

## CHAPTER 1

INTRODUCTION

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**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

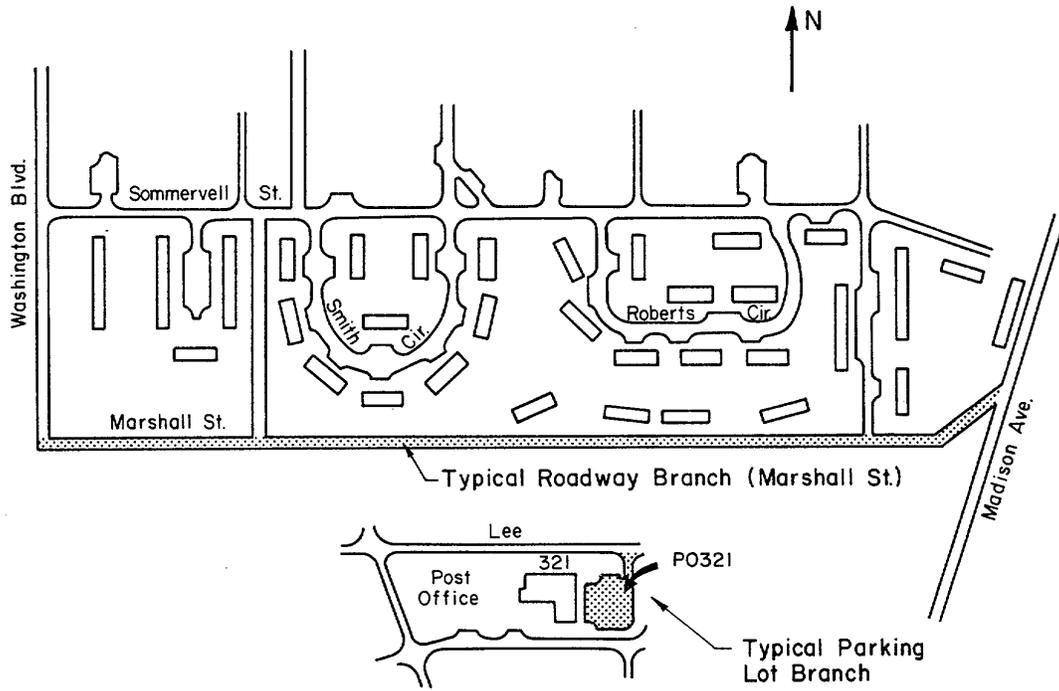


Figure 2-1. Installation map showing typical pavement branches.

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.

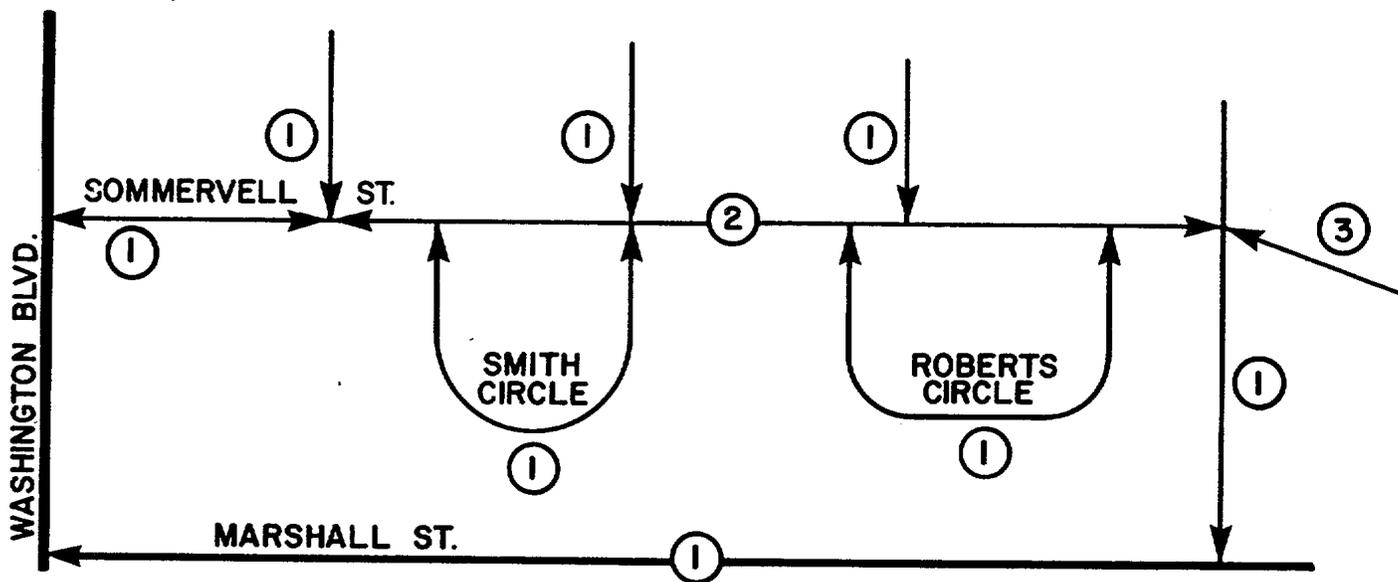


Figure 2-2. Sections identified on an installation map.

(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

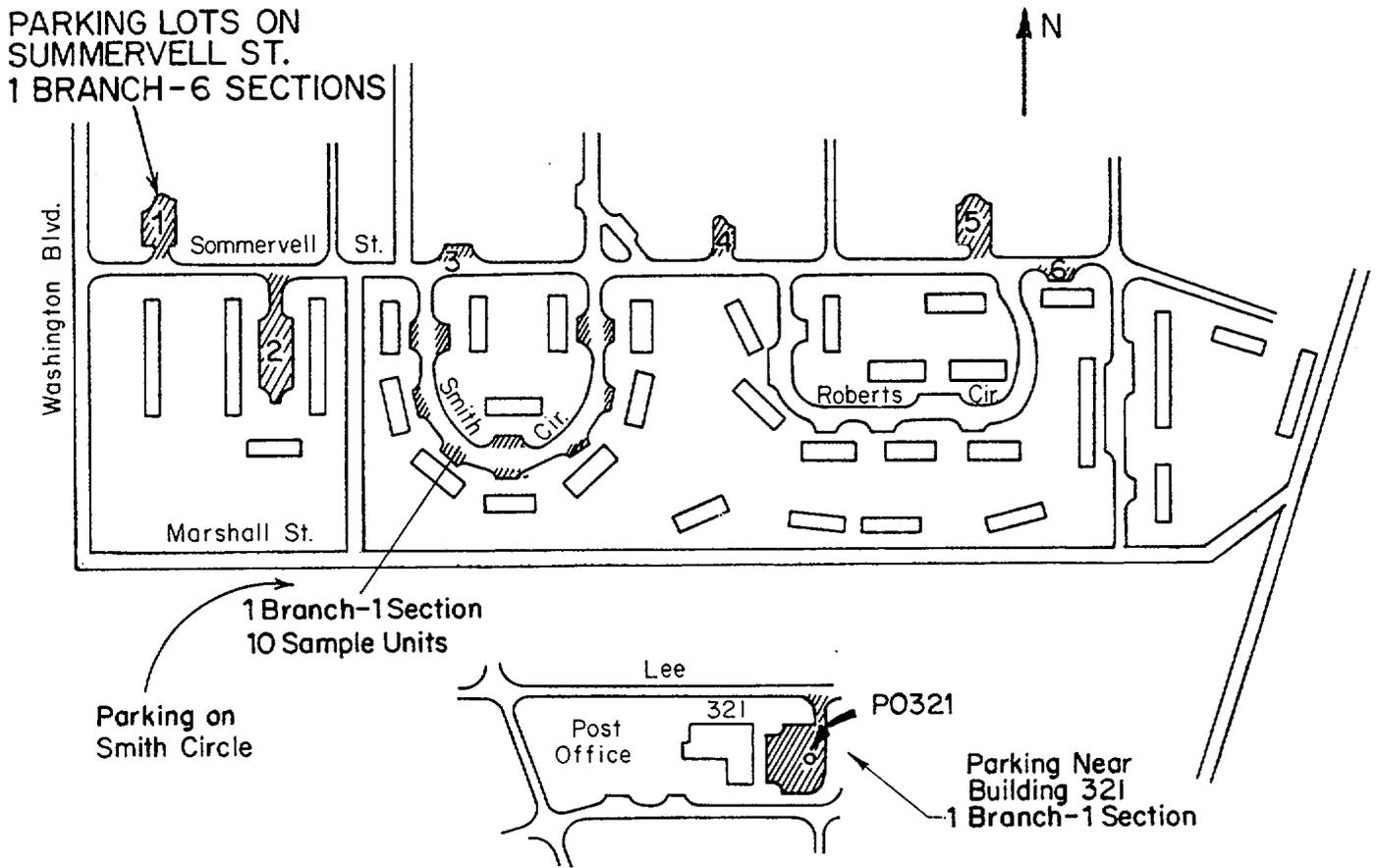


Figure 2-3. Installation map showing various methods of identifying parking area branches.

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.

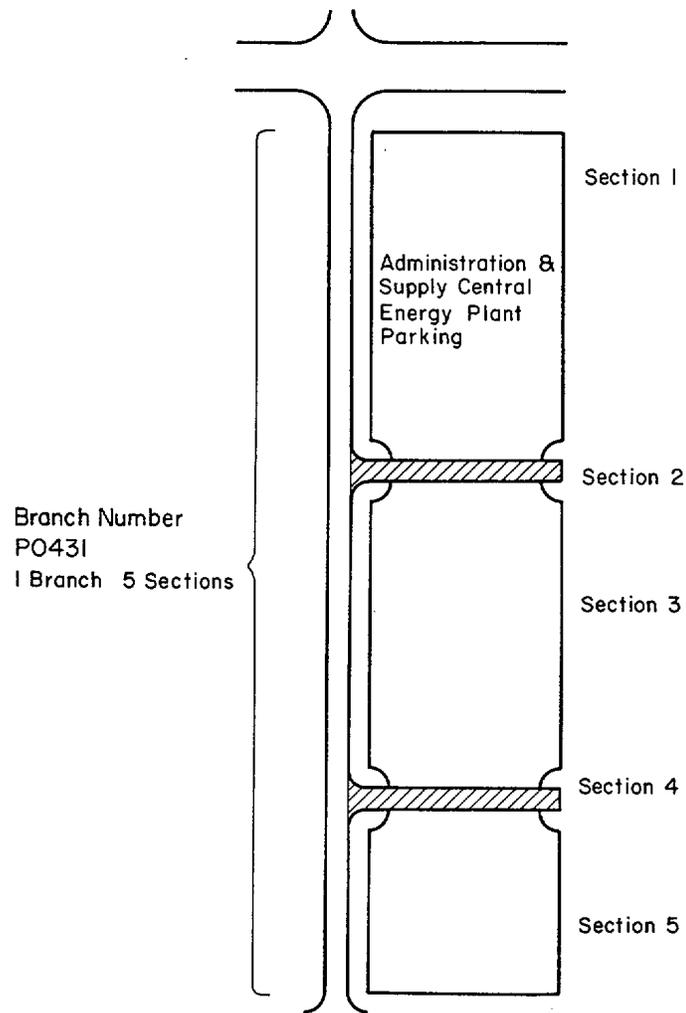


Figure 2-4. Large parking area divided into several sections.

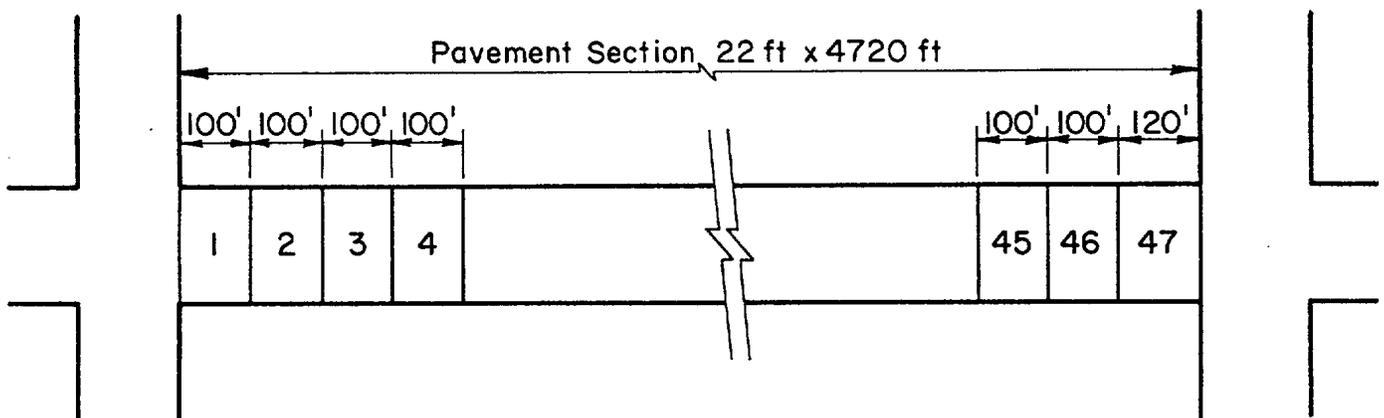


Figure 2-5. Example of a asphalt section divided into sample units.

## 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.

| PCI | RATING    |
|-----|-----------|
| 100 | EXCELLENT |
| 85  | VERY GOOD |
| 70  | GOOD      |
| 55  | FAIR      |
| 40  | POOR      |
| 25  | VERY POOR |
| 10  | FAILED    |
| 0   |           |

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 asphalt or 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.

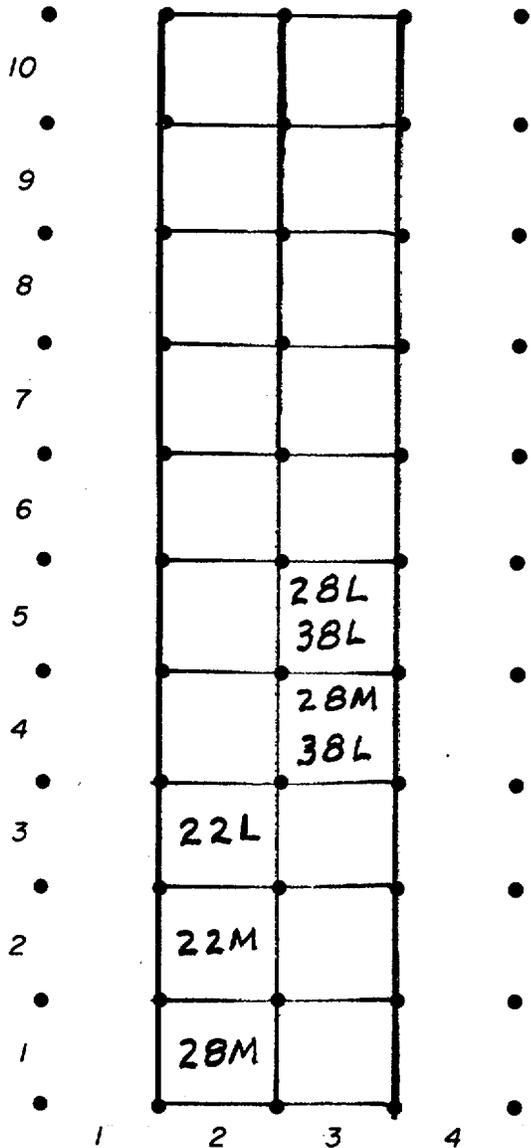
*b. Determining the number of samples.*

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

\* All Distresses Are Counted On A Slab-By-Slab Basis Except Distress 26, 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  | SKETCH: |
|---|---------|
| <ul style="list-style-type: none"> <li>1. Alligator Cracking</li> <li>2. Bleeding</li> <li>3. Block Cracking</li> <li>*4. Bumps and Sags</li> <li>5. Corrugation</li> <li>6. Depression</li> <li>*7. Edge Cracking</li> <li>*8. Jt Reflection Cracking</li> <li>*9. Lane/Shldr Drop Off</li> <li>*10. Long &amp; Trans Cracking</li> <li>11. Patching &amp; Util Cut Patching</li> <li>12. Polished Aggregate</li> <li>*13. Potholes</li> <li>14. Railroad Crossing</li> <li>15. Rutting</li> <li>16. Shoving</li> <li>17. Slippage Cracking</li> <li>18. Swell</li> <li>19. Weathering and Raveling</li> </ul> |         |

| EXISTING DISTRESS TYPE QUANTITY & SEVERITY |      |       |        |       |  |
|--|------|-------|--------|-------|--|
| TYPE                                       | 10   | 1     | 15     | 6     |  |
| QUANTITY & SEVERITY                        | 10 L | 1x6 L | 2x25 L | 6x4 L |  |
|  | 5 L  | 2x8 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).

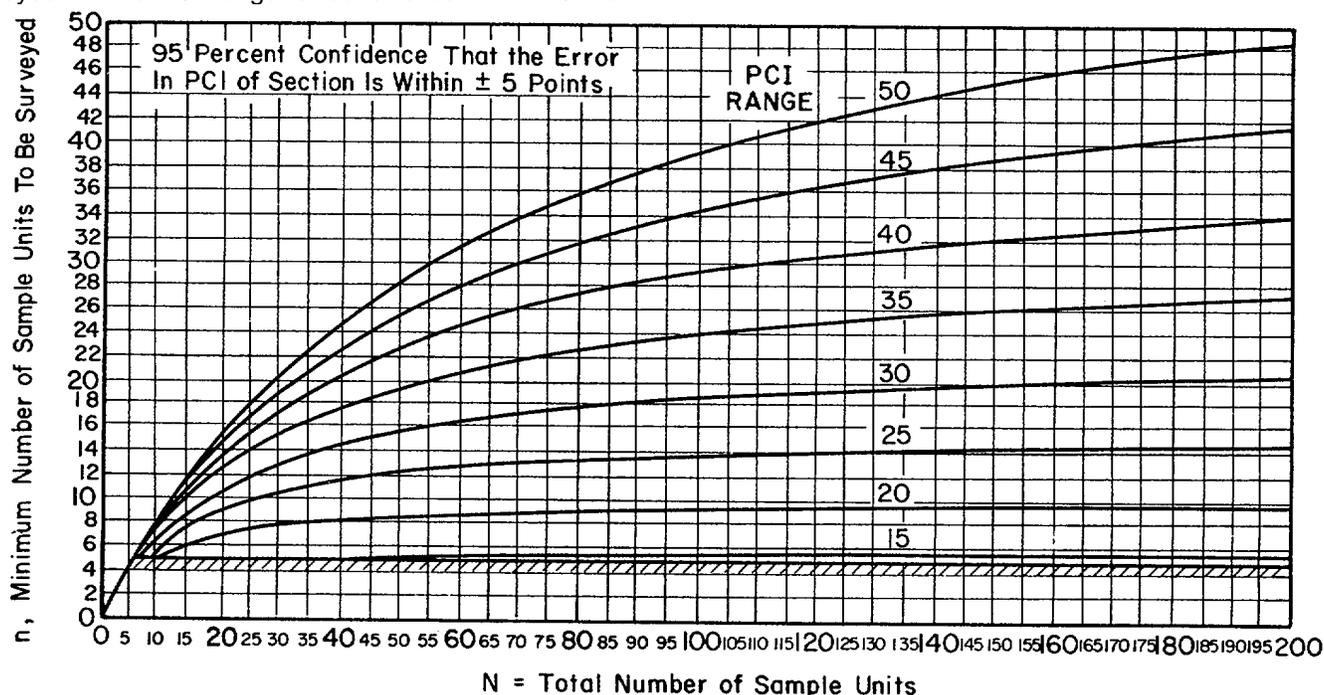
(b) **Given:** Portland cement concrete pavement section with N=30. **Find:** *n*.

**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.

Total Number of Sample Units In Section (N) = 47  
 Minimum Number of Units To Be Surveyed (n) = 13  
 Interval (i) =  $\frac{N}{n} = \frac{47}{13} = 3.6 = 3$   
 Random Start (S) = 3

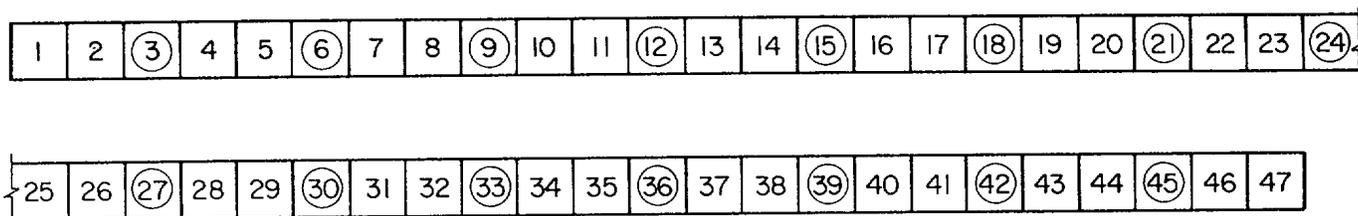


Figure 3-5. Example selection of sample units to be surveyed.

(1) The "sampling interval" (*i*) is determined by  $i=N/n$ , where *N*=total number of available sample units, *n*=minimum number of sample units to be surveyed, and *i* is rounded off to the smaller whole number (e.g., 3.6 is rounded to 3).

(2) The random start (*s*) is selected at random between 1 and the sampling interval (*i*). For example, if *i*=3, the random start would be a number from 1 to 3.

(3) The sample units to be surveyed are identified as *s*, *s+i*, *s+2i*, *s+3i*, etc. If the selected start is 3, then the samples to be surveyed are 3, 6, 9, 12, etc. (See fig 3-5.) This technique is simple to apply and also gives the information necessary to establish a PCI profile along the pavement section.

*d. Selection of additional sample units.* One of the major objections to sampling is the problem of not including very "poor" or "excellent" sample units which may exist in a section. Another problem is the selection of a random sample which contains nontypical distresses such a railroad crossings, potholes, etc.

(1) To overcome these problems, the inspector should label unusual sample units as additional sample units. An additional unit implies that the sample

was not selected at random and/or contains distress(es) which are not representative of the section.

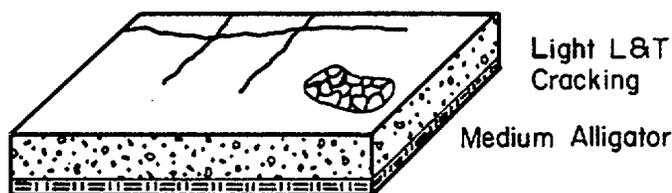
(2) The calculation of the PCI when additional sample units are included is slightly altered and its described in paragraph 3-5.

**3-5. Calculating the PCI from inspection results**

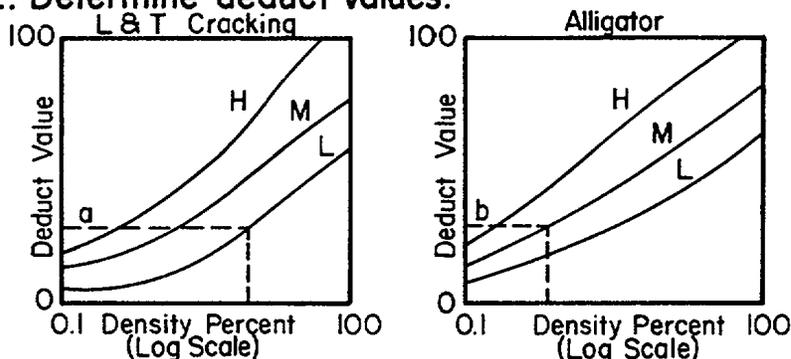
*a. General.* Paragraph 3-4 described two ways of inspecting a pavement section; i.e., inspecting every unit in the section or inspecting by sampling. Data collected during either method of inspection are used to calculate the PCI. This paragraph explains how to calculate the PCI for a particular sample unit, and how to calculate the PCI for the entire pavement section. An important item in the calculation of the PCI is the "deduct value." A deduct value is a number from 0 to 100, with 0 indicating the distress has no impact on pavement condition, and 100 indicating an extremely serious distress which causes the pavement to fail.

*b. Calculating sample unit PCI.* Calculating the PCI for a sample unit is a simple procedure which involves five steps (see fig 3-6):

**Step 1. Inspect sample units: Determine distress types and severity levels and measure density.**

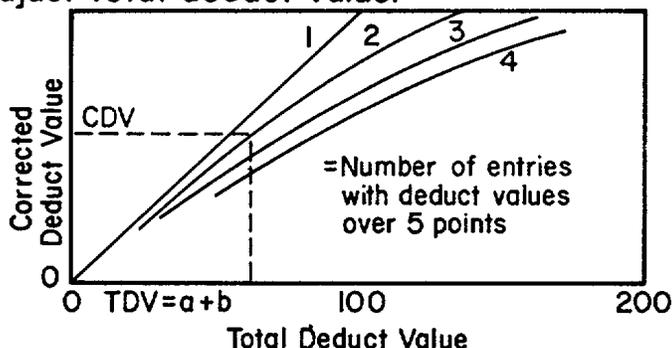


**Step 2. Determine deduct values.**



**Step 3. Compute total deduct value (TDV) a+b.**

**Step 4. Adjust total deduct value.**



**Step 5. Compute pavement condition index (PCI) = 100 - CDV for each sample unit inspected**

Figure 3-6. Steps for calculating PCI for a sample unit.

(1) *Step 1.* Each sample unit is inspected and distress data recorded on DA Form 5145-R for concrete or DA Form 5146-R for bituminous pavements as described in paragraph 3-3. (See figs 3-2 and 3-3.)

(2) *Step 2.* The deduct values are determined from the deduct value curves for each distress type and severity. (See app C.)

(3) *Step 3.* A total deduct value (TDV) is computed by summing all individual deduct values.

(4) *Step 4.* Once the TDV is computed, the corrected deduct value (CDV) can be determined from the correction curves (fig C-20 or fig C-40). When determining the CDV, if any individual deduct value is higher than the CDV, the CDV is set equal to the highest

individual deduct value. For example, assume that two distresses were found in an asphalt pavement, one with a deduct value of 50, and the other with a deduct value of 10. Using figure C-20, the CDV for  $q=2$  ( $q$  = number of individual deducts whose value is greater than 5) is 44. Since 44 is lower than 50, the CDV is set equal to 50.

(5) *Step 5.* The PCI is computed using the relation  $PCI = 100 - CDV$ .

c. *Calculating the PCI for a pavement section.* If all sample units in a section are surveyed, the PCI of the section is computed by averaging the PCIs

of all its sample units. Inspection by sampling, however, requires a different approach. If all surveyed sample units are selected randomly, the PCI of the pavement section is determined by averaging the PCI of its sample units. If any additional sample units are inspected, a weighted average must be used. The weighted average is computed by using the following equation:

$$PCI_s = \frac{(N-A)(PCI_1 + A)(PCO_1) + A(PCO_2)}{N} \quad \text{(Equation 3-1)}$$

where  $PCI_s$  = PCI of pavement section,  $PCI_1$  = average PCI of random samples,  $PCI_2$  = average PCI of additional samples,  $N$  = total number of samples in the section, and  $A$  = number of additional samples inspected.

*d. Example calculation of the PCI for a sample unit.* The field data sheets described in paragraph 3-3 are always used when calculating the PCI of a sample unit.

(1) *Asphalt pavement inspection sheet (fig 3-3).*

(a) The difference between calculating a PCI for an asphalt sample unit and calculating a PCI for a concrete sample unit is in the way the distress density is determined.

1. Density for distresses measured by the square foot is calculated as follows:

$$\text{Density} = \frac{\text{distress amount in square feet}}{\text{sample unit area in square feet}} \times 100$$

2. Density for distresses measured by the linear foot (bumps, edge cracking, joint reflection cracking, lane/shoulder drop off, and longitudinal and transverse cracking) is calculated as follows (see appendix B for distress definitions):

$$\text{Density} = \frac{\text{distress amount in linear feet}}{\text{sample unit area in square feet}} \times 100$$

3. Density for distress measured by number (potholes) is calculated as follows:

$$\text{Density} = \frac{\text{number of potholes}}{\text{sample unit area in square feet}} \times 100$$

(b) After the distress density for each distress type/severity combination is calculated, the deduct values are determined from the distress deduct value curves in figures C-1 through C-19 of appendix C. The corrected deduct value (CDV) is determined from figure C-20 and is calculated as shown in figure 3-3.

(2) *Concrete pavement inspection sheet (fig 3-2).* After inspection, calculate the density of distress

as follows:

$$\text{Density} = \frac{\text{number of slabs containing a particular type}}{\text{distress number of slabs in sample unit}} \times 100$$

For example, two slabs in the pavement sample unit shown in figure 3-2 contained linear cracking (distress 28) at medium severity, so the density is calculated as  $2 \div 20 \times 100$ , or 10 percent. The deduct values are then determined for each distress combination from the distress deduct value curves given in figures C-21 through C-39. The CDV is determined from figure C-40, and the PCI is calculated as shown in figure 3-2.

*e. Determination of distress quantities for a pavement section.* When a pavement has been inspected by sampling, it is necessary to extrapolate the quantities and densities of distress over the entire pavement section to determine total quantities for the section.

(1) If all sample units surveyed were selected at random, the extrapolated quantity of a given distress of a given severity level would be determined as illustrated in the following example for medium-severity alligator cracking:

*Section Information*

Surface type: Asphalt concrete

Area: 24,500 square feet

Total number of sample units in the section: 10

Five sample units were surveyed at random, and the amount of medium-severity alligator cracking was determined as follows:

| <i>Sample Unit ID</i> | <i>Sample Unit Area, Square Feet</i> | <i>Medium-Severity Alligator Cracking, Square Feet</i> |
|-----------------------|--------------------------------------|--|
| 02                    | 2500                                 | 100  |
| 04                    | 2500                                 | 200  |
| 06                    | 2500                                 | 150  |
| 08                    | 2500                                 | 50   |
| 10                    | 2000                                 | 100  |
| <i>Total Random</i>   | 12,000                               | 600  |

The average density for medium-severity alligator cracking is, therefore,  $600/12,000 = 0.05$ . The extrapolated quantity is determined by multiplying the density by the section area, i.e.,  $.05 \times 24,500 = 1225$  square feet.

(2) If additional sample units were included in the survey, the extrapolation process would be slightly different. In the example given in (1) above, assume that sample unit number 01 was surveyed as additional and that the amount of medium-severity alligator cracking

was measured as follows:

| <i>Additional<br/>Sample Unit ID<br/>Cracking,</i> | <i>Sample Unit<br/>Area, Square Feet</i> | <i>Medium-Severity<br/>Alligator<br/>Square Feet</i> |
|--|--|--|
| <u>01</u>  | <u>2500</u>                              | <u>1000</u>  |
| <i>Total<br/>Additional</i>                        | 2500                                     | 1000   |

Since 2500 square feet were surveyed as additional, the section's randomly surveyed area is, therefore, 24,500-2500=22,000 square feet. The extrapolated distress quantity is obtained by multiplying the distress density by the section's randomly surveyed area and then adding the amount of additional distress. In this example:

$$\begin{aligned} \text{Extrapolated Distress Quantity} &= .05 \times 22,000 + 1000 \\ &= 2100 \text{ square feet} \end{aligned}$$

## CHAPTER 4

## MAINTENANCE AND REPAIR (M&amp;R) GUIDELINES

**4-1. Introduction**

M&R needs and priorities are highly related to the PCI, since the PCI is determined by distress information which is a key factor in establishing pavement M&R requirements. This chapter describes how to do a payment evaluation, how to determine feasible M&R alternatives, and how to establish M&R priorities. These guidelines should be based on the PCI, with consideration given to other important factors including pavement load-carrying capacity. Nondestructive pavement testing techniques may be used in this load-carrying capacity evaluation. A specific M&R alternative can often be selected for a pavement section that is in very good or excellent condition without a life-cycle cost analysis. In cases where a life-cycle cost analysis is necessary to select among feasible alternatives, the life-cycle cost analysis method described in chapter 5 should be used.

**4-2. Pavement evaluation procedure**

Evaluation is performed on a section-by-section basis since each section represents a unit of the pavement network that is uniform in structural composition and subjected to consistent traffic loadings. It is necessary to make a comprehensive evaluation of pavement condition before rational determination of feasible M&R alternatives can be made. A step-by-step description of how to complete the DA Form 5147-R, Section Evaluation Summary (fig. E-3) is given below. An example of a completed DA Form 5147-R is shown at figure 4-1.

*a. Overall condition.* The PCI of a pavement section describes the section's overall condition. The PCI, and thus the section condition rating (e.g., good or very good), is based on many field tests and represents the collective judgment of experienced pavement engineers. In turn, the overall condition of the section correlates highly with the needed level of M&R. In figure 4-1 the PCI of the section under consideration was 15, so that number was recorded on line 1 and the appropriate rating-"very poor"-circled.

*b. Variations of the PCI within section.* PCI variation within a section can occur on a localized random basis, and/or a systematic basis. Figure 4-2, which was developed from field data, gives guidelines

that can be used to determine whether variation exists. When a PCI value of a sample unit in the section is less than the sample unit critical PCI value, a localized random variation exists. For example, if the mean PCI of a section is 59, any sample unit with a PCI of less than 42 should be identified as a localized bad area by circling "Yes" under item 2a on the form. This variation should be considered when determining M&R needs. Systematic variation occurs whenever a large, concentrated area of a section has significantly different condition. For example, if traffic is channeled into a certain portion of a large parking lot, that portion may show much more distress or be in a poorer condition than the rest of the area. Whenever a significant amount of systematic variability exists within a section, the section should be subdivided into two or more sections. In that example being considered (fig 4-1) there was no localized random or systematic variation, so "No" was circled at both lines 2a and 2b.

*c. Rate of deterioration of condition-PCI.* Both the long and short-term rate of deterioration of each pavement section should be checked. The long-term rate is measured from the time of construction or time of last overall M&R (such as an overlay). The rate is determined as low, normal, or high using figures 4-3 through 4-6. The figures are for the following four payment types respectively: asphalt concrete (AC) pavements, AC overlay over AC pavements, Portland cement concrete (PCC) pavements, and AC overlay over PCC pavements. Development of the curves delineating the low, normal, and high rate of deterioration was based on field data from Fort Eustis, Virginia. For example, an AC pavement that is 20 years old with a PCI of 50 is considered to have a high long-term rate of deterioration with respect to other AC pavements. Short-term deterioration (i.e., a drop in PCI during the last year) should also be determined since a high short-term deterioration rate can indicate the imminent failure of a pavement section (fig. 4-7). In general, whenever the PCI of a section decreases by 7 or more PCI points in a year, the deterioration rate should be considered high. If the loss in PCI points is 4 to 6, the short-term deterioration rate should be considered normal. It

Section Evaluation Summary

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

1. Overall Condition Rating - PCI 15

Rating - Failed - Very Poor, Poor, Fair, Good, Very Good, Excellent  
 PCI 0-10 11-25 26-40 41-55 56-70 71-85 86-100

2. Variation of Condition Within Section -- PCI

a. Localized Random Variation Yes, No

b. Systematic Variation: Yes, No

3. Rate of Deterioration of Condition -- PCI

a. Long-term period (since construction or last overall repair) Low, Normal, High

b. Short-term period (1 year) Low, Normal, High

4. Distress Evaluation

a. Cause

Load Associated Distress 80 percent deduct value

Climate/Durability Associated 20 percent deduct value

Other ( ) Associated Distress 0 percent deduct value

b. Moisture (Drainage) Effect on Distress Minor, Moderate, Major

5. Deficiency of Load-Carrying Capacity No, Yes

6. Surface Roughness Minor, Moderate, Major

7. Skid Resistance/Hydroplaning Potential Minor, Moderate, Major

8. Previous Maintenance Low, Normal, High

9. Comments: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

DA FORM 5147-R, NOV 82

Figure 4-1. An Example of a Completed DA Form 5147-R, Section Evaluation Summary.

should also be emphasized that short-term deterioration cannot be accumulated to arrive at a long-term rate evaluation. In the example being considered (fig 4-1)

long-term deterioration falls in the normal area and short term is calculated to be 5, also normal; so "Normal" is circled at 3a and 3b.

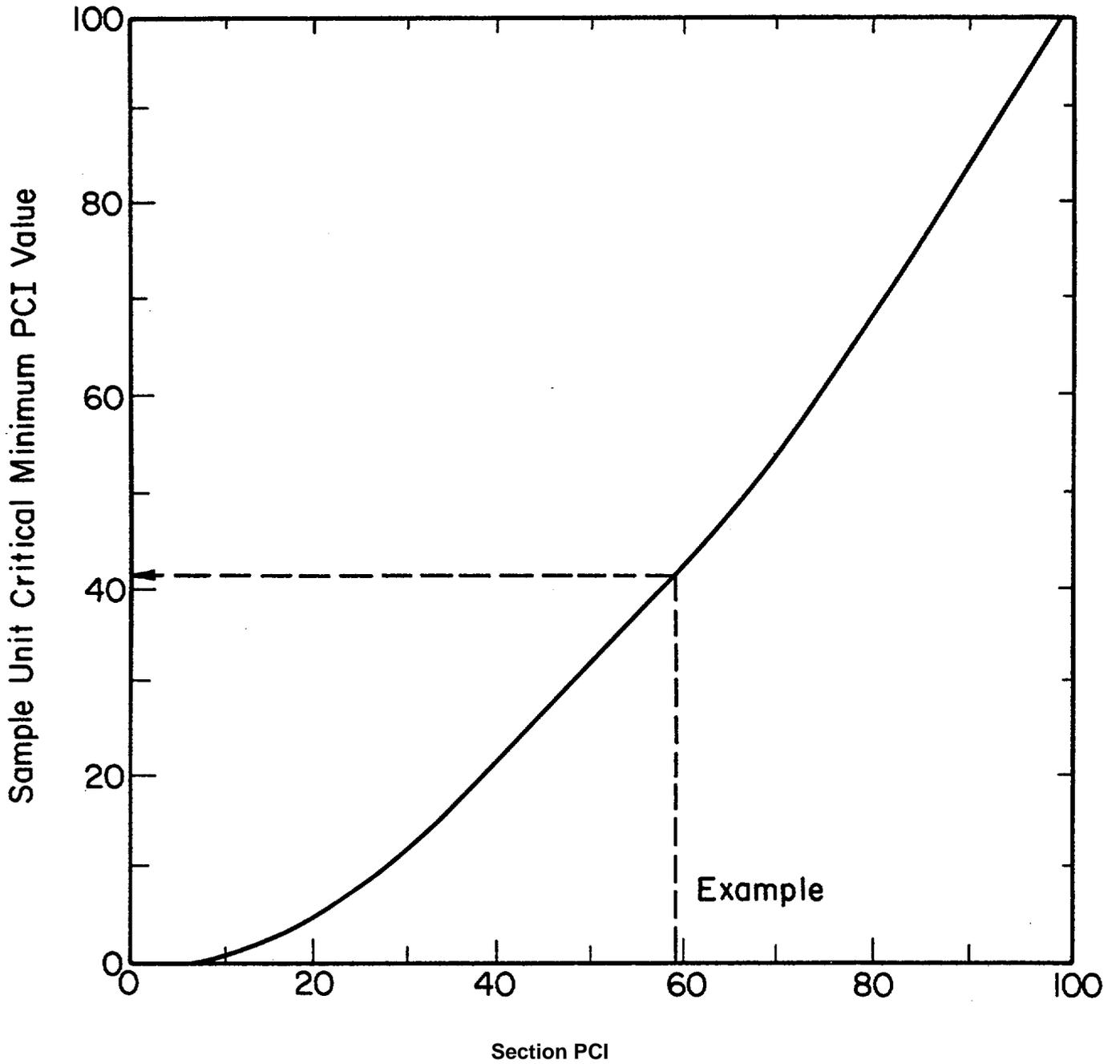


Figure 4-2. Procedure to determine critical minimum sample unit PCI based on mean PCI of section.

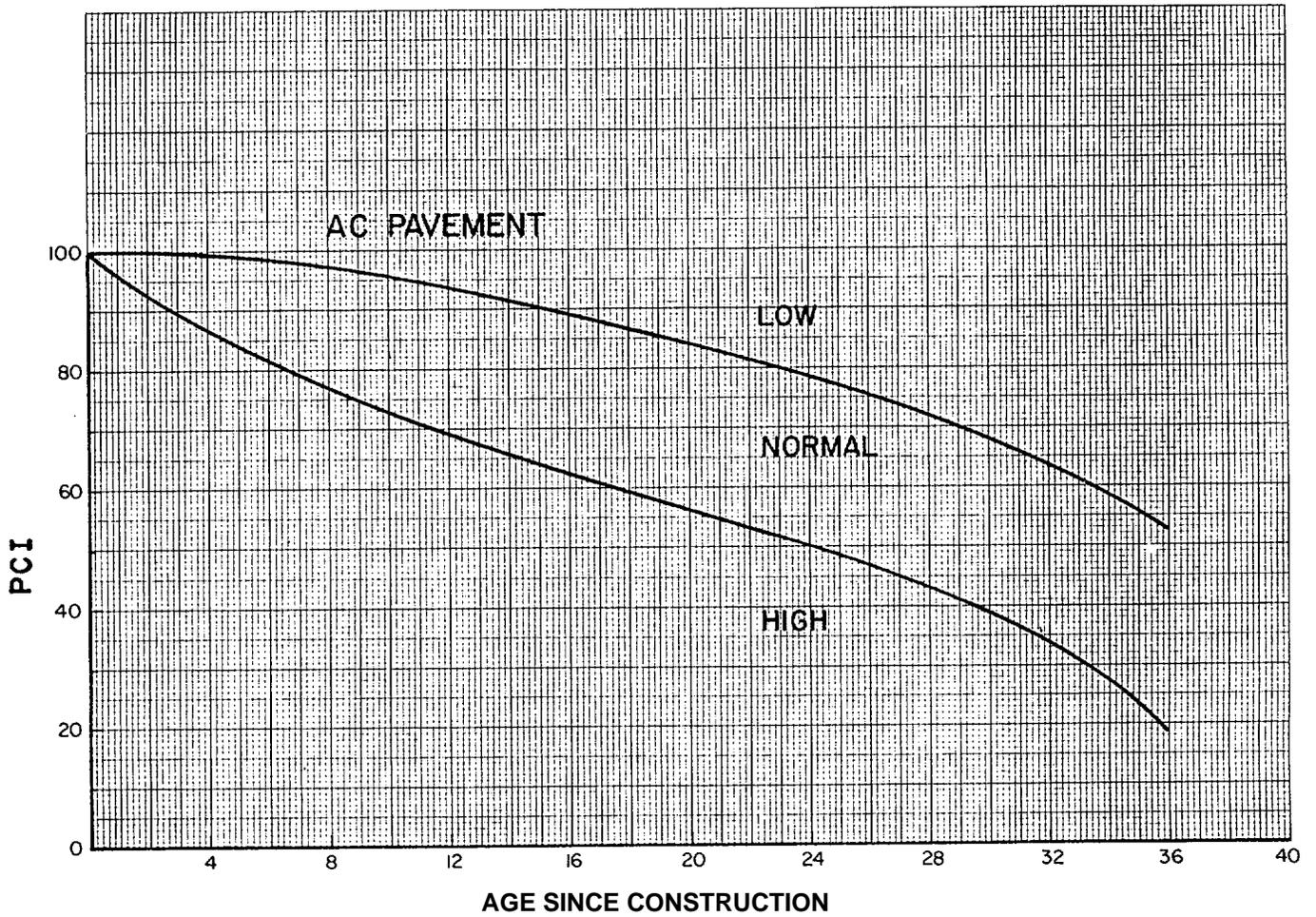


Figure 4-3. Determination of long-term rate of deterioration for asphalt concrete (AC) pavements.

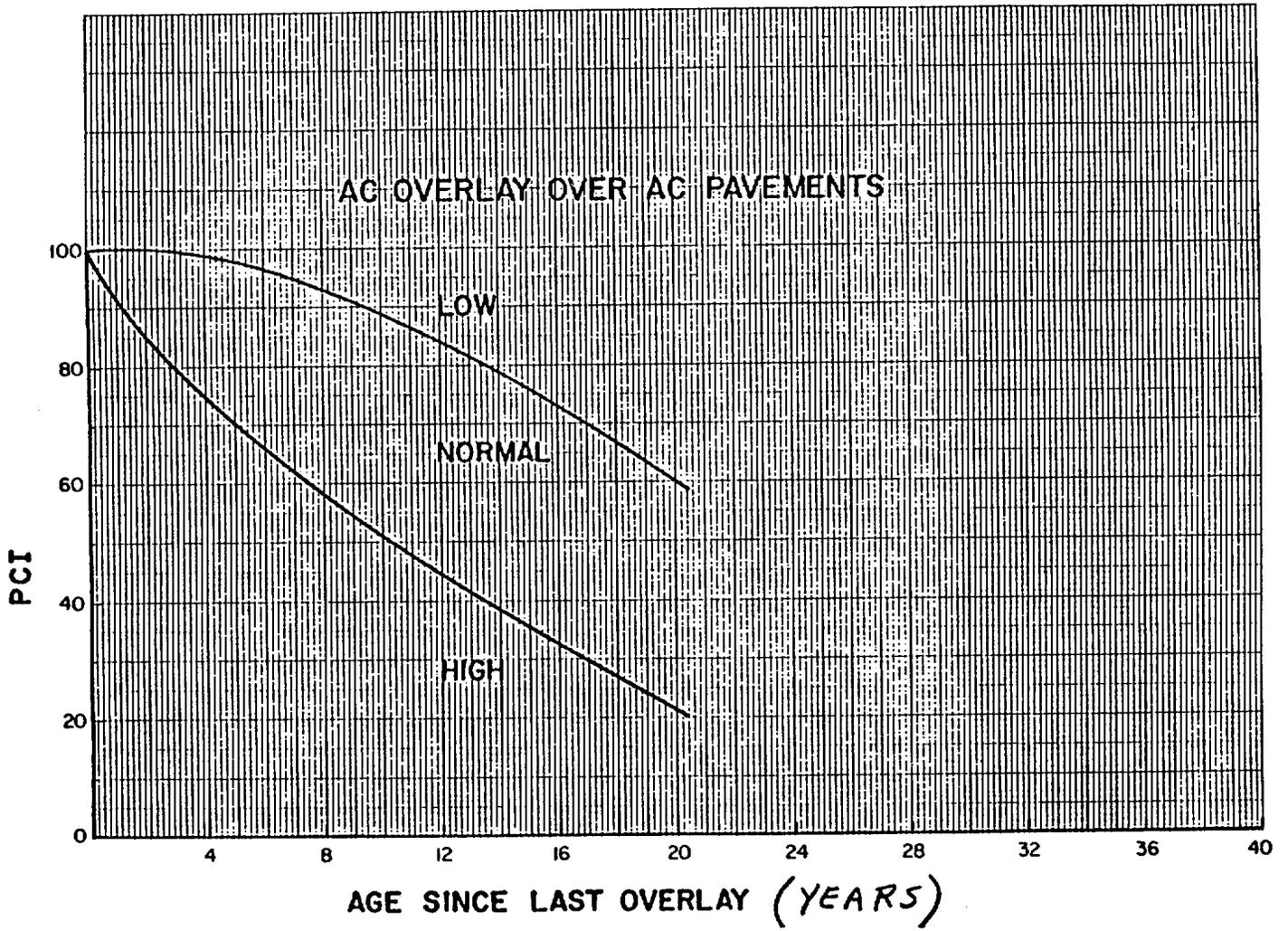


Figure 4-4. Determination of long-term rate of deterioration for asphalt concrete (AC) overlay over AC pavements.

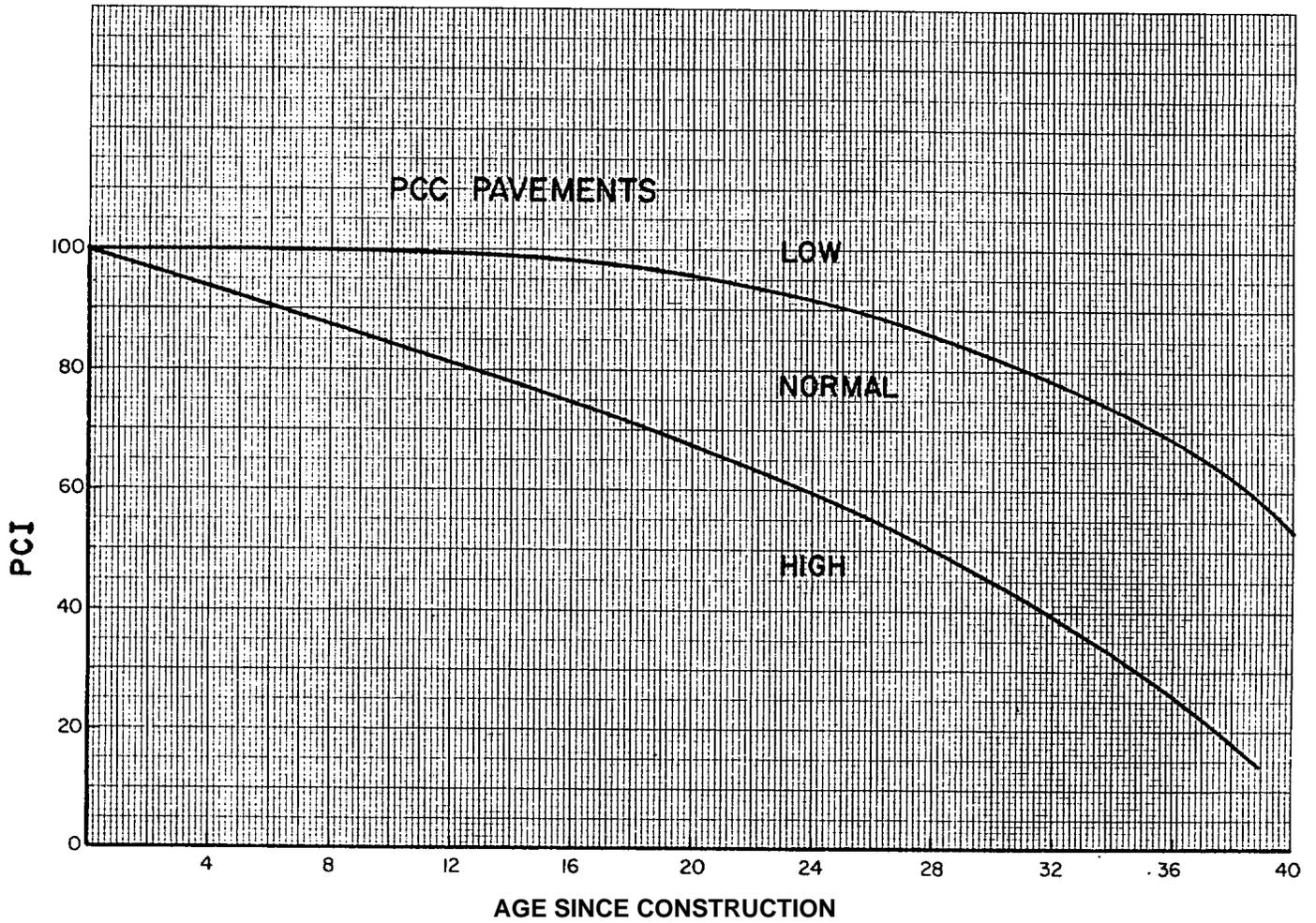


Figure 4-5. Determination of long-term rate of deterioration for Portland Cement Concrete (PCC) pavements.

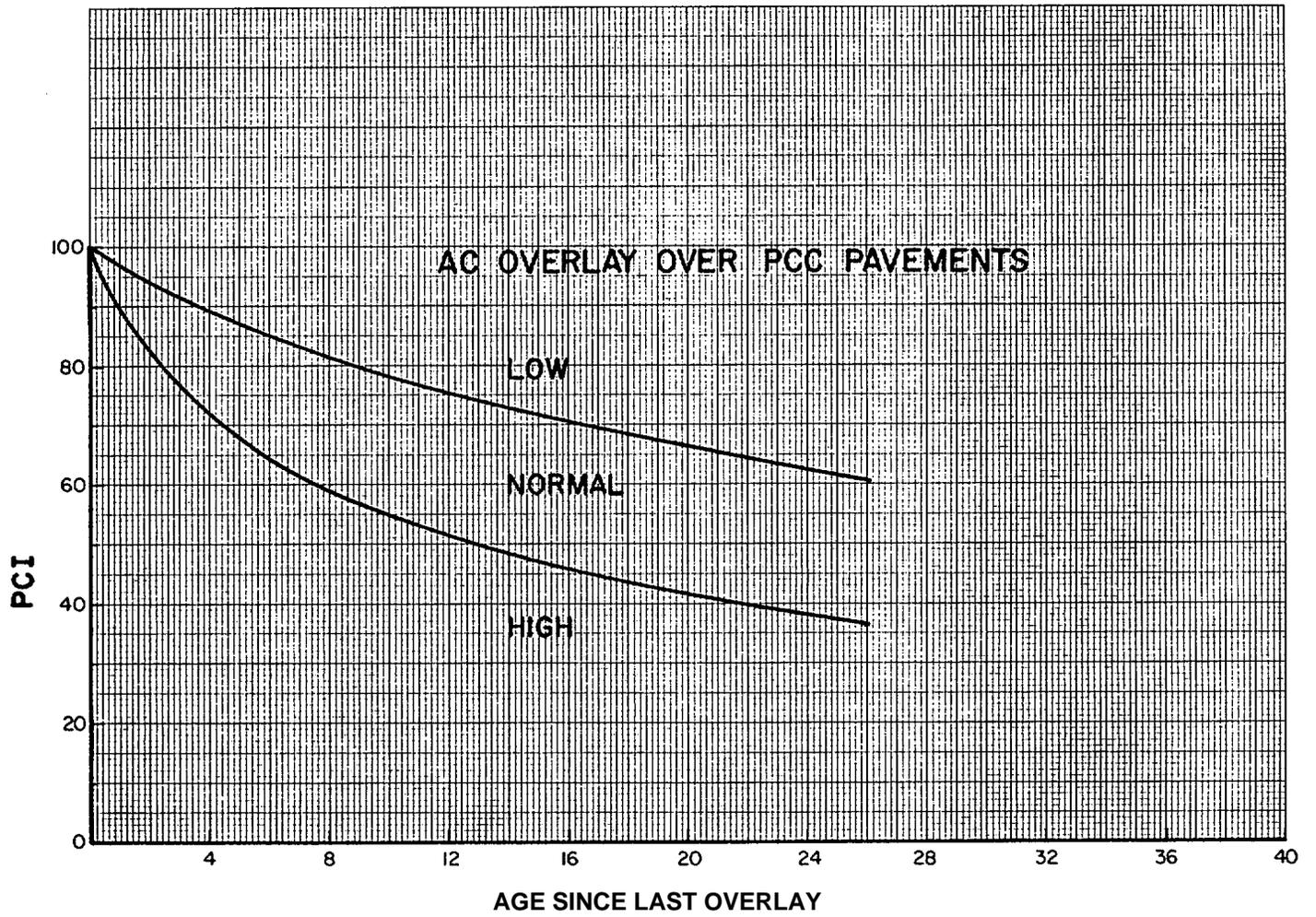


Figure 4-6. Determination of long-term rate of deterioration for asphalt concrete (AC) overlay over Portland Cement Concrete (PCC) pavements.

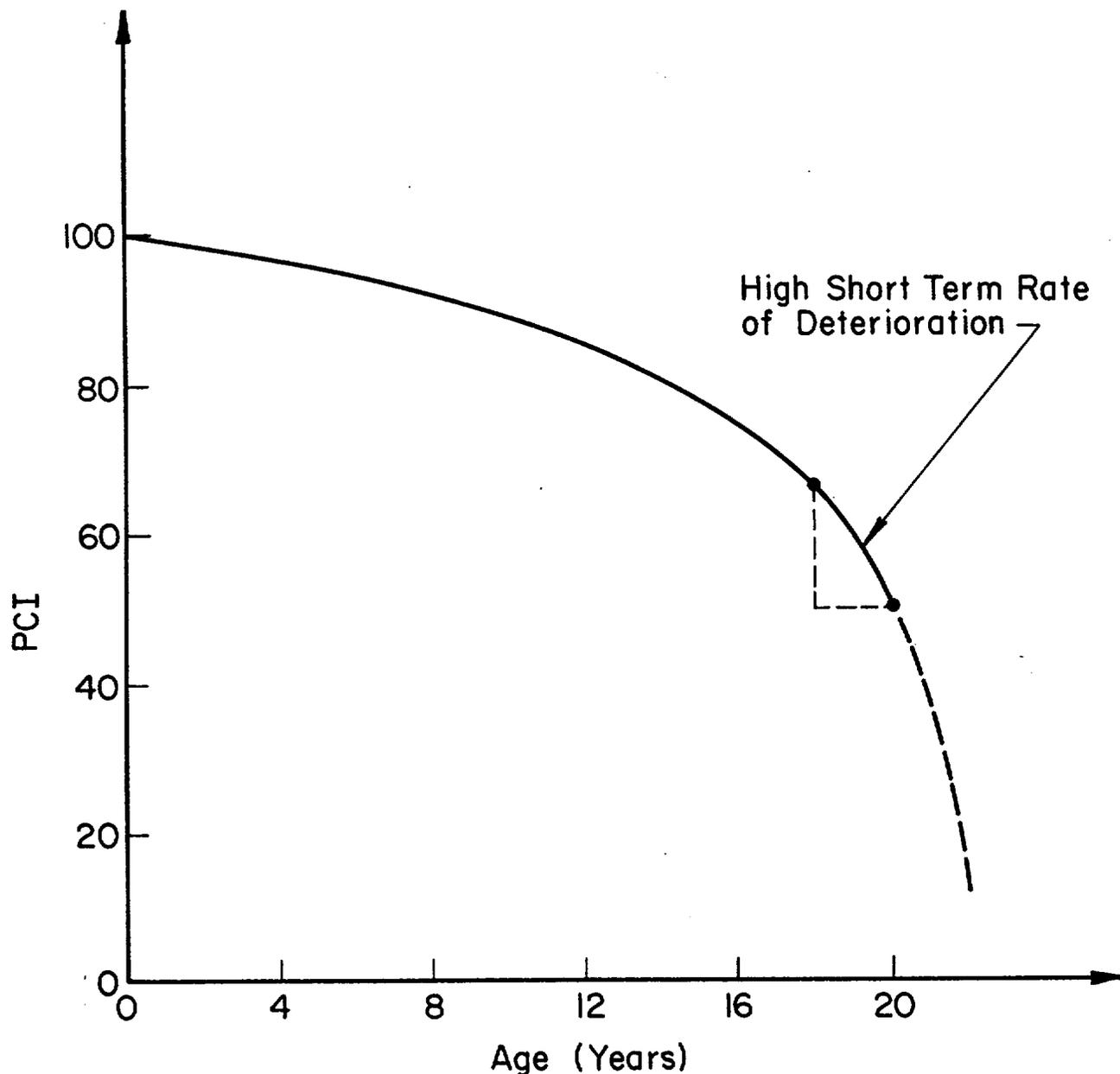


Figure 4-7. PCI us age illustrating high short-term rate of deterioration.

d. *Distress evaluation.* Examination of the specific distress types, severities, and quantities present in a pavement section can help identify the cause of pavement deterioration, its condition, and eventually its M&R needs. Tables 4-1 and 4-2 list general classification of distress types for asphalt-and concrete-surfaced pavement according to their cause and effect on pavement conditions. Conditions at each pavement section will dictate which distresses will be placed in

each group. For evaluation purposes (fig 4-1), distresses have been classified into three groups based on cause. These groups are load associated, climate/durability associated, and other factors. In addition, the effect of drainage on distress occurrence should always be investigated. The following steps should be followed to determine the primary cause or causes of pavement condition deterioration for a given pavement section.

Table 4-1. General Classification of Asphalt Distress Types by Possible Causes  
POSSIBLE CAUSES

| <i>Load</i>                             | <i>Climate/durability</i>                             | <i>Moisture/drainage</i> | <i>Other factors</i>   |
|---|---|--------------------------|------------------------|
| Alligator Cracking                      | Bleeding  | Alligator cracking       | Corrugation            |
| Corrugation                             | Block cracking  | Depression               | Bleeding               |
| Depression                              | Joint reflection cracking                             | Potholes                 | Bumps and sags         |
| Edge cracking                           | Longitudinal and transverse cracking.                 | Swell                    | Lane/shoulder drop off |
| Patching of road-caused caused distress | Patching of climate/durability-swell caused distress. |                          |                        |
| Polished aggregate                      | Potholed  |                          |                        |
| Potholes                                | Swell   |                          |                        |
| Rutting                                 | Weathering and raveling                               |                          |                        |
| Slippage cracking                       |   |                          |                        |

Table 4-2. General Classification of Concrete Distress Types by Possible Causes  
POSSIBLE CAUSES

| <i>Load</i>                          | <i>Climate/durability</i>                          | <i>Moisture/drainage</i>             | <i>Other factors</i>   |
|--------------------------------------|--|--------------------------------------|------------------------|
| Corner break                         | Blow-up  | Corner break                         | Faulting               |
| Divided slab                         | "D" cracking                                       | Divided slab                         | Lane/shoulder drop off |
| Linear cracking                      | Joint seal damage                                  | Patching of moisture-caused distress | Railroad crossing      |
| Patching of load-associated distress | Linear cracking                                    | Pumping                              |                        |
| Polished aggregate                   | Patching of climate/durability-associated distress |                                      |                        |
| Punchout                             | Popouts  |                                      |                        |
| Spalling (joint)                     | Pumping  |                                      |                        |
|                                      | Scaling  |                                      |                        |
|                                      | Shrinkage Cracks                                   |                                      |                        |
|                                      | Spalling (joint)                                   |                                      |                        |
|                                      | Spalling (corner)                                  |                                      |                        |

(1) *Step 1.* The total deduct values (TDVs) attributable to load, climate/durability, and other associated distresses are determined separately. In the example being considered (fig. 4-1) the following distresses and TDVs were measured on an asphalt section of pavement.

| <i>Distress type</i>     | <i>Distress density over section</i> | <i>Severity level</i> | <i>Deduct value</i> | <i>Probable cause</i> |
|--------------------------|--------------------------------------|-----------------------|---------------------|-----------------------|
| Alligator cracking.....  | 10                                   | M                     | 47                  | Load                  |
| Transverse cracking..... | 3                                    | M                     | 17                  | Climate/durability    |
| Rutting.....             | 5                                    | L                     | 21                  | Load                  |
| Total .....              |                                      |                       | 85                  |                       |

The TDV attributable to load is 68; the TDV attributable to climate durability is 17.

(2) *Step 2.* The percentage of deducts attributable to load, climate/durability, and other factors can be computed as described below; the following is based on the example in (1) above:

Load = 6%<sub>s</sub> X 100 = 80 percent  
 Climate/durability = 17/8<sub>s</sub> x 100 = 20 percent  
 Total = 100 percent

(3) *Step 3.* The percent deduct values attributable to each cause are the basis for determining the primary cause(s) of pavement deterioration. In the example given in (1) and (2) above, distresses caused primarily by load have resulted in 80 percent of the total deducts, whereas all other causes have produced only 20 percent. Thus, traffic load is by far the major cause of deterioration for this pavement section. These percentages are indicated on figure 4-1, an example of a completed DA Form 5147-R (Section Evaluation Summary).

(4) *Step 4.* The drainage situation of each pavement section should also be investigated. If moisture is causing accelerated pavement deterioration, it must be determined how it is happening and why (groundwater table, infiltration of surface water, ponding water on the pavement, etc.). If moisture is contributing significantly to the rate of pavement condition deterioration, ways must be found to prevent or minimize this problem. For example, if pumping occurs in concrete joints or cracks, drainage conditions should be examined and foundation support evaluated. Any drainage and foundation defects should be corrected and the joints or cracks filled or sealed. The appropriate effect should be circled on the form. In our example, figure 4-1, circle "MINOR" in line 4b.

*e. Deficiency of load-carrying capacity.*

(1) Before it can be determined whether an existing pavement section is strong enough to support a particular traffic condition, it is necessary to determine the pavement's load-carrying capacity. Methods for determining load-carrying capacity are given in TM 5-822-5 (AFM 88-7) and TM 5-822-6 for roads, and TM 5-827-2 (AFM 88-24) and TM 5-827-3 for airfield pavements.

(2) For example, assume an asphalt pavement section has the following structural composition:

| Layer          | Thickness      | California bearing ratio (CBR) |
|----------------|----------------|--------------------------------|
| Subgrade ..... | .....          | 10                             |
| Base.....      | 10 inches..... | 40                             |
| Surface .....  | 4 inches.....  | -                              |

Further assume that this pavement section is a Class A road (see table 4-3) subjected to the following traffic load:

| Traffic type         | Vehicles/day | Percent of total traffic |
|----------------------|--------------|--------------------------|
| Passenger cars ..... | 1400         | 85                       |

|                                      |     |    |
|--------------------------------------|-----|----|
| Two-axle trucks .....                | 200 | 12 |
| Trucks with three or more axles..... | 50  | 3  |

Table 4-3. Design Index for Flexible Pavements for Roads and Streets, Traffic Categories I Through IV<sup>a</sup>

| Class road Category or street | Category I | Category III | Category IV |   |
|-------------------------------|------------|--------------|-------------|---|
| A                             | 3          | 4            | 5           | 6 |
| B                             | 3          | 4            | 5           | 6 |
| C                             | 3          | 4            | 4           | 6 |
| D                             | 2          | 3            | 4           | 5 |
| E                             | 1          | 2            | 3           | 4 |
| F                             | 1          | 1            | 2           | 3 |

Category I. Traffic essentially free of trucks (99 percent group 1, plus 1 percent group 2).

Category II. Traffic including only small trucks (90 percent group 1, plus 10 percent group 2).

Category III. Traffic including small trucks and a few heavy trucks (85 percent group 1, plus 14 percent group 2, plus 1 percent group 3).

Category IV. Traffic including heavy trucks (75 percent group 1, plus 15 percent group 2, plus 10 percent group 3).

Group 1. Passenger cars and panel and pickup trucks.

Group 2. Two-axle trucks.

Group 3. Three-, four-, and five-axle trucks.

<sup>a</sup>From TM 5-822-5.

(3) According to the information in subparagraph (1) above and table 4-3, the design index for this pavement section is 5. Based on the information in figure 4-8, the pavement thickness required over a CBR of 10 is 12Y inches; over a CBR of 40, the required thickness is 4.0 inches. Therefore, this pavement section is structurally strong enough for the load it is carrying, and load-carrying capacity deficiency is circled "No" in our example, figure 4-1, line 5.

*f. Surface roughness.*

(1) Surface roughness is an important operational condition. Although a rough pavement will usually have a low PCI, the reverse is not necessarily true. For example, a pavement section may have a high percentage of medium-severity alligator cracking (a serious structural distress) and, thus, a low PCI. However, if this is the only distress present, the pavement surface may not be rough.

(2) Minor, moderate, or major surface roughness can be determined by riding over the pavement section at its speed limit and observing its relative riding quality. In our example, figure 4-1, surface roughness was moderate; so "Moderate" was circled at line 6.

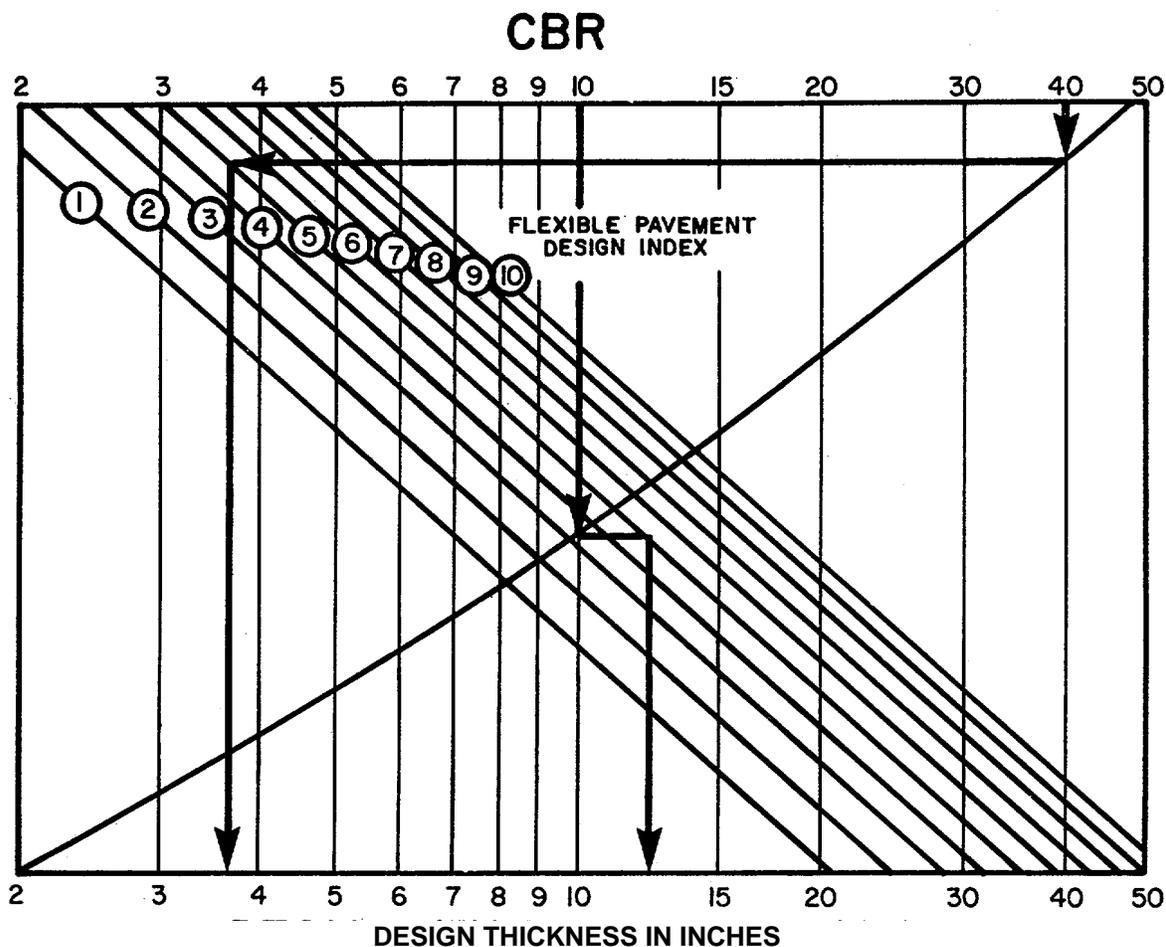


Figure 4-8. Thickness design requirements for flexible pavements (TM 5-822-5, 1 Oct 80, and AFM 88-24, Chap 3).

*g. Skid resistance/hydroplaning potential.* Skid resistance and hydroplaning potential are only of concern for high-speed-traveled roads and airfields. Pavement sections where skid is not of concern should be listed as such on the pavement evaluation sheet. Otherwise, skid resistance must be directly measured with special equipment. If direct measurement is not possible, skid resistance/hydroplaning potential may be evaluated by reviewing distress date. Distresses that can cause skid resistance/hydroplaning potential are bleeding, polished aggregates, rutting, and depression (for asphalt pavements) and polished aggregate (for concrete pavements). In our example, figure 4-1, skid resistance of "Minor" was circled at line 7.

*h. Previous maintenance.*

(1) A pavement section can be kept in operating condition almost indefinitely if extensive maintenance is performed. However, there are many drawbacks to this maintenance strategy, including overall cost, section downtime, increase in roughness

caused by excessive patching, limitations of manpower and equipment, and pavement mission requirements. Therefore, the amount and types of maintenance previously applied to a pavement section must be determined before a new strategy is selected. For example, a pavement with a large patched or replaced portion may have had many distress problems which are likely to continue in the future, and which should be considered in the new strategy.

(2) The evaluation of previous maintenance can be based on the incidence of permanent patching (asphalt pavements), large areas of patching (more than 5 square feet), and/or slab replacement (concrete pavement). Patching and/or slab replacement ranging between 1.5 and 3.5 percent (based on surface area for asphalt and number of slabs for concrete) is considered normal; more than 3.5 percent is considered high, and less than 1.5 percent is considered low. Some pavement sections may have received an excessive

amount of maintenance other than patching. If the engineer feels that a section should be evaluated as having high previous maintenance, then this evaluation should take precedence over evaluation criteria based on only patching and slab replacement. In our example, figure 4-1, patching was in excess of 3.5 percent; so "High" was circled at line 8.

*i. Comments.* Any specific requirements or items that might have an impact on the selection of feasible alternatives should be noted on the form.

#### 4-3. Determination of feasible M&R alternatives

*a. Assumption.* In the process of selecting feasible alternatives, one of the primary assumptions is that the strategy will be implemented within 3 years.

*b. Procedure.* The process of selecting feasible M&R alternatives is summarized in figure 4-9 and is described below.

(1) Determine M&R strategy.

(a) The purpose of this step is to identify the pavement sections that need comprehensive analysis. The data required for the identification are the PCI, distress, pavement rank, pavement usage, traffic, and management policy.

(b) Based on the factors in (a) above, a limiting PCI value is established for each type of pavement; e.g., 75 for primary roads with traffic volume exceeding 10,000 vehicles per day, and 70 for primary roads with traffic volume less than or equal to 10,000 vehicles per day. If a pavement has a PCI above the limiting value, continuation of existing maintenance policy is recommended unless review of the distress data shows that the majority of distress is caused by inadequate pavement strength and/or the rate of pavement deterioration is thought to be high. If any of these factors exists, proceed with the methods listed in (c) below; if not, determine feasible M&R alternatives as discussed in (2) below.

(c) If the M&R strategy decision is to continue existing maintenance policy, the information in tables 4-4 and 4-5 is used as a guide to select the appropriate maintenance method. These tables present feasible maintenance methods for each distress type at a given severity level. If the distress does not have any severity level, the letter "A" is used in place of the severity level. For example, for pumping distress in concrete pavements, the appropriate maintenance method (depending on existing conditions) could be crack sealing, joint sealing, and/or undersealing of the slabs.

(2) Determine feasible M&R alternatives based on pavement condition evaluation summary (fig 41).

(a) The purpose of this step is to determine whether alternatives other than existing maintenance policy should be considered (e.g., overlay or recycling), and, if so, what specific feasible alternatives to consider. This is done by analyzing the section evaluation summary (fig 4-1) for the pavement section under consideration. Based on this analysis, existing maintenance would usually be recommended except when one or more of the following conditions exists:

1. Long or short-term rate of pavement deterioration is high.
2. Load-carrying capacity is deficient (indicated by a "Yes" rating on the summary sheet).
3. Load-associated distress accounts for a majority of the distress deduct value.
4. Surface roughness is rated major.
5. Skid resistance/hydroplaning potential is rated major.
6. Previous M&R applied is rated high.
7. A change in mission requires greater load-carrying capacity.

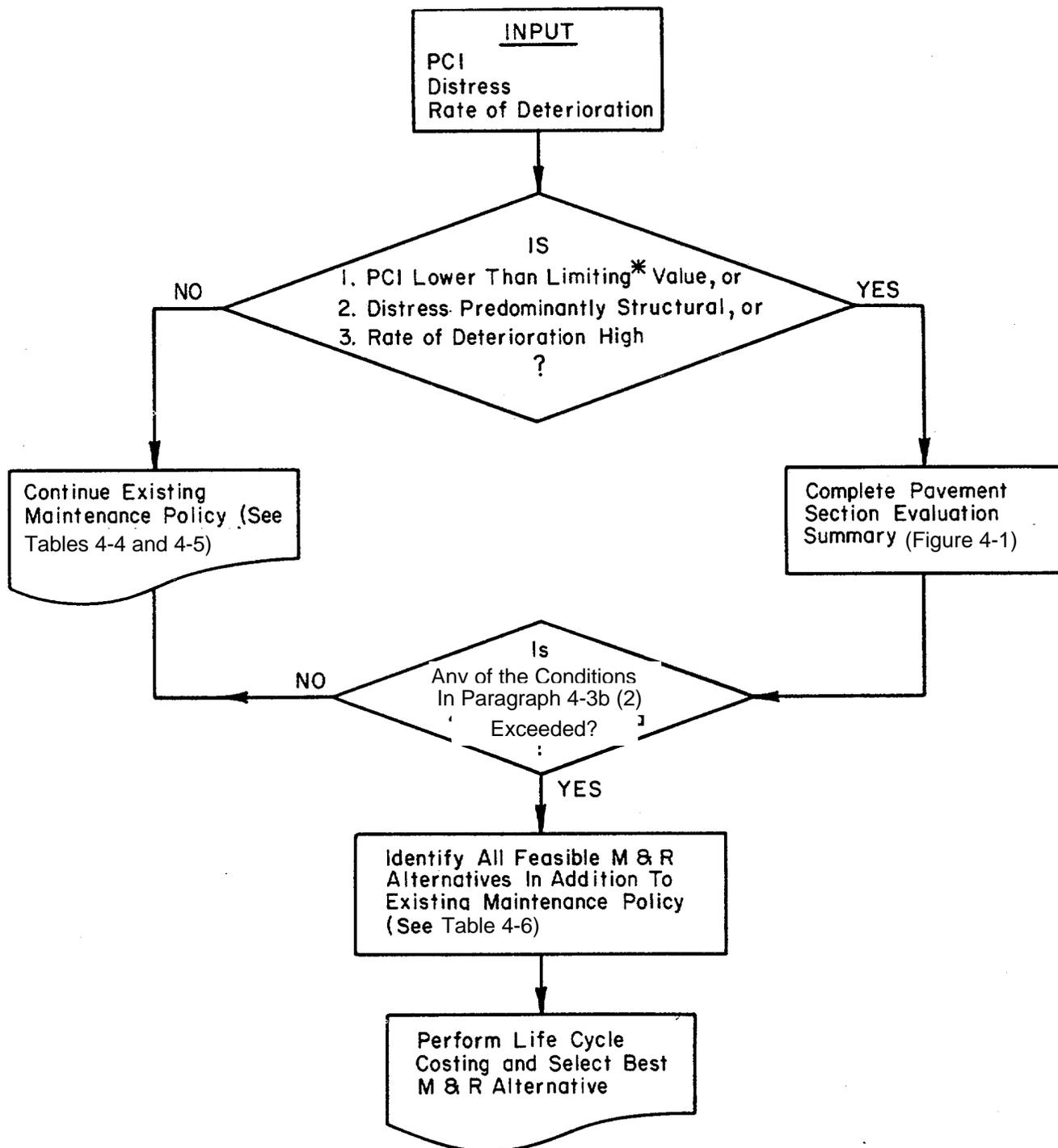
(b) Table 4-6 lists most of the available overall repair procedures for asphalt and jointed concrete pavements.

(c) All feasible alternatives should be identified based on a careful analysis of the section evaluation summary (fig 4-1). Life-cycle cost analysis of the feasible alternatives will help rank the alternatives based on cost, and thus provide necessary information for selecting a cost-effective M&R alternative. A procedure for performing a life-cycle cost analysis is described in chapter 5.

#### 4-4. Establishing M&R priorities

*a. Criteria.* The criteria for establishing priorities for pavement sections where routine M&R is required are different from those used for sections which need major M&R.

*b. Routine M&R.* Priorities for sections requiring routine M&R are a function of existing individual distress types and severity's. A single method is usually applied for a given area, which may consist of many sections, rather than different M&R methods for one section. Distresses that may have a considerable negative effect on the section's operational performance are usually corrected first. For example, medium and high-severity bumps, corrugations, potholes, and shoving would usually receive high priority.



\*SEE PARAGRAPH 4-3B (1) (B) FOR EXAMPLES OF PCI LIMITING VALUES.

Figure 4-9. Process of determining M&R needs.

Table 4-4. Asphalt Concrete Pavement Distress Types and M&R Alternatives.

| Distress Type                       | M&R Method |            |                     |                  |            |                 |                        |                             |                    |                           |  | Notes |
|-------------------------------------|------------|------------|---------------------|------------------|------------|-----------------|------------------------|-----------------------------|--------------------|---------------------------|--|-------|
|                                     | Do Nothing | Crack Seal | Partial Depth Patch | Full Depth Patch | Skin Patch | Pothole Filling | Apply Heat & Roll Sand | Apply Surface Seal Emulsion | Apply Rejuvenation | Apply Aggregate Seal Coat |  |       |
| 1 Alligator Cracking                |            |            | M,H                 | M,H              |            |                 |                        | L                           | L                  |                           |  |       |
| 2 Bleeding                          | L          |            |                     |                  |            |                 | L,M,H                  |                             |                    |                           |  |       |
| 3 Block Cracking                    | L          | L,M,H      |                     |                  |            |                 |                        |                             | L                  | L,M                       |  |       |
| 4 Bumps & Sags                      | L          |            | M,H                 | M,H              | M,H        |                 |                        |                             |                    |                           |  |       |
| 5 Corrugation                       | L          |            | M,H                 | M,H              |            |                 |                        |                             |                    |                           |  |       |
| 6 Depression                        | L          |            | M,H                 | M,H              | M,H        |                 |                        |                             |                    |                           |  |       |
| 7 Edge Cracking                     | L          | L,M        | M,H                 | M,H              |            |                 |                        |                             |                    |                           | If predominant, apply shoulder seal, e.g., aggregate seal coat   |       |
| 8 Joint Reflective Cracking         | L          | L,M,H      | H                   |                  |            |                 |                        |                             |                    |                           |  |       |
| 9 Lane/Shoulder Drop Off            | L          |            |                     |                  |            |                 |                        |                             |                    |                           | If predominant, level off shoulder and apply aggregate seal coat |       |
| 10 Longitudinal Transverse Cracking | L          | L,M,H      | H                   |                  |            |                 |                        | L                           | L                  | L,M                       |  |       |
| 11 Patching & Utility Cut           | L          | M          | H*                  | H*               |            |                 |                        |                             |                    |                           | *Replace patch   |       |
| 12 Polished Aggregate               | A          |            |                     |                  |            |                 |                        |                             |                    | A                         |  |       |
| 13 Potholes                         |            |            | L                   | L,M,H            |            | L,M,H           |                        |                             |                    |                           |  |       |
| 14 Railroad Crossing                | L          |            |                     |                  | L,M,H      |                 |                        |                             |                    |                           |  |       |
| 15 Rutting                          | L          |            | L,M,H               | M,H              | L,M,H      |                 |                        |                             |                    |                           |  |       |
| 16 Shoving                          | L          |            | M,H                 |                  |            |                 |                        |                             |                    |                           |  |       |
| 17 Slippage Cracking                | L          | L          | M,H                 |                  |            |                 |                        |                             |                    |                           |  |       |
| 18 Swell                            | L          |            |                     | M,H              |            |                 |                        |                             |                    |                           |  |       |
| 19 Weathering & Raveling            | L          |            | H                   |                  |            |                 |                        | L,M                         | L                  | M,H                       |  |       |

Note: L = low severity; M = medium severity; H = high severity; A = has only one severity level.

Table 4-5. Jointed Concrete Pavement Distress Types and M&amp;R Alternatives.

| Distress Type                 | M&R Method | Do Nothing | Crack Sealing | Joint Sealing | Partial Depth Patch (Bonded) | Full Depth Patch | Slab Replacement | Under-Sealing | Grinding Slab | Slab Jack-Grout | Notes  |
|-------------------------------|------------|------------|---------------|---------------|------------------------------|------------------|------------------|---------------|---------------|-----------------|--|
| 21 Blow-ups                   |            |            |               |               | L*,M*                        | H*               | H*               |               |               |                 | *Must provide expansion joint  |
| 22 Corner Break               |            | L          | L,M,H         |               |                              | M,H              | H                |               |               |                 |  |
| 23 Divided Slab               |            |            | L,M           |               |                              |                  | M,H              |               |               |                 |  |
| 24 'D' Cracking               |            | L          | L*            | L*            | M,H                          | M,H              | H                |               |               |                 | *If "D" cracks exist, seal all joints and cracks                     |
| 25 Faulting                   |            | L          |               |               |                              |                  | H                |               | M,H           | M,H             |  |
| 26 Joint Seal Damage          |            | L          |               | M*,H          |                              |                  |                  |               |               |                 | *Joint seal local areas  |
| 27 Lane/Shoulder Drop Off     |            | L          |               |               |                              |                  |                  |               |               |                 | If predominant, level off shoulder, apply aggregate seal coat        |
| 28 Linear Cracking            |            | L          | L,M,H         |               | H*                           | H                | H                |               |               |                 | *Allow crack to continue through patch except when using A-C         |
| 29 Large Patch & Utility Cuts |            | L          | M             |               | M*,H*                        | H*               | H                |               |               |                 | *Replace patch   |
| 30 Small Patching             |            | L          | M             |               | M*,H*                        | H*               |                  |               |               |                 | *Replace patch   |
| 31 Polished Aggregate         |            | A          |               |               |                              |                  |                  |               |               |                 | If predominant, apply major or overall repair, e.g. overlay grooving |
| 32 Popouts                    |            | A          |               |               |                              |                  |                  |               |               |                 |  |
| 33 Pumping                    |            |            | A             | A             |                              |                  |                  | A             |               |                 |  |
| 34 Punchouts                  |            | L          | L,M           |               |                              | M,H              | H                |               |               |                 |  |
| 35 Railroad Crossing          |            | L          |               |               |                              |                  |                  |               |               |                 | If M or H, level surface   |
| 36 Scaling/Map Cracks/Crazing |            | L          |               |               | M,H                          | H                |                  |               |               |                 |  |
| 37 Shrinkage Cracks           |            | A          |               |               |                              |                  |                  |               |               |                 |  |
| 38 Corner Spalling            |            | L          |               |               | L,M,H                        |                  |                  |               |               |                 |  |
| 39 Joint Spalling             |            | L          |               | L             | M,H                          | M,H*             |                  |               |               |                 | *If caused by keyway failure, provide load transfer                  |

Note: L = low severity; M = medium severity; H = high severity; A = has only one severity level.

Table 4-6. Types of Overall Repair for Jointed Concrete and Asphalt-Surfaced Pavements.

Table 4-6. Types of Overall Repair for Jointed Concrete and Asphalt-Surfaced Pavements.

#### Jointed-Concrete-Surfaced Pavements

1. Overlay with unbonded, partially bonded, or fully bonded Portland cement concrete (rigid overlay).
2. Overlay with all-bituminous or flexible overlay (nonrigid overlay).
3. Portland cement concrete pavement recycling\* -a process by which an existing Portland cement concrete pavement is processed into aggregate and sand sizes, then used in place of, or in some instance with additions of conventional aggregates and sand, into a new mix and placed as a new Portland cement concrete pavement.
4. Pulverize existing surface in place, compact with heavy rollers, place aggregate on top, and overlay.
5. Replace keel section, i.e., remove central portion of pavement section (subjected to much higher percentage of traffic coverages than rest of pavement width) and replace with new pavement structure.
6. Reconstruct by removing existing pavement structure and replacing with a new one.
7. Grind off thin layer of surface if predominant distress is scaling or other surface distresses; overlay may or may not be applied.
8. Groove surface if poor skid resistance/hydroplaning potential, is the main reason for overall M&R.

#### Asphaltor Tar-Surfaced Pavements

1. Overlay with all-bituminous or flexible overlay.
2. Overlay with Portland cement concrete (rigid overlay).
3. Hot-mix asphalt pavement recycling\* -one of several methods where the major portion of the existing pavement structure (including in some cases, the underlying untreated base material) is removed, sized, and mixed hot with added asphalt cement at a central plant. Process may also include the addition of new aggregate and/or a softening agent. The finished product is a hot-mix asphalt base, binder surface course.
4. Cold-mix asphalt pavement recycling\*\* -one of several methods where the entire existing pavement structure (including, in some cases, the underlying untreated base material) is processed in place or removed and processed at a central plant. The materials are mixed cold and can be reused as an aggregate base, or asphalt and/or other materials can be added during mixing to provide a higher-strength base. This process requires use of an asphalt surface course or surface seal coat.
5. Asphalt pavement surface recycling\* -one of several methods where the surface of an existing asphalt pavement is planed, milled, or heated in place. In the latter case, the pavement may be scarified, remixed, relaid, and rolled. In addition, asphalts, softening agents, minimal amounts of new asphalt hot-mix, aggregates, or combinations of these may be added to obtain desirable mixture and surface characteristics. The finished product may be used as the final surface, or may, in some instances, be overlaid with an asphalt surface course.
6. Apply a porous friction course to restore skid resistance and eliminate hydroplaning potential.
7. Replace keel section, i.e., remove central portion of pavement feature (subjected to much higher percentage of traffic coverage than rest of pavement width) and replace with new pavement structure.
8. Reconstruct by removing existing pavement structure and replacing with a new one.

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\* Federal Highway Administration, Initiation of National Experimental and Evaluation Program (NEEP) Project No. 22, Pavement Recycling ([FHWA] Notice N 5080.64 June 3, 1977).

\*\* Federal Highway Administration Initiation of National Experimental Evaluation Program (NEEP) Project No. 22, Pavement Recycling (LFHWA] Notice N 5080.64 June 3, 1977).

c. *Major M&R.* Priorities among sections requiring major M&R are a function of the overall section condition, as reflected in the PCI, traffic, and management policies. For example, a decision might be made to repair all primary roads with a PCI of less

than 50, secondary roads with a PCI of less than 40, and parking lots with a PCI of less than 30. The above PCI limits are provided as an example. Local conditions at Army installations and commands will dictate what actual values to use.

## CHAPTER 5

## PROCEDURE FOR PERFORMING ECONOMIC

## ANALYSIS OF M&amp;R ALTERNATIVES

**5-1. Introduction**

The results of the pavement condition evaluation and the guidelines for M&R selection may indicate that the engineer should consider more than one M&R alternative. Selecting the best alternative often requires performing an economic analysis to compare the cost-effectiveness of all feasible alternatives. This chapter presents an economic analysis procedure which compares M&R alternatives based on present worth.

**5-2. The procedure**

The procedure for determining the present worth of each M&R alternative consists of the steps described below.

*a. Economic analysis period.* Select an economic analysis period (in years). The period generally used in pavement analysis ranges from 10 to 30 years, depending on future use of the section (abandonment, change of mission, etc.). The analysis period should be the same for all alternatives.

*b. Interest and inflation rates.* Interest and inflation rates to be used in calculating the present cost should be obtained from the installation comptroller. This is a very important step, since the selected rates have a significant impact on the ranking to the alternatives with respect to their present worth. The selection of the rates, therefore, should be based on Army policies and guidelines. It should also be noted that the inflation rate used to compute present worth is the differential inflation rate, i.e., the rate of cost increase above the general inflation rate. Therefore, if the cost increase of a specific item is in line with the cost growth experienced by the economy, the differential inflation rate is assumed to be zero. For example, if the cost of M&R for asphalt pavements is increasing at an annual inflation rate of 14 percent while the general inflation rate is 8 percent, the differential inflation is 6 percent.

*c. Annual cost estimation.* The annual cost should be estimated for each M&R alternative for every year work is planned during the analysis period. The cost of rehabilitation at the end of the analysis period for each M&R alternative should also be determined so that the

pavement will be equivalent to a new pavement. All cost estimates should be based on current prices.

*d. Present worth computation.* The present worth (PW) for each M&R alternative is computed as follows:

$$\text{Present worth} = \left[ \sum_{i=0}^n C_i \times f_i \right] + R \times f_n \quad (\text{Equation 5-1})$$

where—

$n$  = number of years in the analysis period.

$C_i$  = M&R cost for year  $i$  based on current prices.

$f_i$  = present worth factor for  $i^{\text{th}}$  year that is a function of the interest rate ( $r_i$ ) and inflation rate ( $r_f$ ).

$$f_i = \left( \frac{1 + r_f}{1 + r_i} \right)^i$$

$R$  = cost of rehabilitation at the end of the analysis period so that the pavement will be equivalent to a new pavement. The cost is computed based on current prices.

$f_n$  = present worth factor at the end of the analysis period.

$$f_n = \left( \frac{1 + r_f}{1 + r_i} \right)^n$$

The physical interpretation of equation 5-1 is that the present worth of any M&R alternative is the sum of all the discounted M&R costs during the analysis period plus the cost of rehabilitating the pavement at the end of the analysis period (so that it will be equivalent to a new pavement), discounted to the present. After the steps described in a through d above are completed for each M&R alternative, the present worth's of all M&R alternatives are compared to help the pavement engineer select the most cost-effective repair alternative.

*e. Predictions and assumptions.* A number of predictions and assumptions must be made to perform the economic analysis. The engineer must therefore use judgment in selecting the best inputs.

### 5-3. Computations

If automated PAVER is used, the present worth computations are performed by the computer. (See fig 7-4 for an illustration of the computer output.) If a manual paver system is used, DA Form 5148R, Present

Worth Computation Form (fig E-4), is used when performing this computation. A completed DA Form 5148-R, Present Worth Computation Form, is at figure 5-1 and is an example computation for one M&R alternative. The values in this example were computed as follows for year 0:

$$f_i = \left( \frac{1 + r_f}{1 + r_i} \right)^i = \left( \frac{1 + .06}{1 + .10} \right)^0 = 1;$$

and with  $C_i = 14,410$ , the Present Worth (PW) =  $14,410 \times 1 = 14,410$ ; and with  $C_i = 6,000$ , PW =  $6,000 \times 1 = 6,000$ .

For year 5,  $f_i = \left( \frac{1 + .06}{1 + .10} \right)^5 = 0.831$ ; and with  $C_i = 1000$ , PW =  $1000 \times 0.831 = 831$ .

For year 10,  $f_i = \left( \frac{1 + .06}{1 + .10} \right)^{10} = 0.690$ ; and with  $C_i = 1500$ , PW =  $1500 \times 0.690 = 1036$ .

For year 15,  $f_i = \left( \frac{1 + .06}{1 + .10} \right)^{15} = 0.574$ ; and with  $C_i = 1500$ , PW =  $1500 \times 0.574 = 861$ .

For year 20,  $f_i = \left( \frac{1 + .06}{1 + .10} \right)^{20} = 0.477$ ; and with  $C_i = 12,000$ , PW =  $12,000 \times 0.477 = 5721$ .



## CHAPTER 6

## DATA MANAGEMENT-MANUAL PAVER SYSTEM

**6-1. Introduction**

Chapters 2 through 5 discussed the data collection and analysis procedures which constitute the pavement management system. To use this system, it is necessary to store data in a usable manner; this data storage can be achieved by using either a computer system or a manual record keeping system. If a manual system is used, initial data storage is usually small and handled easily. The more the management system is used, the more data that must be collected and stored. Thus, the manual data storage system described in this chapter has been designed so conversion to a computer data storage system will not be complex or time-consuming.

**6-2. Manual system description**

Forms are used to store collected data in the manual PAVER system. Nine forms each containing pertinent information on the pavement network have been designed to store data. Three forms refer to the pavement branches; the remaining six refer to sections within each branch. Each of the forms is listed below and its use is described in the pages following. Blank reproducible forms are provided in appendix E.

- a. DA Form 5149-R, Branch Identification Summary (fig E-5).
- b. DA Form 5149-1-R, Branch Identification Summary Continuation Sheet (fig E-6).
- c. DA Form 5150-R, Section Identification Record (fig E-7).
- d. DA Form 5151-R, Section Pavement Structure Record (fig E-8).
- e. DA Form 5152-R, Section Materials Properties Record (fig E-9).
- f. DA Form 5153-R, Section Traffic Record (fig E-10).
- g. DA Form 5154-R, Section Condition Record (fig E-11).
- h. DA Form 5155-R, Branch Maintenance and Repair Requirements (fig E-12).
- i. DA Form 5156-R, Section Maintenance and Repair Record (fig E-13).

**6-3. Use of the manual data forms**

a. *DA Form 5149-R, Branch Identification Summary.* This form lists all branches in the pavement network, thereby providing an inventory of all network branches and sections. A completed form is shown as an example in figure 6-1. The heading has been completed to show the installation code, name, and location. The initial date is shown (space is provided for updates). The total number of branches in the network is shown. The next section of the form has been marked to record each branch of the network: the branch code, name, use, number of sections, and branch area in square yards. The list of branches can be arranged alphabetically, by quadrants of the installation, or in any other orderly fashion.

b. *DA Form 5149-1-R, Branch Identification Summary Continuation Sheet.* This form provides space to list branch code, branch name, branch use, number of sections, and branch area. Since all installations would have more branches than could be listed on the DA Form 5149-R, the continuation form would be used to complete the total number of branches in the network at all installations using the manual PAVER system.

c. *DA Form 5150-R, Section Identification Record.*

(1) This form provides space for identifying each pavement section and its use. One form should be used for each section in the pavement network. A completed form is shown as an example in figure 6-2. The heading has been completed to show the installation name, date, branch name, section area, number of sample units, and section number. The next section of the form has been marked to show the section belongs to real property, not family housing. The use is vehicular, it is a primary road with curbs, gutters, and sidewalks, and it has an asphalt surface. A sketch of the area is provided in the final section of the form. This sketch should contain at least the following:

(a) Section length dimension, width, or other measurements needed to calculate irregularly shaped areas.

(b) Section limits clearly defined to indicate intersections with other branches of sections.

**BRANCH IDENTIFICATION SUMMARY**

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

| Installation |        |          | Date |     |     | Up Dates |    |    | Total No. of Branches |    |   |
|--------------|--------|----------|------|-----|-----|----------|----|----|-----------------------|----|---|
| Code         | Name   | Location | Mo.  | Da. | Yr. | 1.       | 2. | 3. | 4.                    | 5. |   |
| 99999        | FORT Z | HOME IL  | 10   | 1   | 79  |          |    |    |                       |    | 3 |

| Branch Code |   |   |   |   | Branch Name      | Branch Use     | Number of Sections | Branch Area Sq. Yd. |
|-------------|---|---|---|---|------------------|----------------|--------------------|---------------------|
| I           | 4 | 7 | 3 | 5 | MARSHALL AVE     | ROADWAY        | 5                  | 1388                |
| I           | 2 | 9 | 4 | 6 | PLATOON ST       | ROADWAY        | 3                  | 735                 |
| P           | 0 | 3 | 2 | 1 | PARKING BLDG 321 | PARKING (CARS) | 1                  | 700                 |
|             |   |   |   |   |                  |                |                    |                     |
|             |   |   |   |   |                  |                |                    |                     |
|             |   |   |   |   |                  |                |                    |                     |
|             |   |   |   |   |                  |                |                    |                     |
|             |   |   |   |   |                  |                |                    |                     |
|             |   |   |   |   |                  |                |                    |                     |

Remarks:

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Figure 6-1. An example of a completed DA Form 5149-R, Branch Identification Summary.

**SECTION IDENTIFICATION RECORD**

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

| Installation Name | Date    | Branch Name  | Section Area                     | No. of Sample Units | Section No. |
|-------------------|---------|--------------|----------------------------------|---------------------|-------------|
| FORT Z            | 10 2 79 | MARSHALL AVE | 25 ft. x 500 ft.<br>1388 sq. yd. | 5                   | 1           |

| Traffic Types And Uses            |                                       |   |   | General Information                       |   |   |
|-----------------------------------|---------------------------------------|---|---|---|---|---|
| <input type="radio"/> Aircraft    | <input type="radio"/> Runway          | <input checked="" type="checkbox"/> Vehicular     | <input checked="" type="checkbox"/> Primary | Curb And Gutter                           | Sidewalks   | Surface Type                            |
| <input type="radio"/> Fixed Wing  | <input type="radio"/> Taxiway         | <input checked="" type="checkbox"/> Real Property | <input type="radio"/> Secondary             | <input checked="" type="checkbox"/> Left  | <input checked="" type="checkbox"/> Left _____ ft.  | <input type="radio"/> PCC               |
| <input type="radio"/> Rotary Wing | <input type="radio"/> Parking or Pads | <input type="radio"/> Family Housing              | <input type="radio"/> Tertiary              | <input checked="" type="checkbox"/> Right | <input checked="" type="checkbox"/> Right _____ ft. | <input checked="" type="checkbox"/> AC  |
|                                   | <input type="radio"/> Apron           |   | <input type="radio"/> Parking - Storage     | <input type="radio"/> None                | <input type="radio"/> None _____                    | <input type="radio"/> Surface Treatment |
|                                   | <input type="radio"/> Other           |   | <input type="radio"/> Other                 |   |   | <input type="radio"/> Other             |

Sketch:

On sketch: note any subsurface drainage (type, location) and, secondary structures, such as, manholes, water shut-offs, etc.

**NOTES:**

- 5 SAMPLE UNITS @ 100' MARSHALL STREET STRUCTURE CARRIES THROUGH THE INTERSECTION.
- CURB DROP INLETS - 4 LOCATED IN SECTION. MAINLINE IS ON SOUTH SIDE OF PYMT CROSS OVER PIPE FROM NORTH INLET. INLETS ARE IN CONC CURB.
- NO SUBSURFACE DRAINAGE.
- NO SHOULDERS.

DA FORM 5150-R, NOV 82

Figure 6-2. An example of a completed DA Form 515-R, Section Identification Record.

(c) All shoulder information and secondary structure information, including location and number of manholes, catch basins, etc. (Location of these structures is important since they can affect maintenance and/or rehabilitation practices.)

(d) Sample units in the section (Locating sample units will help when verifying inspection results and planning future inspections.)

(e) North arrow.

(2) Information from the form can be used to plan inspections and estimate maintenance or rehabilitation costs. It is essential to note the identification of real property and family housing areas, since the funds used for work in family housing is different.

*d. Form 5151-R, Section Pavement Structure Record.* This form is designed for recording information concerning the existing structural layers of the pavement. This information is important when evaluating the pavement load-capacity capacity and determining feasible M&R alternatives. This form is divided into four areas: initial construction, overlays, surface treatment, and a heading. A completed form is shown as an example in figure 6-3. Some details concerning completion of this form are given in the paragraphs that follow.

(1) Information referring to the original construction is recorded on the lower area of the form. This information may not always be easily obtained. A little research, however, should provide usable data. If repair work has been performed on the section, the thickness and type of material should be available for recording in the central two sections of the form. The material codes in table 6-1 should be used, when possible.

(2) In the example shown in figure 6-3, the installation name, date, branch name and section is shown in the top area of the form. The next area, used to record data on surface treatment, remains blank because no surface treatments have been performed to date. In the next area data is recorded concerning the asphaltic concrete overlay placed in October 1978. In the area at the bottom of the form, all the information available concerning initial construction is recorded. This includes the silty clay subgrade, the crushed stone base and the asphaltic concrete leveling and surface courses complete with thickness and construction dates.

(3) In the portion of the form providing space for recording overlays or surface treatments, space is provided to record the location of placement if the entire section is not repaired. It is important to note that if an entire section is not overlaid, a new section must be defined. Also, if a section's surface is removed by rotomilling, the overlay should be recorded and the milling noted in the comments portion of the card. The original surface thickness should also be reduced by the appropriate amount.

(4) In the event the surface is heater scarified and recompacted, this should be recorded as a surface treatment and noted in the comments portion of the card.

*e. DA Form 5152-R, Section Materials Properties Record.* This form stores information on the material properties of the pavement section. It should contain any available test data on each pavement layer. (Typical tests for each pavement layer are listed in table 6-2.) This card, in conjunction with the Pavement Structure Card, can be used to evaluate the load-carrying capacity of the section. Also, the material properties information and condition record can provide feedback on the performance of different paving materials. A completed form is shown as an example in figure 6-4.

*f. DA Form 5153-R, Section Traffic Record.* The Section Traffic Record stores information on the type and volume of traffic using the facility. A method for recording traffic on roads and streets is provided; however, traffic on branches such as parking areas and storage areas are recorded freeform in the space at the bottom of the card. A completed form is shown as an example in figure 6-5. The form is completed as follows:

(1) The installation, name, date, branch name and section number is recorded in the area at the top of the form. In the center area the dates of the surveys are recorded (September 1978 and August 1979 in the example.) The volume index of each type of traffic observed must be determined and recorded. Table 6-3 identifies traffic types and provides the method for determining a volume index. (Note: Traffic type a is passenger vehicles; b is two-axle trucks; c is trucks with three or more axles; d is 60-kip track vehicles; e is 90-kip track vehicles; and f is 120-kip track vehicles.) The volume index for each type of traffic is based on the operations per lane per day for that type of traffic. In the example considered, the following data was taken.

| <i>Date</i>  | <i>Type of traffic using the pavement section</i> | <i>Volume per lane per day</i> |
|--------------|---|--------------------------------|
| Sep 78 ..... | Passenger, panel, and .....                       |                                |
|              | pickups   | 2500                           |
| Sep 78 ..... | Two-axle trucks and buses                         | 85                             |
| Sep 78 ..... | Trucks with three or more .....                   |                                |
|              | axles   | 15                             |
| Aug 79 ..... | Passenger, panel, and .....                       |                                |
|              | pickups   | 4500                           |
| Aug 79 ..... | Two-axle trucks and buses                         | 250                            |
| Aug 79 ..... | Trucks with three or more .....                   |                                |
|              | axles   | 9                              |

Using these data, the volume indices for each traffic type was determined from table 6-3 as follows:

**SECTION PAVEMENT STRUCTURE RECORD**

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

|                   |          |                 |                |
|-------------------|----------|-----------------|----------------|
| Installation Name | Date     | Branch Name     | Section Number |
| FORT Z            | 10 10 79 | MARSHALL STREET | 1              |

|                   |                  | Material | Material Code |  |  | Thickness(in.) | Date Const. | Location (If less than entire section)* |    |
|-------------------|------------------|----------|---------------|--|--|----------------|-------------|---|----|
|                   |                  |          |               |  |  |                |             | From                                    | To |
| Surface Treatment | Surf. Treat. (3) |          |               |  |  |                |             |   |    |
|                   | Surf. Treat. (2) |          |               |  |  |                |             |   |    |
|                   | Surf. Treat. (1) |          |               |  |  |                |             |   |    |

|          |             | Material            | Material Code |   |   | Thickness(in.) | Date Const. | Location (If less than entire section)* |    |
|----------|-------------|---------------------|---------------|---|---|----------------|-------------|---|----|
|          |             |                     |               |   |   |                |             | From                                    | To |
| Overlays | Overlay (3) |                     |               |   |   |                |             |   |    |
|          | Overlay (2) |                     |               |   |   |                |             |   |    |
|          | Overlay (1) | ASPHALT CON. MIX C. | 1             | 2 | 0 | 1.5            | 10/78       |   |    |

|                      |                    | Material      | Material Code |   |   | Thickness(in.) | Date Const. | Comments |
|----------------------|--------------------|---------------|---------------|---|---|----------------|-------------|----------|
|                      |                    |               |               |   |   |                |             |          |
| Initial Construction | Surface            | ASPHALT CONC  | 1             | 2 | 0 | 2.0            | 6/60        |          |
|                      | Leveling           | ASPHALT CONC  | 1             | 2 | 0 | 2.0            | 6/60        |          |
|                      | Base               | CRUSHED STONE | 3             | 1 | 1 | 8.0            | 5/60        |          |
|                      | Subbase            |               |               |   |   |                |             |          |
|                      | Select             |               |               |   |   |                |             |          |
|                      | Compacted Subgrade | SILTY CLAY    | 3             | 4 | 5 | 12             | 5/60        |          |
|                      | Natural Subgrade   | SILTY CLAY    | 3             | 4 | 5 | -              | -           |          |

\*New Section of Branch Must Then be Identified  
 DA FORM 5151-R, NOV 80

Figure 6-3. An example of a completed DA Form 5151-R, Section Pavement Structure Record.

Table 6-1. Material Codes

Material Codes.  
100 Surface Materials\*

|     |  |     |                         |
|-----|--|-----|-------------------------|
| 110 | Portland Cement Concrete                         | 155 | slurry seal             |
| 111 | plain  | 156 | fog seal                |
| 112 | reinforced concrete pavements (RCP)              | 157 | asphalt rubber chip     |
| 113 | continuously reinforced concrete pavement (CRCP) | 158 | fabric                  |
| 114 | prestressed                                      | 159 | dust layering           |
| 115 | fibrous  | 160 | Preformed Joint Fillers |
|     |  | 161 | bituminous fiber        |
| 120 | Asphalt Concrete                                 | 162 | cork                    |
|     |  | 163 | self-expanding cork     |
| 130 | Road Mix Bituminous Surface                      | 164 | self-expanding rubber   |
| 140 | Sand-Asphalt                                     | 165 | sponge rubber           |
| 141 | plant mix  | 166 | closed cell plastic     |
| 142 | road mix   |     |                         |
|     |  | 170 | Joint and Crack Sealers |
| 150 | Surface Treatments                               | 171 | hot-poured              |
| 151 | single-layer aggregate seal                      | 172 | cold-poured             |
| 152 | double-layer aggregate seal                      |     |                         |
| 153 | three- or more layer aggregate seal              | 180 | Others                  |
| 154 | sand seal  |     |                         |

200 Treated or Stabilized Materials

|     |                                |     |                           |
|-----|--------------------------------|-----|---------------------------|
| 210 | Cement Treated                 | 240 | Asphalt-Treated Plant Mix |
| 211 | gravel and crushed stone       | 241 | crushed stone             |
| 212 | sand                           | 242 | gravel                    |
| 213 | silt and clay                  | 243 | sand                      |
| 220 | Lime-Flyash Treated            | 250 | Asphalt-Treated Road Mix  |
| 221 | gravel and crushed stone       | 251 | crushed stone             |
| 222 | sand                           | 252 | gravel                    |
| 223 | slag                           | 253 | sand                      |
| 230 | Lime-Treated Fine-Grained Soil | 280 | Others                    |

300 Untreated Materials

|     |                           |     |                    |
|-----|---------------------------|-----|--------------------|
| 310 | Crushed Stone             | 333 | high fines content |
| 311 | well-graded               |     |                    |
| 312 | poorly graded (one-sized) | 340 | Fine-Grained Soils |
| 313 | high fines content        | 341 | sandy silt         |
|     |                           | 342 | silt               |
| 320 | Gravel                    | 343 | clayey silt        |
| 321 | well-graded               | 344 | sandy clay         |
| 322 | poorly graded             | 345 | silty clay         |
| 323 | high fines content        | 346 | clay               |
|     |                           | 347 | organic silt       |
| 330 | Sand                      | 348 | organic clay       |
| 331 | well-graded               |     |                    |
| 332 | poorly graded             | 380 | Others             |

\*For unpaved roads, refer to treated or untreated materials list for identification purposes.

**SECTION MATERIALS PROPERTIES RECORD**

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

|                   |             |              |                |
|-------------------|-------------|--------------|----------------|
| Installation Name | Date        | Branch Name  | Section Number |
| FORT Z            | 10   1   79 | MARSHALL AVE | 1              |

| Pavement Layer | Material Properties              | Value/Unit | Comments   |
|----------------|----------------------------------|------------|--|
| OVERLAY 1      | TESTS 1978<br>MARSHALL STABILITY | 1600 LBS   | — AVG OF FIELD TESTS.<br><br>— TESTED INSITU 10/78<br><br>— TESTED INSITU 9/78 |
|                | FLOW                             | 11 .01 INS |  |
|                | AIR VOIDS                        | 4%         |  |
|                | UNIT WEIGHT                      | 141 PCF    |  |
|                | INSITU DENSITY                   | 138 PCF    |  |
| SURFACE        | NO PROPERTIES AVAILABLE          |            |  |
| LEVELING       | " "                              | "          |  |
| BASE COURSE    | CBR                              | 60         |  |
|                | INSITU MOISTURE                  | 12%        |  |
| SUBGRADE       | CBR                              | 15         |  |
|                | INSITU DRY DENSITY               | 116 PCF    |  |
|                | INSITU MOISTURE                  | 20%        |  |
|                |                                  |            |  |
|                |                                  |            |  |
|                |                                  |            |  |

DA FORM 5152-R, NOV 80

Figure 6-4. An example of a completed DA Form 5152-R, Section Materials Properties Record.

Table 6-2. Typical Layer Materials Properties

- |  |   |
|--|---|
| <p>1. Asphalt Concrete (Surface, Leveling, Base):<br/>                 Marshall stability (pounds)....Asphalt content (%)<br/>                 Flow (0.01 inch) .....Unit weight<br/>                 (pounds/cubic foot)<br/>                 Air voids (5) .....Asphalt penetration<br/>                 (millimeters x 10<sup>1</sup>)</p> <p>2. Portland Cement Concrete (PCC):<br/>                 Modus of rupture (pounds/square inch)<br/>                 Compressive strength (pounds/square inch)<br/>                 Entrained air (%).....<br/>                 Water/cement ratio (gallon/sack).</p> <p>3. Base-Subbase Materials:<br/>                 k-value (pounds/square inch)<br/>                 CBR.....<br/>                 In-situ dry density (% of optimum).<br/>                 In-situ moisture content.....</p> | <p>4. Subgrade:<br/>                 Unified classification .....Liquid limit<br/>                 CBR.....Optimum moisture<br/>                 control (%)<br/>                 K-value (pounds/square inch)....In-situ moisture content<br/>                 (%)<br/>                 Plasticity index.....In-situ dry density (% of<br/>                 optimum)</p> |
|--|---|

(a) The volume of traffic for traffic type a was found on the traffic survey of September 1978 to be 2500. Looking down column a, table 6-3, that value (2000-3999) was located. Looking horizontally to the far right the column identified as "Volume Index" was reached at 5. That value 5 was recorded on the form as the volume index for type a traffic for the survey date 9/78.

(b) The volume of traffic for traffic type b was found on the traffic survey of September 1978 to be 85. Looking down column b, table 6-3, that value (50-199) was located. Looking horizontally to the far right the

Table 6-3. Traffic Volume Index for Roads  
**TRAFFIC TYPE**

| a   | b                 | c                 | d                | e                | f                |   |
|---|-------------------|-------------------|------------------|------------------|------------------|---|
| ANNUAL AVERAGE OPERATION PER LANE PER DAY |                   |                   |                  |                  |                  |   |
| NONE                                      | NONE              | NONE              | NONE             | NONE             | NONE             | 0 |
| LESS THAN<br>100                          | LESS THAN<br>10   | LESS THAN<br>10   | LESS THAN<br>1   | LESS THAN<br>1   | LESS THAN<br>1   | 1 |
| 100-499                                   | 10-49             | 10-49             | 1-4              | 1-4              | 1-4              | 2 |
| 500-999                                   | 50-199            | 50-199            | 5-9              | 5-9              | 4-9              | 3 |
| 1000-1999                                 | 200-499           | 200-499           | 10-19            | 10-19            | 10-19            | 4 |
| 2000-3999                                 | 500-999           | 500-999           | 20-49            | 19-49            | 20-39            | 5 |
| 4000-5999                                 | 1000-1499         | 1000-1499         | 50-99            | 50-99            | 40-59            | 6 |
| 6000-7999                                 | 1500-1999         | 1500-1999         | 100-199          | 100-149          | 60-79            | 7 |
| 8000-9999                                 | 2000-2499         | 2000-2499         | 200-399          | 150-199          | 80-99            | 8 |
| MORE THAN<br>10,000                       | MORE THAN<br>2500 | MORE THAN<br>2500 | MORE THAN<br>400 | MORE THAN<br>200 | MORE THAN<br>100 | 9 |

- a Passenger, panel and pickups.
- b Two-axle trucks and buses; also half-or full-track vehicles less than 20 kip, and fork lift trucks less than 5 kip.
- c Trucks with three or more axles. Also half- or full-track vehicles 20-40 kip, and forklift trucks 5-10 kip.
- d 60-kip track vehicles and/or 15 kip forklifts. Number of operations per lane per day for tracked vehicles 40-60 kip and/or forklift trucks 10-15 kip.
- e 90 kip track vehicles and/or 20 kip forklifts.
- f 120 kip track vehicles and/or 35 kip forklifts.

|                |        |   |   |   |   |   |   |   |   |   |   |   |
|----------------|--------|---|---|---|---|---|---|---|---|---|---|---|
| DATE OF SURVEY | 9/1973 |   |   |   |   |   |   |   |   |   |   |   |
| TRAFFIC TYPE   | a      | b | c | d | e | f | a | b | c | d | e | f |
| VOLUME INDEX   | 5      | 3 | 2 | 0 | 0 | 0 |   |   |   |   |   |   |

"Volume Index" was reached at 3. That value 3 was recorded on the form for type *b* traffic.

(c) The volume of traffic for traffic type *c* was found on the traffic survey to be 15. Looking down column *c*, table 6-3, that value (10-49) was located. Looking horizontally to the far right the "Volume Index" was reached at 2. That value 2 was recorded on the form for type *c* traffic.

(d) The volume of traffic for traffic types *d*, *e*, and *f* was zero. The "Volume Index" was therefore zero and that value was recorded on the form for traffic types *d*, *e*, and *f*.

(e) The volume indices for the traffic survey of August 1979 was determined as indicated above for the 1978 survey. The values determined ( $a=6$ ,  $b=4$ ,  $c=1$ ,  $d=0$ ,  $e=0$ ,  $f=0$ ) were recorded on the form for the survey dated 8/79.

(2) Space is provided at the bottom of Form 5153-R marked "Parking Lots-Airfields-Other." This space should be used for describing the type and volume of traffic using facilities other than roads. For example, if the pavement section being considered is a parking lot, the description of traffic can be, "The dominant type of vehicle using the parking lot is passenger cars, averaging 12 hours per day." This information is used when evaluating the existing pavement section or when designing a new cross-section.

*g. DA Form 5154-R, Section Condition Record.* The Section Condition Record stores data obtained from the condition survey of the section's sample units and summarizes the distress found in the section.

(1) A completed DA Form 5154-R is shown as an example in figure 6-6. The form is completed as follows:

(a) The installation name, the branch name, the date and the section number is recorded at the top of the form.

(b) The average PCI of the sample units (in the example, 70) is recorded as well as the condition rating (good).

(c) Ratings for ride quality, safety, and drainage are recorded by marking the appropriate space (G for good, F for fair, P for poor). In the example the ratings are good. The ratings on the form are for general information since the PCI accounts for each of these factors through distress types.

(d) The total number of sample units in the section is recorded (in the example, 5).

(e) The number of random units surveyed is recorded. In the example, five units (all the units) were surveyed.

(f) The number of additional units surveyed is recorded (in the example, zero). If the

section is inspected by sampling, the number of random and additional units surveyed is recorded. If all sample units are surveyed, the number is recorded as random units.

(g) The PCI range is computed, by subtracting the lowest sample unit PCI from the highest sample unit PCI, and recorded (in the example, 20).

(h) The minimum number of sample units to be surveyed is determined and recorded (in the example, 5). Determination of minimum number of sample units to be surveyed is described in chapter 3. If the minimum number of sample units required is greater than the number of random units surveyed, more units must be selected at random and surveyed.

(i) The pavement type is determined and recorded. (In the example, AC is marked to indicate asphalt-surfaced pavement. If the pavement had been concrete, PCC would have been marked.)

(j) The section dimensions and area are marked (in the example, 25 feet by 500 feet, 1388 square yards).

(k) The method of determining the section distress data is marked. (In the example, "Actual Quantities" is marked because the entire section was inspected. If inspection by sampling was used the circle next to extrapolated quantities should be marked.)

(l) Once it has been determined that a sufficient number of sample units have been surveyed, the section distress data portion of the form can be completed. If actual quantities are used (i.e., the entire section inspected), the section's values are found by totaling the quantity of each distress type and severity level. The section density and deduct values are then computed as normally done for a sample unit (See para 3-5d(1) for asphalt pavements and para 3-5d(2) for concrete pavements). (In the example the distress portion of the form has been completed starting with Distress Type 1, Severity Level L, Quantity 30, Section Density .24 and Deduct Value 4.)

(m) The deduct values are totaled (in the example, 47).

(n) On the last line of the form the percent deducts related to structural, environmental, or other conditions is marked (in the example, 75 percent structural, 25 percent other).

(2) The completed Section Condition Record with distress information can be used to evaluate M&R requirements and to provide quantities of repair for cost estimates. It is very important to note that the deduct



values determined from these data *cannot be used* to complete the PCI of the section.

(3) The percent of deducts relating to structural, environmental, or other conditions are used when performing the section evaluation described in chapter 4.

**SECTION CONDITION RECORD**

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

|                   |                        |                    |                |
|-------------------|------------------------|--------------------|----------------|
| Installation Name | Branch Name            | Date               | Section Number |
| <b>FORT Z</b>     | <b>MARSHALL AVENUE</b> | <b>10   1   79</b> | <b>1</b>       |

Average PCI 70 Condition Rating GOOD

Ride Quality G  F  P  Safety G  F  P  Drainage G  F  P

Total No. of Sample Units 5 No. of Random Units Surveyed 5

No. of Additional Units Surveyed 0

PCI Range 20 Minimum of Units to be Surveyed 5

Pavement Type  AC  PCC Section Area 25 ft. x 500 ft. = 1388 sq. yd. Section Distress Data  Extrapolated Quantities  Actual Quantities

| Distress Type | Severity Level | Quantity | Section Density | Deduct Value | Comments   |
|---------------|----------------|----------|-----------------|--------------|--|
| 1             | L              | 30       | .24             | 4            | RUTS OCCUR IN CONJUNCTION WITH MEDIUM ALLIGATOR CRACKS (1M). |
| 1             | M              | 80       | .64             | 17           |  |
| 7             | M              | 300      | 2.4             | 12           |  |
| 15            | L              | 80       | .64             | 14           |  |
|               |                |          |                 |              |  |
|               |                |          |                 |              |  |
|               |                |          |                 |              |  |
|               |                |          |                 |              |  |
|               |                |          |                 |              |  |
|               |                |          |                 |              |  |
|               |                |          |                 | Total        | 47   |

Percent Deducts Structural Related 75 Environmental          Other 25

Figure 6-6. An example of a completed DA Form 5154-R, Section Condition Record.

*h. DA Form 5155-R, Branch Maintenance and Repair Requirements.* This form stores information on required M&R activities; it is completed by using information previously recorded on DA Forms 5150-R through 5154-R. A form should be completed for each branch of the pavement network. For a detailed explanation of how to determine M&R requirements, see chapter 4.

(1) A completed DA Form 5155-R is shown as an example in figure 6-7. The form was completed as follows:

(a) The installation name, date, branch name and total number of sections in the branch was recorded at the top of the form. (In the example there are 6 sections in the branch.)

(b) All branch maintenance and repair work required was listed. The section number where the work was needed was recorded. The work item was described. The work class was recorded (*M* for maintenance, rather than *R* for repair, or *C* for new construction). The location of the proposed work (*R* for roadway, rather than *PL* for parking lot, *A* for airfield, or *O* for other) was recorded. The thickness of the proposed work was recorded. The quantity of the work item was recorded. The estimated cost of the work item was recorded. The priority that the work item rated was recorded. A final column provides space for recording the date the work item is completed.

(c) The lower area of the form is for remarks. An appropriate comment was recorded.

(2) The information on the Branch M&R Requirements form may change frequently. For example, when a work item is completed, other priorities may change. So the date of completion of the work item must be recorded and priorities updated at that time.

(3) Since the information on the Branch M&R Requirements form(s) changes frequently, a new form should be made when necessary. Information on completed M&R activities should always be transferred to a DA Form 5156-R, Section Maintenance and Repair Record, as a permanent record.

*i. DA Form 5156-R, Section Maintenance and Repair Record.* This form stores information on maintenance and repairs that have been completed. It can be compiled from data from DA Form 5155-R and as-built records. A separate form is used for each section; this allows the expenditures for maintenance of each section to be monitored. This type of information may be valuable when determining M&R requirements or when performing economic analyses on other sections. The information on DA Form 5156-R is very

similar to that kept on DA Form 5155-R, except that the completion date of M&R is listed for *each* activity and the cost should be the *actual* cost of M&R rather than an estimate. A completed DA Form 5156-R is shown as an example in figure 6-8. The form was completed similar to DA Form 5155-R. The actual rather than the proposed thickness, quantity and cost were recorded.

#### **6-4. Manual record keeping system-general**

The manual record keeping system consists primarily of the nine forms described in paragraph 6-3. Those forms are used for information storage. To use data efficiently, this information must be stored in an orderly fashion. Figure 6-9 is an example of such a system; it can be described as follows:

*a. Branch summary.* One folder stores the network inventory. This is the information recorded on DA Form 5149-R, Branch Identification Summary.

*b. Branch identification information.* One folder stores branch identification information. This folder serves as a heading card and as the storage slot for DA Form 5155-R, M&R Requirements. (This allows anticipated maintenance activities for each section of the branch to be stored in one location.) The branch identification forms should be filed in the order shown on the DA Forms 5149-R, Branch Identification Summary.

*c. Branch sections.* After the Branch Identification Summary forms, a series of file folders should be provided for each section of the branch. One folder each is provided for DA Forms 5149-1-R, 5150-R, 5151-R, 5152-R, 5153-R, and 5154-R. (These forms contain basic information on the section.)

*d. Inspection forms.* Field survey data on the sample unit inspection sheets should be retained. This information is included on the DA Form 5154-R, Section Condition Record (fig 6-6); however, the inspection sheets can help verify data, and would be essential if the installation wanted to convert from the manual PAVER system to a computerized PAVER system.

#### **6-5. Record upkeep**

Once the initial division of the pavement network into branches and sections has been completed, the filing system can be started. As the initial inspections take place, the information on DA Forms 5149-1-R through 5153-R can be compiled. As branches are completed, data analyses can begin (chap 4).

*a. Updating forms.* Forms must be updated once maintenance activities begin. If overlays or surface treatments are applied, the DA Form 5151-R, Section

**BRANCH MAINTENANCE & REPAIR REQUIREMENTS**

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

| Installation Name | Date    | Branch Name  | Total No. of Sections |
|-------------------|---------|--------------|-----------------------|
| FORT E            | 10/1/79 | MARSHALL AVE | 1                     |

Work Class : M = Maintenance R = Repair C = New Construction Location : R = Roadway PL = Parking Lot A = Airfield O = Other

| Section No. | Work Description                | Work Class | Loc. | Thickness, inches | Quantity/Unit | Est. Cost | Priority | Date Completed, M/Y |
|-------------|---------------------------------|------------|------|-------------------|---------------|-----------|----------|---------------------|
| I           | * DEEP PATCH MED. ALLIG. CRACKS | M          | R    | 6                 | 10 SQ. YD.    | \$100.00  | 1        |                     |
| II          | CRACK FILL MED. EDGE CRACKS     | M          | R    | -                 | 300 LIN. FT.  | 450.00    | 2        |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |
|             |                                 |            |      |                   |               |           |          |                     |

Remarks \* PATCHING OF MED. ALLIGATOR CRACKS WILL ELIMINATE EXISTING RUTS.

Figure 6-7. An example of a completed DA Form 5155-R, Branch Maintenance and Repair Requirements.

**SECTION MAINTENANCE AND REPAIR RECORD**  
 For use of this form, see TM 5-623; the proponent agency is USACE.

|                   |           |          |           |              |                |
|-------------------|-----------|----------|-----------|--------------|----------------|
| Installation Name | Date      |          |           | Branch Name  | Section Number |
| FORT Z            | Mo.<br>11 | Da.<br>1 | Yr.<br>79 | MARSHALL AVE | 1              |

| Work Performed |                     |                                     |           |               |          |
|----------------|---------------------|-------------------------------------|-----------|---------------|----------|
| Date of M & R  | Description of Work | Location                            | Thickness | Quantity/Unit | Cost     |
| 10/20/79       | DEEP PATCHES        | WHEEL PATHS<br>SAMPLE UNITS 1,3,4,5 | 6 INS.    | 15 SQ YDS.    | \$150.00 |
| 10/22/79       | CRACK FILLING       | EDGES SAMPLE UNITS 1-3              | -         | 300 LIN. FT.  | 400.00   |
|                |                     |                                     |           |               |          |
|                |                     |                                     |           |               |          |
|                |                     |                                     |           |               |          |
|                |                     |                                     |           |               |          |
|                |                     |                                     |           |               |          |
|                |                     |                                     |           |               |          |
|                |                     |                                     |           |               |          |
|                |                     |                                     |           |               |          |
|                |                     |                                     |           |               |          |
|                |                     |                                     |           |               |          |
|                |                     |                                     |           |               |          |
|                |                     |                                     |           |               |          |
|                |                     |                                     |           |               |          |

|          |
|----------|
| Remarks: |
|          |
|          |
|          |

Figure 6-8. An example of a completed DA Form 5156-R, Section Maintenance & Repair Record.

Pavement Structure Record Card, must be updated. Also, as work is completed, information from the DA Form 5155-R, Branch M&R Requirements, must be transferred to the DA Form 5156R, Section M&R Record. Performance of maintenance activities will also change the condition of the section; thus, the condition survey should also be updated.

*b. Updating of condition survey.* If a section receives no maintenance, the condition survey should be updated based on the rate of deterioration. Initially, this rate can be estimated by briefly inspecting the section to observe changes in distress types or

severity's. Until data are compiled, sections should be reviewed at least annually to observe this change in condition. Once the rate of deterioration is determined, sections with low rates may be inspected at more infrequent intervals. If the filing system is updated continuously as work is performed and inspections are completed, it should not be necessary for the pavement engineer to perform a condition survey of the entire system all at one time.

*c. Economic analysis.* Any economic analysis performed to determine M&R strategies for given sections should also be filed with the section information cards.

Following each branch folder are the folders for each section of the branch. DA Forms 5149-1-R, 5150-R, 5151-R, 5152-R, 5153-R, and 5154-R are kept in these folders.

Branch Identification Folder-- One is provided for each branch. DA Form 5155-R, Branch Maintenance and Repair Requirements, is stored here.

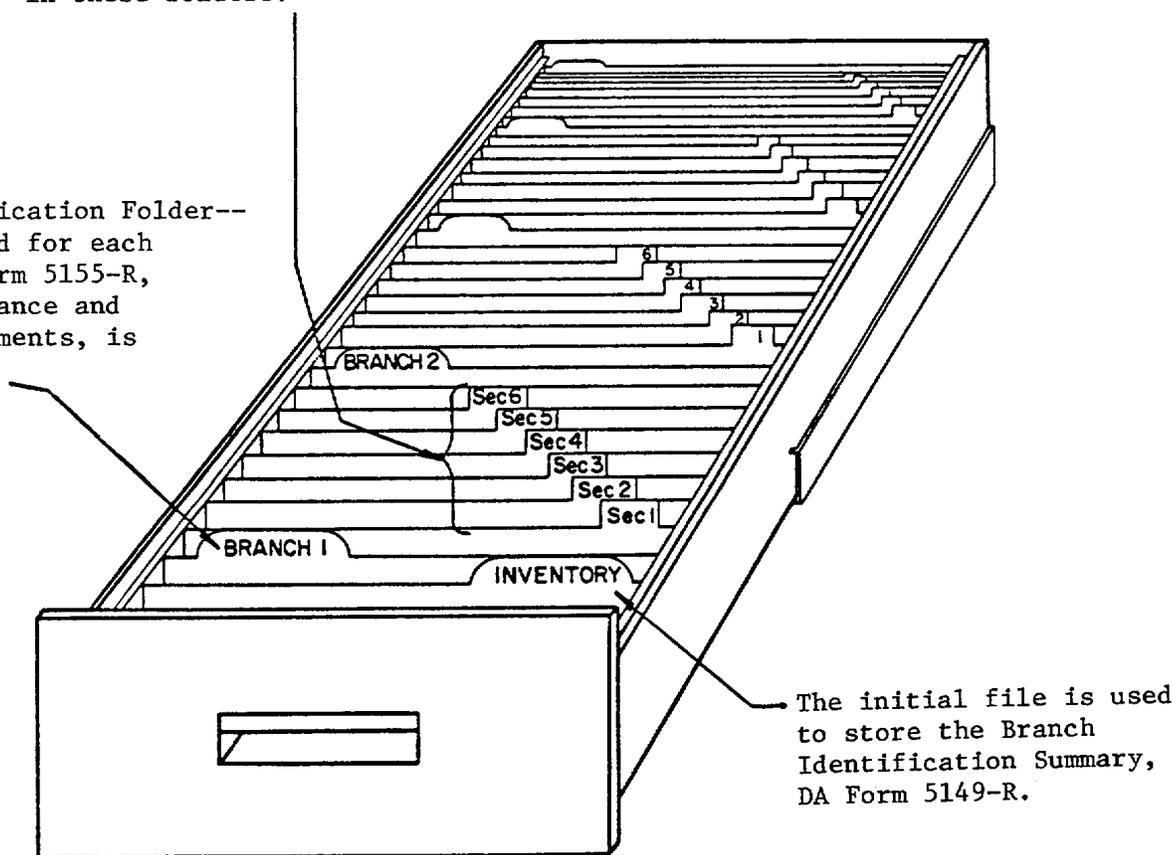


Figure 6-9. Example of a filing sequence for a manual record keeping system.

## CHAPTER 7

## DATA MANAGEMENT-COMPUTERIZED PAVER SYSTEM

**7-1. Purpose**

*a. Computerized data management.* The manual data management system described in chapter 6 is a systematic way of recording and storing information needed for effective pavement maintenance management. However, for medium to large-sized installations, the number of record cards can increase to the point where it is very time consuming to manually search, sort, and compile information for various maintenance management applications. An optional computerized system is available to automatically perform data retrieval, sorting, and compilation. In addition, the computer may be used to perform a number of calculations that in a manual system would have to be accomplished manually.

*b. Description of system.* This chapter briefly describes the computerized PAVER system. Specific user instructions may be obtained from the assigned responsible agency—the US Army Facilities Engineering Support Agency (USAFESA), Fort Belvoir, VA 22060.

**7-2. Use of computerized PAVER**

Generally, the computerized system is recommended for expediency of data handling and report generation. It may become advantageous to use it for pavement networks with a large number of pavement sections (more than 200). However, if the choice of system is not clear-cut, it is always possible to set up a manual system and then later convert to a computerized system.

**7-3. System description**

PAVER is operated via a desk-top computer terminal normally located in the Buildings and Grounds Division of the Facilities Engineering Organization. This terminal sends and receives information from a central computer via standard telephone lines. The user stores information about the pavement network in the computer by typing in data on the terminal or by having data keypunched and read in through a card reader. The user retrieves information from the computer by typing in commands which cause various options of reports to be printed on the terminal. Reports may be produced interactively (instantly) or in batch (retrieved at a later time). A brief description and the possible use of

each automated system report, including content and use, is contained in appendix D.

*a. PAVER data input/update forms.* The data stored in the computer is virtually the same as that recorded on the record cards of the manual system. To make this data machine-readable, special input/update forms are used. By using an ADD/CHANGE/DELETE code, each input form can be used to store new information in the computer or to make changes or deletions to information that has already been stored. An outstanding feature of the PAVER input/update program is that the PCI and extrapolated distress data for the pavement section are computed as the condition survey data are input or revised.

*b. PAVER report outputs.* There are two types of PAVER reports: the writer reports and the computation reports.

*(1) Writer reports.* Writer reports are preformatted reports generated by the PAVER Data Base Manager feature called the report writer, which sorts through PAVER stored information to meet specific user requirements at the time of report generation. There are several such reports available, including those for generating inspection results, pavement inventory, pavement structure, work required, and work completed history. An example of a pavement inspection report is shown in figure 7-1. An example of pavement ranking in an increasing order of PCI is shown in figure 7-2.

*(2) Computation reports.* Computation reports are special reports that require further processing (computations) of the data stored in PAVER and/ or new data provided by the user. One of the currently available reports develops routine M&R requirements based on stored pavement distress data and the engineer maintenance policy (which can be stored in PAVER). An example output is shown in figure 7-3. Another available report computes the present worth of any M&R alternative using the economic analysis procedure presented in chapter 5. An example output is shown in figure 7-4. Other computation reports can be developed as needed.



REPORT DATE- 07/05/82

PCI REPORT

INSTALLATION NUMBER = 051215

FORT EUSTIS

| BRANCH NUMBER | BRANCH USE                          | SECTION NUMBER | PCI | RATING | SURFACE TYPE | SECTION AREA/SY      | PAVEMENT RANK |
|---------------|-------------------------------------|----------------|-----|--------|--------------|----------------------|---------------|
| IMONR         | ROADWAY                             | 01             | 50  | FAIR   | AC           | 608                  | TERTIARY      |
|               | 11/27/79 [FROM] NR BLDG 832         |                |     |        | [TO]         | W EDGE LUCAS PL      |               |
| IBUTN         | ROADWAY                             | 02             | 52  | FAIR   | AC           | 392                  | TERTIARY      |
|               | 11/08/79 [FROM] E EDGE PATTON AVE   |                |     |        | [TO]         | W EDGE PERSHING AVE  |               |
| IMULB         | ROADWAY                             | 04             | 52  | FAIR   | AC           | 1683                 | TERTIARY      |
|               | 02/20/80 [FROM] NR BLDG 3905        |                |     |        | [TO]         | END OF PAVEMENT      |               |
| I12ST         | ROADWAY                             | 03             | 52  | FAIR   | AC           | 399                  | TERTIARY      |
|               | 02/11/81 [FROM] E'LY EDGE PATTON    |                |     |        | [TO]         | W'LY EDGE LEE BLVD   |               |
| IDICK         | ROADWAY                             | 01             | 53  | FAIR   | AC           | 966                  | TERTIARY      |
|               | 12/03/79 [FROM] S EDGE LEE BLVD     |                |     |        | [TO]         | N EDGE TYLER AVE     |               |
| IREIN         | ROADWAY                             | 01             | 53  | FAIR   | AC           | 694                  | TERTIARY      |
|               | 02/11/81 [FROM] E'LY EDGE MADISON   |                |     |        | [TO]         | W'LY EDGE WILSON LN  |               |
| IMONR         | ROADWAY                             | 05             | 54  | FAIR   | PCC          | 1622                 | SECONDARY     |
|               | 12/05/79 [FROM] S EDGE TAYLOR AVE   |                |     |        | [TO]         | N EDGE BUNDY ST      |               |
| IWILN         | ROADWAY                             | 01             | 55  | FAIR   | AC           | 1670                 | TERTIARY      |
|               | 11/29/79 [FROM] PERSHING AVE        |                |     |        | [TO]         | JUST BEYOND JURASIN  |               |
| IBACK         | ROADWAY                             | 01             | 56  | GOOD   | AC           | 5155                 | TERTIARY      |
|               | 02/04/80 [FROM] E EDGE HARRISON RD  |                |     |        | [TO]         | W EDGE MULBRY IS RD  |               |
| ISKIF         | ROADWAY                             | 01             | 56  | GOOD   | PCC          | 1391                 | TERTIARY      |
|               | 01/12/82 [FROM] BLDG 408            |                |     |        | [TO]         | BLDG 414             |               |
| ITINC         | ROADWAY                             | 01             | 56  | GOOD   | AC           | 3068                 | TERTIARY      |
|               | 01/09/80 [FROM] W ED MADI BLDG 2783 |                |     |        | [TO]         | TINCO2 BLDG 2798     |               |
| IMULB         | ROADWAY                             | 02             | 57  | GOOD   | AC           | 12551                | PRIMARY       |
|               | 02/20/80 [FROM] N EDGE WILSON BLVD  |                |     |        | [TO]         | ENTR PINES GOLF CLUB |               |
| IKELL         | ROADWAY                             | 01             | 58  | GOOD   | AC           | 3378                 | TERTIARY      |
|               | 10/30/79 [FROM] S'LY EDGE MONROE    |                |     |        | [TO]         | ROD & GUN CLUB       |               |
| I06ST         | ROADWAY                             | 01             | 58  | GOOD   | AC           | 2020                 | TERTIARY      |
|               | 11/09/79 [FROM] E'LE EDGE BULLARD   |                |     |        | [TO]         | W'LY EDGE JACKSON    |               |
| IWRIG         | ROADWAY                             | 01             | 60  | GOOD   | PCC          | 1371                 | TERTIARY      |
|               | 10/18/79 [FROM] E'LY EDGE WASH NO   |                |     |        | [TO]         | W'LY EDGE WALKER ST  |               |
| IKERR         | ROADWAY                             | 01             | 63  | GOOD   | AC           | 4897                 | TERTIARY      |
|               | 01/16/80 [FROM] N'LY EDGE LEE BLVD  |                |     |        | [TO]         | BLDG 425 3RD PORT    |               |

Figure 7-2. Example of pavement ranking in an increasing order of PCI.

REPORT DATE - 81/02/02.

MAINTENANCE AND REPAIR GUIDELINES

|              |                  |                |          |
|--------------|------------------|----------------|----------|
| BRANCH NAME  | - DICKMAN STREET | SECTION LENGTH | - 414 LF |
| BRANCH NMBR  | - IDICK          | SECTION WIDTH  | - 21 LF  |
| SECTION NMBR | - 01             | SECTION AREA   | - 966 SY |

|                 |            |             |      |
|-----------------|------------|-------------|------|
| INSPECTION DATE | - 12/03/79 | SECTION PCI | - 53 |
|-----------------|------------|-------------|------|

| DISTRESS TYPE  | DIS SEV | DIST-QTY WORK-QTY | WORK TYPE                               | MATL CODE | LABOR HOURS | LABOR COST\$ | MAT'L COST\$ | EQUIP COST\$ | TOTAL COST\$ |
|----------------|---------|-------------------|---|-----------|-------------|--------------|--------------|--------------|--------------|
| ALLIGATOR CR   | L       | 680 SF            |   |           |             |              |              |              |              |
|                |         | 680 SF            | SEAL COATING                            | 155       | 0.0         | 0            | 0            | 0            | 67           |
| ALLIGATOR CR   | M       | 60 SF             |   |           |             |              |              |              |              |
|                |         | 60 SF             | SHALLOW PATCH                           | 120       | 30.0        | 360          | 11           | 66           | 468          |
| ALLIGATOR CR   | H       | 15 SF             |   |           |             |              |              |              |              |
|                |         | 15 SF             | DEEP PATCH                              | 120       | 12.0        | 135          | 5            | 26           | 167          |
| BLEEDING       | L       | 8 LF              |   |           |             |              |              |              |              |
|                |         |                   | --- NO MAINTENANCE POLICY AVAILABLE --- |           |             |              |              |              |              |
| DEPRESSION     | L       | 18 SF             |   |           |             |              |              |              |              |
|                |         |                   | --- NO MAINTENANCE POLICY AVAILABLE --- |           |             |              |              |              |              |
| EDGE CR        | H       | 4 LF              |   |           |             |              |              |              |              |
|                |         | 6 SF              | SHALLOW PATCH                           | 120       | 0.0         | 0            | 0            | 0            | 43           |
| LONG/TRANS CR  | L       | 287 LF            |   |           |             |              |              |              |              |
|                |         |                   | --- NO MAINTENANCE POLICY AVAILABLE --- |           |             |              |              |              |              |
| PATCH/UTIL CUT | L       | 100 SF            |   |           |             |              |              |              |              |
|                |         |                   | --- NO MAINTENANCE POLICY AVAILABLE --- |           |             |              |              |              |              |
| PATCH/UTIL CUT | M       | 50 SF             |   |           |             |              |              |              |              |
|                |         | 50 LF             | CRACK FILLING                           | 171       | 0.0         | 0            | 0            | 0            | 32           |
| POTHOLE        | H       | 4 NMBR            |   |           |             |              |              |              |              |
|                |         | 4 EA              | DEEP PATCH                              | 120       | 16.0        | 192          | 8            | 35           | 224          |
| RUTTING        | L       | 10 SF             |   |           |             |              |              |              |              |
|                |         |                   | --- NO MAINTENANCE POLICY AVAILABLE --- |           |             |              |              |              |              |
|                |         |                   |   | TOTAL     | 58.0        | 687          | 24           | 127          | 1001         |

Figure 7-3. Example of M&R requirements report.

REPORT DATE - 80/12/19.

COMPARISON OF M&R ALTERNATIVES  
CENTRAL AVE  
SECTION 01

ANALYSIS PERIOD - 20 YEARS  
INFLATION RATE 6.00 PERCENT  
INTEREST RATE 10.00 PERCENT

| ALTERNATIVE | DESCRIPTION                                  | NET PRESENT COST |
|-------------|--|------------------|
| B           | PATCH JOINTS AND OVERLAY WITH 2 IN AC        | 28858.           |
| A           | CONTINUE JOINT PATCHING AND SLAB REPLACEMENT | 36842.           |
| C           | RECONSTRUCT WITH CONCRETE                    | 50642.           |

DETAILED COMPARISON OF M&R ALTERNATIVES

| YEAR       | ALT A<br>COST | PRES<br>COST | ALT B<br>COST | PRES<br>COST | ALT C<br>COST | PRES<br>COST |
|------------|---------------|--------------|---------------|--------------|---------------|--------------|
| 0 (FY80)   | 14410         | 14410        | 20410         | 20410        | 46000         | 46000        |
| 1 (FY81)   | 0             | 0            | 0             | 0            | 0             | 0            |
| 2 (FY82)   | 0             | 0            | 0             | 0            | 0             | 0            |
| 3 (FY83)   | 0             | 0            | 0             | 0            | 0             | 0            |
| 4 (FY84)   | 0             | 0            | 0             | 0            | 0             | 0            |
| 5 (FY85)   | 7610          | 6323         | 1000          | 830          | 0             | 0            |
| 6 (FY86)   | 0             | 0            | 0             | 0            | 0             | 0            |
| 7 (FY87)   | 0             | 0            | 0             | 0            | 0             | 0            |
| 8 (FY88)   | 0             | 0            | 0             | 0            | 0             | 0            |
| 9 (FY89)   | 0             | 0            | 0             | 0            | 0             | 0            |
| 10 (FY90)  | 7610          | 5254         | 1500          | 1035         | 1200          | 828          |
| 11 (FY91)  | 0             | 0            | 0             | 0            | 0             | 0            |
| 12 (FY92)  | 0             | 0            | 0             | 0            | 0             | 0            |
| 13 (FY93)  | 0             | 0            | 0             | 0            | 0             | 0            |
| 14 (FY94)  | 0             | 0            | 0             | 0            | 0             | 0            |
| 15 (FY95)  | 7610          | 4365         | 1500          | 860          | 0             | 0            |
| 16 (FY96)  | 0             | 0            | 0             | 0            | 0             | 0            |
| 17 (FY97)  | 0             | 0            | 0             | 0            | 0             | 0            |
| 18 (FY98)  | 0             | 0            | 0             | 0            | 0             | 0            |
| 19 (FY99)  | 0             | 0            | 0             | 0            | 0             | 0            |
| 20 (FY00)  | 13610         | 6488         | 12000         | 5720         | 8000          | 3813         |
| TOTAL      | 50850         | 36841        | 36410         | 28857        | 55200         | 50642        |
| SALVAGE    | 0             | 0            | 0             | 0            | 0             | 0            |
| PRES WORTH |               | 36841        |               | 28857        |               | 50642        |

Figure 7-4. Example of economic analysis report.

#### 7-4. System use and update

PAVER should be used and updated in a manner similar to the manual system. Some of the computer reports can be used as an aid in scheduling work for the pavement maintenance crew or to generate work to be done by contract. Other reports can be used to communicate pavement condition and maintenance requirements to higher management. PAVER will automatically delete the corresponding project from the pavement work plan and will store the work in completed projects as work history, thereby capturing the history of the distresses, repairs, quantities, and associated cost.

*a. Pavement inspection information.* As pavement sections are inspected, information should be input to PAVER; PAVER will not delete the results from any previous inspection of the section unless specifically required to do so by the user. Therefore, pavement

condition information showing a condition profile over a period of time will be readily available.

*b. Work requirements.* Work requirements are determined as shown in figure 4-9. However, PAVER can expedite this process considerably. For those sections where existing maintenance policy is to continue (usually the majority of sections in a pavement network), work requirements can be automatically developed by PAVER based on user maintenance policy and distress results of pavement inspections. For pavement sections where economic analysis is desirable to compare several M&R alternatives, PAVER can be used to perform the computations.

*c. Incorporation of improvements.* It should be noted that PAVER has been designed so new technological procedures/improvements can be incorporated into it as they become available.