TECHNICAL MANUAL

PAVEMENT MAINTENANCE MANAGEMENT

HEADQUARTERS, DEPARTMENT 0F THE ARMY

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PAVEMENT MAINTENANCE MANAGEMENT

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CHAPTER 1

INTRODUCTION

1-1. Purpose

The purpose of this manual is to describe a pavement maintenance management system (PAVER) for use at military installations. This system is available in either a manual or computerized mode. The maintenance standards prescribed should protect Government property with an economical and effective expenditure of maintenance funds commensurate with the functional requirements and the planned future use of the facilities. The majority of pavements on Army installations were built many years ago, and thus, many have reached their economic design life. Because of limited maintenance funds, timely and rational determination of maintenance and repair (M&R) needs and priorities are very important factors. These factors can be determined by using PAVER as described in this manual. The use of PAVER by personnel who have the responsibility for pavement maintenance should assure uniform, economical, and satisfactory surfaced area maintenance and repair. When information in this publication varies from that contained in the latest issue of Federal or Military specifications, the specifications shall apply. Reference to Federal, Military or other specifications is to the current issues of these specifications as identified by their basic number(s).

1-2. Applicability

This manual applies to Army elements responsible for maintenance and repair (M&R) of asphalt or concrete-surfaced roads, streets, parking lots, and hardstands. Airfield pavement management is covered by AFR 93-5 which becomes part of this manual by reference. (See app A.)

1-3. Scope

The system presented in this manual consists of the following components:

a. Network identification. The process of dividing installation pavement networks into manageable segments for the purpose of performing pavement inspection and determining M&R requirements and priorities (chap 2).

b. Pavement condition inspection. THE process of inspecting installation pavement to determine existing distresses and their severity and to compute the pavement condition index (PCI)-a rating system that measures the pavement integrity and surface operational condition (chap 3).

c. M&R determination. The process of establishing M&R requirements and priorities based on inspection data, PCI, and other relevant information such as traffic, loading, and pavement structural composition (chap 4).

d. Economic analyses of M&R alternatives. The process of using life-cycle cost analysis to rank various M&R alternatives (chap 5).

e. Data management. A manual system (card system) for handling data is described in chapter 6. An automated system is described briefly in chapter 7.

1-4. Implementation of PAVER

The level of implementation is a function of the installation size, existing pavement condition and available manpower and money resources. The highest level of implementation would be the inclusion of all pavements on the installation and use of the automated system. The lowest level would be use of the PCI as the basis for project approvals and establishment of priorities. A gradual implementation may be practical for many installations. This includes starting with a specific group of pavements at the installation (such as primary roads and pavements experiencing a high rate of deterioration or requiring immediate attention) and then including other pavements on a predefined schedule. Technical advise concerning any procedures outlined in this manual may be obtained from US Army Facilities Engineering Support Agency, ATTN: FESA-EB, Fort Belvoir, VA 22060.

1-5. PAVER forms

DA Forms 5145-R through 5156-R (figs E-1 through E-13) used for PAVER and described hereafter in this manual will be reproduced locally on 8½ by 11-inch paper. Appendix E contains blank reproducibles.

CHAPTER 2

PAVEMENT NETWORK IDENTIFICATION

2-1. Introduction

Before PAVER can be used, the installation pavements must be divided into components. This chapter defines the process. The guidelines for division of airfield pavements are given in AFR 935.

2-2. Definitions

a. Pavement network. An installation's pavement network consists of all surfaced areas which provide accessways for ground or air traffic, including roadways, parking areas, hardstands, storage areas, and airfield pavements.

b. Branch. A branch is any identifiable part of the pavement network which is a single entity and has a distinct function. For example, individual streets, parking areas, and hardstands are separate branches of a pavement network. Similarly, airfield pavements such as runways, taxiways, and aprons are separate branches.

c. Section. A section is a division of a branch; it has certain consistent characteristics throughout its area or length. These characteristics are:

(1) Structural composition (thickness and materials).
(2) Construction history.
(3) Traffic.
(4) Pavement condition.

d. Sample unit. A sample unit is any identifiable area of the pavement section; it is the smallest component of the pavement network. Each pavement section is divided into sample units for the purpose of pavement inspection. (See AFR 93-5 for size of sample units for airfield pavements.)

(1) For asphalt or tar-surfaced pavements (including asphalt overlay of concrete), a sample unit is defined as an area of approximately 2500 square feet (plus or minus 1000 square feet).

(2) For concrete pavements with joint spacing less than or equal to 30 feet, the sample unit is an area of 20 slabs (plus or minus 8 slabs).

(3) For slabs with joint spacing more than 30 feet, imaginary joints should be assumed. These imaginary joints should be less than 30 feet apart. This is done for the purpose of defining the sample unit. For example, if slabs have a joint spacing of 50 feet, imaginary joints may be assumed at 25 feet. Thus, each slab would be counted as two slabs for the purpose of pavement inspection.

2-3. Guidelines for pavement identification

a. Dividing the pavement network into branches. The first step in using PAVER is to identify the pavement branches. The easiest way to identify these branches is to use the installation's existing name identification system.

(1) For example, Marshall Street in figure 2-1 would be identified as a branch. Areas such as parking lots and storage areas that do not have names already assigned can be given descriptive names which associate them with their area.

(2) In addition to descriptive names, branches are assigned a unique code to help store and retrieve data from the PAVER files. This code has five characters which are numbers of letters given to the branches using any logical order. The first letter of the code will identify the type of branch as shown in table 2-1. For example, the parking lot 321 shown in figure 2-1 is given the code *P0321*. The code *P0321* is derived from P representing parking lots and *0321* representing the nearest building to the parking area. Since the building number has less than four digits, a zero is used on the left to provide the required characters.

b. Dividing branches into sections.

(1) Since branches are large units of the pavement network, they rarely have consistent or uniform characteristics along their entire length. Thus, for the purpose of pavement management, each branch must be subdivided into sections with consistent characteristics. As defined in paragraph 2-2c, a section must have uniform structural composition, traffic, and the same construction history.

(2) After each section is initially inspected, pavement condition within the section can be used to subdivide it into other sections if a considerable variation in condition is encountered. For example, a section containing part of a two-lane road that has one lane in a significantly different condition than the other lane should be subdivided into two sections. Unique situations such as those that

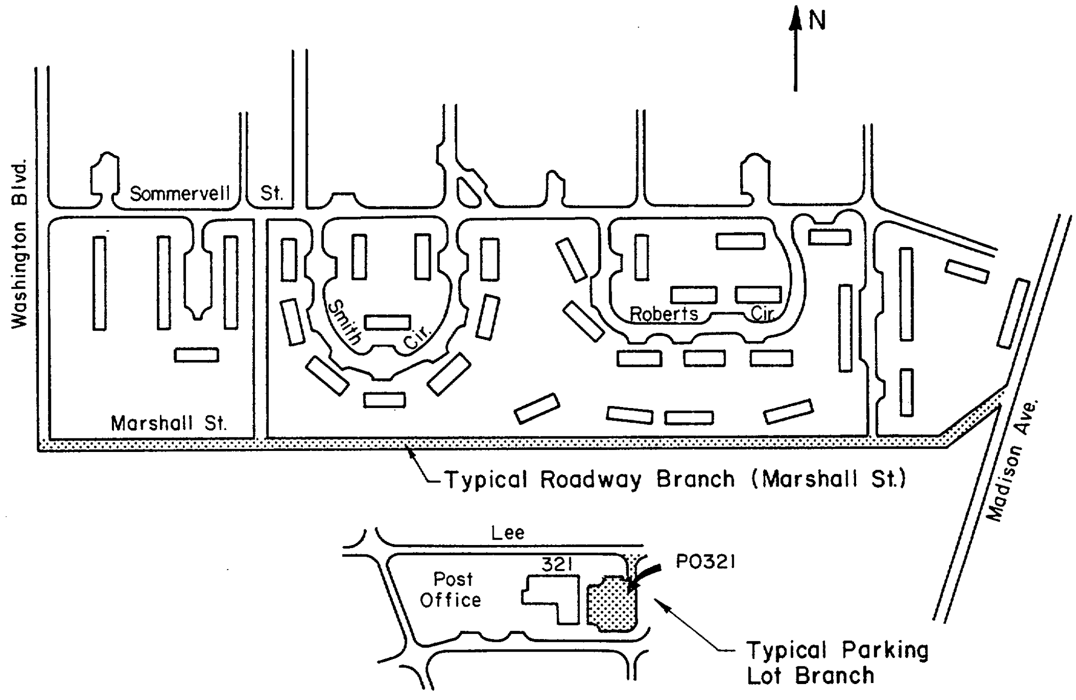


Figure 2-1. Installation map showing typical pavement branches.

Table 2-1. Branch Codes.

Type of Branch	First Letter in Branch Code
Installation road	1
Parking lot	P
Motor pool	M
Storage/hardstands	S
Runway	R
Taxiway	T
Helicopter pad	H
Apron	A
Other	X

Table 2-1. Branch Codes

occur at roadway intersections should also be placed in separate sections. However, it must be remembered that the major section's structure usually carries through an intersection. The structure should be checked if there is doubt as to which pavement would continue through the intersection. Some guidelines for dividing pavement network branches into sections are:

(a) Pavement structure. Structure is one of" the most important criteria for dividing a branch into sections. Structural information is not always available for all branches of a pavement network. To collect structure information, available construction records can be searched and patching repairs can be observed. In addition, pavement coring programs can be developed to determine the structural composition of remaining pavement sections or to verify existing information.

(b) Traffic. The volume and load intensity of traffic should be consistent within each individual section.

(c) Construction history. All portions of a section should have been constructed at the same time. Pavement constructed in intervals should be divided into

separate sections corresponding to the dates of construction. Areas that have received major M&R work should also be considered as separate sections.

(d) Pavement rank. Pavement rank can also be used to divide a branch into sections. If a branch changes along its length from primary to secondary, or secondary to tertiary, a section division should be made. If a branch becomes a divided roadway along its length, a separate section should be defined for each direction of traffic. (Definitions of primary, secondary, and tertiary roads and streets may be found in TM 5-822-2.)

(e) Drainage facilities and shoulders. It is recommended that shoulder type and drainage facilities be consistent throughout a section.

(f) Test areas. An area where materials have been placed for testing should be identified as a separate section.

(3) By using the criteria in subparagraphs (2) *(a)* through *(f)* above, the pavement branches can be divided into sections. Sections are numbered beginning with 1 at the north or west end of the branch. The numbers then increase in a southerly or easterly direction. Each section should be identified on the installation map.

(4) To identify a section on the installation map, place an arrow at the starting point and ending point of each section (figure 2-2). Sample units should be numbered in ascending order from the beginning of each section.

(5) Subparagraphs (2)*(a)* through *(f)* above that apply to roadways may also be applied to branch types such as parking areas, storage areas, hardstands, etc. These branch types are usually considered one section, but may be subdivided. For example, a parking lot could be divided into more than one section; if the parking lot's drive areas were well defined, each drive area would be identified as a separate section.

(6) Small parking lots (usually allowing parking of less than 10 vehicles each) may be considered as one section if they are located close together and have consistent characteristics. For example, figure 2-3 shows a grouping of small parking lots around Smith Circle. These lots may be considered as a branch with one section. However, if the lots are relatively large and/or do not have consistent characteristics, such as those shown bordering Sommervell in figure 2-3, they may be defined as one branch, but each lot should be considered an individual section.

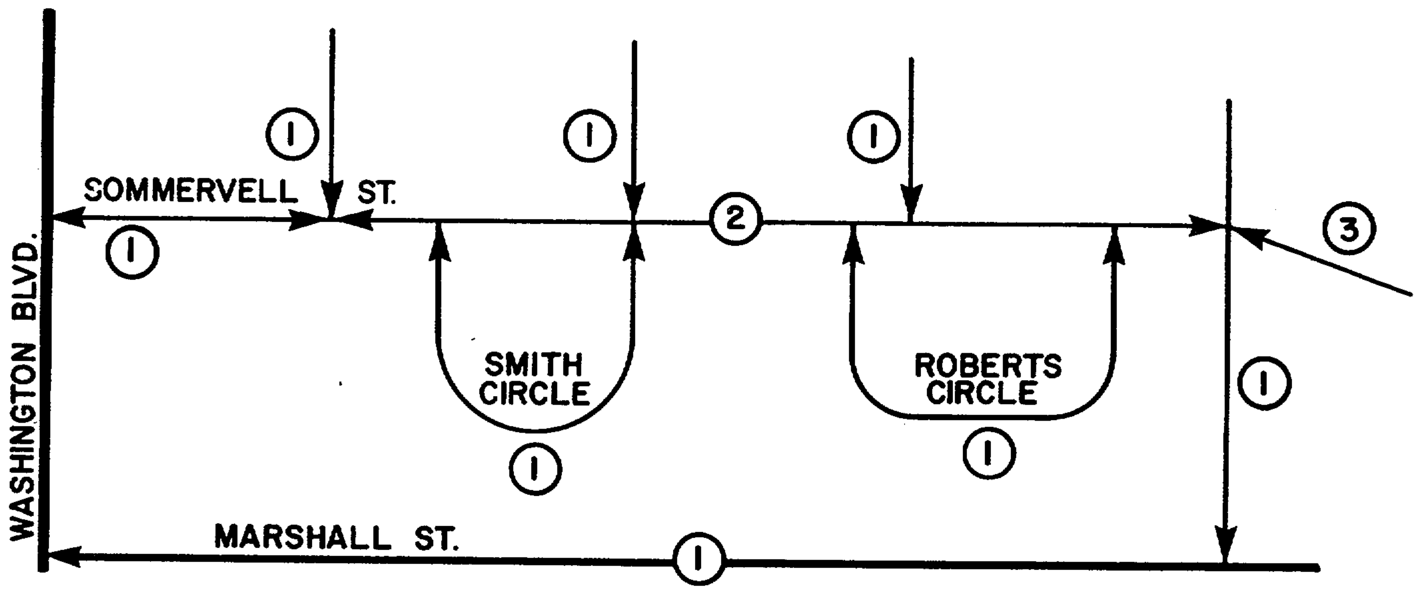


Figure 2-2. Sections identified on an installation map.

(7) An example of dividing a parking area into sections is shown in figure 2-4. The area is very large and defined as one branch with five sections. The basic division of sections is based on traffic patterns and use. Field observations of these types of branches will help decide how to divide such an area into sections.

c. Dividing a section into sample units. A sample unit is the smallest component of the pavement network and is used for inspection purposes to determine existing pavement distress and condition.

(1) The sizes of the sample units are described in paragraph 2-2d. For asphalt pavements, a sample unit may vary in size from approximately 1500 square feet to 3500 square feet, with a recommended average of 2500 square feet. For concrete pavement, a-sample unit may vary in size from approximately 12 to 28 slabs, with a recommended average of 20 slabs. A

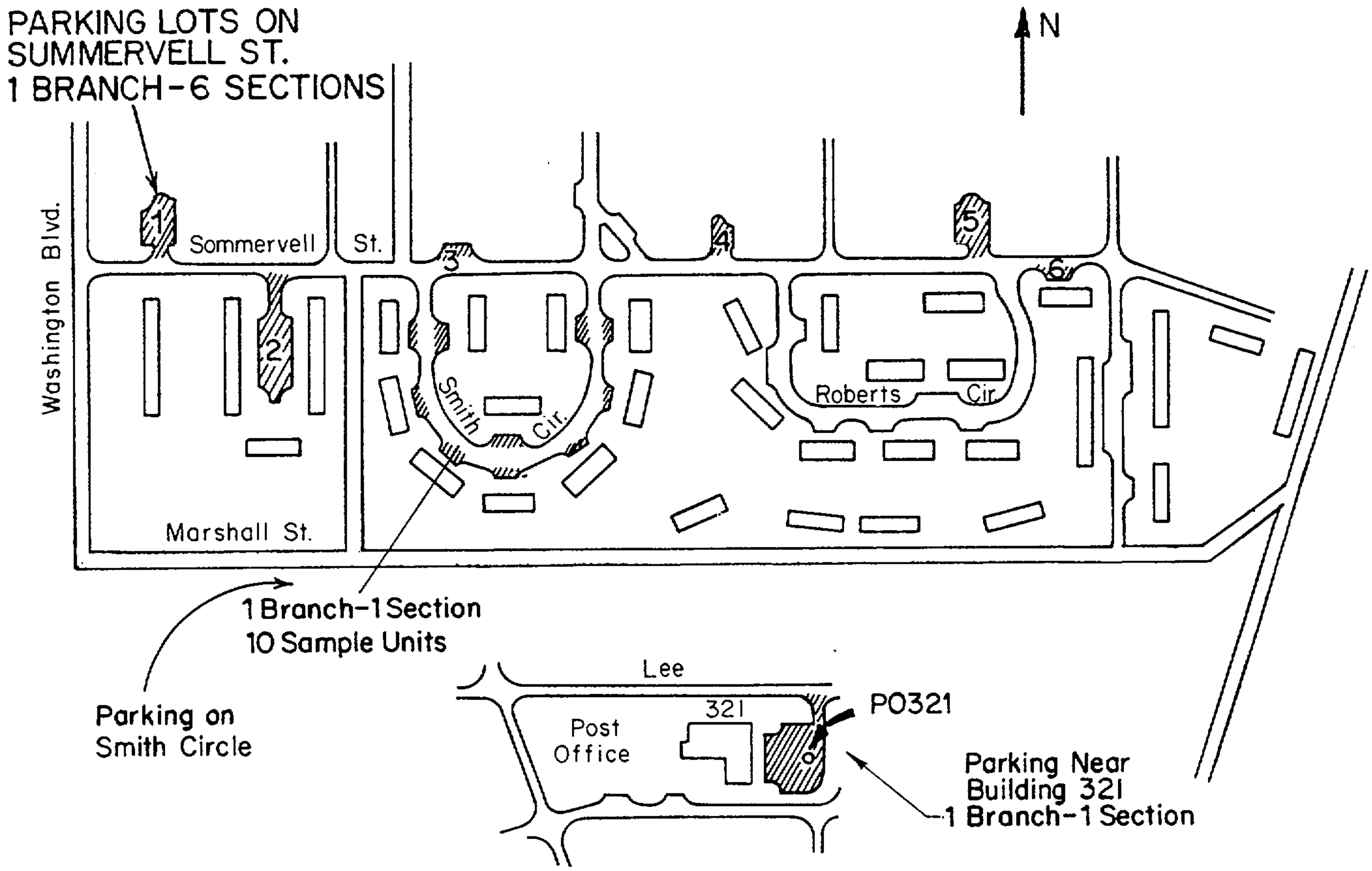


Figure 2-3. Installation map showing various methods of identifying parking area branches.

A significant factor in selecting a typical sample unit size for a section is convenience. For example, an asphalt pavement section that is 22 feet wide by 4720 feet long can be divided into sample units that are 22 feet wide by 100 feet long, or 2200 square feet. The last sample units of the section may have to be of different lengths because of the length of the section. In the above example, the section is divided into 46 units that are each 100 feet long and one unit that is 120 feet long. Thus, the last sample unit has an area of 22 x 120 or 2640 square feet. The above example is shown in figure 2-5.

(2) A schematic diagram of each section (such as that shown in figure 2-5) will be made showing the size and location of its sample units. These sketches are required for future inspections to relocate the sample units.

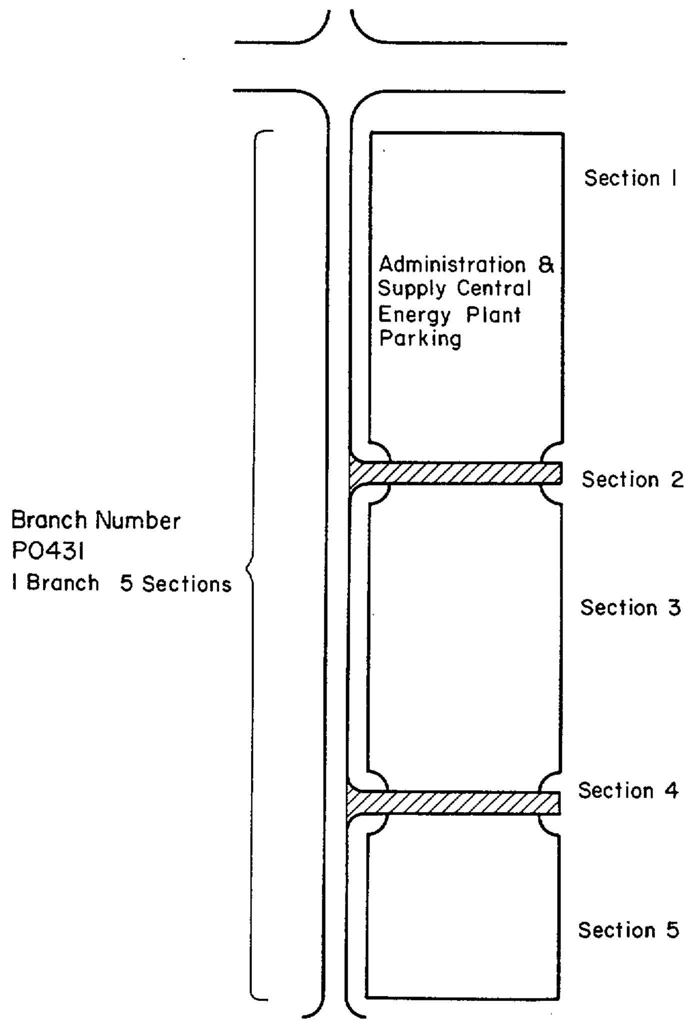


Figure 2-4. Large parking area divided into several sections.

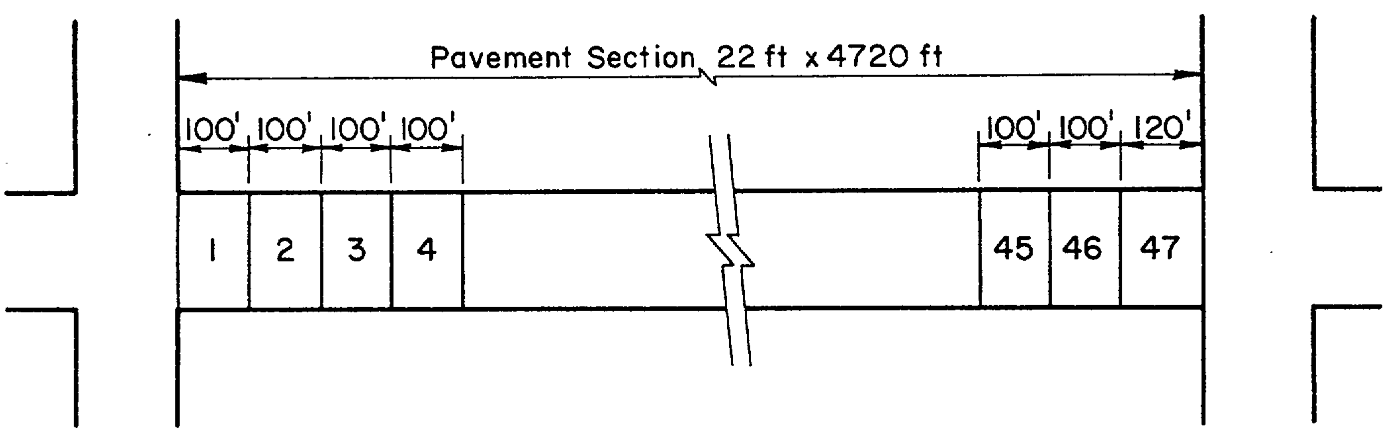


Figure 2-5. Example of a asphalt section divided into sample units.

CHAPTER 3

PAVEMENT CONDITION SURVEY AND RATING PROCEDURES

3-1. Introduction

An important component of PAVER is the pavement condition survey and rating procedures. Data obtained from these procedures are the primary basis for determining M&R requirements and priorities. This chapter explains how to conduct a condition survey inspection and how to determine the pavement condition index (PCI). It is essential to have a thorough working knowledge of the PCI and condition survey inspection techniques.

3-2. Pavement condition rating

Pavement condition is related to several factors, including structural integrity, structural capacity, roughness, skid resistance/hydroplaning potential, and rate of deterioration. Direct measurement of all of these factors requires expensive equipment and highly trained personnel. However, these factors can be assessed by observing and measuring distress in the pavement.

a. PCI. The pavement condition rating is based on the PCI, which is a numerical indicator based on a scale of 0 to 100. The PCI measures the pavement's structural integrity and surface operational condition. Its scale and associated ratings are shown in figure 3-1.

b. Determination of PCI. The PCI is determined by measuring pavement distress. The method has been field tested and has proven to be a useful device for determining M&R needs and priorities.

3-3. Pavement inspection.

a. General. Before a pavement network is inspected, it must be divided into branches, sections, and sample units as described in chapter 2. Once this division is complete, survey data can be obtained and the PCI of each section determined.

b. Inspection procedures for jointed concrete pavement sections. There are two methods which may be used to inspect a pavement. Both methods require that the pavement section be divided into sample units. The first method-entire section inspection-requires that all sample units of an entire pavement section be inspected. The second method-inspection by sampling-requires that only a portion of the sample units in a section be inspected. For both methods, the sample units must be assigned sample unit numbers.

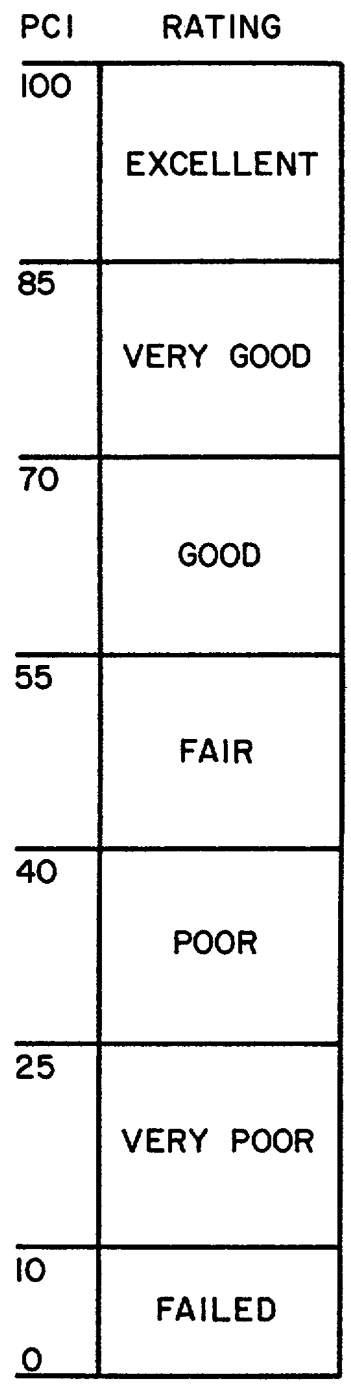


Figure 3-1. PCI scale and condition rating.

(1) For entire section inspections, the inspector walks over each slab in each sample unit and records the distress(es) observed on DA Form 5145-R (Concrete Pavement Inspection Sheet) (fig E-1). One form is used for each sample unit. The inspector sketches the sample unit using the preprinted dots as joint intersections (imaginary joints should be labeled). The appropriate number code for each distress found in the slab is entered in the square representing the slab. The letter *L* (low), *M* (medium), or *H* (high) is included along with the distress number code to indicate the severity level of the distress. Distresses and severity level definitions are listed in appendix B. Since the PCI was based on these definitions, it is imperative that the inspector follow appendix B closely when performing an inspection.

(2) The equipment needed to perform a survey is a hand odometer for measuring slab size, a 10-foot straightedge and rule for measuring faulting and land/shoulder drop off, and the PCI distress guide (app B).

(3) The Inspection Sheet has space for a summary of each distress and severity level(s) of distress contained in the sample unit. These data are used to compute the PCI for the sample unit as outlined in paragraph 3-5. Figure 3-2 is an example of DA Form 5145-R showing the summary of distresses for the sample unit.

c. Inspection procedures for asphalt, tar-surfaced, and/or asphalt over concrete pavement. As with jointed concrete pavements, the pavement section must first be divided into sample units. During either the entire section inspection or inspection by sampling, the inspector walks over each sample unit, measures each distress type and severity, and records the data on the DA Form 5146-R, Asphalt Pavement Inspection Sheet (fig E-2).

(1) The equipment needed is a hand odometer used to measure distress lengths and areas, a 10-foot straightedge, and a ruler to measure the depth of ruts or depressions.

(2) One form is used for each sample unit. One column on the form is used to represent each identified distress type. The number of that distress type is indicated at the top of the column. Amount and severity of each distress identified is listed in the appropriate column. An example of a completed DA Form 5146-R Asphalt Pavement Inspection Sheet is shown at figure 3-3. Distress No. 6 (depression) is recorded as *6x4L*, which indicates that the depression is a 6-foot by 4=foot area and of low severity. Distress No. 10 (longitudinal and transverse cracking) is measured in linear feet; 3-2 thus, *10L* indicates 10 linear feet of light cracking, etc. The total distress data are used to compute the PCI for the sample unit. That computation is explained later in paragraph 3-5. An example of the summary of the distress types densities and severities for an asphaltor tar-surfaced sample unit is shown in figure 3-3.

d. Remarks.

(1) For both jointed concrete and asphalt or tar-surfaced pavement, it is important that each sample unit be identified concisely so it can be located for additional inspections, comparison with future inspections, maintenance requirements, and random sampling purposes. One way to do this is to keep a file of previous inspection data, including a sketch of the section which shows the location of each sample unit. (See fig 2-5 as an example.)

(2) It is imperative that the distress definitions listed in appendix B be used when performing pavement inspections. If these definitions are not followed, an accurate PCI cannot be determined.

3-4. Inspection by sampling

a. General. Inspection of every sample unit in a pavement section may be necessary if exact quantities are needed for contracting; however, such inspections require considerable effort, especially if the section is large. Because of the time and effort involved, frequent surveys of an entire section subjected to heavy traffic volume may be beyond available manpower, funds, and time. Therefore, sampling plans have been developed to allow adequate determination of the PCI and M&R requirements by inspecting only a portion of the sample units in a pavement section. The sampling plans can reduce inspection time considerably and still provide the accuracy required. The number and location of sample units to be inspected is dependent on the purpose of inspection. If the purpose is to determine the overall condition of the pavement in the network (e.g., initial inspection to identify projects, budget needs, etc.), then a survey of one or two sample units per section may suffice. The units should be selected to be representative of the overall condition of the section. If the purpose, however, is to analyze various M&R alternatives for a given pavement section (e.g., project design, etc.), then more sampling should be performed. The following paragraphs present the sampling procedure for this purpose.

b. Determining the number of samples.

(1) The first step in performing inspection by sampling is to determine the minimum number of sample units (*n*) that must be surveyed. This is done by using figure 3-4.

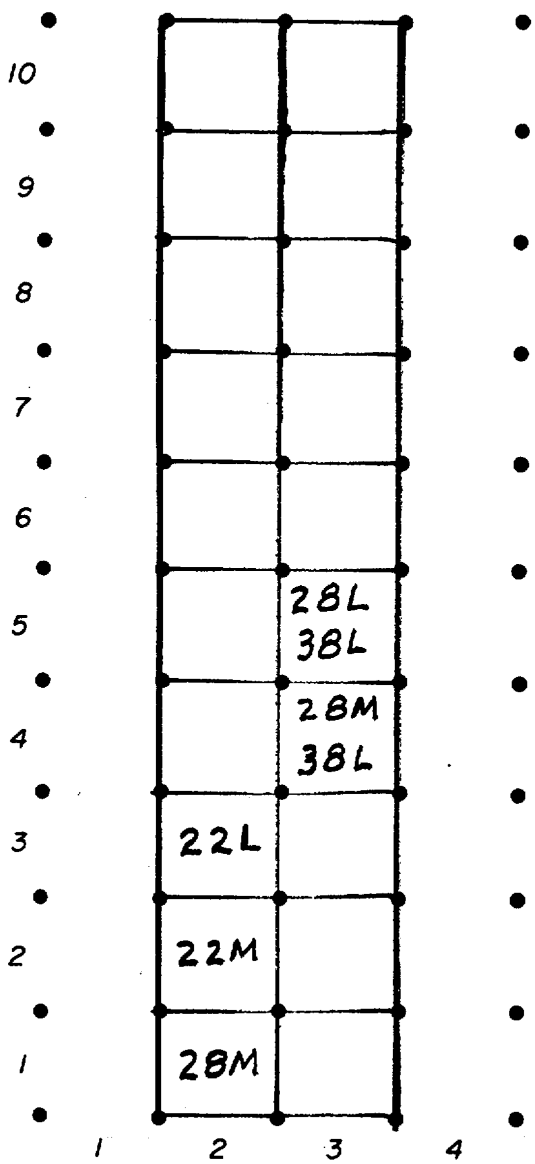
CONCRETE PAVEMENT INSPECTION SHEET

For use of is form, see TM 5-623; the proponent agency is USACE.

BRANCH MARSHALL AVE SECTION 1

DATE 10 / 3 / 79 SAMPLE UNIT 1

SURVEYED BY SK SLAB SIZE 15' x 20'



Distress Types

21. Blow-Up Buckling/Shattering
22. Corner Break
23. Divided Slab
24. Durability ("D") Cracking
25. Faulting
26. Joint Seal Damage
27. Lane/Shldr Drop Off
28. Linear Cracking
29. Patching, Large & Util Cuts
30. Patching, Small
31. Polished Aggregate
32. Popouts
33. Pumping
34. Punchout
35. Railroad Crossing
36. Scaling/Map Cracking/Crazing
37. Shrinkage Cracks
38. Spalling, Corner
39. Spalling, U Joint

DIST. TYPE	SEV.	NO. SLABS	% SLABS	DEDUCT VALUE
26*	M			4
22	L	1	5	4
22	M	1	5	8
28	L	1	5	3
28	M	2	10	9
38	L	2	10	1
q= 2	TOTAL DEDUCT VALUE			29
CORRECTED DEDUCT VALUE (CDV)				24

PCI = 100 - CDV = 76

RATING = VERY GOOD

* All Distresses Are Counted On A Slab-By-Slab Basis Except Distress26, Which Is Rated For the Entire Sample Unit.

DA FORM 5145-R, NOV 82

Figure 3-2. An example of a completed DA Form 5145-R, Concrete Pavement Inspection Sheet.

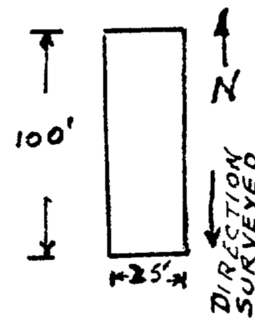
ASPHALT PAVEMENT INSPECTION SHEET
For use of this form, see TM 5-623; the proponent agency is USACE.

BRANCH MOTORPOOL RD. SECTION 1
DATE 10/21/79 SAMPLE UNIT 1
SURVEYED BY SK AREA OF SAMPLE 2500

Distress Types

1. Alligator Cracking
2. Bleeding
3. Block Cracking
*4. Bumps and Sags
5. Corrugation
6. Depression
*7. Edge Cracking
*8. Jt Reflection Cracking
*9. Lane/Shldr Drop Off
*10. Long & Trans Cracking
11. Patching & Util Cut Patching
12. Polished Aggregate
*13. Potholes
14. Railroad Crossing
15. Rutting
16. Shoving
17. Slippage Cracking
18. Swell
19. Weathering and Raveling

SKETCH:



EXISTING DISTRESS TYPE QUANTITY & SEVERITY

	TYPE →	10	1	15	6		
QUANTITY & SEVERITY							
		10 L	1 x 6 L	2 x 25 L	6 x 4 L		
		5 L	2 x 8 M				
		15 L					
		5 M					
		10 L					
		5 M					
TOTAL SEVERITY	L	40	6	50	24		
	M	10	16				
	H						

PCI CALCULATION

DISTRESS TYPE	DENSITY	SEVERITY	DEDUCT VALUE
1	0.24	L	4
1	0.64	M	17
6	0.96	L	4
10	1.60	L	4
10	0.4	M	3
15	2.0	L	13
q= 2	TOTAL DEDUCT VALUE		45
CORRECTED DEDUCT VALUE (CDV)			33

PCI = 100 − CDV = 67

RATING = GOOD

* All Distresses Are Measured In Square Feet Except Distresses 4,7,8,9 and 10 Which Are Measured In Linear Ft; Distress 13 Is Measured In Number of Potholes.

DA FORM 5146-R, NOV 82

Figure 3-3. An example of a completed DA Form 5146-R, Asphalt Pavement Inspection Sheet.

(2) The curves shown in figure 3-4 are used to select the minimum number of sample units that must be inspected. This will provide a reasonable estimate of the true mean PCI of the section. The estimate is within plus or minus 5 points of the true mean PCI about 95 percent of the time. When performing the initial inspection, the PCI range for a pavement section (i.e., lowest sample unit PCI subtracted from the highest sample unit PCI) is assumed to be 25 for asphalt concrete (AC) surfaced pavements and 35 for Portland cement concrete (PCC) surfaced pavements. For subsequent inspections, the actual PCI range (determined from the previous inspection) is used to determine the minimum number of sample units to be surveyed. As illustrated in figure 3-4, when the total number of samples within the section is less than five, every sample unit should be surveyed. If N is greater than five, at least five sample units should be surveyed.

(3) Examples of first assumption for number of sample units to be surveyed *n* follow:

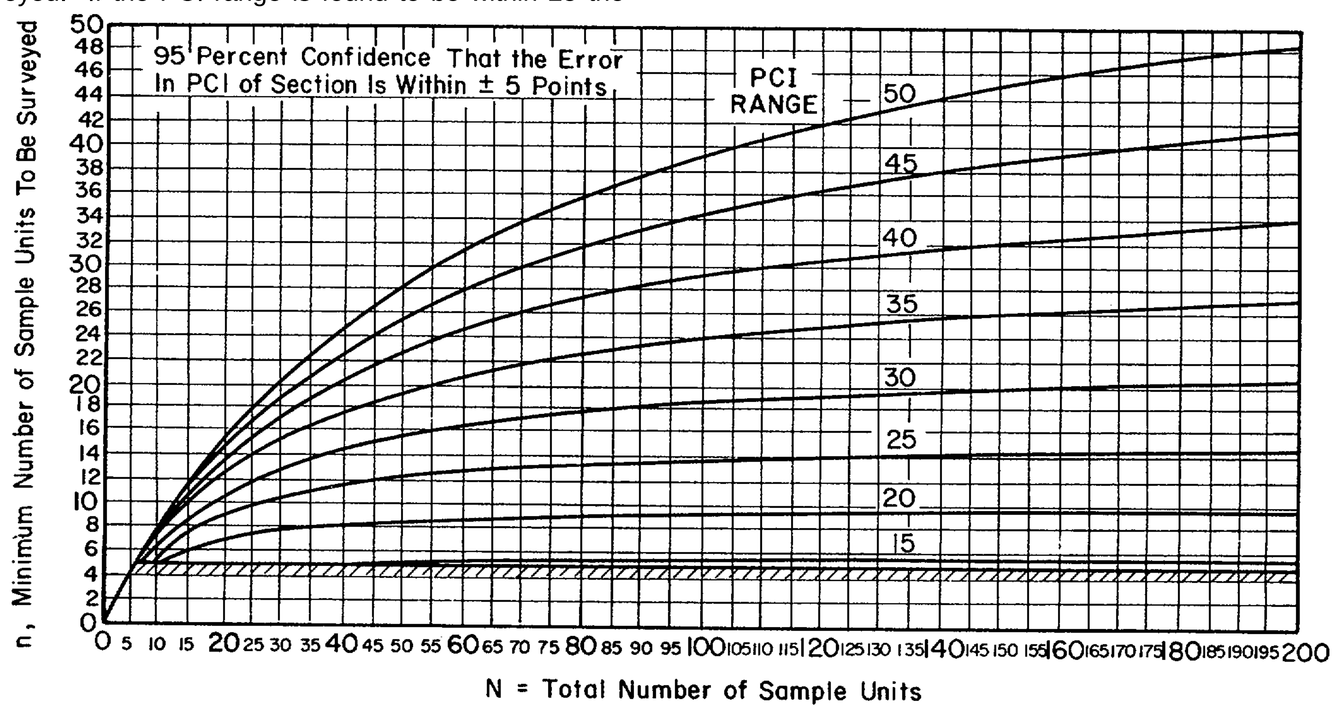
(a) **Given**: Asphalt concrete pavement section with total number of sample units, N=20.
Find: *n*.

Answer: Start at 20 on the N scale (fig 3-4), proceed vertically to the appropriate curve (PCI range= 25) and read 9 on the n scale. Nine sample units should be surveyed. If the PCI range is found to be within 25 the sampling is complete. However, if the PCI range of the samples taken was found to be 40, it would be necessary to go back to figure 34. Start at 20 on the N scale again, proceed vertically to the curve PCI range=40, and read 13 on the n scale. In this unusual case it would be necessary to survey the additional 4 samples (9+4 = 13).

(b) **Given**: Portland cement concrete pavement section with *N*=30. **Find**: *n*.
Answer: Start at 30 on the N scale, proceed vertical to appropriate curve (PCI range=35) and read 15 on the *n* scale.

(c) **Given**: An AC or PCC pavement section with *N*<5. **Find**: *n.*
Answer: Survey all sample units.

c. Selection of samples. Determining specific sample units to inspect is as important as determining the minimum number of samples (n) to be surveyed. The recommended method for selecting the samples is to choose samples that are equally spaced; however, the first sample should be selected at random. This technique, known as systematic sampling, is illustrated in figure 3-5 and is briefly described below.



PCI = Pavement Condition Index
PCI RANGE = Highest Sample Unit PCI - Lowest Sample Unit PCI
Assumed PCI Range for asphalt Concrete =25
Assumed PCI Range for Portland Cement Concrete = 35

Figure 3-4. Determination of minimum number of sample units to be surveyed.