Pavement Management for Airports, Roads, and Parking Lots

Pavement Management for Airports, Roads, and Parking Lots

Second Edition

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To My Parents

Abdallah Shahin

Nazira Ibrahim

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Preface

Pavements need to be managed, not simply maintained. Although it is difficult to change the way we do business, it will be more difficult to explain to future generations how we failed to manage our resources and preserve our infrastructure.

When asked for reasons why they did not use the latest in pavement management technology, pavement managers gave many answers.

"The only time I have is spent fighting fires."

"We normally use a 2-inch overlay."

"Just spray the pavement black at the end of the year."

"I can't afford to do inspections; I'd rather use the money to fix the pavement."

Managers and engineers who have adopted pavement technology understand that pavement management is a matter of "Pay now, or pay much more later." Agencies are finding that they cannot afford to pay later; it is more costly to rehabilitate badly deteriorated pavements. Unfortunately, the pavement infrastructure managed by some agencies is at a point where a large sum of money will be needed for restoration. Agencies blessed with a good pavement infrastructure need to start a pavement management system as soon as possible. They need to: inventory the pavement infrastructure, assess its current and projected condition, determine budget needs to maintain the pavement condition above an acceptable level, identify work requirements, prioritize projects, and optimize spending of maintenance funds. The primary objective of this book is to present pavement management technology to engineering consultants, highway and airport agencies, and universities.

Features New to This Edition

The majority of the chapters in the first edition have been updated to reflect new developments since it was published in 1994. These updates include the following:

- Introduction of virtual databases, Chapter 2
- Automated distress data collection, Chapter 3
- Development of airfields, Foreign Object Damage (FOD) potential index, Chapter 3
- Determination of Aircraft Classification Number / Pavement Classification Number (ACN/PCN) using Nondestructive Deflection Testing (NDT), Chapter 4
- Determining budget requirements to meet specific management objectives, Chapter 10
- Project formulation based on network level work planning, Chapter 10

Three new pavement management special application chapters have been added: Impact of Bus Traffic on Pavement Costs (Chapter 12), Impact of Utility Cuts on Pavement Life and Rehabilitation Costs (Chapter 13), and Development of Council District Budget Allocation Methodology for Pavement Rehabilitation (Chapter 14). A new chapter has also been added that presents pavement management implementation steps (Chapter 15).

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1

Introduction

1.1 Background

In the past, pavements were maintained, but not managed. The pavement engineer's experience tended to dictate the selection of Maintenance and Repair (M&R) techniques with little regard given to life cycle costing nor to priority as compared to other pavement requirements in the network. In today's economic environment, as the pavement infrastructure has aged, a more systematic approach to determining M&R needs and priorities is necessary. Pavement networks must now be managed, not simply maintained.

Recent developments in microcomputers and pavement management technology have provided the tools needed to manage pavements economically. A Pavement Management System (PMS) provides a systematic, consistent method for selecting M&R needs and determining priorities and the optimal time of repair by predicting future pavement condition. The consequences of poor maintenance timing are illustrated in Figure 1–1. If M&R is performed during the early stages of deterioration, before the sharp decline in pavement condition, over 50% of repair costs can be avoided. In addition to cost avoidance, long periods of closure to traffic and detours can also be avoided. A PMS is a valuable tool that alerts the pavement manager to the critical point in a pavement's life cycle.

1.2 Project vs. Network Level Management

"Project-level" management often includes performing in-depth pavement evaluation and design for the pavement sections in the project. The end product is to select the specific M&R type(s) to be performed as well as the layer thicknesses when applicable. Project management can be performed with little or no consideration given to the resource requirements of other pavement sections in the network. This is acceptable as long as money is abundant, but this is seldom the case. In the past, most pavement

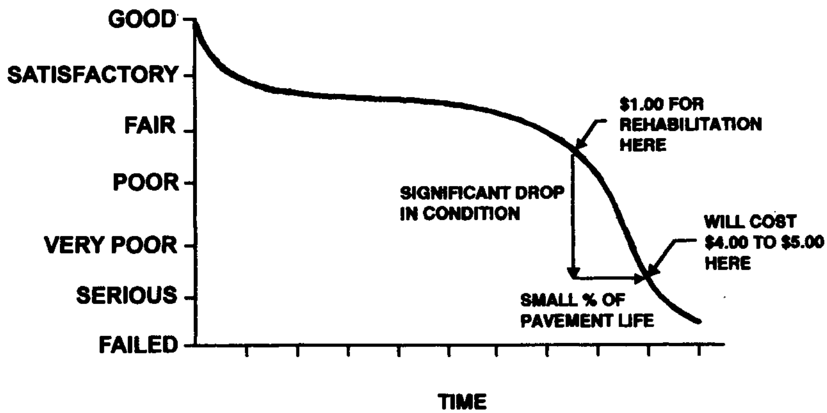

Figure 1–1. Conceptual illustration of a pavement condition life cycle.

engineers have been trained to work at the project level. Top management is now demanding budget projection that considers the agency's entire network before projects are prioritized and executed.

1.3 The Pavement Management Process

The ad hoc approach to pavement management normally leads to gradual deterioration in the overall condition of the pavement network and thus increased backlog of unfunded major M&R requirements. This approach consists of the habitual application of selected few M&R alternatives (such as 1.5 inch overlay) to pavement that are either in very poor condition or politically important. This is normally done regardless of the needs of the other pavements in the network.

A systematic approach to pavement management is needed to insure optimum return on investment. The following approach has evolved over the past thirty years as part of the development of the PAVER pavement management system (Micro PAVER 2004). The approach is a process that consists of the following steps:

1.3.1 Inventory definition (Chapter 2)

The pavement network is broken into branches and sections. A branch is an easily identifiable entity with one use, i.e. a runway, taxiway, roadway, etc.. Each branch is divided into uniform sections based on construction, condition, and traffic. A section can only be of the same pavement type, i.e. asphalt or concrete. A section can also be viewed as the smallest pavement area where major M&R, such as overlay or reconstruction, will be scheduled.

Section identification is normally performed using AutoCAD or Geographical Information systems (GIS). This allows the creation of GIS shape files which are useful to display pavement data.

1.3.2 Pavement Inspection (Chapters 3, 4, 5, and 6)

1.3.2.1 Airfield Pavements

At a minimum, pavement inspection consists of a distress survey every 1 to 5 years. Skid resistance measurement and Nondestructive Deflection Testing (NDT) are normally performed every 5 to 10 years. Runway longitudinal profile measurement is usually not performed unless there is a pilot complaint about pavement roughness.

1.3.2.2 Roadways and Parking Lots

It is recommended that distress surveys be performed every three years in order to meet the GASB 34 requirements. If automated data collection is used for the roadway survey, then both longitudinal and transverse profiles are measured. The longitudinal profile is usually measured for the right and left wheel path. NDT is usually not performed except for project level management.

1.3.3 Condition Assessment (Chapters 3, 4, 5, and 6)

1.3.3.1 Airfield Pavements

The inspection results are reduced to condition indicators that can be used for pavement management. A widely used distress index is the Pavement Condition Index (PCI). The PCI for airfields (Shahin et al. 1977), ASTM D5340, is a score from 0 to 100 that measures the pavement structural integrity (not capacity) and surface operational condition. It correlates with the needed level of M&R and agrees closely with the collective judgment of experienced pavement engineers.

The skid resistance data is reduced to a friction index for the runway. The NDT data is reduced to a structural index such as the Aircraft Classification Number/ Pavement classification Number (ACN/PCN).

1.3.3.2 Roadways and Parking Lots

Similar to airfield pavements, a PCI for roads and parking lots is calculated from the gathered distress data (Shahin et al. 1981), ASTM 6433. The longitudinal profile is used to calculate the International Roughness Index (IRI), ASTM E1926. The pavement section IRI is the average IRI of the right and left wheel path. The transverse profile is used to calculate the pavement rutting depth or rutting index.

1.3.4 Condition Prediction (Chapter 7)

There is no such thing as one prediction model that will work for all locations and conditions. Therefore, it is important that the management system includes a prediction modeling engine that can be used to formulate different models for different locations and conditions. The models are used to predict the future condition of the pavement sections assuming that the traffic will continue to be the same as in the past. An accurate condition prediction is also important for the analysis of different budget consequences.

1.3.5 Condition Analysis (Chapter 9)

Condition analysis allows managers to compare past, current, and future conditions, assuming no major M&R is performed. This provides managers with the ability to assess the consequence of past budget decisions and the value of having a management system, especially if the system has been in place for several years.

1.3.6 Work Planning (Chapters 8, 10, and 11)

Work planning provides the ability to determine budget consequence for a specified budget or, alternately, budget requirements to meet specified management objectives. Typical management objectives include maintaining current network condition, reaching a certain condition in x years, or eliminating all backlog of major M&R in x years. Regardless of the analysis scenario, the output should include the recommended M&R category for each pavement section for each year of the analysis. Projects are formulated by grouping sections to minimize cost and traffic delays.

1.4 Book Organization

The book is organized in the same logical sequence of the pavement management process. Pavement network definition is presented in Chapter 2. Pavement condition measurement is presented in Chapters 3 through 6. The chapters cover distress, deflection, roughness, and skid, respectively. Pavement condition prediction is presented in Chapter 7. It is important to realize that pavement condition prediction is an important part of the pavement management process. The accuracy of the prediction will influence the accuracy of both the network and project level analysis. Chapter 8 presents an introduction to M&R techniques as a background for work planning. The network level pavement management analysis is presented in Chapters 9 and 10. Chapter 9 presents the inventory and condition reporting while Chapter 10 presents the M&R work planning. The project level analysis is presented in Chapter 11. Chapters 12 through 14 present special applications where pavement management technology is used to address specific questions. Chapters 12 and 13 address the impact of buses and utility cut patching on pavement life and rehabilitation cost. Chapter 14 addresses M&R budget allocation among city council districts. Chapter 15 provides a summary of pavement management implementation steps and benefits. Figure 1–2 is a flow chart of the book organization.

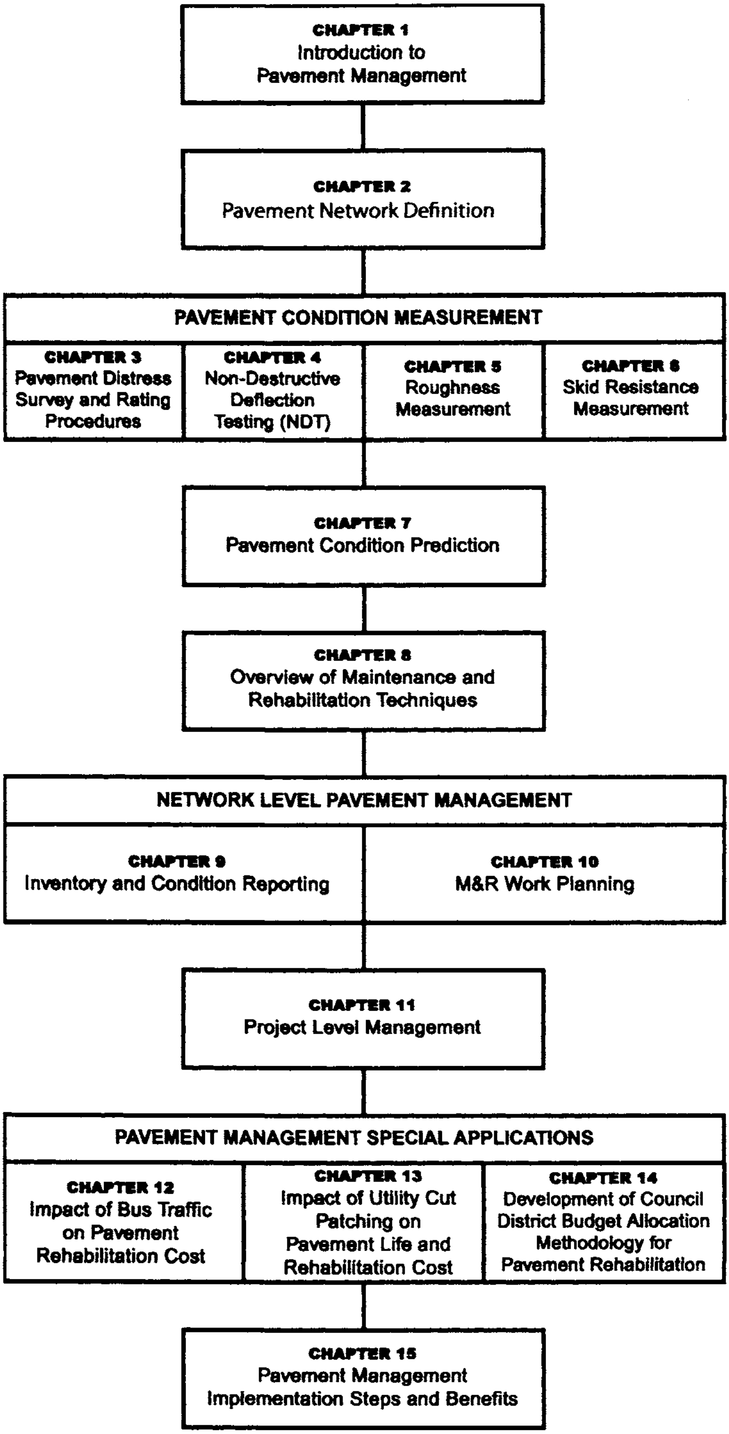

Figure 1-2. Book Organization.

References

American Public Works Association (APWA), 2004. e-mail: paver@apwa.net web: www.apwa.net/about/SIG/MicroPAVER

ASTM D5340, Standard Test Method for Airport Pavement Condition Index Surveys.

ASTM D6433, Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys.

ASTM E 1926, Standard Practice for Computing International Roughness Index of Roads from Longitudinal Profile Measurements.

Shahin, M. Y., Darter, M. I., and Kohn, S. D. (1976-1977). Development of a Pavement Maintenance Management System, Vol. I-V. U.S. Air Force Engineering Services Center (AFESC), Tyndall AFB.

Shahin, M. Y., and Kohn, S. D. (1981). Pavement Maintenance Management For Roads and Parking Lots. Technical Report M-294. U.S. Army Construction Engineering Laboratory.

University of Illinois at Urbana-Champaign (UIUC) Technical Assistance Center (TAC), 2004. e-mail: techctr@uiuc.edu web: www:tac.uiuc.edu

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2

Pavement Network Definition

This chapter presents guidelines for identifying and defining pavement networks, branches, and sections. These guidelines should be viewed just as guidelines and may be modified as necessary to accommodate unusual situations or specific agency requirements. The initial data collection for each pavement section can be very time consuming. This normally occurs if an extensive coring or testing program is undertaken during the initial setup of the pavement management system (PMS). By following the guidelines presented in this chapter, costly errors can be avoided the first time through, resulting in an effective database and quick return on investment in starting a PMS.

2.1 Network Identification

The first step in establishing a PMS is the network identification. A network is a logical grouping of pavements for M&R management. The pavement manager may be responsible for the management of roads, parking lots, airfields, and other types of surfaced or unsurfaced vehicular facilities. The manager should decide which facility types will be identified as separate networks. Other factors to consider besides facility types are funding sources, minimum operational standards, and geographical location. The following are examples of network identifications by different agencies:

- An airport may identify its pavements as two networks, one for airfields and one for roads and parking lots.
- A military base may identify its roads as two networks, one for family housing and one for non-family housing.
- A large city may identify its pavements as many networks, one for each city council district. Alternatively, it may identify all the pavements as one network and then create a separate computerized database for each council district.

- A commercial industry with many geographical locations, such as a department store or a hotel chain, may identify the pavements at each geographical location as one network.

2.2 Branch Identification

A branch is a readily identifiable part of the pavement network and has a distinct use. For example, an individual street or a parking lot would each be considered a separate branch of the pavement network. Similarly, an airfield pavement such as a runway or a taxiway would each be considered a separate branch.

Branch naming conventions should be implemented that are logical to the pavement managers and PMS users. To begin, each street on the network map is identified as a separate branch and given the street name. The process can also be used on parking lots; however, parking lots that do not already have assigned names can be given descriptive names to associate them with their location. For example, the closest building numbers can be used as part of the name. Also, depending on their size and location, many smaller lots can be combined to form one branch if necessary.

2.3 Section Identification

A branch does not always have consistent characteristics throughout its entire area or length. Consequently, branches are divided into smaller components called "sections" for managerial purposes. A section should be viewed as the smallest management unit when considering the application and selection of major maintenance and repair (M&R) treatments. A section must also be of the same surface type (for example, concrete, asphalt over concrete, etc.). Each branch consists of at least one section, but may consist of more if pavement characteristics vary throughout the branch. Factors to consider when dividing branches into sections are: pavement structure, construction history, traffic, pavement rank (or functional classification), drainage facilities and shoulders, condition, and size. Following is a discussion of each of these factors.

2.3.1 Pavement Structure

The pavement structure is one of the most important criteria for dividing a branch into sections. The structural composition (thickness and materials) should be consistent throughout the entire section. Construction records are a good source of this information. The records may be verified by taking a limited number of cores. An extensive coring program should be avoided at the start of the PMS implementation unless resources are unlimited.

A nondestructive deflection testing (NDT) program may also be performed (see Chapter 4) to provide information regarding structural uniformity. Figure 2–1 shows how the results of NDT were used to divide an approximate one–mile branch into two sections, even though the surface appearance was about the same.

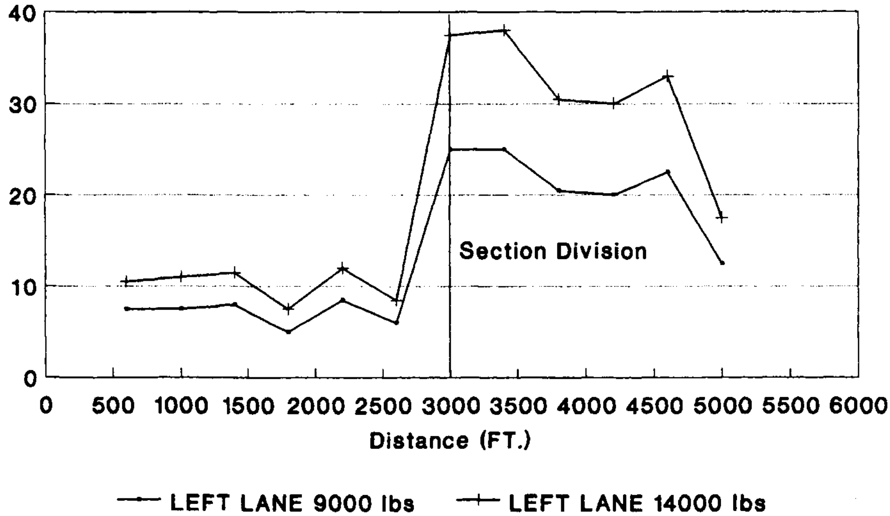

Figure 2-1. Example Use of Nondestructive Deflection Testing (NDT) to Define Pavement Sections.

When initiating a PMS, limiting pavement coring and NDT will minimize costs. When information from additional coring or NDT becomes available in the future, they can be used to verify the pavement sectioning.

2.3.2 Construction History

Pavements constructed during different years, by different contractors, or using different techniques should be considered separate sections. Areas that have received major repairs, such as many slab replacements or patches, should also be divided into separate sections.

2.3.3 Traffic

The volume and load intensity of traffic should be consistent within each individual section. For roads and streets, primary consideration should be given to the number of lanes and truck traffic. For streets with four or more lanes and two directions of traffic, a separate section may be defined for each direction, particularly if the highway is divided. A significant change in truck volume between directions should be a major consideration in section definition. An intersection could be treated as a separate section only if it is likely to receive major rehabilitation independent of the surrounding pavement.

For airfield pavements, it is important that traffic channelization be considered, particularly for aprons and runways. Figure 2–2 is an example runway branch divided into nine sections based on traffic channelization. The runway width of 150 ft. was divided into three lanes, each 50 ft. wide. Traffic on runways is normally channelized within the central 50 to 75 ft. However, the outside areas do receive traffic near taxiway exits, which should be taken into consideration when dividing the runway into sections.

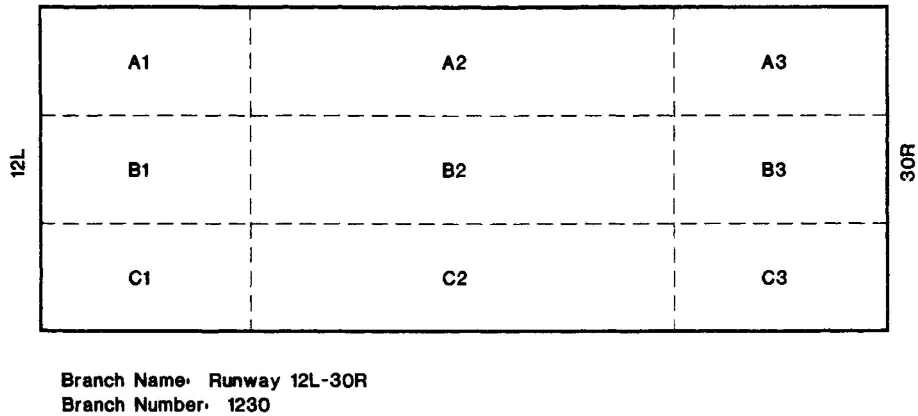

Figure 2-2. Example Runway Division into Sections.

2.3.4 *Pavement Functional Classification (Rank)*

A change in rank normally reflects a change in traffic. If the rank changes along the branch length (for example, from primary to secondary or, from arterial to collector), a section division should be made.

2.3.5 *Drainage Facilities and Shoulders*

To the extent that drainage and shoulder provisions affect pavement performance, it is recommended that these provisions be consistent throughout a section.

2.3.6 *Condition*

Systematic changes in pavement condition should be considered when defining pavement sections. Condition is an important variable because it reflects many of the factors discussed above. Changes in distress types, quantities, or causes should be taken into consideration. Experience has shown that a combination of a distress condition index and NDT profiles leads to very successful section definitions. Figure 2–3 shows the deflection and distress index profiles used to divide a runway into distinct sections.

2.3.7 *Section Size*

Section size can have a considerable impact on the economics of implementation. Defining very short sections, to ensure uniformity, requires a higher implementation effort and cost. The sections may also be too small to schedule individual M&R work productively. If they are too large, the characteristics may not be consistent across the entire area. This situation could result in nonuniform sections which in turn results in inefficient design and budget decisions. The same guidelines for road and street section sizes apply to parking lots. In the case of very small parking lots (designed for few vehicles), the small parking lots can be grouped into one section

It is also recommended that sections be numbered in a consistent way. For example, west to east, north to south, and clockwise for circular roads.

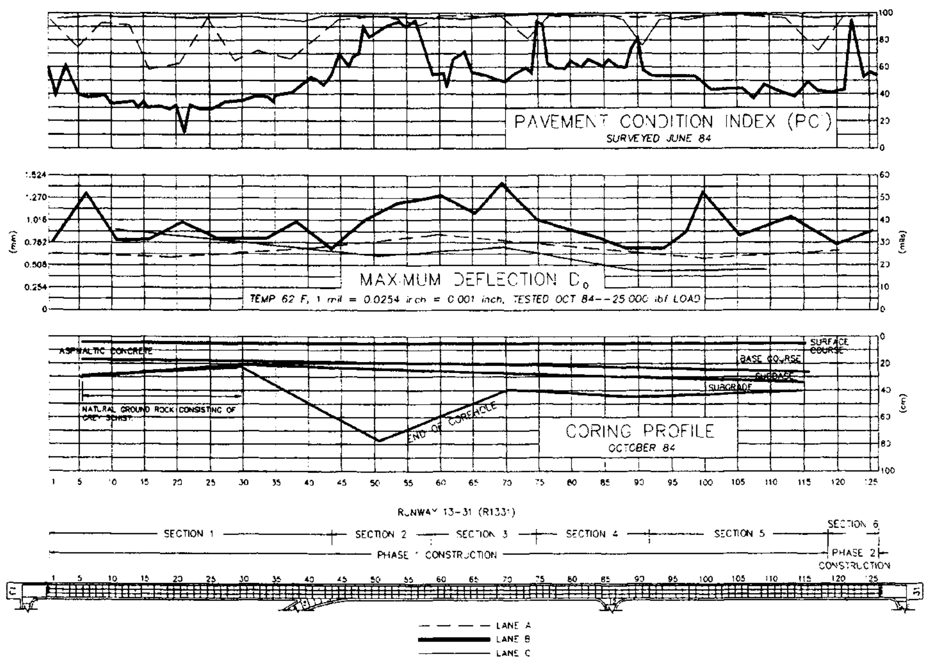

Figure 2-3. Example Use of Distress Condition Index, Deflection, and Coring Profiles for Runway Division into Sections. (From Engineering and Research International Consulting Reports 1984).

2.4 Examples of Network Division into Branches and Sections

Figure 2–4 – *Road Network*; The sections identifications clearly show to which section the road intersection belongs.

Figure 2–5 – *Parking Area*; The driveways to the parking areas are identified as separate sections (sections 2 and 4).

Figure 2–6 – *Department Store/Hotel*; A total of three branches are defined: Road, Parking, and Receiving. The Parking branch is divided into sections to reflect the higher volume of parking closest to the store/hotel entrance.

Figure 2–7 – *Civil Aviation Airfield pavement*; The network is divided into three branches; Runway 8–26, Taxiway, and Apron. The runway, 4,000 ft. long, is divided into two sections, A and B, based on construction history, condition, and traffic. The runway keel is not identified as a separate section due to the width of the runway which is only 100 ft.

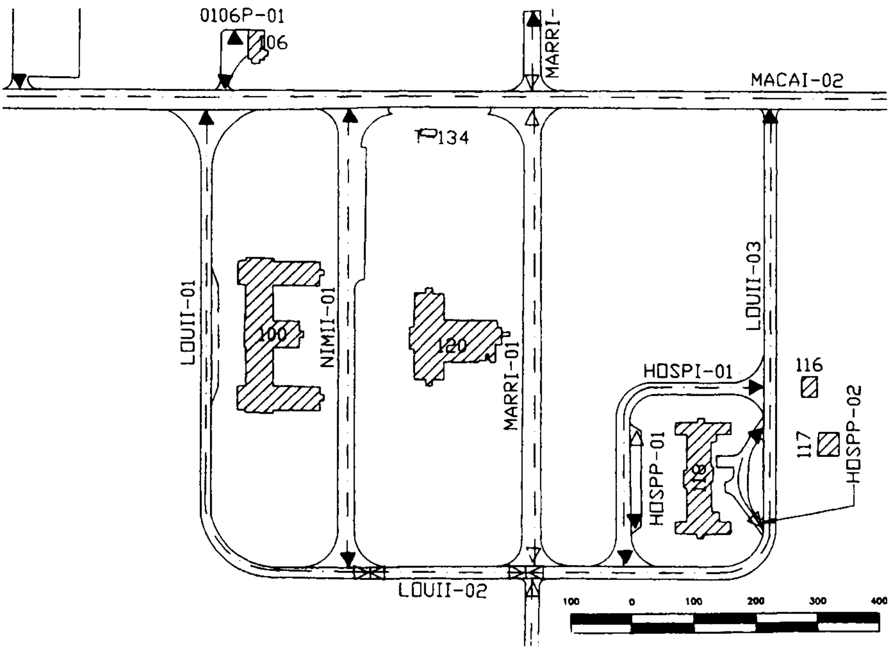

Figure 2-4. Example Road Section Definition For a Road Network. (From Shahin and Walther 1990)

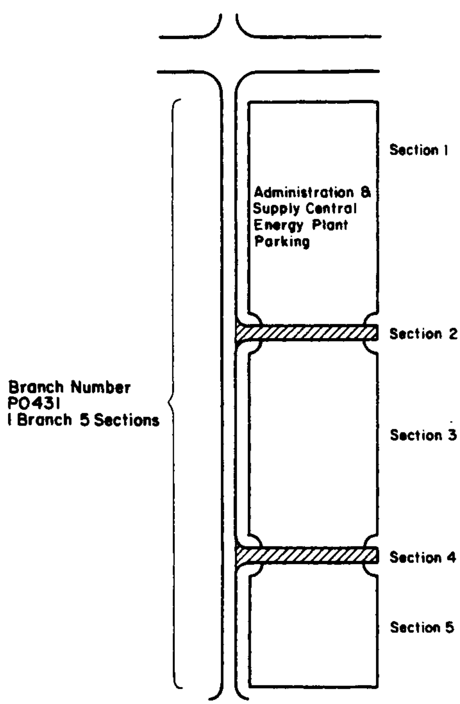

Figure 2-5. Example Parking Area Section Definition. (From Shahin and Walther 1990)

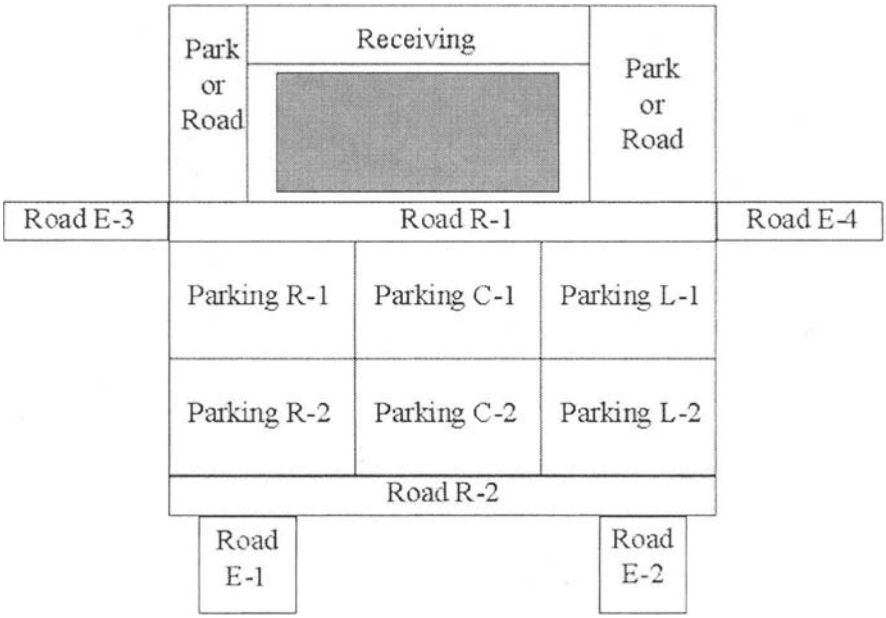

Figure 2-6. Example Department Store Pavement Section Definition.

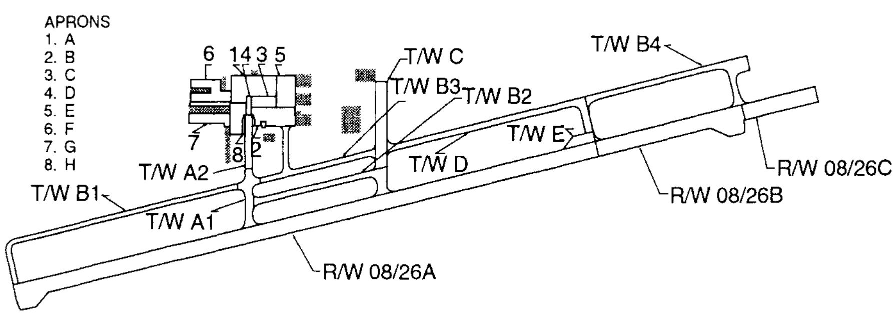

Figure 2-7. Example Civil Aviation Airport Section Definition. (Ohio Department of Transportation Aviation 2004).

2.5 Other Network Definition Considerations for Computerized PMS

2.5.1 Database Combine/Subset

A database in a computerized PMS may contain more than one network. A major advantage to smaller databases is efficient data entry and report generation. However, this advantage can be achieved easily if the computerized PMS allows for the capability of combining or subsetting databases as needed.

2.5.2 Key Field Unique ID

In some computerized systems, such as the Micro PAVER system, when the user makes an entry in a key field (such as Network ID, Branch ID, or Section ID) for the first time, the entry is assigned an additional hidden unique ID that remains associated with the entry even though the user may change the value of the entry in the future. This is a good feature because a user is able to change network, branch, or section name at any time without having to transfer or re-link the associated data, such as inspections or work history. However, for example, if a large city decides to define the pavement in each Council District as a separate network, each network will be automatically assigned a hidden Unique ID. If the networks are combined later, they will retain their unique identity even if the names are changed to be the same.

Therefore, in the above example, if the city wishes to have the ability to place all the pavements in one network at some time in the future, it is best to start with all the pavements in one network (thus one Unique ID). The Micro PAVER software database combine/subset capability can be used then to break the network into different databases (i.e., one for each Council District).

2.5.3 Branch Identification (Branch ID)

In Micro PAVER, each branch is identified in two ways: (1) by an alphanumeric descriptive name called the "Branch Name" and (2) by an alphanumeric code called the "Branch ID." The Branch ID is a unique code used to help store and retrieve data from the database. In selecting the code, review of existing codes at the agency is recommended to ensure compatibility. Also, some reports may list the Branch ID and not the Branch Name. For this reason, abbreviating the Branch Name as a Branch ID may make reports easier to read. For example, the Branch Name "Green Street" could be given the Branch ID "GREEN"; similarly, runway 12–30 would be given the ID "R1230."

2.5.4 Inventory User-Defined Fields

The Micro PAVER system allows the user to define additional inventory fields at the Network, Branch, and Section levels. These fields can be used for generating queries or sorting information. The following are examples of these fields.

2.5.4.1 Example Additional Network-Level Fields

a. Geographical location—this is particularly useful for a commercial industry with pavement networks located in different geographical locations (i.e., different states or countries).

b. Climatic zone—an example use of this field is for combining networks to develop condition prediction models.

c. Classification—an example use of this field is for grouping airports by category of use or, in the case of commercial industry, for grouping by stores by different class of service.

d. Funding source—this is especially useful if the networks are defined based on source of M&R funds.

2.5.4.2 Example Additional Branch-Level Fields

a. Route designation—e.g., state route.

b. Shared use—e.g., use of a runway by both civilian and military.

2.5.4.3 Example Additional Section-Level Fields

a. Maintenance District ID

b. Council District ID

c. Presence of curb and gutter

d. Bus traffic

2.5.5 Virtual Database Formulation

Virtual databases are formulated by creating virtual sections from the physically defined pavement sections. The primary purpose of virtual databases is data presentations and reporting. A virtual section can consist of any number of physical sections that may belong to different branches and networks. For example, an airfield virtual database may contain only three virtual sections; one for runways, one for taxiways, and one for aprons. Such a database may be very useful when briefing upper management.

In formulating a virtual section, the user will have to select the data aggregation rules. For numerical conditions, e.g. PCI, the aggregation can be based on any of the following rules; area weighted average, arithmetic average, average minus one standard deviation, minimum value, etc.

More than one virtual database can be created for a given physical database. Each of the virtual databases can be used for a different reporting requirement.

References

Engineering and Research International (ERI). Consulting Reports, (1984); Savoy, IL.

Ohio Department of Transportation Aviation. 2004. Personal Communication. Andrew Doll and Mark Justice.

Shahin, M. Y. and Walther, J. A. (1990) Pavement Maintenance Management for Roads and Streets Using the PAVER System; USACERL Technical Report MO-90/05, July.

U.S. Army Engineering Research and Development Center-Construction Engineering Research Laboratory (ERDC-CERL), 2004. Micro PAVER Pavement Management System, 2004. e-mail: paver@cecer.army.mil web: www.cecr.army.mil/paver

3

Pavement Condition Survey and Rating Procedure

3.1 Overview

An important feature of a pavement management system (PMS) is the ability to determine both the current condition of a pavement network and predict its future condition. To predict condition reliably, an objective, repeatable rating system for identifying the pavement's condition must be used. The pavement distress condition rating procedure presented here is the Pavement Condition Index (PCI) developed by the U.S. Army Corps of Engineers (Shahin et al. 1976-1994). The use of PCI for airfield pavement, roads, and parking lots has received wide acceptance and has been formally adopted as standard procedure by many agencies worldwide. These agencies include the Federal Aviation Administration, The U.S. Department of Defense, the American Public Works Association, and many others. The PCIs for airfields and roads have also been published as ASTM standards, D5340 and D6433, respectively.

The PCI is a numerical index, ranging from 0 for a failed pavement to 100 for a pavement in perfect condition (Fig. 3–1). Calculation of the PCI is based on the results of a visual condition survey in which distress type, severity, and quantity are identified. The PCI was developed to provide an index of the pavement's structural integrity and surface operational condition. The distress information obtained as part of the PCI condition survey provides insight into the causes of distress and whether it is related to load or climate.

The degree of pavement deterioration is a function of distress type, distress severity, and amount or density of distress. Producing one index that would take into account all three factors was a considerable challenge. To overcome this challenge, "deduct values" were introduced as a type of weighing factor to indicate the degree of effect that each combination of distress type, severity level, and distress density has on pavement condition. The deduct values were developed based on in-depth knowledge of pavement behavior, input from many experienced pavement engineers, field testing and