product updates are provided on the Micro Paver™ website at <http://www.cecer.army.mil/paver/>.

b. Other PMS Software. Other PMS software has been developed and used by consulting engineer firms that provide pavement evaluation and management services. Some firms may offer or sell their software programs for use by an individual or an agency.

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APPENDIX 1. RELATED READING MATERIAL

1. Electronic copies of the latest versions of the following FAA publications are available on the FAA website at <http://www.faa.gov/>. Printed copies can be requested from the Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Ave, Landover, MD 20785. The Department of Transportation, however, will charge a fee for some of these documents.
 - a. AC 150/5320-12, Measurement, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces.
 - b. AC 150/5370-11, Use of Nondestructive Testing Devices in the Evaluation of Airport Pavements.
 - c. AC 150/5380-6, Guidelines and Procedures for Maintenance of Airport Pavements.
2. Copies of *(ASTM) D 5340, Standard Test Method for Airport Pavement Condition Index Surveys*, can be obtained from the American Society for Testing and Materials at <http://www.astm.org/>.
3. “Pavement Management for Airports, Roads, and Parking Lots”, M.Y. Shahin, Second Edition, Springer, 2005.