Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

A Best Practice for the Implementation of a Pavement Management System For Small and Medium Airports

Architectural & Engineering Services
Civil Engineering Directorate
Airport Engineering

ATR-045

Real Property Services Branch
Architectural and Engineering Services
Civil Engineering Directorate
Airport Engineering Division
National Capital Area

September 2002

Acknowledgements

Public Works and Government Services Canada would like to thank the Canadian Airfield Pavement Technical Group and in particular Mr. Wayne Palzat for their contribution to the development of this document.

If you have any questions on this best practice, please contact:

Manager
Airport Engineering Division
Architectural and Engineering Services
Public Works and Government Services Canada
(819) 956-1569
(819) 956-3891

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Summary

This document contains the best practice for the implementation of a pavement management system (PMS) for small to medium airports. The goal of the PMS implementation is to provide the airport operators with a tool that will allow them to make objective decisions regarding the maintenance and rehabilitation of their pavement network and help them to select cost effective maintenance and rehabilitation treatment for their pavement.

Introduction

Until very recently the maintenance of airfield pavements was done on a piecemeal basis without addressing the priorities of the pavement network. With increasing economic pressures throughout the industry, reduced funding for pavement maintenance and repair (M&R) requires that existing funds be used more effectively. A pavement management system is needed to assist airport operators in optimizing the use of funds available for pavement maintenance and rehabilitation.

A Pavement Management System (PMS) is not a single activity but a group of activities, which provides the means for tracking distress, maintenance, and rehabilitation in conjunction with the original construction and rehabilitation history across a pavement network. A PMS provides tools to airport operators for making decisions regarding the timing and type of maintenance activities, and to distribute funds for pavement maintenance and rehabilitation in a balanced way, which meets the budget constraints of the airport.

Public Works and Government Services Canada (PWGSC) has developed this best practice document to provide guidance to small and medium airports for the implementation of a pavement management system using a computerized software program. Included in this document is a sample terms of reference for hiring a consultant to implement a PMS (appendix).

MicroPAVER was employed as the example in this guideline because of the following important features:

- the software package has default values to allow new users to develop prediction models based on the experience of other airports, if sufficient data for their own airport has not yet been collected.
- technical support is readily available,
- it is public domain software and allows the owner more freedom of usage (the airport can share the databases between consultants),
- allows flexibility in future upgrades, and
- is supported by many organizations and owned by the American Public Works Association, who provides funding for research and development of the software.

Other pavement management systems are readily available to airport operators and this guideline can be employed to implement a PMS using any software package.

MicroPAVER is a windows based program which can store pavement conditions historical information, traffic data, work required information, construction and maintenance history information and layer and material property data. The program allows airport managers to:

1) develop and organize the pavement inventory,
2) assess the current condition of the pavement network,
3) develop models to predict pavement life cycle curves,
4) report on past and future pavement performance, and
5) develop scenarios for pavement maintenance and rehabilitation based on budget or operational requirements.

Implementation Steps

The implementation of a PMS requires an investment and commitment of time and resources. The following is a discussion of the steps that should be considered during the implementation of a PMS. Figure 1 is a graphical representation of this implementation process. In most instances, for small and medium airports it is not cost effective to provide the staff resources required to install and operate a PMS. The implementation process is involved and best left to a consultant who has experience in implementing a PMS using a computerized pavement management system.

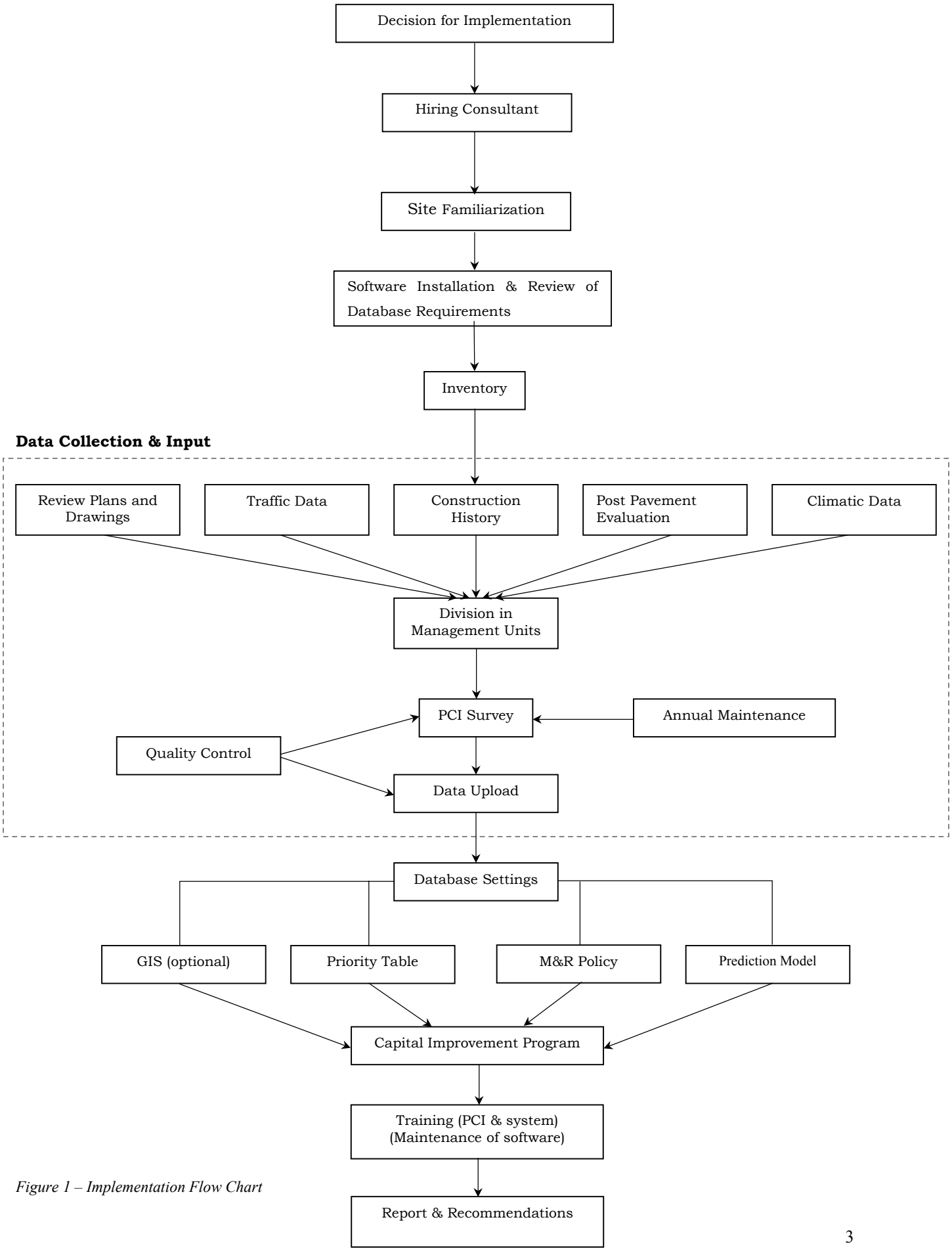

Figure 1 – Implementation Flow Chart

Call for Proposals

The first step is a call for proposals to outline the tasks to be undertaken during the implementation of the pavement management system. The appendix contains an example of terms of reference for hiring a consultant outlining the phases and tasks that should be identified prior to the commencement of any work. The terms of reference in the appendix are considered the minimum requirements for the implementation process and were compiled on the basis of using MicroPAVER Version 4.2 database as an example.

Site Familiarization

After the selected consultant is awarded the PMS project, a site visit must be conducted to assess the site conditions to plan data collection in order to ensure that the survey and the division of the airport network into hierarchical units is conducted in accordance with airport requirements. The sections and the sample unit can be grouped in areas, which contain particular distresses or experience similar conditions. It is also important to compare the plan dimensions with the real site dimensions (length, width, station location, etc…) in order to allow for an accurate localization of sample units.

Data Collection and Entry

Data must be collected and then entered into the database. The more thorough the initial data collection, the more comprehensive management of the pavement system can be achieved. The airport pavement system must be organized into the following hierarchy:

- **Network** is the entire airport pavement system (runways, aprons, taxiways, access roads, etc.)
- **Branch** is an identifiable part of the pavement network that has distinct function. Airfield pavements of such as runways, aprons, taxiways are each considered to be separate branches.
- **Section** is a subdivision of a branch and has consistent characteristics throughout its length and width. These characteristics include structural composition, layer thickness, construction history, pavement condition and traffic volumes.
- **Sample Unit** is a defined portion of a pavement section that is used in performing visual condition surveys. A sample unit[1] is a conveniently defined

[1] For flexible airport pavements such as asphalt concrete or bituminous surface treatment, sample units are typically 465 ±185 square metres. Sample units in rigid pavements are usually comprised of approximately 20 ±8 adjacent slabs.

portion of a pavement designated only for the purpose of pavement inspection as outlined in ASTM D5340-98[2] standard.

Information is entered through the inventory module of MicroPAVER. The information consists of the section ID, station location, dimensions, types, and ranks of pavements. The Inventory Module also allows the user to quickly create various summary charts; for example the user can plot the percentage of pavement and their condition at last inspection (figure2). This summary chart provides a snapshot of the condition of the pavement network.

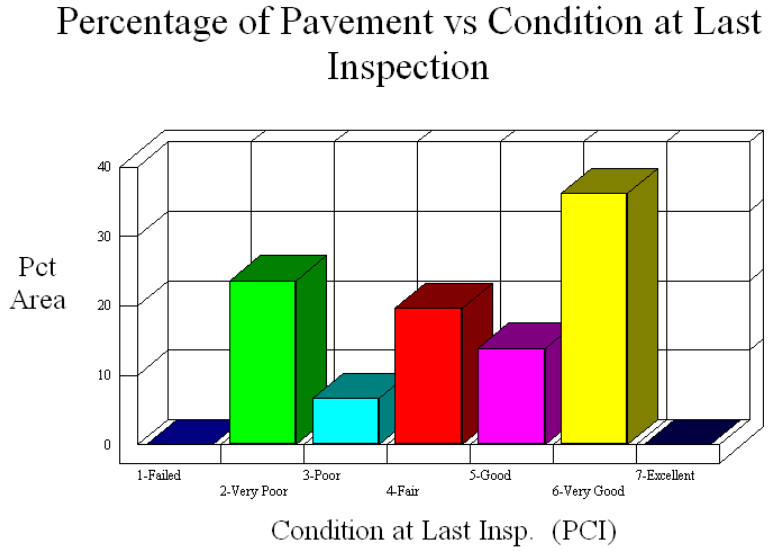

Figure 2 – Example of Summary Chart produced from the inventory module

The majority of the data may be collected from various sources such as Master Plans, Airport Development plans, as-built drawings, project specifications from pavement projects at the airport and field inspections. The data collection and review should be followed by a field inspection for Pavement Condition Index (PCI).

A visual condition survey to determine the PCI of the pavement structures of the airport provides engineers and managers with a numerical value for the pavement condition that reflects the structural integrity and operational surface condition of the pavements. This survey is done after the initial site familiarization visit.

Some agencies prefer a higher standard of maintenance and use a higher sampling rate for sections that are subject to a higher traffic or particular condition. For the first inspection,

[2] ASTM Standard Test Method for Airport Pavement Condition Index Surveys.

it is recommended that the ASTM procedure for selecting sample units be followed. The sampling rate can be adjusted to suit the particular condition of the airport. The sample units in the field should be marked in order that they may be re-evaluated during subsequent inspections to track pavement deterioration.

Additional information that can be included into the MicroPAVER database, if available: non-destructive testing data, frost data, friction data, post pavement evaluations, and roughness data. However, this information is not used in the assessment of pavement condition in version 4.2 of MicroPAVER. Future versions of the software may take into consideration some of the above data during the pavement assessment process. Photographs and GIS information can also be included.

Quality Control

The reports and prediction models of MicroPAVER are dependent on the accuracy of the database created; therefore it is important that the database data be checked for errors. Once the data is inputted into the database, various printouts can be generated and used to verify the information against the original field data sheets and historical data.

Selection of Critical PCI & Work Priorities

MicroPAVER allows the airfield pavement manager to set a critical PCI value and to establish work priorities. The development of a work priority table allows the user to define priorities based on facility use, critical value of PCI or type of pavement which is used by the maintenance and rehabilitation (M&R) module, to develop a prioritized list of recommended pavement improvement projects.

Figure 3 is a typical PCI scale that can be used to manage maintenance and rehabilitation operations. However, users can adjust the critical PCI to reflect the behaviour of various sections of their pavement based on their own experience. For example, with a pavement experiencing a high deterioration rate, preventive maintenance such as crack sealing may not be cost efficient and thus the critical PCI value may be adjusted.

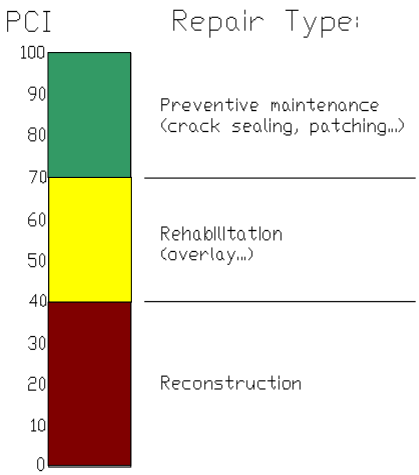

Figure 3: PCI level vs. maintenance and rehabilitation type

It is important to note that non-representative samples (which contain unusual distress or less distress) must be surveyed and recorded as additional samples to ensure that non-representative distresses will not be extrapolated to the rest of the pavement. The first sample unit to be inspected in each section is chosen randomly and the spacing between the sample unit to be surveyed is a function of the sampling rate (as outlined in ASTM D5340-98). Figure 4 is an example of a typical sampling plan for a smaller airport.

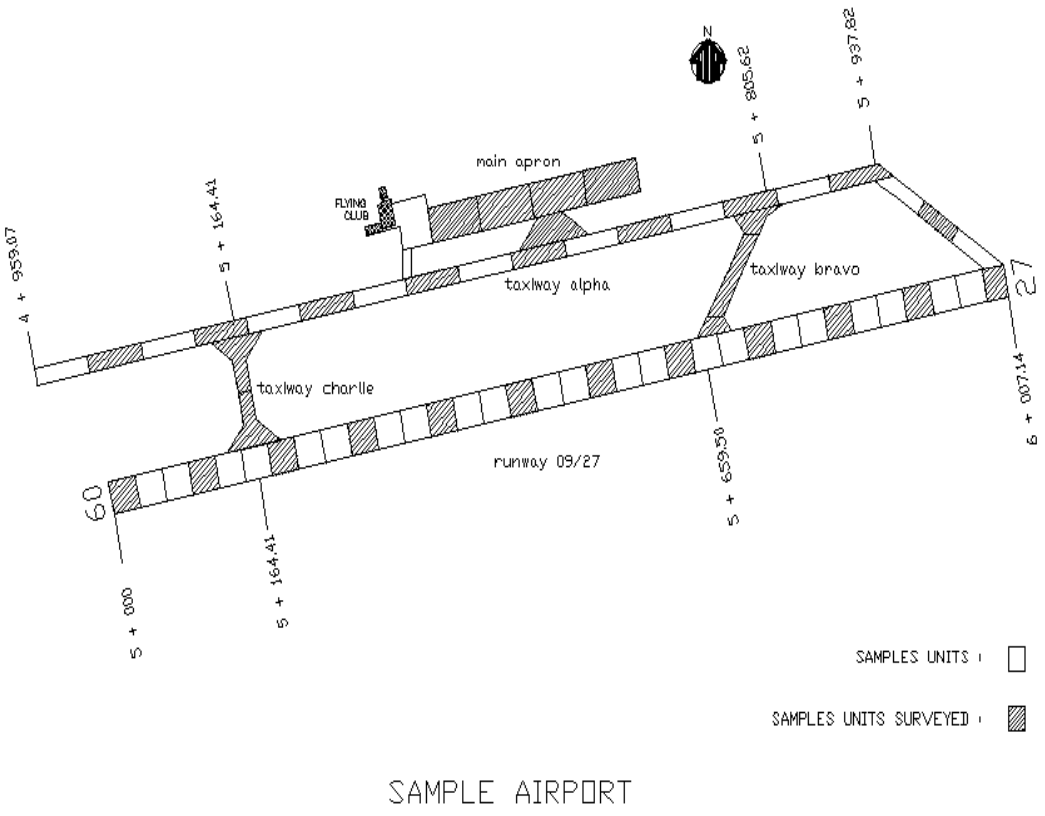

Figure 4 – Example of Sampling Plan for a small airport

Annual System Update

A continuous update of the construction history is needed to keep the MicroPAVER prediction tools at an optimum level of accuracy. It is important to implement an inspection schedule to maintain the PCI value up to date for each section. The maximum spacing between the PCI survey is 5 years[3] but it is not unreasonable to inspect the runway each year and other facilities every two or three years. The sections that experience a higher deterioration rate should be subjected to more frequent inspection. It is also important to note that the PCI procedure allows changing the number of samples based on the standard deviation between sample units in the same section. To increase the software accuracy, it is also important to track Maintenance and Rehabilitation work, to update the performance model after each inspection and to keep the repair cost table current.

[3] Procedure for U.S. Army and U.S. Air Force Airfield Pavement Condition Survey TM 5-826-6/AFR 93-5

Pavement sections with a PCI below the critical PCI value (as set by the user) are given higher priority for funding than those sections with a PCI above the critical level.

In general, the M&R Report gives first priority to any sections with PCI values below the critical level, prioritizing them according to their branch use and rank. Movement areas including primary and secondary runways, and primary taxiways receive the highest priority among sections with PCIs below critical level. Pavement sections with PCI above the critical value receive attention only if sufficient resources exist to address all the rehabilitation needs of facilities with a PCI below the critical value, or if they exhibit load-related distress at which point they are assigned a high priority.

Maintenance & Rehabilitation Development

The M&R policy consists of identifying all possible distress types and severity combinations that could occur on airfield pavements along with the maintenance and repair methods currently used to address these problems.

It is common for several distress types to be present in a given pavement area. In this situation, all alternative repair strategies should be analyzed carefully to determine which one(s) would be the most effective in correcting all pavement deficiencies. If future major rehabilitation such as a structural overlay or reconstruction is scheduled for a section, the impact of deferring routine maintenance work on that section can also be considered.

Cost Table Development

Unit cost data pertaining to various maintenance, repair and construction activities commonly used in the airports area should be compiled. The unit work costs are stored in MicroPAVER's M&R Plan Tables. The cost data are used in various ways in the MicroPAVER software, including the generation of the M&R Plan reports.

Pavement Performance Models

The Prediction Model and Condition Analysis modules of MicroPAVER can be used for modeling and predicting future pavement condition. Pavement sections with the same surface type, pavement use, and pavement rank can be grouped into families. A curve is fit through the pavement condition index versus age data for each family group, and section condition prediction is performed assuming that the behavior of a section is similar to the behavior of its family. This pavement condition prediction method is very useful in situations where limited historical data are available.

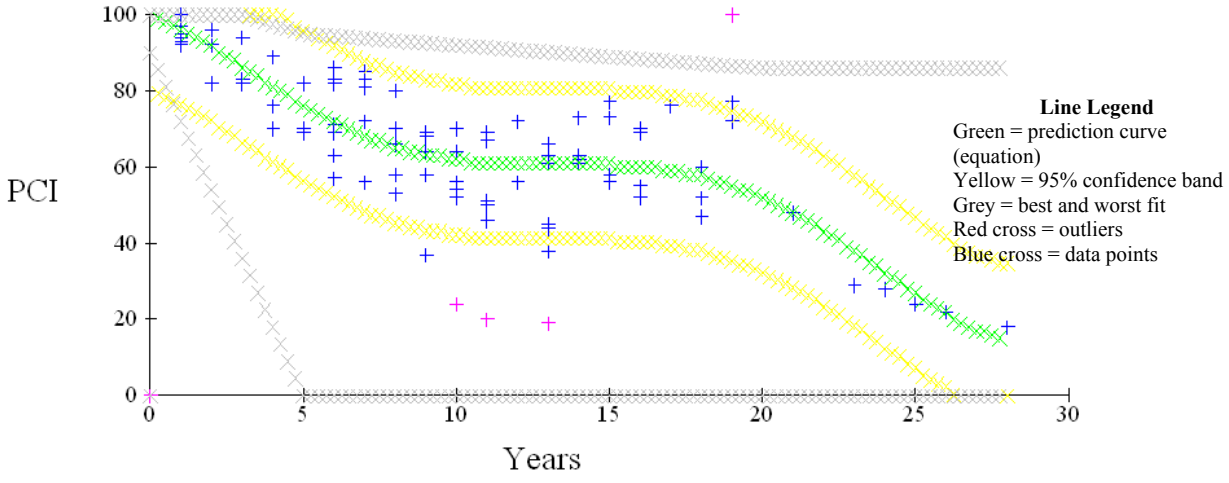

Figure 5 – Pavement Life Prediction Curve

A default prediction curve is included in the program based upon typical values from other airports. This gives users a prediction curve that can be used until sufficient data is collected for the airport to develop its own curves. Each pavement section is assigned a family. When predictions about future performance of a pavement is desired, a section's family assignment is used to predict its future condition. If the user has not assigned a family model to a section, MicroPAVER will use its default family to predict future pavement performance. However, such factors such as original construction, maintenance, weather, traffic, etc will greatly affect the life of a pavement. Thus a generic curve, like the default family, is unlikely to be as accurate as a model that is based upon site-specific factors into consideration. The program is designed to allow users to blend unique knowledge about their pavements, measured local condition

information and powerful modeling tools together to produce highly accurate estimates of future pavement life (figure 5).

Incorporation of historical data into prediction modeling to develop a representative prediction family model can be done but care and sound engineering judgement is required.

Feasible Repair Alternatives and Associated Costs

MicroPAVER allows the user the flexibility to develop different what-if scenarios and generate a list of feasible repair alternatives and associated costs.

Capital Improvement Program

Once the MicroPAVER software is customized to reflect the particular airport conditions and all the systems inventory and distress data entered, the collected information can be analyzed. Data analysis could include evaluating the visual distress data (current PCI, cause of deterioration, rate of deterioration), calculating the remaining service life for each pavement section, developing an annual maintenance plan, and preparing a multi-year network management program that outlines the improvement needs for each pavement section of the airport. The multi year plan will provide recommendations outlining the best correcting action alternatives and cost for each pavement section.

GIS Capability

MicroPAVER includes an interface with Geographical Information Systems for viewing and presenting pavement data on maps. The GIS interface is not required for the implementation of the PMS, however its use would enhance the PMS.

Report Generation

MicroPAVER is capable of producing a variety of reports from the information in the database.

Table 1 - MicroPAVER Report Type and Description

Report	Information Description
Summary Charts	Produces a chart analyzing information in the database by current age ranges, areas, sections, and PCI.
List	Lists information about each branch, including: network identification, and Branch number, name, use, area and number of sections.
Inventory	Provides information about each section, including: network identification, branch number and use, section number, category, family, zone, rank, surface type, and area.
Work History	Lists, for a selected pavement section, all information on construction and maintenance history stored in the database.
PCI	Identifies, for each section, the PCI associated with the most recent visual inspection. Also, lists the network identification number, branch and section information, last construction date, last inspection date, and age.
Inspection	Prints all distress data collected for each sample unit surveyed in a section, and also includes extrapolated quantities for sections based on sample unit qualities.
Prediction Model	Allows the user to model and predict pavement condition by grouping into families pavement sections having the same surface type, pavement use and pavement rank. The "family curve" fit through the data is used to perform condition prediction for selected pavement sections.
Condition Analysis	This program module provides the user with the capability to predict future condition for a single section, group of sections, or all sections. The module can also produce a plot of PCI over time for a given section enabling the user to track pavement performance and to estimate deterioration rate. The overall condition of the pavement network at any point in the future can be predicted. This projected condition can be used to help plan future maintenance and repair activities, to inform management about network condition, and to illustrate the impact of performing no major repairs.
Inspection Schedule	Prepares a plan outlining when each pavement section should be reinspected.
M&R Plan	Calculates, using the stored M&R policy, the type and cost of routine repair required to repair distresses in specific pavement sections. The policy can be applied to all, or a portion of, the pavement network.

MicroPAVER and PCI Training

A comprehensive training course on the use of MicroPAVER must be provided to airport staff so that they have the skills necessary to operate the program efficiency and effectively. In addition, airport staff should accompany the consultant during the actual field inspections in order to acquire field experience in performing condition surveys using the PCI method.

Conclusion

A computerized pavement management system is a very useful tool for the planning of maintenance and rehabilitation for airfield pavements.

The MicroPAVER system is such a package, suitable for small to medium sized airports. It allows airport operators to record important information on the condition of their pavements, alternative methods and costs for maintenance and rehabilitation and to develop various “what-if” scenarios to facilitate future planning. The options generated from these scenarios can provide the basis for airport operators to make decisions on their future needs for maintenance and rehabilitation based on budget and operational requirements.

There are many different packages available on the market that may have similar capabilities and/or additional features over MicroPAVER. It is left to the airport operator and consultant to agree upon the particular software package that would be best suited to the particular airport and its level of operations.

References

Pavement Management Plan – Juneau International Airport, prepared by Pavement Consultants Inc. Washington, November 1998.

Standard Test Method for Airport Pavement Condition Index Survey, D5340-98. ASTM, 1998

Procedure for U.S. Army and U.S. Air Force Airfield Pavement Condition Survey, TM 5-826-6/AFR 93-5.

Pavement Design and Management Guide, Transportation Association of Canada, 1997

Pavement Management for Airport Road and Parking Lots, M.Y. Shahin, Chapman & Hall 1994.

Appendix - Sample Terms of Reference for Consultant for Implementation of PMS

This terms of reference is considered the minimum requirements for the implementation process and were compiled on the basis of using MicroPAVER (ver 4.2) as the software package. They can be applied to the implementation process using other PMS software packages.

Scope of services:

The anticipated work consists of the following four phases and associated tasks. This represents the minimum that will be required to successfully implement a Pavement Management System at the *airport name*.

Phase 1 : Records reviews

Task 1. Kick-off meeting
Task 2. Construction & Rehabilitation Historical Data Input & Inspection planning

Note: If available, the airport will provide the construction and rehabilitation history to the selected consultant. Otherwise, the consultant must identify the sources of the airport's construction history (if any) and collect the information for input into the PMS.

Phase 2 : Data collection

Task 3. Pavement Condition Index (PCI) Survey

Phase 3 : Data analysis

Task 4. Analysis of PCI Data
Task 5. Capital improvement program

Phase 4 : Reporting and training

Task 6. Mapping
Task 7 Airport Pavement Condition Report
Task 8. MicroPAVER Training

Task Details

Task 1. Kick-off meeting

After the selected consultant is awarded the PMS project, the airport authority will host an initial kick-off meeting at the Airport. During this meeting, the final scope of work and work schedule will be discussed and approved. Each deliverable will be discussed in

detail, which will ensure that everyone will leave the meeting with an understanding of the schedule and final products expected from this project.

Task 2. Construction & Rehabilitation Historical Data Input & Inspection planning

Prior to initiating field work, the consultant will identify sources from which to collect construction and rehabilitation history of the airport pavement system. This data is to be compiled and inputted into the PMS database. Furthermore, this data will be used to divide the airfield pavement into units referred to as: network, branch, section and sample units, according to the procedures outlined in the FAA Advisory Circular (AC) 150/5380-6 *"Guidelines and Procedures for Maintenance of Airport Pavements"* and ASTM Standard D5340-98, *"Standard Test Method for Airport Pavement Condition Index Surveys"*. The consultant must comply with all the security requirements for access to the site and should make the inspection schedule available to the Airport Authority for the final fieldwork planning.

Task 3. Pavement Condition Index (PCI) Survey

The PCI procedure, outlined in FAA AC 150/5380-6 and further refined in ASTM Standard D5340-98, will be used during this project to evaluate the condition of pavements based upon visual indications of deterioration. Digital picture of common distresses in each pavement section should be take and added to the database.

Task 4. Analysis of PCI Data

The consultant shall input the following data into the database: Construction & rehabilitation historical data, PCI distress data, available non-destructive testing (NTD) data, friction data and roughness data. The software should be customized so that it reflects local pavement performance, local maintenance and rehabilitation policies and local maintenance and rehabilitation cost. At the end of this task, the Prediction Models and the Maintenance and Rehabilitation planner should be completely customized to the Airport.

During this task, the consultant will address the following issues:

- Pavement performance models.
- Maintenance policies and cost tables.
- Feasible repair alternatives and associated costs.

Task 4.1 Pavement Performance Models

The consultant shall create a performance model for each section of the pavement using the PCI survey result and past pavement evaluation results if possible. Alternatively, MicroPAVER supplies a default curve, which can be used in the first instance and refined with time as data, becomes available.

Task 4.2 Maintenance policies and cost tables.

The consultant, in consultation with the Airport Authority, will develop maintenance policies for the customization of the MicroPAVER Maintenance and Rehabilitation planner. An associated table of cost should also be created for each type of work. The consultant will also have to develop a prioritization scheme to assist in ranking pavement projects according to the airport current practice.

Task 4.3 Feasible Repair Alternatives and Associated Costs.

The consultant shall use MicroPAVER to run different what-if scenarios and generate a list of feasible repair alternatives and associated costs.

Task 5. Capital improvement program

Once the MicroPAVER software is customized to reflect the particular airport condition and all the systems inventory and distress data entered, the collected information will be analyzed. Data analysis will include:

- evaluating the visual distress data (current PCI, cause of deterioration, rate of deterioration),
- calculating the remaining service life for each pavement section,
- developing an annual maintenance plan, and
- preparing a five year network management program that outlines the improvement needs for each pavement section of the airport.

The five-year plan will provide recommendations outlining the best correcting action alternatives and cost for each pavement section. Maps and graphs will be developed to show the result of this task.

Task 6. Mapping

The consultant will prepare CAD map for the airside and groundside pavements. These maps will show important pavement dimensions, how the pavement is subdivided into sample unit, and identify specific sample units that were inspected along with their condition.

Note: If a Geographical Information System (GIS) is considered as an optional task, the consultant should link the map with the MicroPAVER software using its GIS interface.

Task 7. Airport Pavement Condition Report

A report will be prepared at the completion of the project. Service life forecasts for each pavement section will be provided and recommended projects for inclusion in the airport pavement rehabilitation program will be made. This report will include maps, graphs, and photographs detailing the condition of the pavements and the maintenance and rehabilitation recommendations.

A detailed project report will also be prepared. This report will document the project work undertaken and contain results of the project. It will include the prioritization scheme, maintenance policies, and customized performance models that were used to generate the capital improvement program and the maintenance plans. It will summarize the results of pavement evaluation and contain the capital improvement program. It will also contain a copy of the maintenance policies generated for the airport.

Task 8. MicroPAVER Training

The consultant will provide in-depth training in PCI surveys and MicroPAVER to airport personnel.

PCI training

A half-day classroom course will be conducted prior to the PCI fieldwork. Airport staff will accompany the inspector during the actual field inspections in order to acquire field experience in performing visual surveys.

MicroPAVER training

At the completion of the project, the PMS database will be installed on the Airport computer. A comprehensive two-day course in the use of MicroPAVER will be provided.

At the completion of the training process, the Airport staff will have the skill necessary to operate the program efficiently and effectively.

Note: For better budget control, it is recommended that the consultant be asked to submit his prices based on Phases/Tasks.