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UNIFIED FACILITIES CRITERIA (UFC)

PAVEMENT MAINTENANCE MANAGEMENT

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UNIFIED FACILITIES CRITERIA (UFC)
PAVEMENT MAINTENANCE MANAGEMENT

U.S. ARMY CORPS OF ENGINEERS (Preparing Activity)

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location

This UFC supersedes TM 5-623, dated November 1982. The format of this UFC does not conform to UFC 1-300-01; however, the format will be adjusted to conform at the next revision. The body of this UFC is the previous TM 5-623, dated November 1982.

FOREWORD

\1\
The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD(AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the more stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Support Agency (AFCESA) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale should be sent to the respective service proponent office by the following electronic form: Criteria Change Request (CCR). The form is also accessible from the Internet sites listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site http://dod.wbdg.org/.

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TECHNICAL MANUAL

PAVEMENT MAINTENANCE MANAGEMENT

HEADQUARTERS, DEPARTMENT 0F THE ARMY

NOVEMBER 1982

TECHNICAL MANUAL
No. 5-623

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PAVEMENT MAINTENANCE MANAGEMENT

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CHAPTER 1

INTRODUCTION

1-1. Purpose

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

1-2. Applicability

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

1-3. Scope

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

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

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

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

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

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

1-4. Implementation of PAVER

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

1-5. PAVER forms

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

CHAPTER 2

PAVEMENT NETWORK IDENTIFICATION

2-1. Introduction

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

2-2. Definitions

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

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

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

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

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

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

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

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

2-3. Guidelines for pavement identification

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

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

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

b. Dividing branches into sections.

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

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

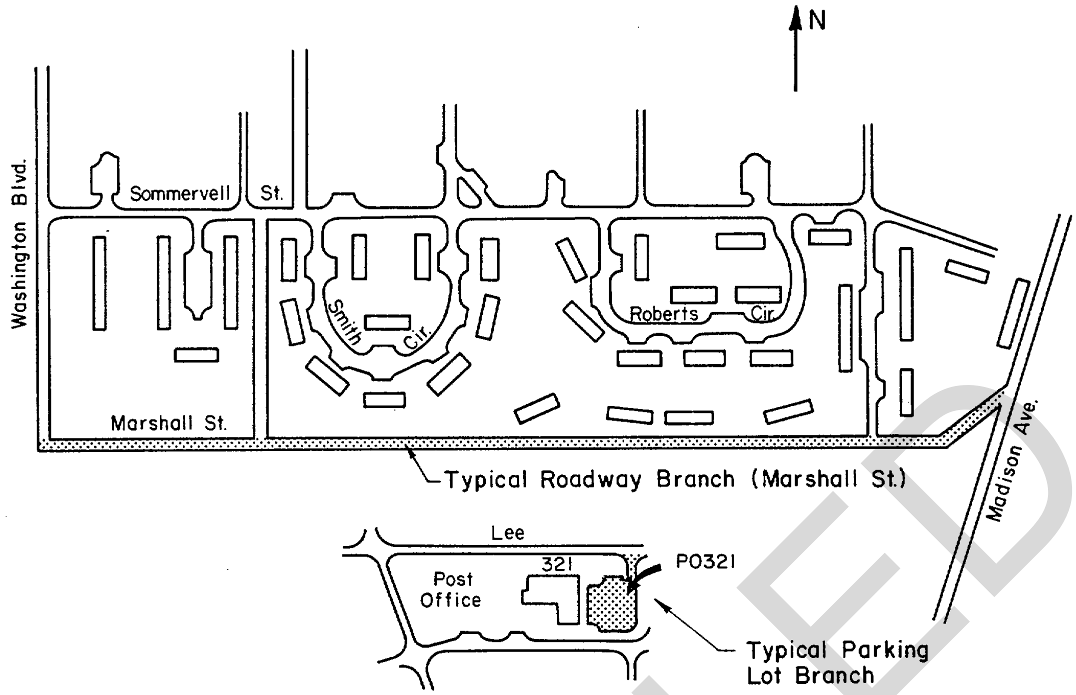


Figure 2-1. Installation map showing typical pavement branches.

Table 2-1. Branch Codes.

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

Table 2-1. Branch Codes

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

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

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

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

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

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

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

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

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

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

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

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

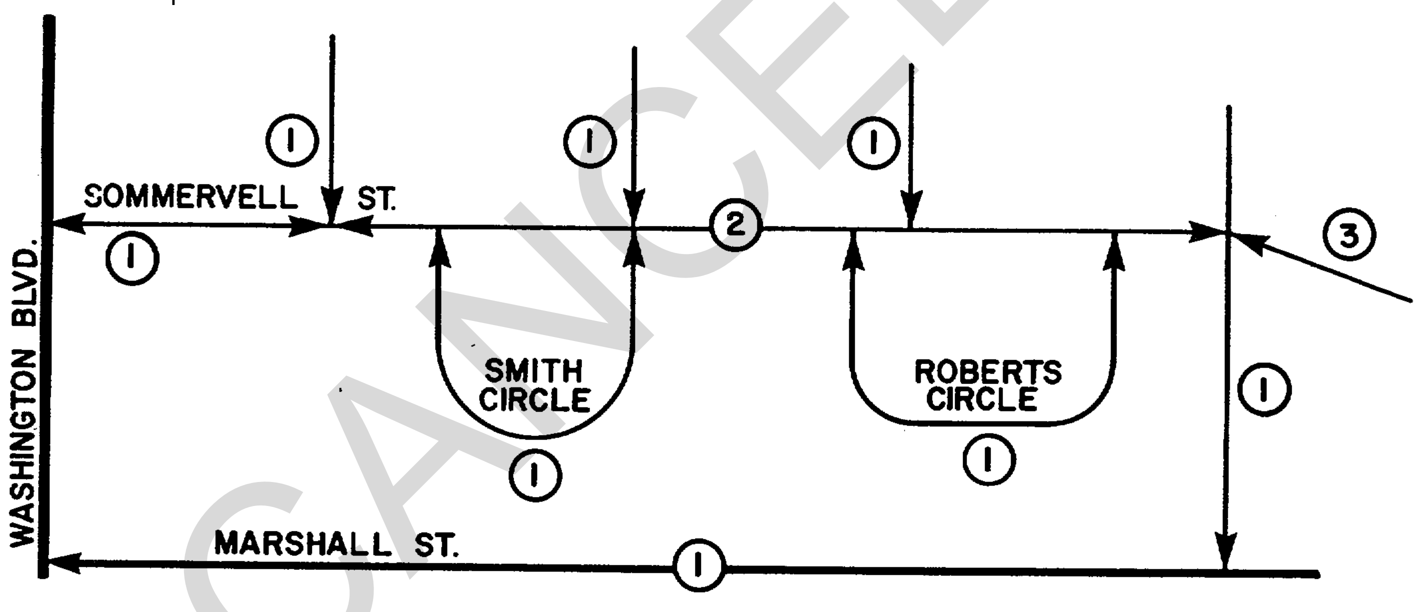


Figure 2-2. Sections identified on an installation map.

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

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

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

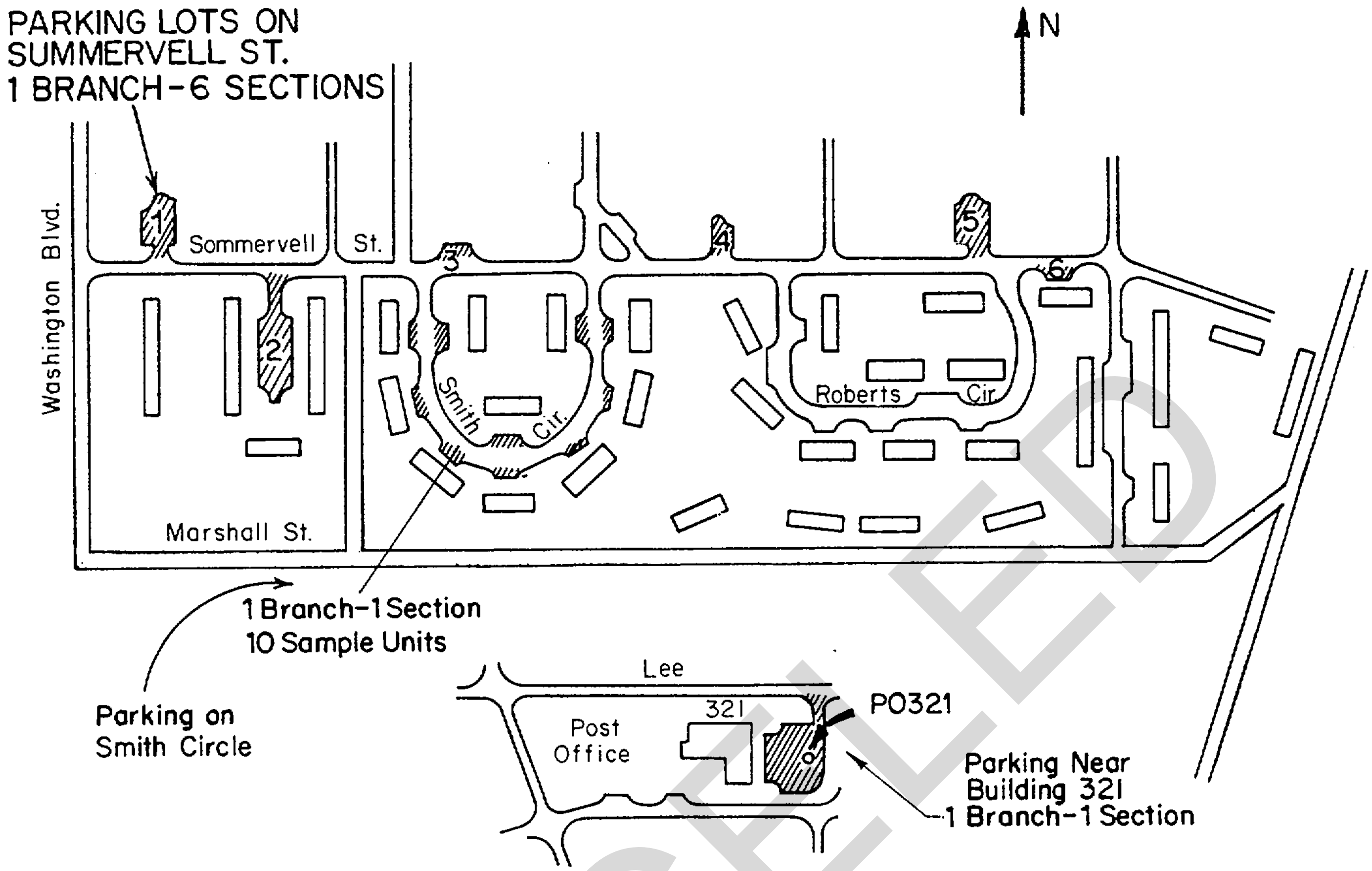


Figure 2-3. Installation map showing various methods of identifying parking area branches.

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

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

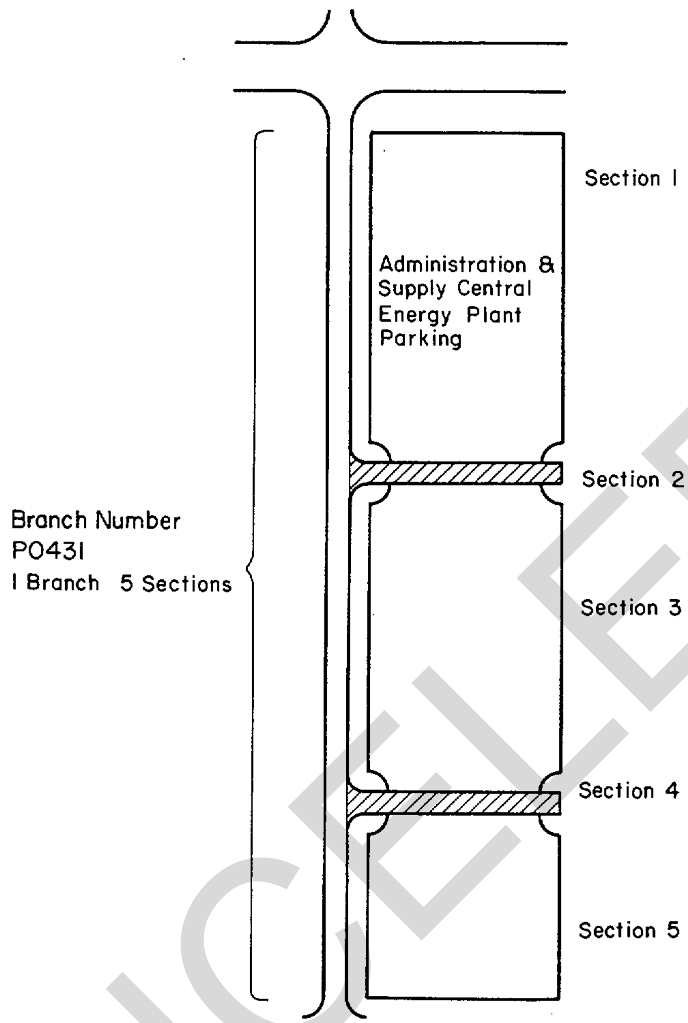


Figure 2-4. Large parking area divided into several sections.

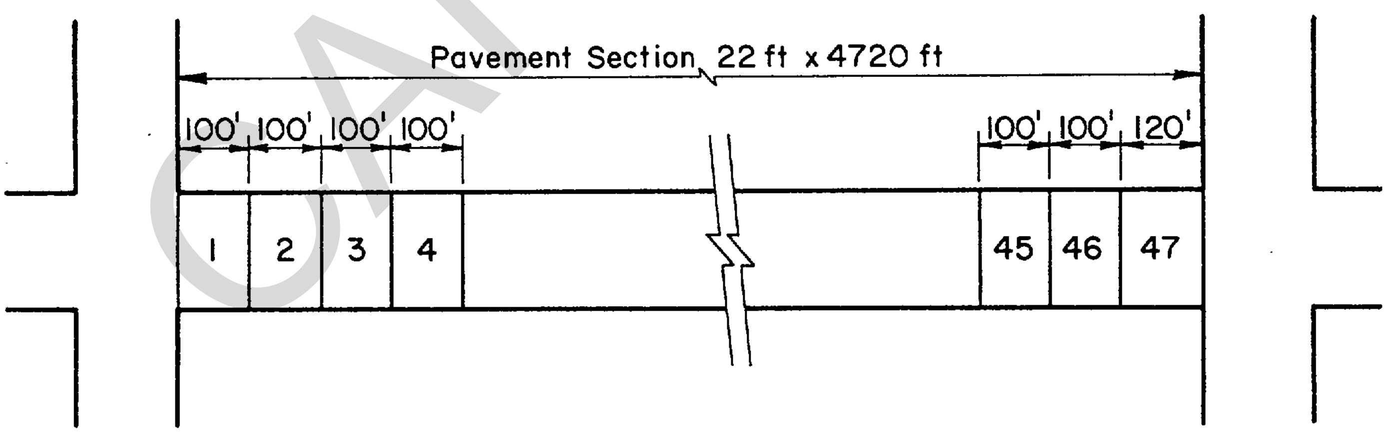


Figure 2-5. Example of a asphalt section divided into sample units.

CHAPTER 3

PAVEMENT CONDITION SURVEY AND RATING PROCEDURES

3-1. Introduction

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

3-2. Pavement condition rating

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

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

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

3-3. Pavement inspection.

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

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

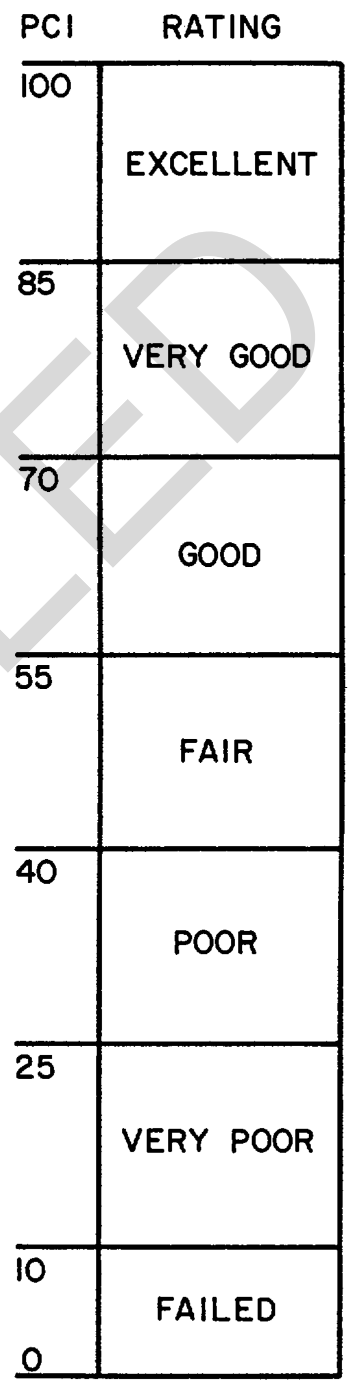


Figure 3-1. PCI scale and condition rating.

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

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

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

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

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

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

d. Remarks.

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

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

3-4. Inspection by sampling

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

b. Determining the number of samples.

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

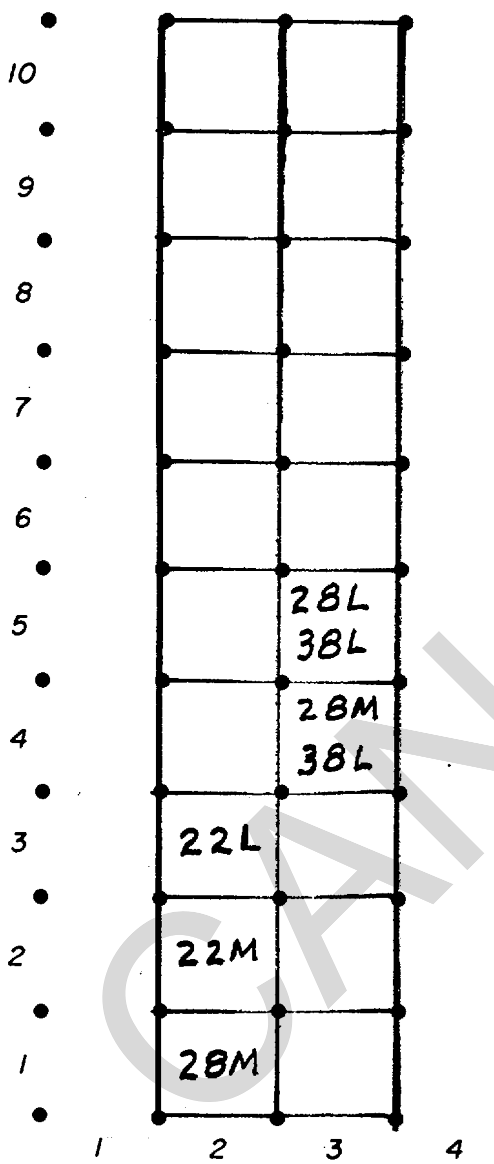
CONCENTRATE PAVEMENT INSPECTION SHEET

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

BRANCH MARSHALL AVE SECTION 1

DATE 10 / 3 / 79 SAMPLE UNIT 1

SURVEYED BY SK SLAB SIZE 15' x 20'



Distress Types

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

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

PCI = 100 - CDV = 76

RATING = VERY GOOD

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

DA FORM 5145-R, NOV 82

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

ASPHALT PAVEMENT INSPECTION SHEET

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

BRANCH MOTORPOOL RD. SECTION 1

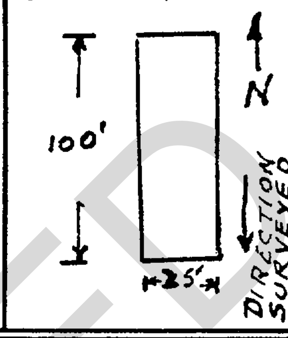
DATE 10/21/79 SAMPLE UNIT 1

SURVEYED BY SK AREA OF SAMPLE 2500

Distress Types

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

SKETCH:



EXISTING DISTRESS TYPE QUANTITY & SEVERITY

TYPE →	10	1	15	6		
QUANTITY & SEVERITY						
	10 L	1×6 L	2×25L	6×4 L		
	5L	2×8M				
	15L					
	5M					
	10L					
	5M					
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:

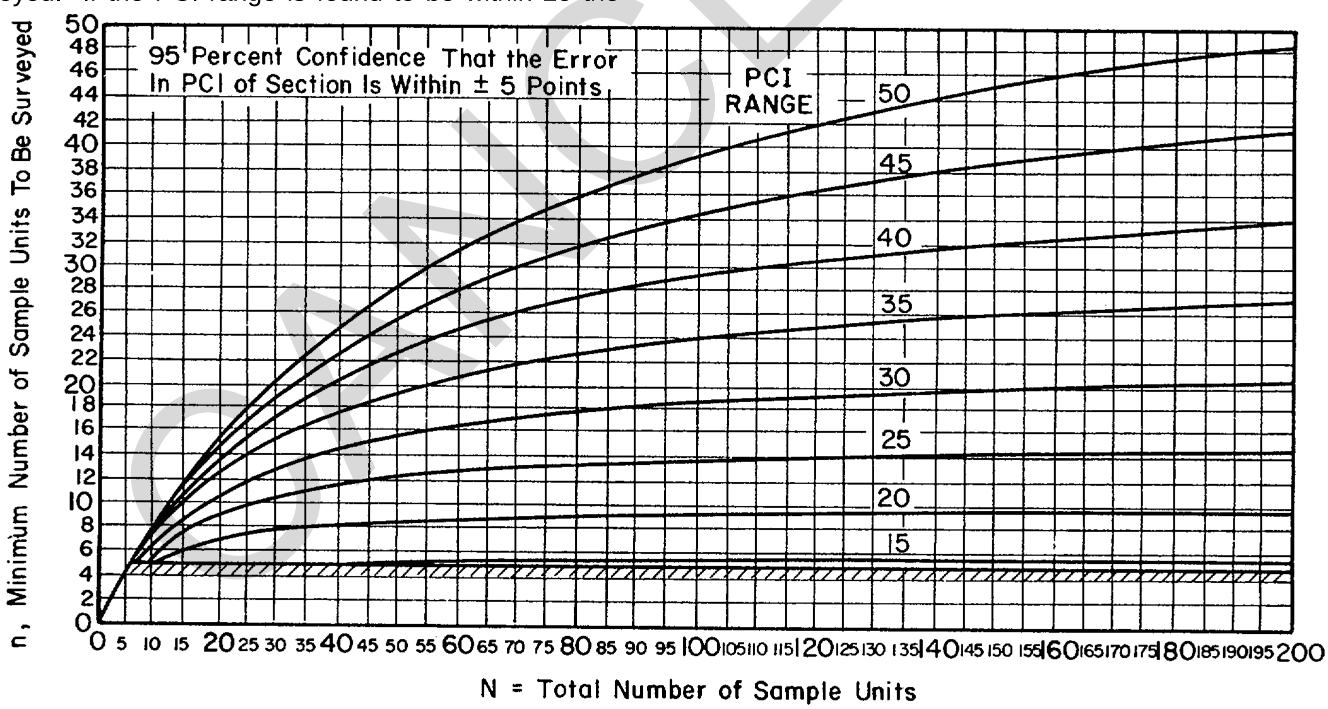
(a) **Given**: Asphalt concrete pavement section with total number of sample units, N=20.
Find: *n*.

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.

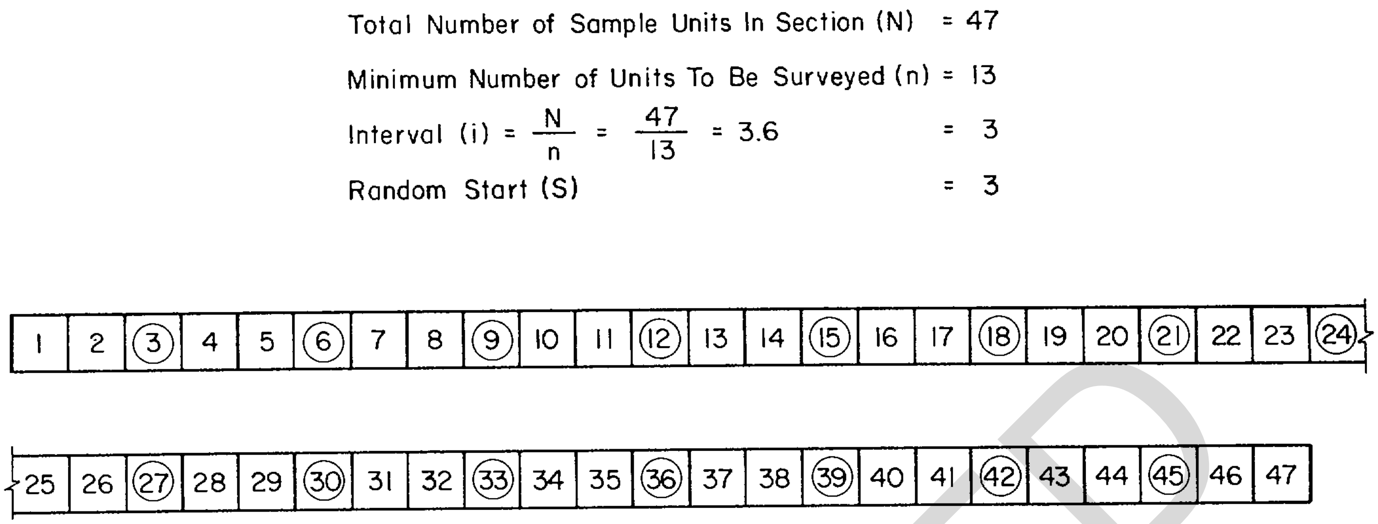


Figure 3-5. Example selection of sample units to be surveyed.

(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.

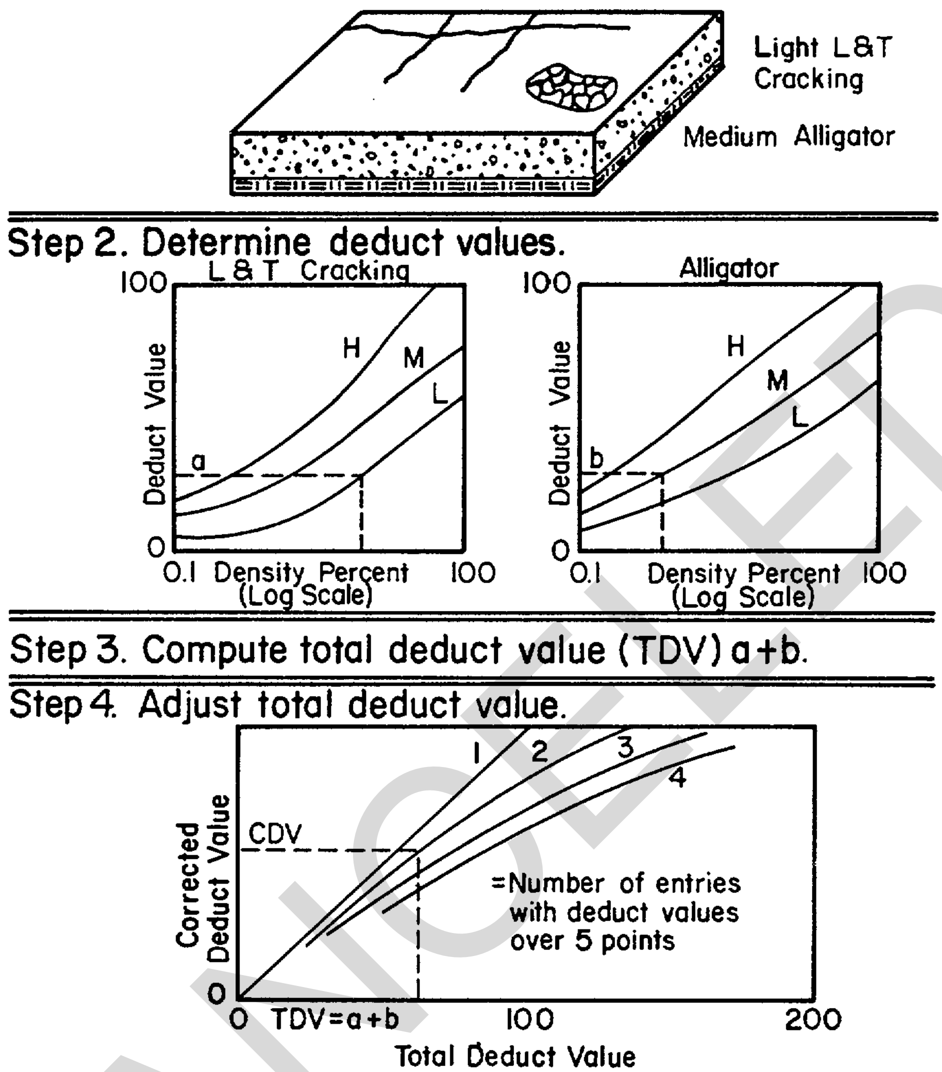
(2) The calculation of the PCI when additional sample units are included is slightly altered and its described in paragraph 3-5.

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 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:

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

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:

$$\text{Density} = \frac{\text{distress amount in square feet}}{\text{sample unit area in square feet}} \text{X100}$$

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):

$$\text{Density} = \frac{\text{distress amount in linear feet}}{\text{sample unit area in square feet}} \text{X100}$$

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

$$\text{Density} = \frac{\text{number of potholes}}{\text{sample unit area in square feet}} \text{X100}$$

(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:

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

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 20X 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:

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

The average density for medium-severity alligator cracking is, therefore, 600/12,000 = 05. The extrapolated quantity is determined by multiplying the density by the section area, i.e., .05X24,500=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:

Additional Sample Unit ID	*Sample Unit Area, Square Feet*	*Medium-Severity Alligator Cracking, Square Feet*
01	2500	1000
Total Additional	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:

Extrapolated Distress Quantity =.05 x 22,000 + 1000
=2100 square feet

CHAPTER 4

MAINTENANCE AND REPAIR (M&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 live-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 - PCI	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.

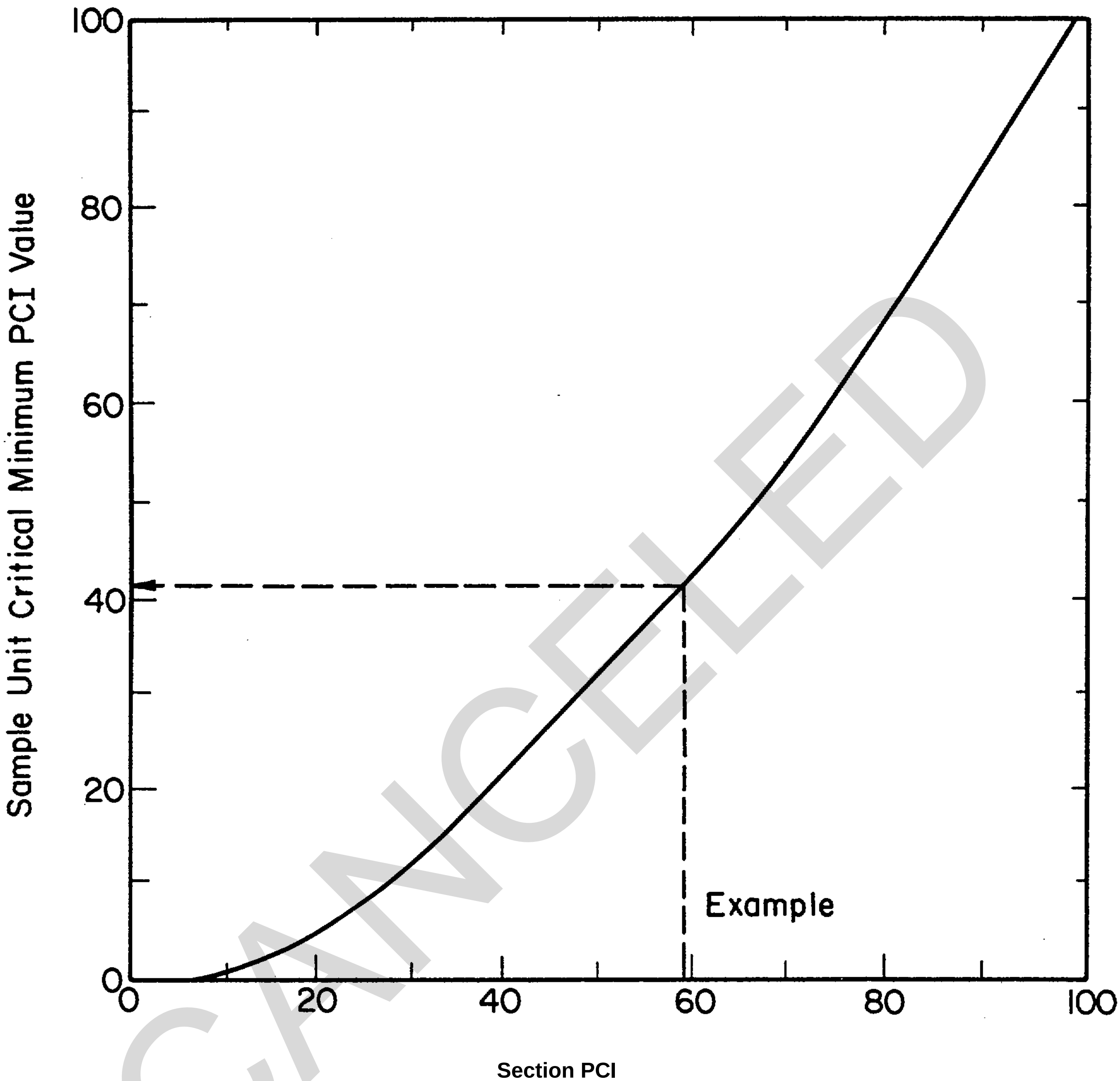


Figure 4-2. Procedure to determine critical minimum sample unit PCI based on mean PCI of section.

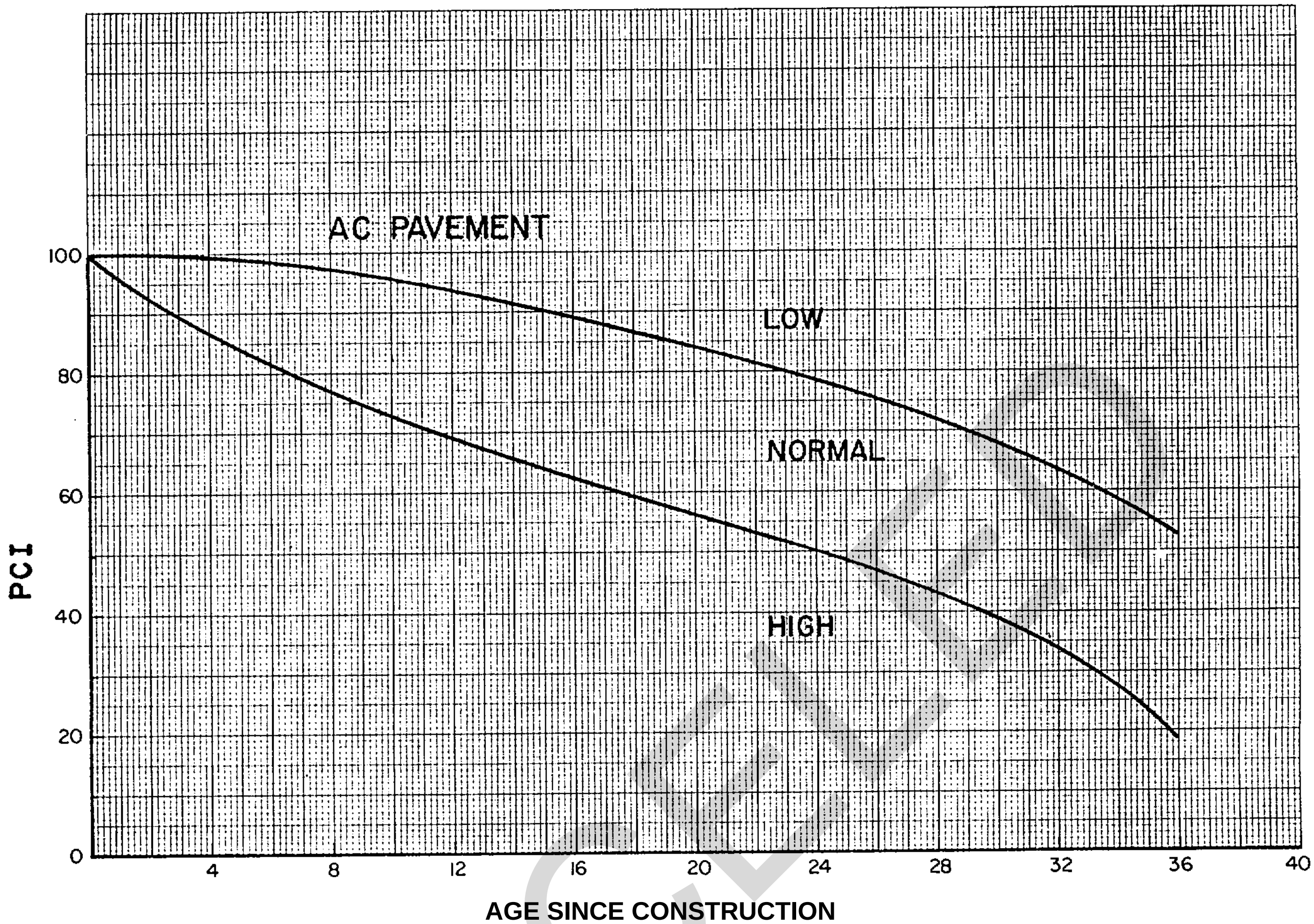


Figure 4-3. Determination of long-term rate of deterioration for asphalt concrete (AC) pavements.

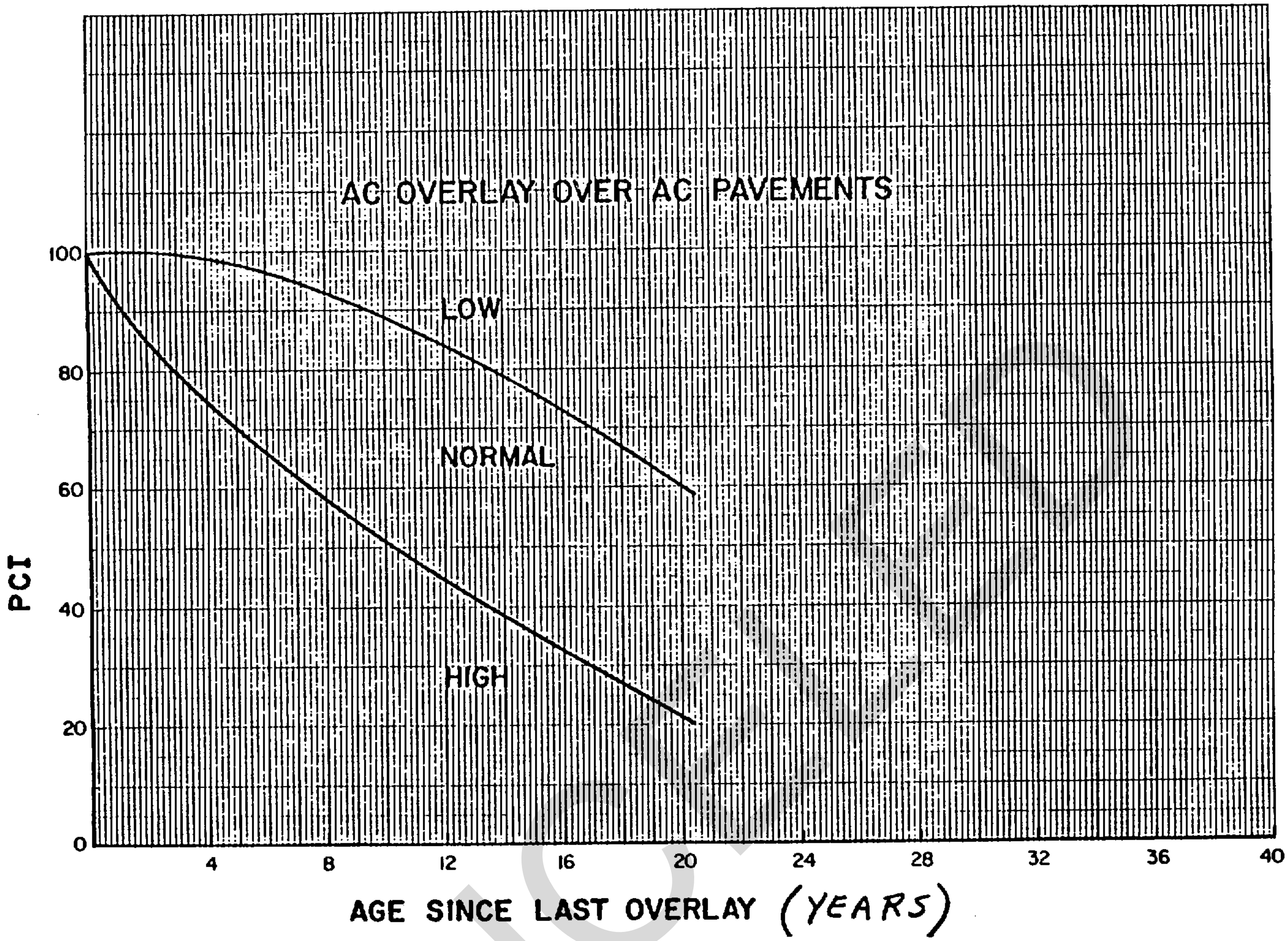


Figure 4-4. Determination of long-term rate of deterioration for asphalt concrete (AC) overlay over AC pavements.

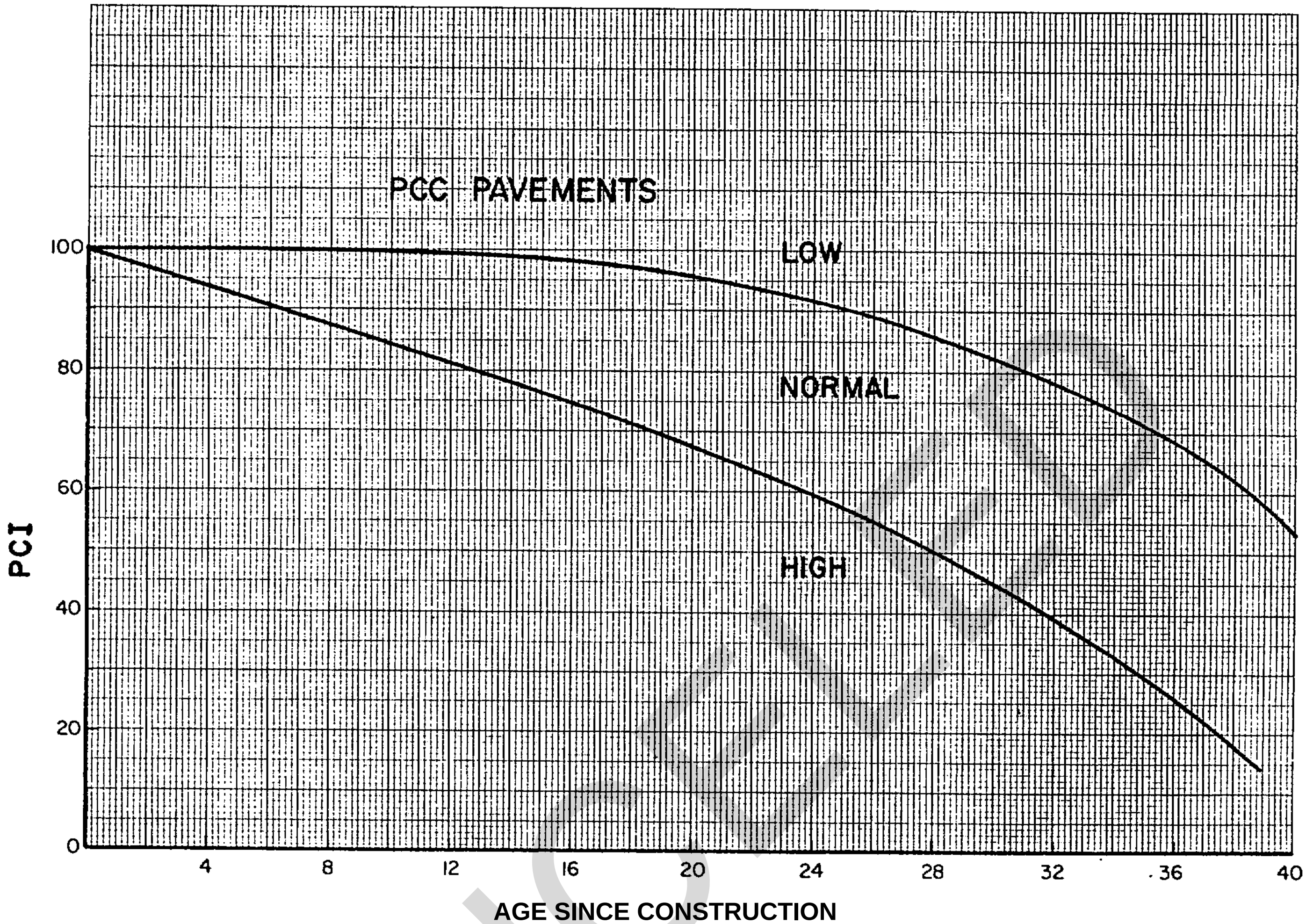


Figure 4-5. Determination of long-term rate of deterioration for Portland Cement Concrete (PCC) pavements.

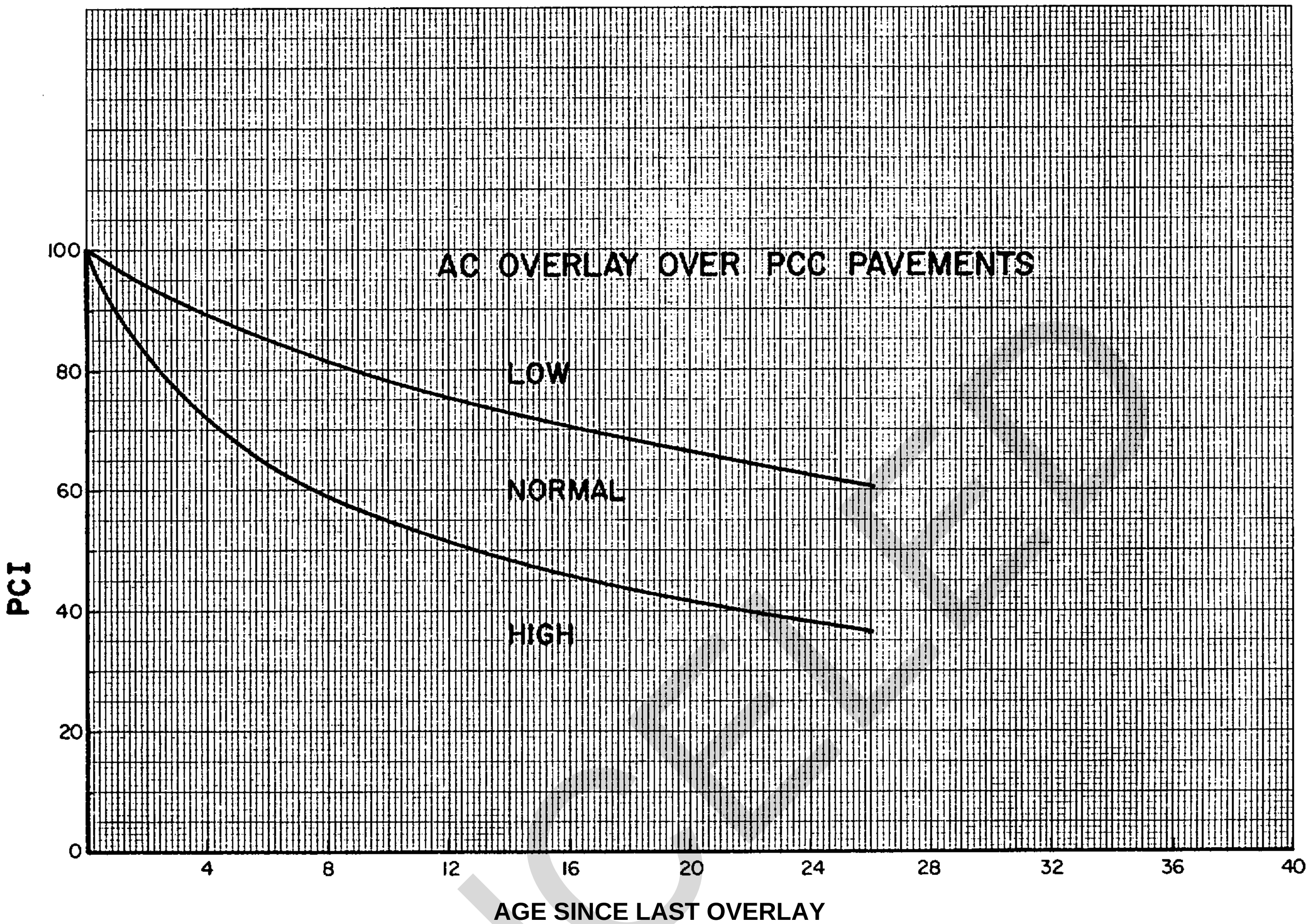


Figure 4-6. Determination of long-term rate of deterioration for asphalt concrete (AC) overlay over Portland Cement Concrete (PCC) pavements.

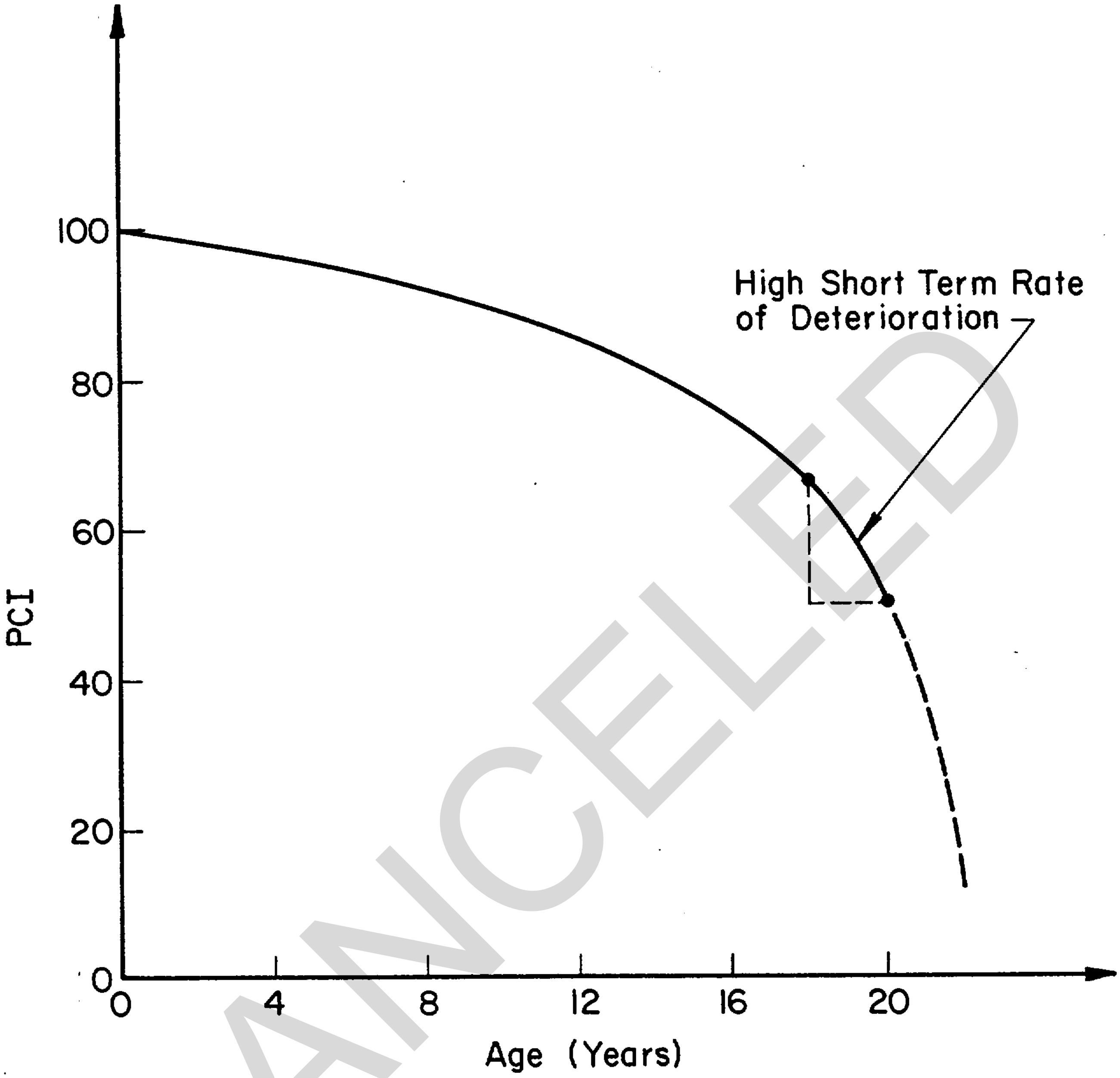


Figure 4-7. PCI us age illustrating high short-term rate of deterioration.

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

Load	*Climate/durability*	*Moisture/drainage*	*Other factors*
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

Load	*Climate/durability*	*Moisture/drainage*	*Other factors*
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.

Distress type	*Distress density over section*	*Severity level*	*Deduct value*	*Probable cause*
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%s X 100 = 80 percent
Climate/durability =	17/8s 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[a]

Class road Category or street	*Category I*	*Category II*	*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.
*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.

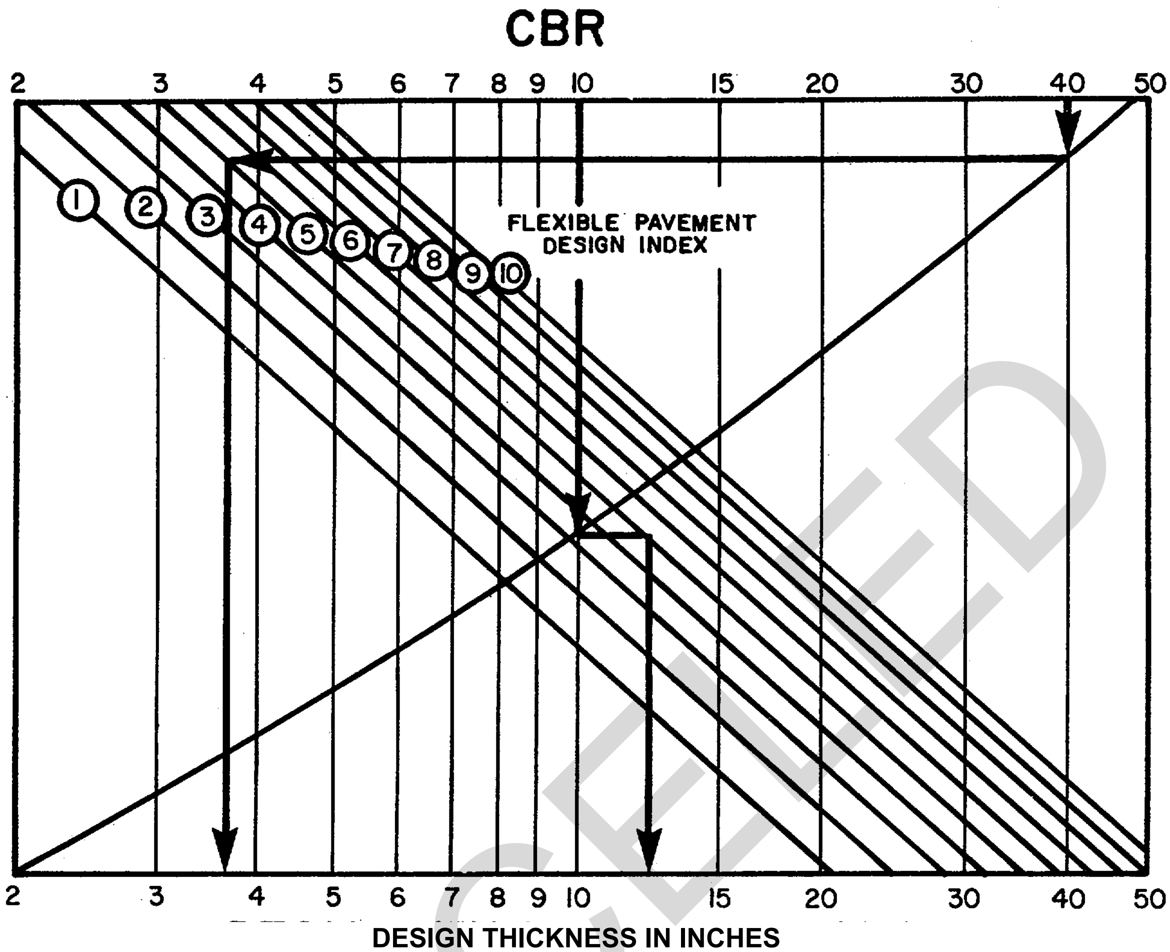


Figure 4-8. Thickness design requirements for flexible pavements (TM 5-822-5, 1 Oct 80, and AFM 88-24, Chap 3).

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.

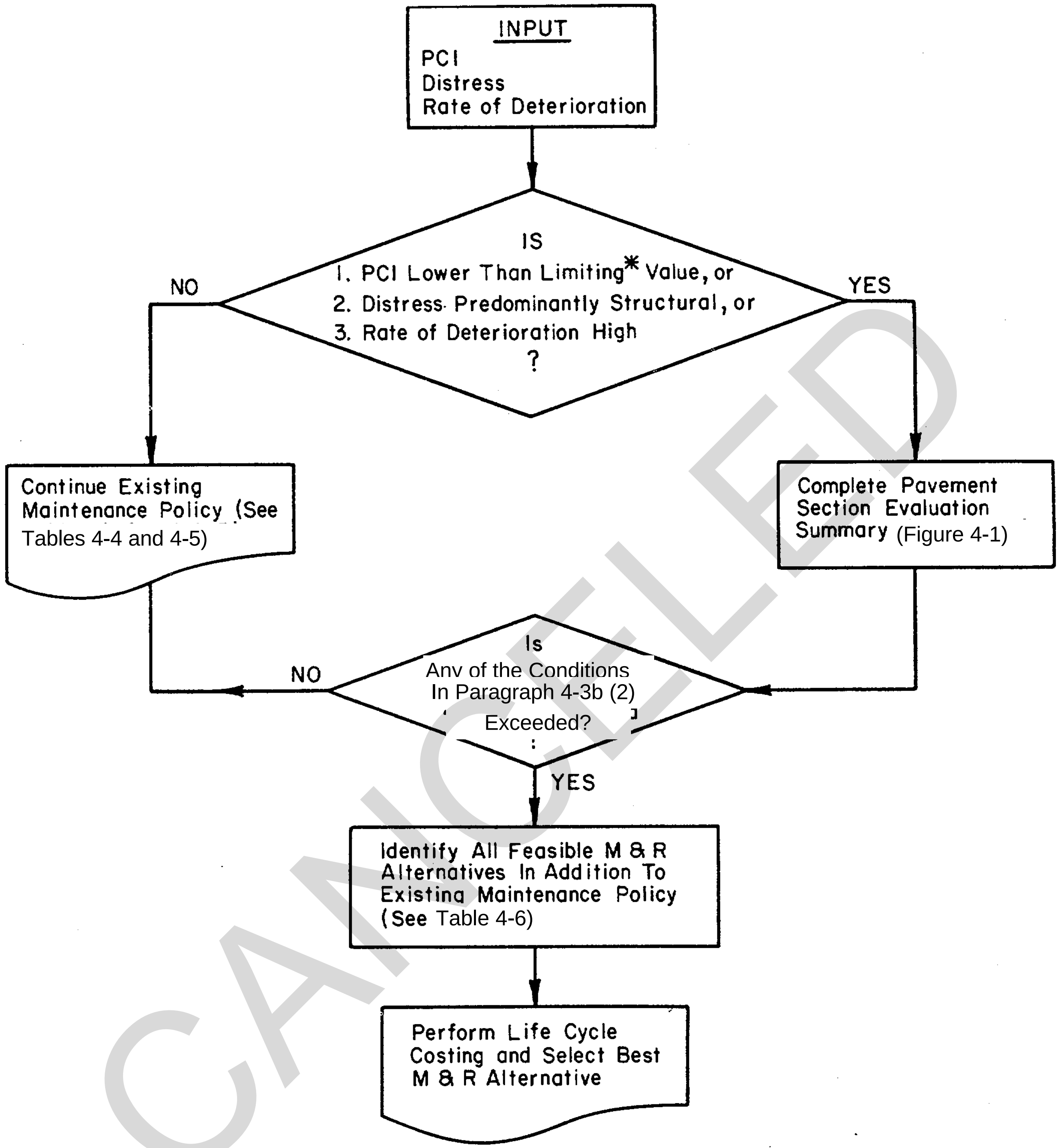
(b) Table 4-6 lists most of the available overall repair procedures for asphalt and jointed concrete pavements.

(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	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	Notes
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&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.

<u>Jointed-Concrete-Surfaced Pavements</u>

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 aistresses; overlay may or may not be applied.
8. Groove surface if poor skid resistance/hydroplaning potential, is the main reason for overall M&R.

<u>Asphaltor Tar-Surfaced Pavements</u>

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).

** <u>Federal Highway Administration Initiation of National Experimental Evaluation Program (NEEP) Project No. 22,</u> 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&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:

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

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^{th} year that is a function of the interest rate (r_t) and inflation rate (r_f).

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

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.

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

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:

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

and with C_i = 14,410, the Present Worth (PW) = 14,410 × 1 = 14,410; and with C_i = 6,000, PW = 6,000 × 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 × 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 × 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 × 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 × 0.477 = 5721.

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

M & R ALTERNATIVE PATCH JOINTS THEN OVERLAY WITH 2 INCH ASPHALT CONCRETE.

ANALYSIS PERIOD 20 YEARS INTEREST RATE 10 %

DIFFERENTIAL INFLATION RATE 6 %

YEAR	M & R WORK DESCRIPTION	COST $	f	PRESENT WORTH $
0(1980)	PATCH JOINTS	14,410	1.0	14,410
0(1980)	OVERLAY WITH 2 IN. A.C.	6,000	1.0	6,000
5(1985)	FILL CRACKS	1,000	0.831	831
10(1990)	FILL CRACKS	1,500	0.690	1,036
15(1995)	FILL CRACKS	1,500	0.574	861
20(2000)	REPLACE 2 IN. A.C. USING			
	COLD MILLING.	12,000	0.477	5,721
			TOTAL	$28,859

DA FORM 5148-R, NOV 82

Figure 5-1. An example of a completed DA Form 5148-R, Present Worth Computation Form.

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.			4.			
9,9,9,9,9	FORT Z	HOME IL	10	1	79	2.			5.			3
						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:

DA FORM 5149-R, NOV 82

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

SECTION IDENTIFICATION RECORD

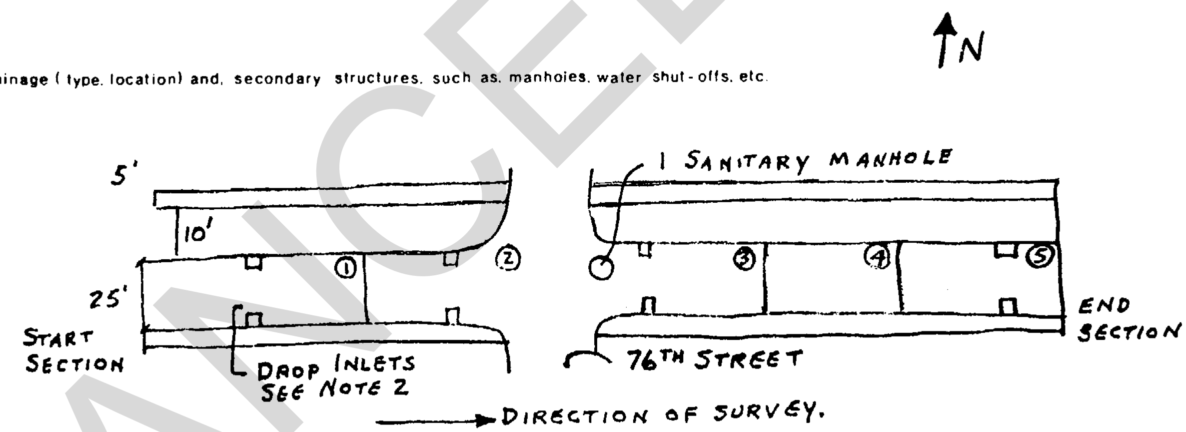
For use of this form, see TM 5-623; the proponent agency is USACE.

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. 1388 sq. yd	5	1

Traffic Types And Uses				General Information		
				Curb And Gutter	Sidewalks	Surface Type
○ Aircraft ○ Fixed Wing ○ Rotary Wing	○ Runway ○ Taxiway ○ Parking or Pads ○ Apron ○ Other	☒ Vehicular ☒ Real Property ○ Family Housing	☒ Primary ○ Secondary ○ Tertiary ○ Parking - Storage ○ Other	☒ Left ☒ Right ○ None	☒ Left ___ ft. ☒ Right ___ ft. ○ None ___	○ PCC ☒ AC ○ Surface Treatment ○ Other

Sketch:

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



NOTES:

1. 5 SAMPLE UNITS @ 100' MARSHALL STREET STRUCTURE CARRIES THROUGH THE INTERSECTION.
2. CURB DROP INLETS - 4 LOCATED IN SECTION. MAINLINE IS ON SOUTH SIDE OF PVMT CROSS OVER PIPE FROM NORTH INLET. INLETS ARE IN CONC CURB.
3. NO SUBSURFACE DRAINAGE.
4. 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.

Date	*Type of traffic using the pavement section*	*Volume per lane per day*
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)								
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
- 111 plain
- 112 reinforced concrete pavements (RCP)
- 113 continuously reinforced concrete pavement (CRCP)
- 114 prestressed
- 115 fibrous

120 Asphalt Concrete

130 Road Mix Bituminous Surface

140 Sand-Asphalt
- 141 plant mix
- 142 road mix

150 Surface Treatments
- 151 single-layer aggregate seal
- 152 double-layer aggregate seal
- 153 three- or more layer aggregate seal
- 154 sand seal
- 155 slurry seal
- 156 fog seal
- 157 asphalt rubber chip
- 158 fabric
- 159 dust layering

160 Preformed Joint Fillers
- 161 bituminous fiber
- 162 cork
- 163 self-expanding cork
- 164 self-expanding rubber
- 165 sponge rubber
- 166 closed cell plastic

170 Joint and Crack Sealers
- 171 hot-poured
- 172 cold-poured

180 Others

200 Treated or Stabilized Materials

210 Cement Treated
- 211 gravel and crushed stone
- 212 sand
- 213 silt and clay

220 Lime-Flyash Treated
- 221 gravel and crushed stone
- 222 sand
- 223 slag

230 Lime-Treated Fine-Grained Soil

240 Asphalt-Treated Plant Mix
- 241 crushed stone
- 242 gravel
- 243 sand

250 Asphalt-Treated Road Mix
- 251 crushed stone
- 252 gravel
- 253 sand

280 Others

300 Untreated Materials

310 Crushed Stone
- 311 well-graded
- 312 poorly graded (one-sized)
- 313 high fines content

320 Gravel
- 321 well-graded
- 322 poorly graded
- 323 high fines content

330 Sand
- 331 well-graded
- 332 poorly graded
- 333 high fines content

340 Fine-Grained Soils
- 341 sandy silt
- 342 silt
- 343 clayey silt
- 344 sandy clay
- 345 silty clay
- 346 clay
- 347 organic silt
- 348 organic clay

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 MARSHALL STABILITY	1600 LBS	
	FLOW	11 .01 INS	
	AIR VOIDS	4%	
	UNIT WEIGHT	141 PCF	
	INSITU DENSITY	138 PCF	AVG OF FIELD TESTS.
SURFACE	NO PROPERTIES AVAILABLE		
LEVELING	" "	"	
BASE COURSE	CBR	60	TESTED INSITU 10/78
	INSITU MOISTURE	12%	
SUBGRADE	CBR	15	TESTED INSITU 9/78
	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

1. Asphalt Concrete (Surface, Leveling, Base):
   Marshall stability (pounds)... Asphalt content (%)
   Flow (0.01 inch) .... Unit weight (pounds/cubic foot)
   Air voids (5) .... Asphalt penetration (millimeters x 10^1)

2. Portland Cement Concrete (PCC):
   Modus of rupture (pounds/square inch)
   Compressive strength (pounds/square inch)
   Entrained air (%).................
   Water/cement ratio (gallon/sack).

3. Base-Subbase Materials:
   k-value (pounds/square inch)
   CBR...................................
   In-situ dry density (% of optimum).
   In-situ moisture content.......

4. Subgrade:
   Unified classification .... Liquid limit
   CBR.. Optimum moisture control (%)
   K-value (pounds/square inch).... In-situ moisture content (%)
   Plasticity index.......................... In-situ dry density (% of optimum)

(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	VOLUME INDEX
ANNUAL AVERAGE OPERATION PER LANE PER DAY						
NONE	NONE	NONE	NONE	NONE	NONE	0
LESS THAN 100	LESS THAN 10	LESS THAN 10	LESS THAN 1	LESS THAN 1	LESS THAN 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 10,000	MORE THAN 2500	MORE THAN 2500	MORE THAN 400	MORE THAN 200	MORE THAN 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

SECTION TRAFFIC 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

Roads or Streets																								
Date of Survey	9/78						8/79																	
Traffic Type	a	b	c	d	e	f	a	b	c	d	e	f	a	b	c	d	e	f	a	b	c	d	e	f
Volume Index	5	3	2	0	0	0	6	4	1	0	0	0												

Parking Lots – Airfields – Other	
Date of Survey	Description

DA FORM 5153-R, NOV 82

Figure 6-5. An example of a completed DA Form 5153-R, Section Traffic Record.

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
FORT Z	MARSHALL AVENUE	10 / 1 / 79	1

Average PCI 70 Condition Rating GOOD

Ride Quality G X F ___ P ___ Safety G X F ___ P ___ Drainage G X 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 Quanities ☒ Actual Quantities

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

Percent Deducts Structural Related 75 Environmental ___ Other 25

DA FORM 5154-R, NOV 82

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.

PAGE 1 OF 1

Installation Name	Date	Branch Name	Total No. of Sections
FORT Z	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
1	* DEEP PATCH MED. ALLIG. CRACKS	M	R	6	10 SQ. YD.	$100.00	1	
11	CRACK FILL MED. EDGE CRACKS	M	R	-	300 LIN. FT.	450.00	2	

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

DA FORM 5155-R, NOV 82

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

SECTION MAINTENANCE AND REPAIR RECORD

PAGE 1 of 1

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

Installation Name	Date Mo.	Date Da.	Date Yr.	Branch Name	Section Number
FORT Z	11	1	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 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:

DA FORM 5156-R, NOV 82

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.

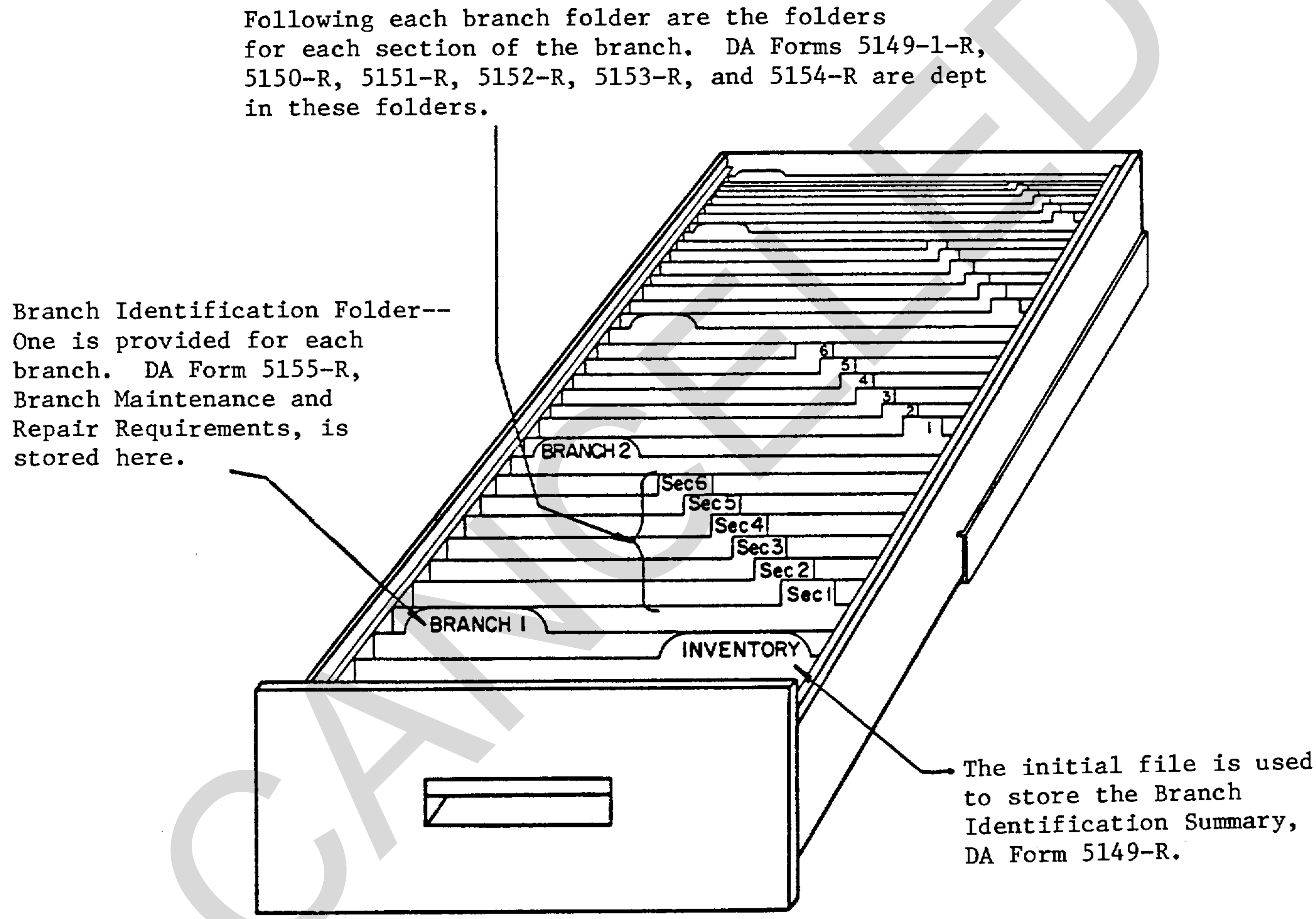


Figure 6-9. Example of a filing sequence for a manual record keeping system.

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- 02/02/81

PAVEMENT INSPECTION
FORT EUSTIS

BRANCH NAME - DICKMAN STREET
BRANCH NUMBER - IDICK
SECTION NUMBER - 01

SECTION LENGTH - 414 LF
SECTION WIDTH - 21 LF
SECTION AREA - 966 SY

INSPECTION DATE - 12/03/79 PCI= 53 RATING= FAIR
CONDITION- RIDING-C1 SAFETY-C1 DRAINAGE-C1 SHOULDERS-C1 OVERALL-C1

TOTAL NUMBER OF SAMPLES IN SECTION= 4
NUMBER OF SAMPLES SURVEYED= 4
RECOMMEND ALL SAMPLE UNITS TO BE SURVEYED.

EXTRAPOLATED DISTRESS QUANTITIES FOR SECTION-

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY-PCT	DEDUCT-VALUE
ALLIGATOR CR	HIGH	15 SF	0.17	14.2
ALLIGATOR CR	LOW	680 SF	7.82	29.5
ALLIGATOR CR	MEDIUM	60 SF	0.69	17.7
BLEEDING	LOW	8 LF	0.09	0.0
DEPRESSION	LOW	18 SF	0.20	4.0
EDGE CR	HIGH	4 LF	0.04	7.4
LONG/TRANS CR	LOW	287 LF	3.30	7.6
PATCH/UTIL CUT	LOW	100 SF	1.15	2.4
PATCH/UTIL CUT	MEDIUM	50 SF	0.57	7.0
POTHOLE	HIGH	4 NMBR	0.04	40.2
RUTTING	LOW	10 SF	0.11	1.0

Figure 7-1. Example of inspection report.

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]	TINC02 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.

392-550 0 - 83 - 5 : QL 3

REPORT DATE - 81/02/02.

MAINTENANCE AND REPAIR GUIDELINES

BRANCH NAME - DICKMAN STREET
BRANCH NMBR - IDICK
SECTION NMBR - 01

SECTION LENGTH - 414 LF
SECTION WIDTH - 21 LF
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

INFLATION RATE 6.00 PERCENT
ANALYSIS PERIOD - 20 YEARS
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 COST	ALT A PRES COST	ALT B COST	ALT B PRES COST	ALT C COST	ALT C PRES 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.

APPENDIX A

REFERENCES

A-1. References for PAVER (roads)

Army Technical Manual 5-624	Maintenance and Repair of Surface Areas.
Army Technical Manual 5-822-2	General Provisions and Geometric Design for Roads, Streets, Walks and Open Storage Areas.
Army Technical Manual 5-822-5	Flexible Pavements for Roads, Streets, Walks and Open Storage Areas.
Army Technical Manual 5-822-6	Rigid Pavements for Roads, Streets, Walks and Open Storage Areas.

A-2. References for PAVER (airfields)

Air Force Regulation 93-5*	Airfield Pavement Evaluation Program.
Army Technical Manual 5-827-2	Flexible Airfield Pavement Evaluation.
Army Technical Manual 5-827-3	Rigid Airfield Pavement Evaluation.

*May be obtained from Air Force Publications Distribution Center, Baltimore, MD 21220.

APPENDIX B

DISTRESS IDENTIFICATION GUIDE

B-1. User instructions.

a. Types of distress found in jointed concrete and asphalt-surfaced pavements are listed alphabetically in this appendix. Each listing includes the name of the distress, its description, a narrative and photographic description of its severity levels, and its standard measurement or count criteria. Nineteen distress types have been identified for each of the asphalt and jointed concrete-surfaced pavements; however, only some of these distress types will be encountered frequently during the inspection. Common distress types for asphalt surfaced pavements include alligator cracking, block cracking, bumps, joint reflection cracking, longitudinal and transverse cracking, patching, potholes, rutting, and weathering. Common distress types for jointed concrete pavements include corner break, divided slab, joint seal damage, linear cracking, patching (more than 5 square feet), scaling, shrinkage cracks, corner spalling, and joint spalling. The rest of the distress types included in this appendix may not be encountered as frequently, except in specific geographic locations. For example, durability ("D") cracking in concrete pavements may be encountered frequently in pavements subjected to a high number of freeze-thaw cycles.

b. It is important that the pavement inspector be thoroughly familiar with all common distress types and their levels of severity. When determining the PCI for a pavement, section, it is imperative that the inspector follow the definitions and criteria described in this manual and appendix. The inspector should study this appendix before an inspection and carry a copy for reference during the inspection.

B-2. Distress in asphalt pavements

a. During the field condition surveys and validation of the PCI, several questions were commonly asked regarding the identification and measurement of some of the distresses. The answers to these questions are included under the section titled "How to Measure" for each distress. For convenience, however, items that are frequently referenced are listed below:

(1) If alligator cracking and rutting occur in the same area, each is recorded separately at its respective severity level.

(2) If bleeding is counted, polished aggregate is not counted in the same area.

(3) Bumps and sags are measured in units of linear feet.

(4) If a crack occurs at the ridge or edge of a bump, the crack and bump are recorded separately.

(5) If any distress (including cracking and potholes) is found in a patched area, is it not recorded; its effect on the patch, however, is considered in determining the severity level of the patch.

(6) A significant amount of polished aggregate should be present before it is counted.

(7) Potholes are measured by the number of holes having a certain diameter, not in units of square feet.

b. The above is not intended to be a complete list. To properly measure each distress type, the inspector must be familiar with its individual measurement criteria.

c. Nineteen distress types for asphalt-surfaced pavement are listed alphabetically following paragraph B-4.

B-3. Distress in jointed concrete pavements

a. Nineteen distress types for jointed concrete pavements are listed alphabetically following the asphalt distress types. Distress definitions apply to both plain and reinforced jointed concrete pavements, with the exception of linear cracking distress, which is defined separately for plain and reinforced jointed concrete.

b. During the field condition surveys and validation of the PCI, several questions were often asked regarding the identification and counting method of some of the distresses. The answers to these questions are included under the section titled "How to Count" for each distress. For convenience, however, items that are frequently referenced are listed below:

(1) Faulting is counted only at joints. Faulting associated with cracks is not counted separately

since faulting is incorporated into the severity level definitions of cracks. Crack definitions are also used in defining corner breaks and divided slabs.

(2) Joint seal damage is not counted on a slabby-slab basis. Instead, a severity level is assigned based on the overall condition of the joint seal in the area.

(3) Cracks in reinforced concrete slabs that are less than Y inch wide are counted as shrinkage cracks. Shrinkage cracks should not be used to determine if the slab is broken into four or more pieces.

(4) If the original distress of a patch is more severe than the patch, the original distress is the distress type recorded.

(5) Low-severity scaling (i.e., crazing) should only be counted if there is evidence that future scaling is likely to occur.

c. The above is not intended to be a complete list. To properly measure each distress type, the inspector must be familiar with its individual criteria.

d. The severity level of blow-up and railroad distress in jointed concrete pavements is rated according to the distress effect in ride quality (para B-4).

B-4. Ride quality

a. Ride quality must be evaluated in order to establish a severity level for the following distress types:

(1) Bumps.
(2) Corrugation.
(3) Railroad crossings.
(4) Shoving.
(5) Swells.

b. To determine the effects these distresses have on ride quality, the inspector should use the following severity-level definitions of ride quality:

(1) *L (low).* Vehicle vibrations (e.g., from corrugation) are noticeable, but no reduction in speed is necessary for comfort or safety, and/or individual bumps or settlements cause the vehicle to bounce slightly, but create little discomfort.

(2) *M (medium).* Vehicle vibrations are significant and some reduction in speed is necessary for safety and comfort, and/or individual bumps or settlements cause the vehicle to bounce significantly, creating some discomfort.

(3) *H (high).* Vehicle vibrations are so excessive that speed must be reduced considerably for safety and comfort, and/or individual bumps or settlements cause the vehicle to bounce excessively, creating substantial discomfort, and/or a safety hazard, and/or high potential vehicle damage.

c. Ride quality is determined by riding in a standard-size automobile over the pavement section at the posted speed limit. Pavement sections near stop signs should be rated at the normal deceleration speed used when approaching the sign.

ALPHABETICAL LISTING OF DISTRESS TYPES-ASPHALT-SURFACED PAVEMENT

Name of Distress: Alligator Cracking.

Description: Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphalt concrete surface under repeated traffic loading. Cracking begins at the bottom of the asphalt surface (or stabilized base) where tensil stress and strain are highest under a wheel load. The cracks propagate to the surface initially as a series of parallel longitudinal cracks. After repeated traffic loading, the cracks connect, forming many-sided, sharp-angled pieces that develop a pattern resembling chicken wire or the skin of an alligator. The pieces are less than 2 feet on the longest side.

Alligator cracking occurs only in areas subjected to repeated traffic loading, such as wheel paths. Therefore, it would not occur over an entire area unless the entire area were subjected to traffic loading. (Pattern-type cracking which occurs over an entire area that is not subjected to loading is called block cracking, which is not a load associated distress.)

Alligator cracking is considered a major structural distress and is usually accompanied by rutting.

Severity Levels: L-Fine, longitudinal hairline cracks running parallel to each other with none or only a few interconnecting cracks. The cracks are not spalled * (figs B-1 and B-2).

*Crack spalling is a breakdown of the material along the sides of the crack.

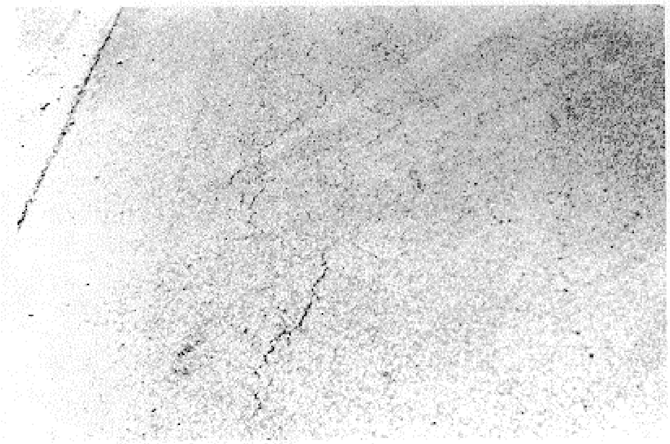


Figure B-1. Low-severity alligator cracking.

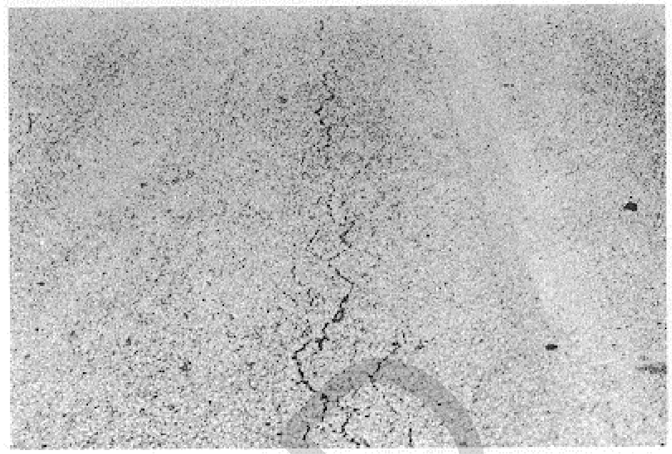


Figure B-2. Low-severity alligator cracking.

M-Further development of light alligator cracks into a pattern or network of cracks that may be lightly spalled (figs B-3, B-4, and B-5).

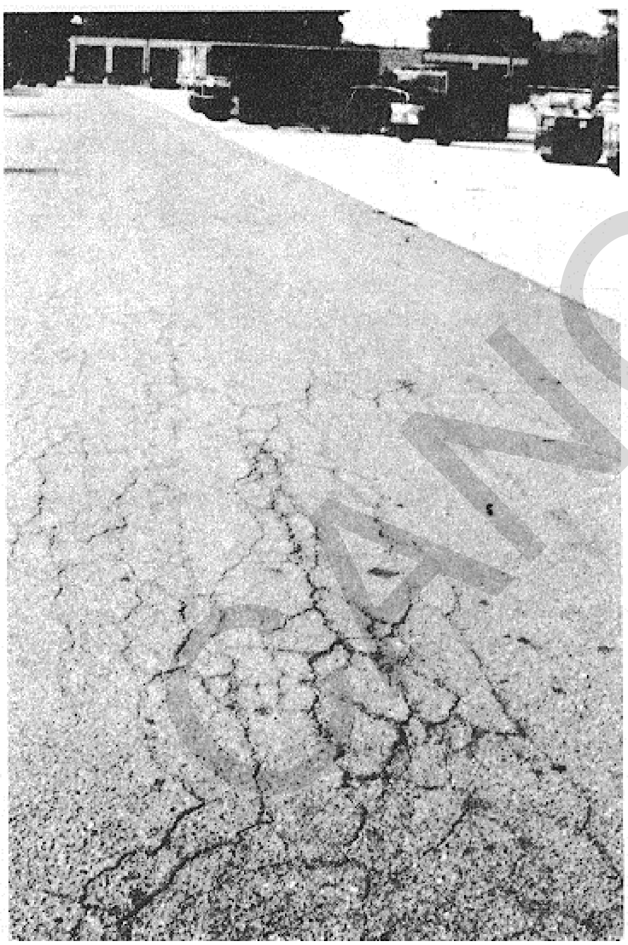


Figure B-3. Medium-severity alligator cracking

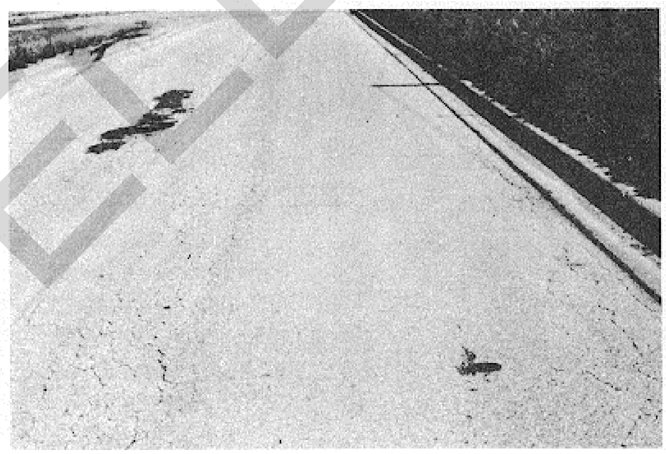


Figure B-4. Medium-severity alligator cracking.

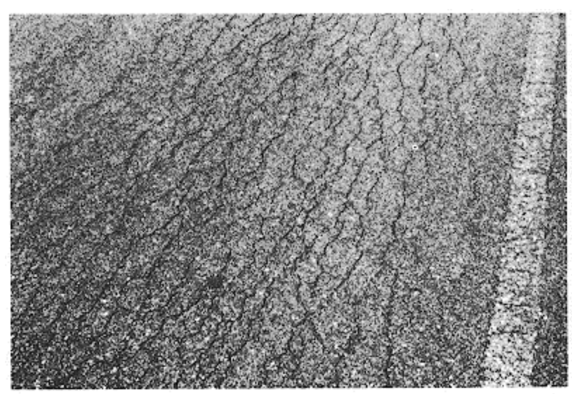


Figure B-5. Medium-severity alligator cracking.

H-Network or pattern cracking has progressed so that the pieces are well defined and spalled at the edges. Some of the pieces may rock under traffic (fig B-6 and B-7).

Figure B-6. High-severity alligator cracking.

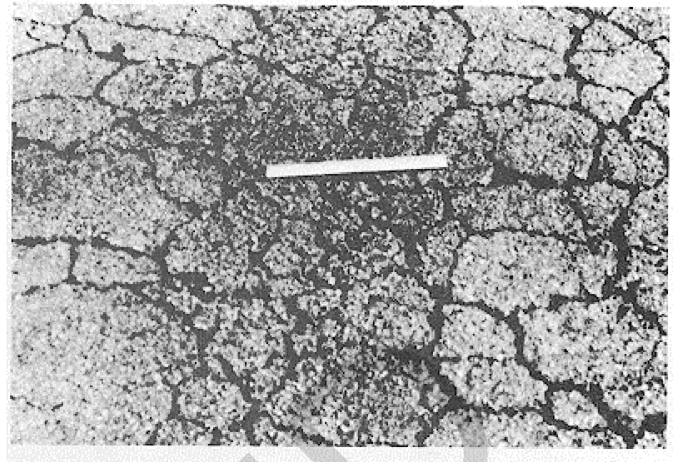


Figure B-7. High-severity alligator cracking.

How to Measure: Alligator cracking is measured in square feet of surface area. The major difficulty in measuring this type of distress is that two or three levels of severity often exist within one distressed area. If these portions can be easily distinguished from each other, they should be measured and recorded separately. However, if the different levels of Severity cannot be divided easily, the entire area should be rated at the highest severity level present.

Name of Distress: Bleeding

Description: Bleeding is a film of bituminous material on the pavement surface which a creates shiny, glass like, reflecting surface that usually becomes quite sticky. Bleeding is caused by excessive asphalt cement or tars in the mix, excess application of a bituminous sealant, and/or low air void content. It occurs when asphalt fills the voids of the mix during hot weather and then expands onto the pavement surface. Since the bleeding process is not reversible during cold weather, asphalt or tar will accumulate on the surface.

Severity Levels: L-Bleeding has only occurred to a very slight degree and it is noticeable only during a few days of the year. Asphalt does not stick to shoes or vehicles (fig B-8).

M-Bleeding has occurred to the extent that asphalt sticks to shoes and vehicles during only a few weeks of the year (fig B-9).

Figure B-8. Low-severity bleeding.

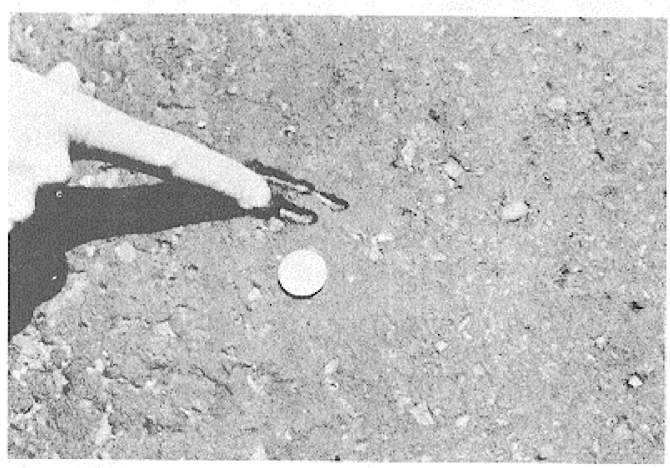


Figure B-9. Medium-severity bleeding.

H-Bleeding has occurred extensively and considerable asphalt sticks to shoes and vehicles during at least several weeks of the year (fig B-10).

Figure B-10. High-severity bleeding.

How to Measure: Bleeding is measured in square feet of surface area. If bleeding is counted, polished aggregate should not be counted.

Name of Distress: Block Cracking

Description: Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 1 by 1 foot to 10 by 10 feet. Block cracking is caused mainly by shrinkage of the asphalt concrete and daily temperature cycling (which results in daily stress/strain cycling). It is not load-associated. Block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large proportion of pavement area, but sometimes will occur only in nontraffic areas. This type of distress differs from alligator cracking in that alligator cracks form smaller, many-sided pieces with sharp angles. Also, unlike block cracks, alligator cracks are caused by repeated traffic loadings, and are therefore found only in traffic areas (i.e., wheel paths).

Severity Levels: L-Blocks are defined by low*-severity cracks (fig B-11).

*See definition of longitudinal and transverse cracking.

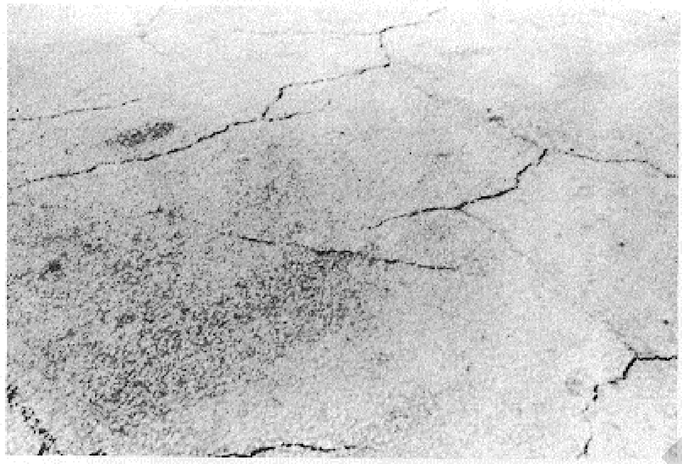


Figure B-11. Low-severity block cracking.

M-Blocks are defined by medium*-severity cracks (fig B-12 and B-13).

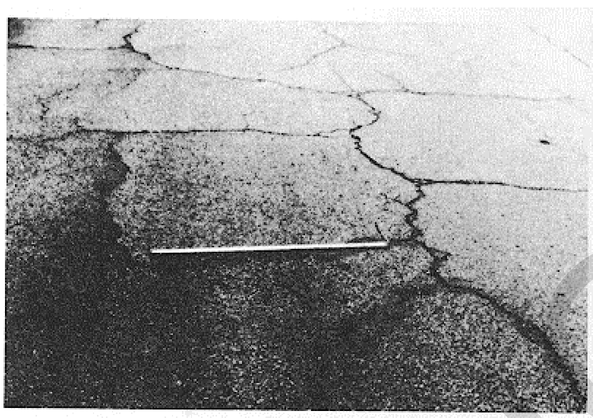


Figure B-12. Medium-severity block cracking.

Figure B-13. Medium-severity block cracking.

H-Blocks are defined by high*-severity cracks (fig B-14).

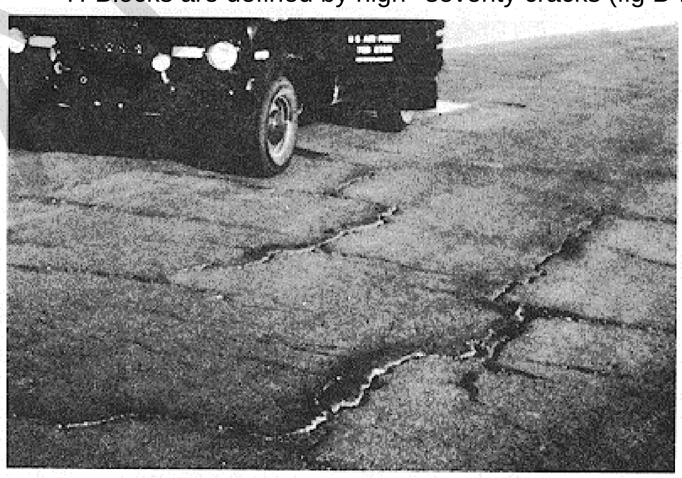


Figure B-14. High-severity block cracking.

*See definition of longitudinal and transverse cracking.

How to Measure: Block cracking is measured in square feet of surface area. It usually occurs at one severity level in a given pattern section; however, any areas of the pavement section having a distinctly different level of severity should be measured and recorded separately.

Name of Distress: Bumps and Sags.

Description: Bumps are small, localized, upward displacements of the pavement surface. They are different form shoves in that shoves are caused by unstable pavement. Bumps, on the other hand, can be caused by several factors, including-

1. Buckling or bulging of underlying Portland cement concrete (PCC) slabs in asphalt concrete (AC) overlay over PCC pavement.
2. Frost heave (ice, lens growth).
3. Infiltration and buildup of material in a crack in combination with traffic loading (sometimes called tenting).

Sags are small, abrupt, downward displacements of the pavement surface.

Distortion and displacement which occurs over large areas of the pavement surface, causing large and/or long dips in the pavement is called swelling.

Severity Levels: L-Bump or sag causes low-severity ride quality (fig B-15).

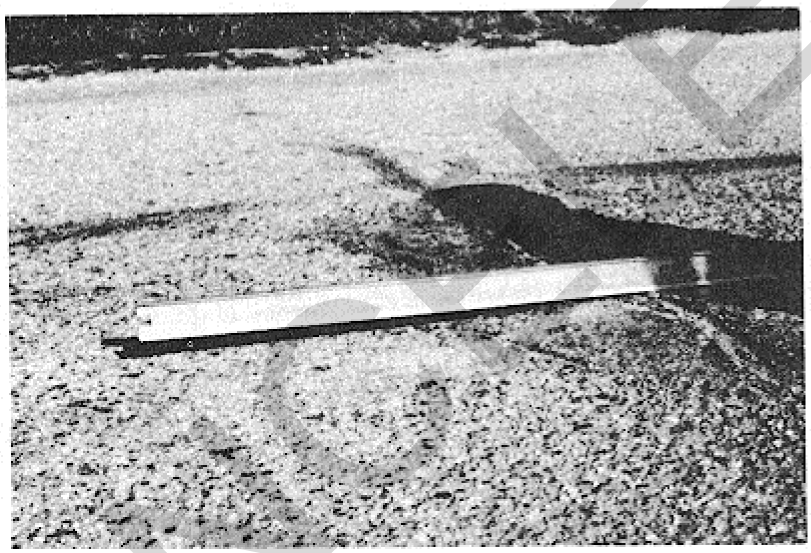


Figure B-15. Low-severity bumps and sags.

M-Bump or sag causes medium-severity ride quality (figs B-16, B-17, and B-18).

Figure B-16. Medium-severity bumps and sags.

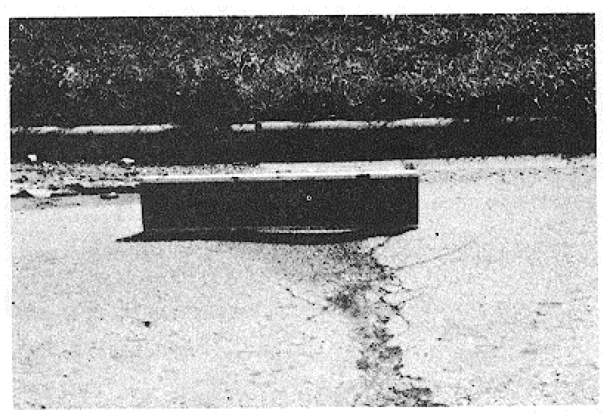


Figure B-17. Medium-severity bumps and sags.

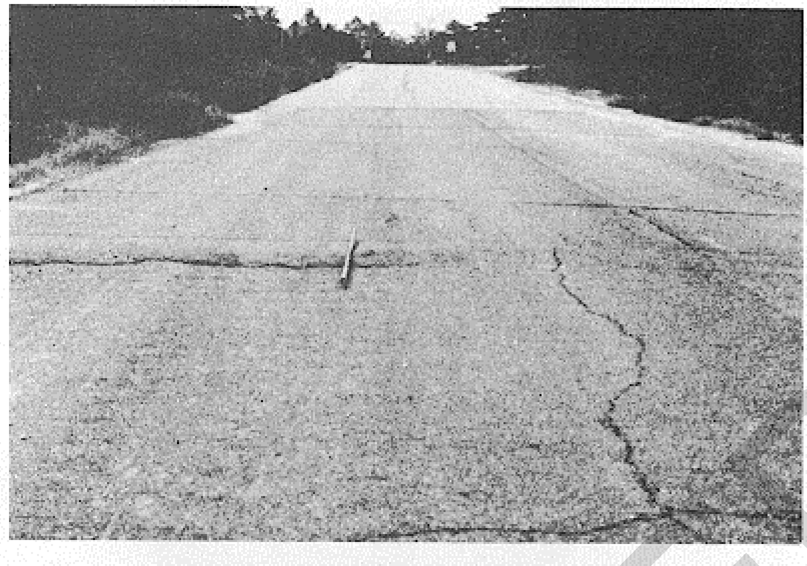


Figure B-18. Medium-severity bumps and sags.

H-Bump or sag cause high-severity ride quality (fig B-19).

How to Measure: Bumps or sags are measured in linear feet. If bumps appear in a pattern perpendicular to traffic flow and are spaced at less than 10 feet, the distress is called corrugation. If the bump occurs in combination with a crack, the crack is also recorded.

Name of Distress: Corrugation.

Description: Corrugation (also known as washboarding) is a series of closely spaced ridges and valleys (ripples) occurring at fairly regular intervals-usually less than 10 feet along the pavement. The ridges are perpendicular to the traffic direction. This type of distress is usually caused by traffic action combined with an unstable pavement surface or base. If bumps occur in a series of less than 10 feet, due to any cause, the distress is considered corrugation.

Severity Levels. L-Corrugation produces low-severity ride quality (fig B-20).

Figure B-19. High-severity bumps and sags.

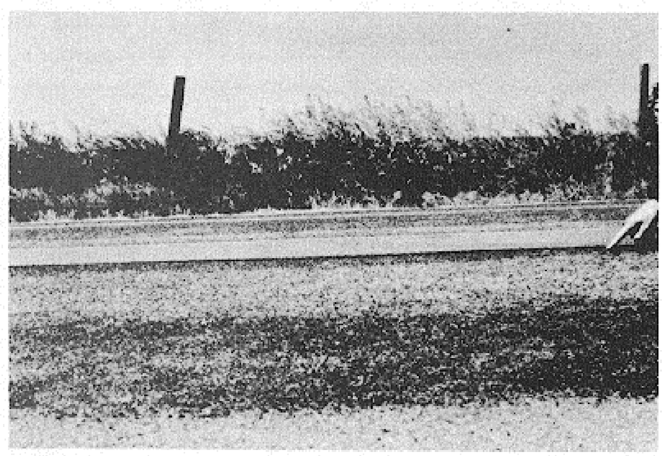


Figure B-20. Low-severity corrugation.

M-Corrugation produces medium-severity ride quality (figs B-21 and B-22).

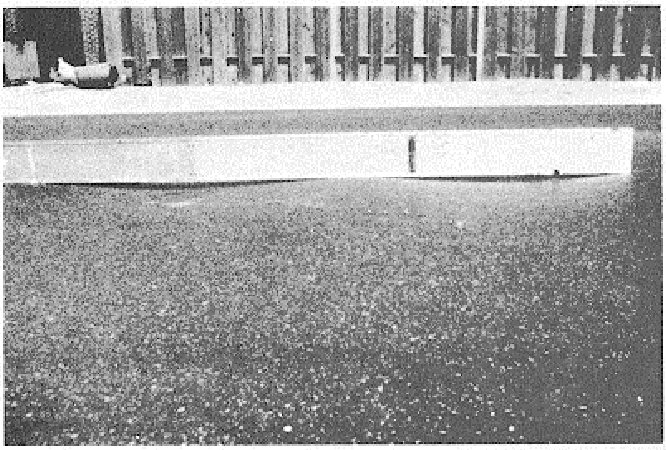


Figure B-21. Medium-severity corrugation.

Figure B-22. Medium-severity corrugation.

H-Corrugation produces high-severity ride quality (fig B-23).

How to Measure: Corrugation is measured in square feet of surface area.

Name of Distress: Depression.

Description: Localized pavement surface areas with elevations slightly lower than those of the surrounding pavement are called depressions. In many instances, light depressions are not noticeable until after a rain, when ponding water creates "birdbath" areas; on dry pavement, depressions can be spotted by looking for stains caused by ponding water. Depressions are created by settlement of the foundation soil or are a result of improper construction. Depressions cause some roughness, and when filled with water of sufficient depth, can cause hydroplaning. Sags, unlike depressions, are abrupt drops in elevations.

Severity Levels: Maximum depth of depression:
L-1/2 to 1 inch.
M-1 to 2 inches.
H-more than 2 inches.
See figures B-24 through B-26.

Figure B-23. High-severity corrugation.

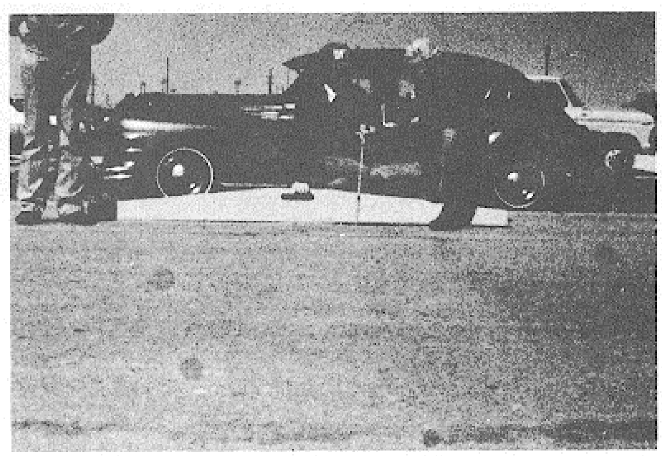


Figure B-24. Low-severity depression.

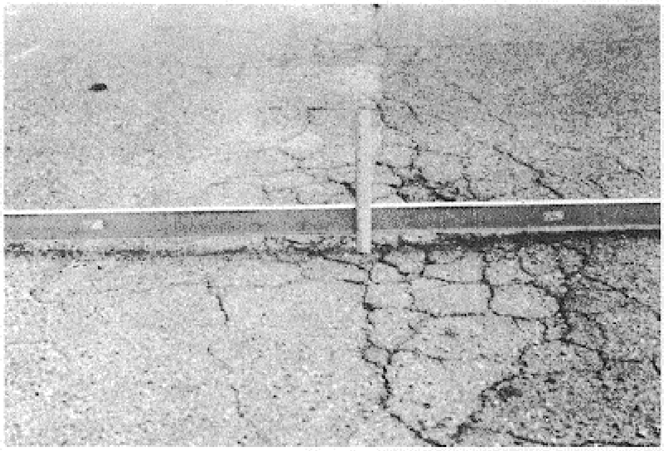


Figure B-25. Medium-severity depression.

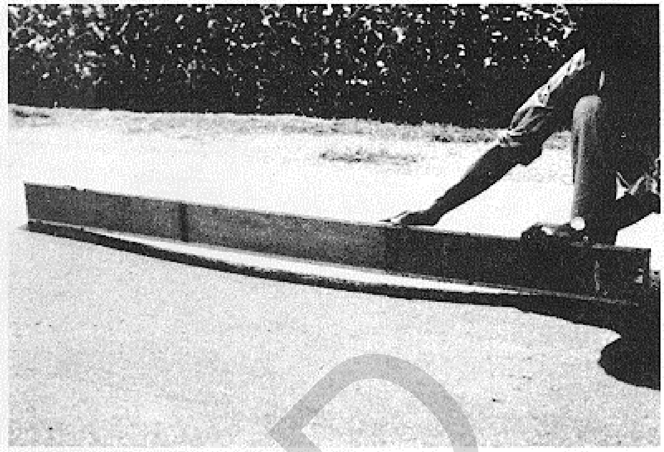


Figure B-26. High-severity depression.

How to Measure: Depressions are measured in square feet of surface area.

Name of Distress: Edge Cracking.

Description: Edge cracks are parallel to and usually within 1 to 2 feet of the outer edge of the pavement. This distress is accelerated by traffic loading and can be caused by frost-weakened base or subgrade near the edge of the pavement. The area between the crack and pavement edge is classified as raveled if it breaks up (sometimes to the extent that pieces are removed).

Severity Levels: L-Low or medium cracking with no breakup or raveling (fig B-27).

M-Medium cracks with some breakup and raveling (fig B-28).

Figure B-27. Low-severity edge cracking.

Figure B-28. Medium-severity edge cracking.

H-Considerable breakup or raveling along the edge (figs B-29 and B-30).

Figure B-29. High-severity edge cracking.

Figure B-30. High-severity edge cracking.

How to Measure: Edge cracking is measured in linear feet.

Name of Distress: Joint Reflection Cracking (from Longitudinal and Transverse PCC Slabs).

Description: This distress occurs only on asphalt-surfaced pavements which have been laid over a PCC slab. It does not include reflection cracks from any other type of base (i.e., cement- or lime-stabilized); such cracks are listed as longitudinal cracks and transverse cracks. Joint reflection cracks are mainly caused by the thermal- or moisture-induced movement of the PCC slab beneath the AC surface. This distress is not load-related; however, traffic loading may cause a breakdown of the AC surface near the crack. If the pavement is fragmented along a crack, the crack is said to be spalled. A knowledge of slab dimensions beneath the AC surface will help to identify these distresses.

Severity Levels: L-One of the following conditions exists (fig B-31):

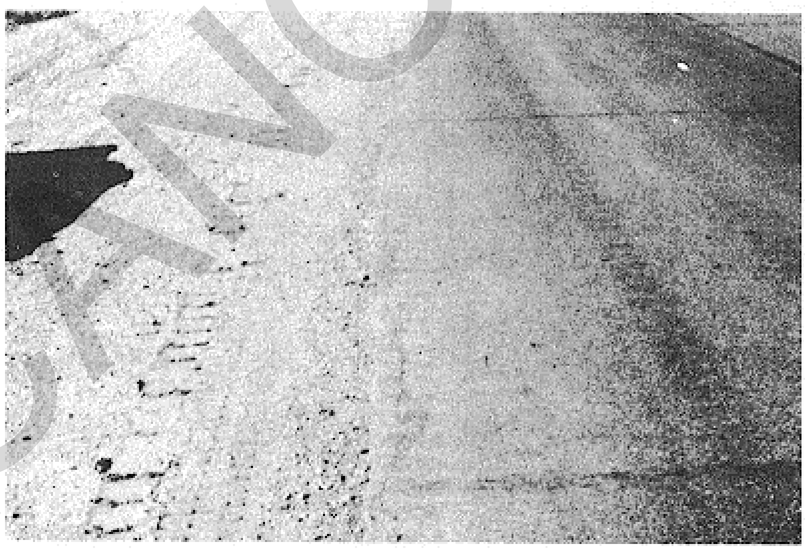


Figure B-31. Low-severity joint reflection cracking.

1. Nonfilled crack width is less than X inch, or
2. Filled crack of any width (filler in satisfactory condition).

M-One of the following conditions exists (fig B-32):

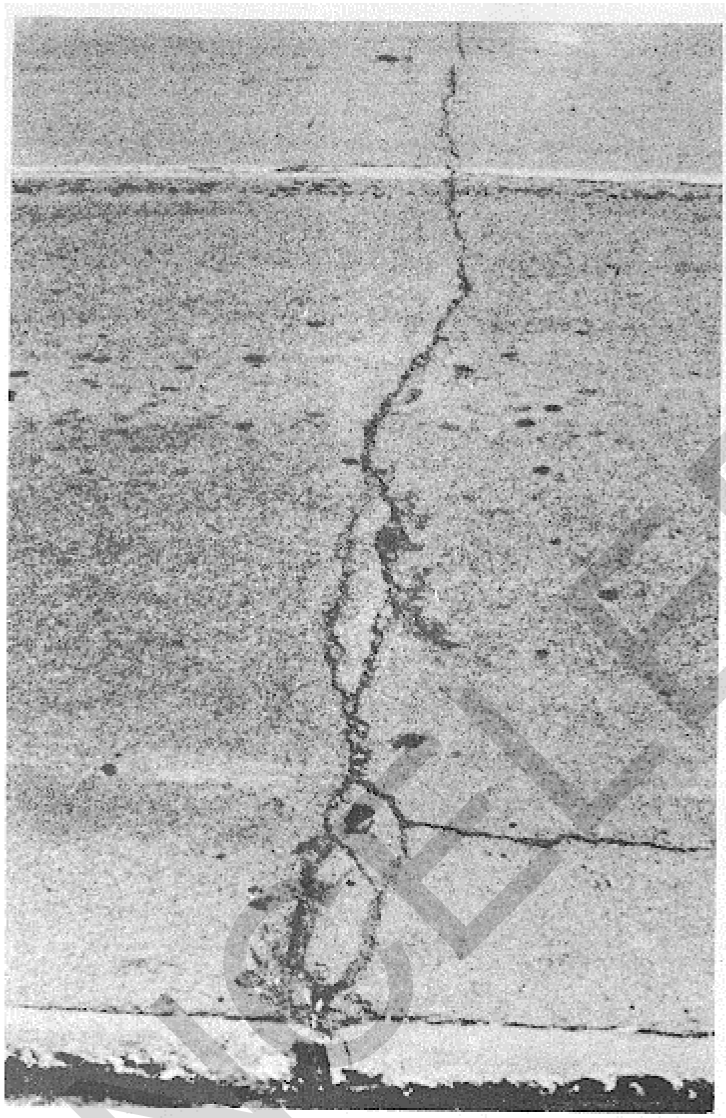


Figure B-32. Medium-severity joint reflection cracking.

1. Nonfilled crack width is % to 3 inches.
2. Nonfilled crack of any width up to 3 inches surrounded by light random cracking (fig B-32).
3. Filled crack of any width surrounded by light random cracking.

H-One of the following conditions exists (fig B-33):

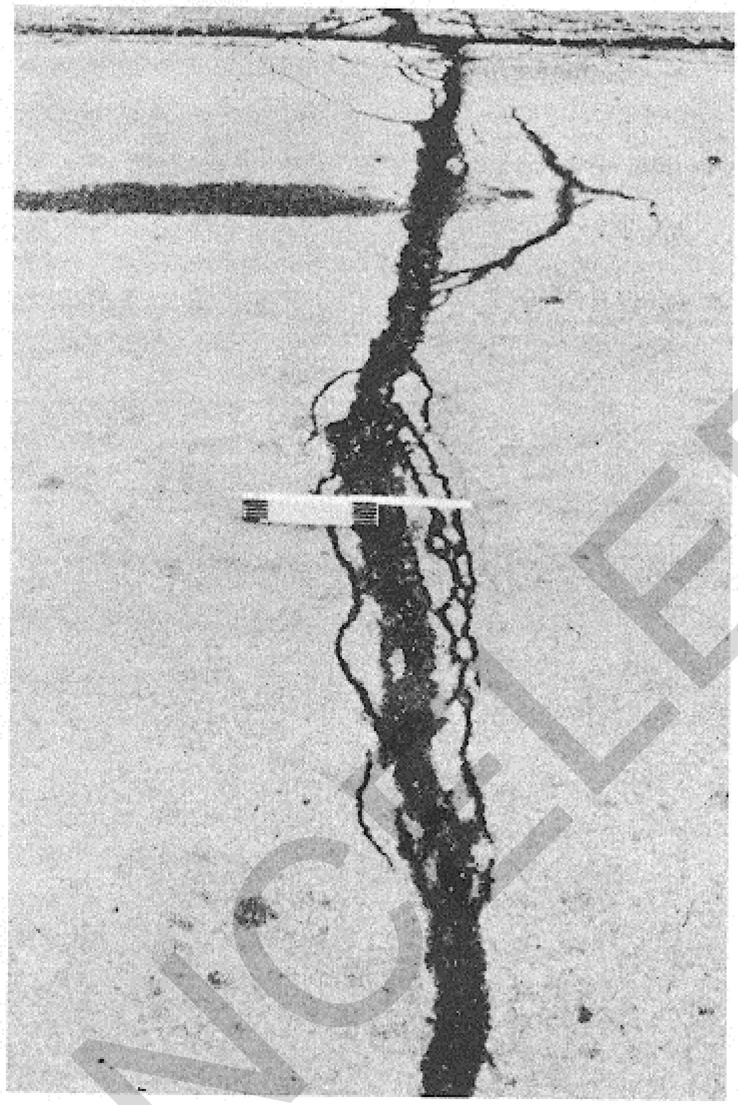


Figure B-33. High-severity joint reflection cracking.

1. Any crack, filled or nonfilled, surrounded by medium- or high-severity random cracking.
2. Nonfilled cracks over 3 inches.
3. A crack of any width where a few inches of pavement around a crack is severely broken. (Crack is severely broken.)

How to Measure: Joint reflection cracking is measured in linear feet. The length and severity level of each crack should be recorded separately. For example, a crack that is 50 feet long may have 10 feet of high severity; these would all be recorded separately. If a bump occurs at the reflection crack, it is also recorded.

Name of Distress: Lane/Shoulder Drop Off.

Description: Lane/shoulder drop off is a difference in elevation between the pavement edge and the shoulder. This distress is caused by shoulder erosion, shoulder settlement, or by building up the roadway without adjusting the shoulder level.

Severity Levels: L-The difference in elevation between the pavement edge and shoulder is 1 to 2 inches (fig B-34).

M-The difference in elevation is over 2 to 4 inches (fig B-35).

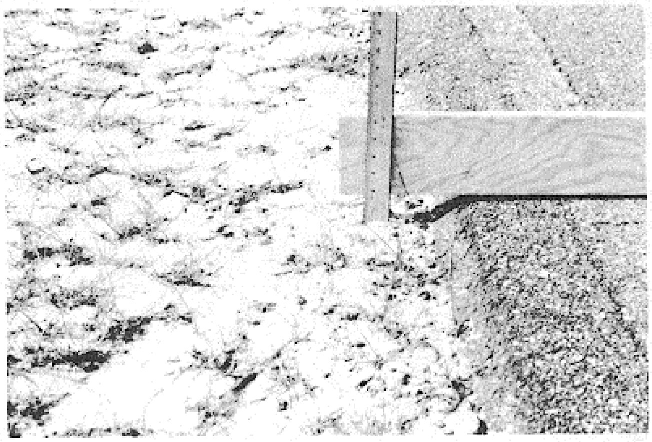


Figure B-34. Low-severity lane/shoulder drop off.

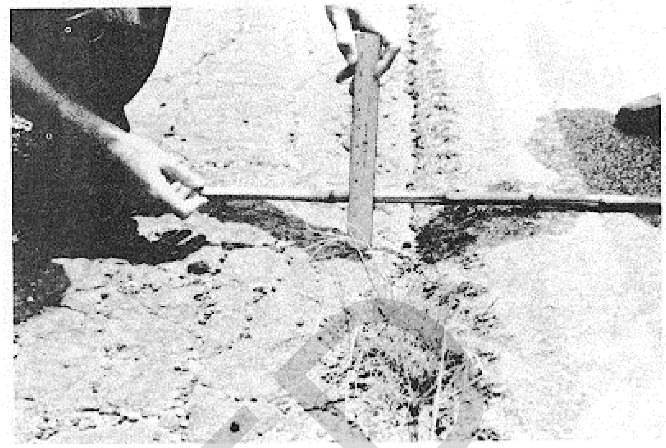


Figure B-35. Medium-severity lane/shoulder drop off.

H-The difference in elevation is greater than 4 inches (figs B-36 and B-37).

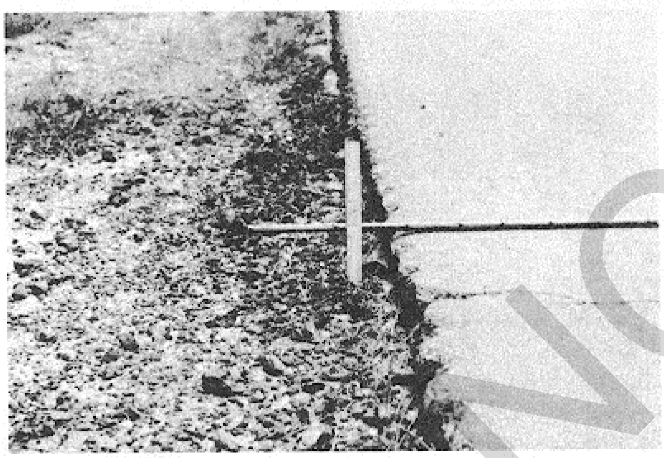


Figure B-36. High-severity lane/shoulder drop off.

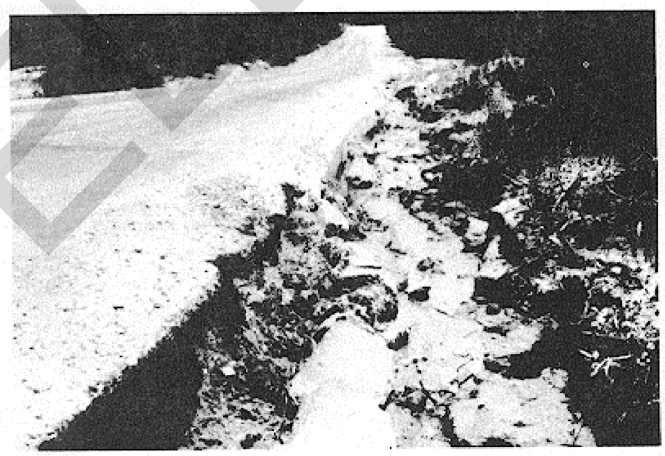


Figure B-37. High-severity lane/shoulder drop off

How to Measure: Lane/shoulder drop off is measured in linear feet.

Name of Distress: Longitudinal and Transverse Cracking (Non-PCC Slab Joint Reflective).

Description: Longitudinal cracks are parallel to the pavement's centerline or laydown direction. They may be caused by-

1. A poorly constructed paving lane joint.
2. Shrinkage of the AC surface due to low temperatures or hardening of the asphalt and/or daily temperature cycling.
3. A reflective crack caused by cracking beneath the surface course, including cracks in PCC slabs (but not PCC joints).

Transverse cracks extend across the pavement at approximately right angles to the pavement centerline or direction of laydown. These may be caused by conditions 2 and 3 above. These types of cracks are not usually load-associated.

Severity Levels: L-One of the following conditions exists (see fig B-38):

1. Nonfilled crack width is less than % inches, or
2. Filled crack of any width (filler in satisfactory condition).

M-One of the following conditions exists (figs B-39 and B-40):

Figure B-38. Low-severity longitudinal and transverse cracking.

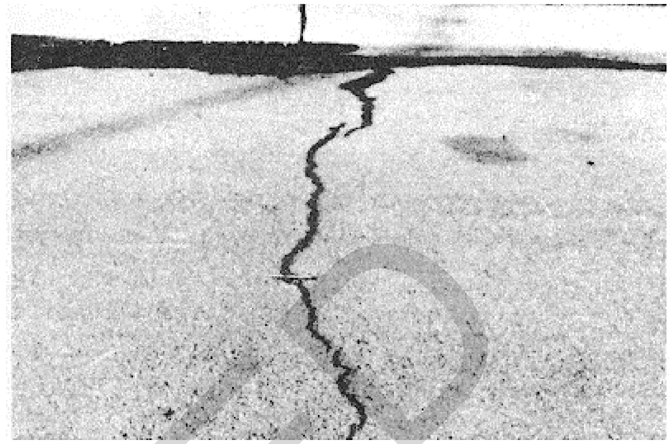


Figure B-39. Medium-severity longitudinal and transverse cracking.

1. Nonfilled crack width is X8 to 3 inches.
2. Nonfilled crack of any width up to 3 inches surrounded by light and random cracking.
3. Filled crack of any width surrounded by light random cracking.

H-One of the following conditions exists (fig B-41):

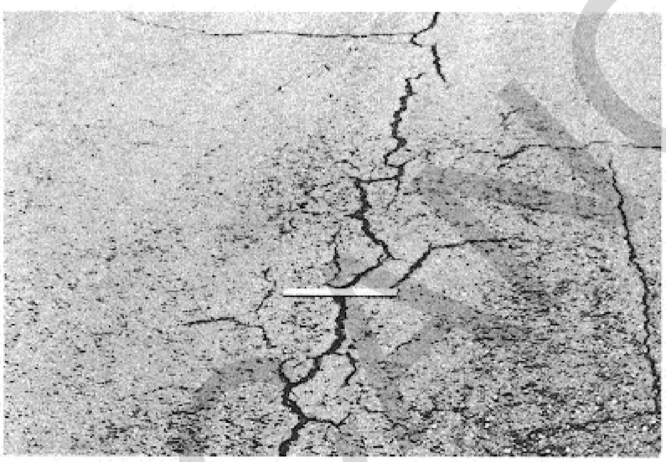


Figure B-40. Medium-severity longitudinal and transverse cracking (A4 inch crack surrounded by light random cracks).

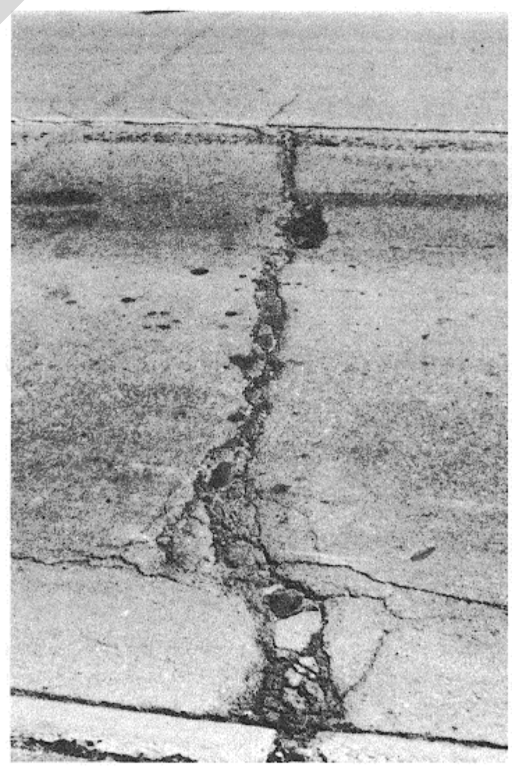


Figure B-41. High-severity longitudinal and transverse cracking.

1. Any crack filled or nonfilled surrounded by medium- or high-severity random cracking.
2. Nonfilled crack over 3 inches.
3. A crack of any width where a few inches of pavement around the crack is severely broken.

How to Measure: Longitudinal and transverse cracks are measured in linear feet. The length and severity of each crack should be recorded after identification. If the crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately. If a bump or sag occurs at the crack, it is also recorded.

Name of Distress: Patching and Utility Cut Patching.

Description: A patch is an area of pavement which has been replaced with new material to repair the existing pavement. A patch is considered a defect no matter how well it is performing. (A patched area or adjacent area usually does not perform as well as an original pavement section.) Generally, some roughness is associated with this distress.

Severity Levels: L-Patch is in good condition and satisfactory. Ride quality is rated as low-severity or better (figs B-42, B-43, and B-44).

M-Patch is moderately deteriorated and/or ride quality is rated as medium-severity (fig B-45).

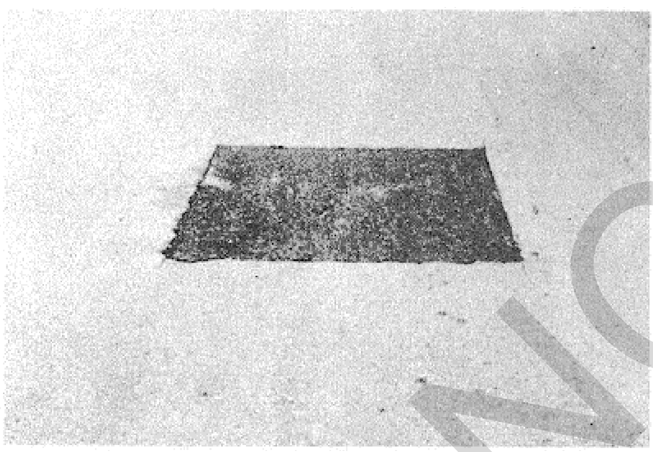


Figure B-42. Low-severity patching and utility cut patching.

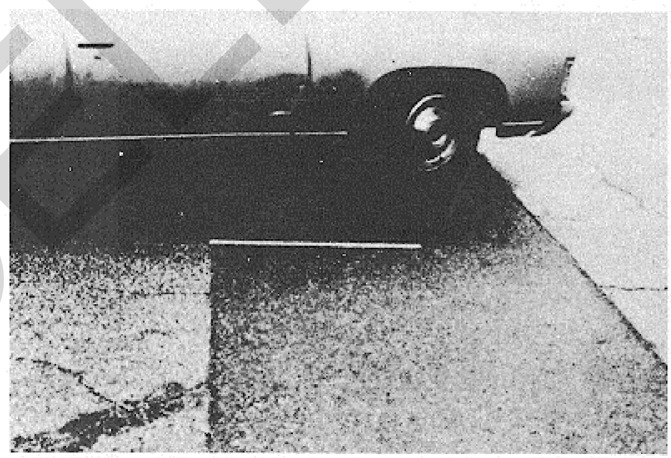


Figure B-43. Low-severity patching and utility cut patching.

Figure B-44. Low-severity patching and utility cut patching.

Figure B-45. Medium-severity patch.

H-Patch is badly deteriorated and/or ride quality is rated as high severity. Patch needs replacement soon (fig B-46).

How to Measure: Patching is rated in square feet of surface area. However, if a single patch has areas of differing severity, these areas should be measured and recorded separately. For example, a 25-square-foot patch may have 10 square feet of medium severity and 15 square feet of low severity. These areas would be recorded separately. No other distresses (e.g., shoving or cracking) are recorded within a patch (e.g., even if patch material is shoving or cracking, the area is rated only as a patch).

If a large amount of pavement has been replaced, it should not be recorded as a patch, but considered as new pavement (e.g., replacement of full intersection).

Name of Distress: Polished Aggregate.

Description: This distress is caused by repeated traffic applications. When the aggregate in the surface becomes smooth to the touch, adhesion with vehicle tires is considerably reduced. When the portion of aggregate extending above the surface is small, the pavement texture does not significantly contribute to reducing vehicle speed. Polished aggregate should be counted when close examination reveals that the aggregate extending above the asphalt is negligible, and the surface aggregate is smooth to the touch. This type of distress is indicated when the number on a skid resistance test is low or has dropped significantly from previous ratings.

Severity Levels: No degrees of severity are defined. However, the degree of polishing should be significant before it is included in the condition survey and rated as a defect (fig B-47).

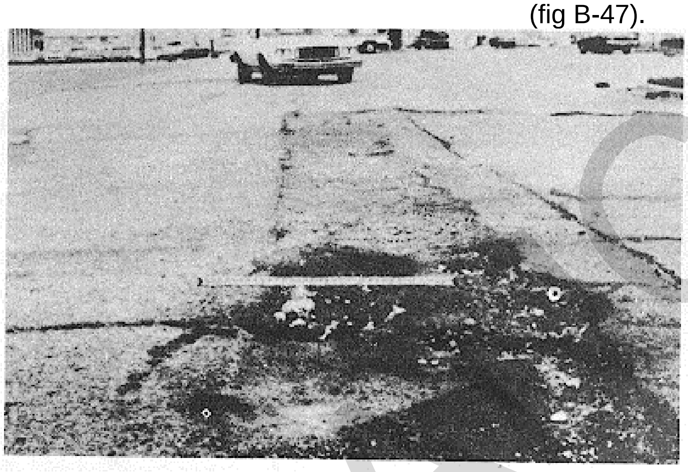


Figure B-46. High-severity patching and utility cut patching.

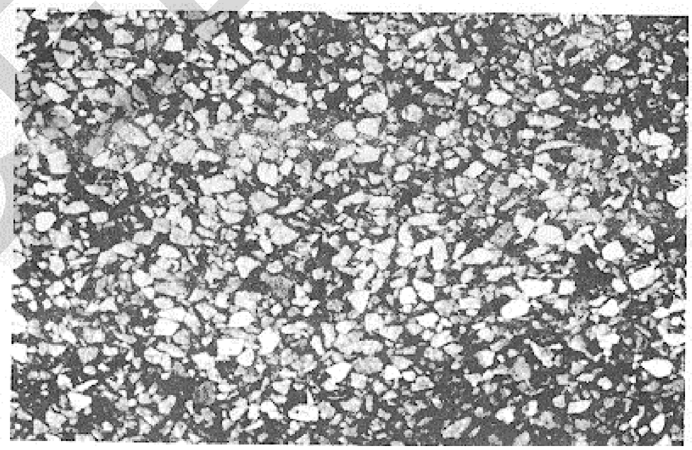


Figure B-47. Polished aggregate.

How to Count: Polished aggregate is measured in square feet of surface area. If bleeding is counted, polished aggregate should not be counted.

Name of Distress: Potholes.

Description: Potholes are small (usually less than 3 feet in diameter), bowl-shaped depressions in the pavement surface. They generally have sharp edges and vertical sides near the top of the hole. Their growth is accelerated by free moisture collection inside the hole. Potholes are produced when traffic abrades small pieces of the pavement surface. The pavement then continues to disintegrate because of poor surface mixtures, weak spots in the base or subgrade, or because it has reached a condition of high-severity alligator cracking. Potholes are generally structurally related distresses and should not be confused with raveling and weathering. Thus, when holes are created by high-severity alligator cracking, they should be identified as potholes, not as weathering.

Severity Levels: The levels of severity for potholes under 30 inches in diameter are based on both the diameter and the depth of the pothole according to the following table.

Maximum depth of pothole	*Average diameter (inches)*		
	4 to 8	Over 8 to 18	Over 18 to 30
1/2 to 1	L	L	M
>1 to 2	L	M	H
>2	M	M	H

If the pothole is over 30 inches in diameter, the area should be determined in square feet and divided by 5 square feet to find the equivalent number of holes. If the depth is 1 inch or less, they are considered medium severity. If the depth is over 1 inch, they are considered high severity (figs B-48 through B-52).

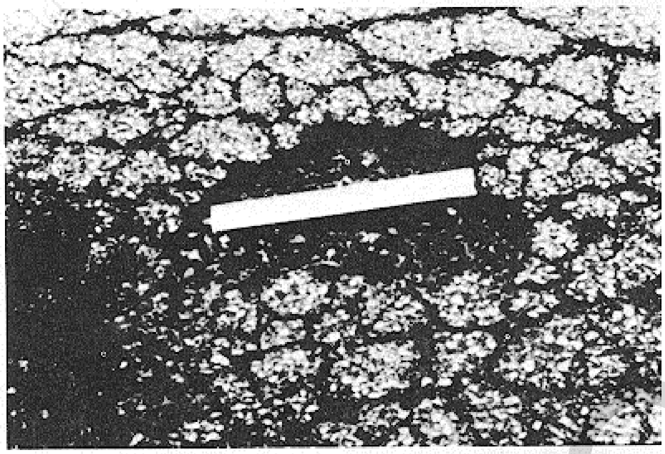


Figure B-48. Low-severity pothole.

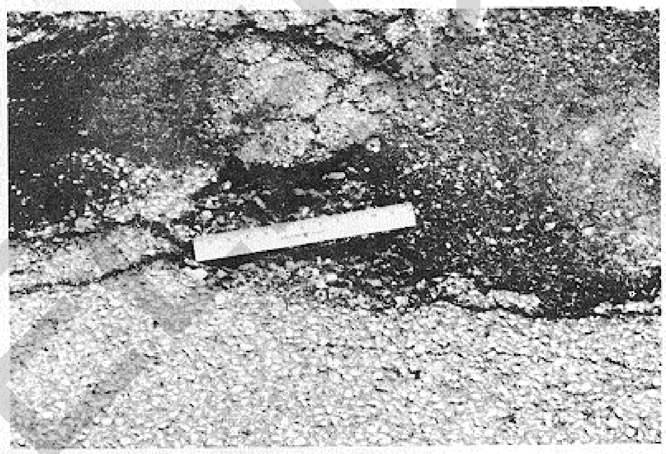


Figure B-49. Low-severity pothole.

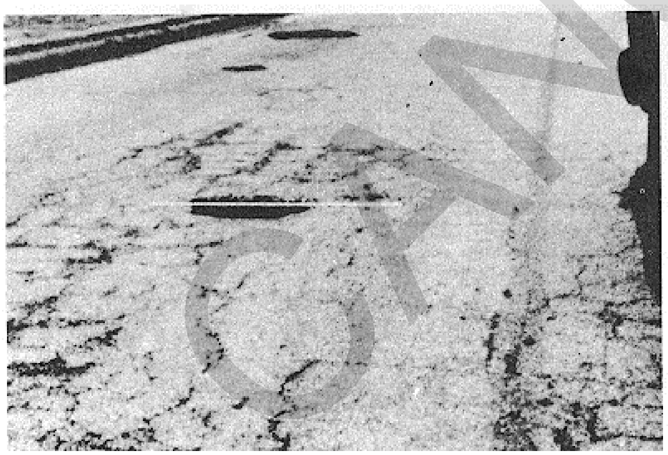


Figure B-50. Medium-severity pothole.

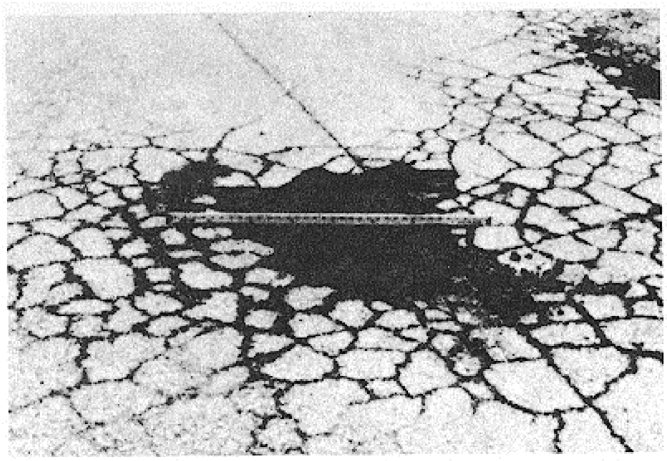


Figure B-51. High-severity pothole.

How to Measure: Potholes are measured by counting the number that are low-, medium-, and high-severity and recording them separately.

Name of Distress: Railroad Crossing.

Description: Railroad crossing defects are depressions or bumps around and/or between tracks.

Severity Levels: L-Railroad crossing causes low-severity ride quality (fig B-53).

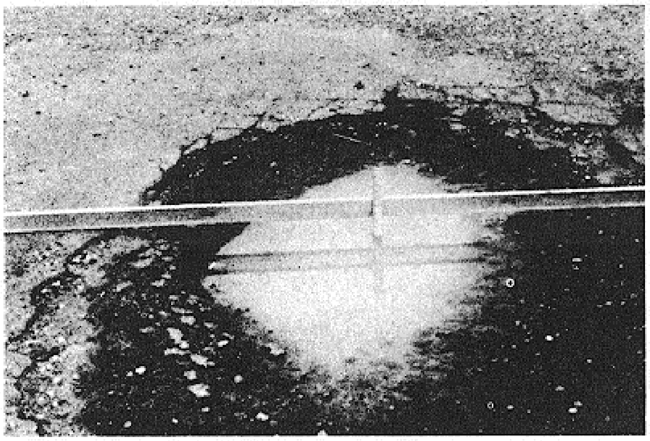


Figure B-52. High-severity pothole.

Figure B-53. Low-severity railroad crossing.

M-Railroad crossing causes medium-severity ride quality (fig B-54).

H-Railroad crossing causes high-severity ride quality (fig B-55).

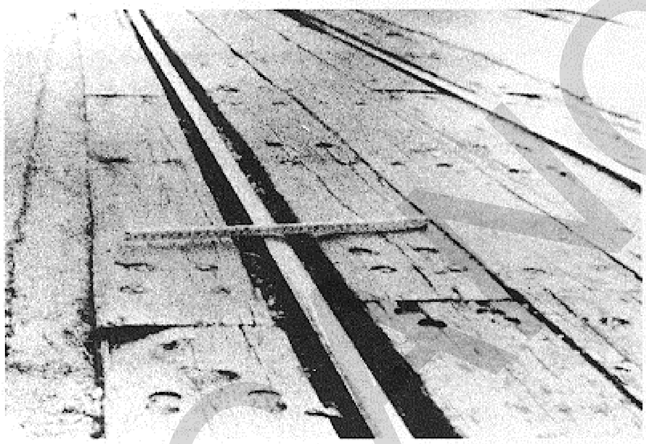


Figure B-54. Medium-severity railroad crossing.

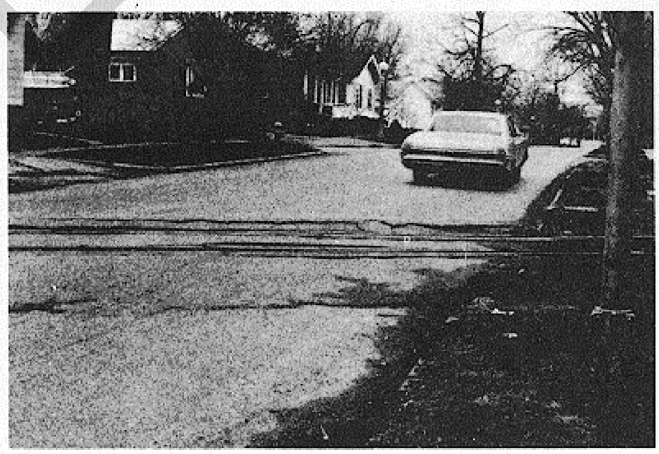


Figure B-55. High-severity railroad crossing.

How to Measure: The area of the crossing is measured in square feet of surface area. If the crossing does not affect ride quality, it should not be counted. Any large bump created by the tracks should be counted as part of the crossing.

Name of Distress: Rutting.

Description: A rut is a surface depression in the wheel paths. Pavement uplift may occur along the sides of the rut, but in many instances, ruts are noticeable only after a rainfall, when the paths are filled with water. Rutting stems from a permanent deformation in any of the pavement layers or subgrade, usually caused by consolidated or lateral movement of the materials due to traffic loads. Significant rutting can lead to major structural failure of the pavement.

Severity Levels: Mean Rut Depth:
L-1/4- to 1/2 inches.
M--> 1/2 to 1 inches.
H-> 1 inches.
See figures B-56 through B-59.

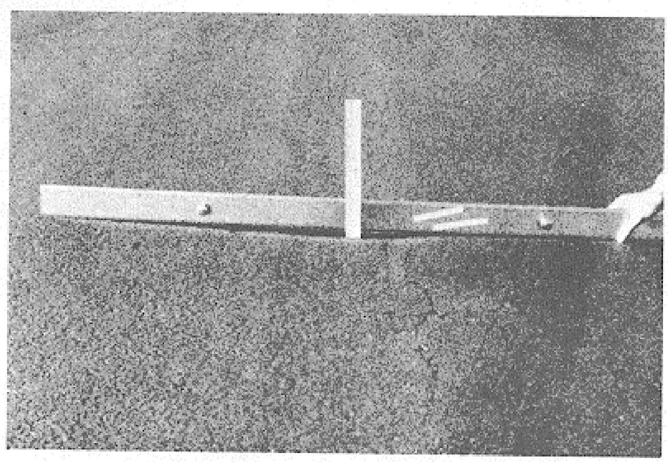


Figure B-56. Low-severity rutting.

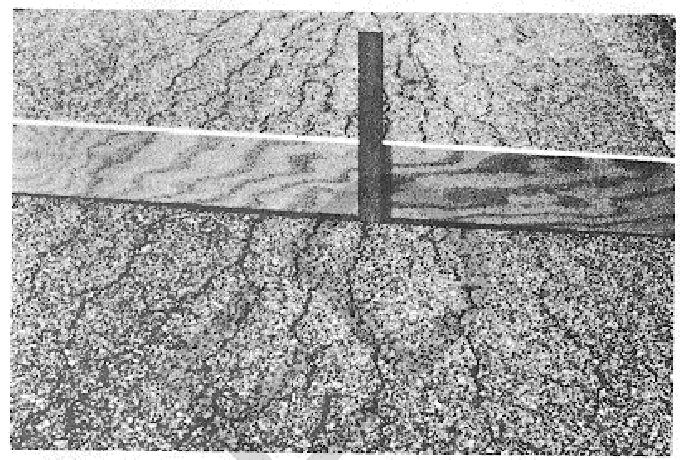


Figure B-57. Low-severity rutting.

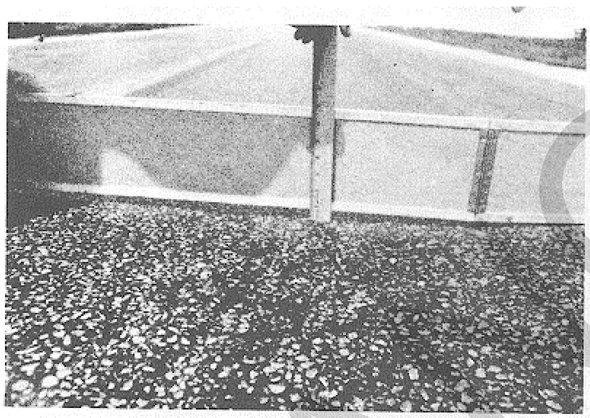


Figure B-58. Medium-severity rutting.

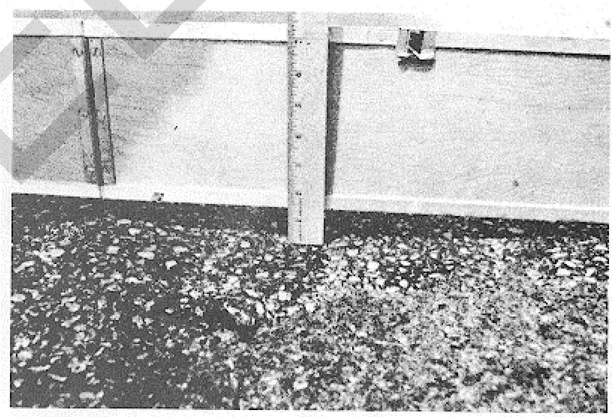


Figure B-59. High-severity rutting.

How to Measure: Rutting is measured in square feet of surface area, and its severity is determined by the mean depth of the rut (see above). The mean rut depth is calculated by laying a straightedge across the rut, measuring its depth, then using measurements taken along the length of the rut to compute its mean depth in inches.

Name of Distress: Shoving.

Description: Shoving is a permanent, longitudinal displacement of a localized area of the pavement surface caused by traffic loading. When traffic pushes against the pavement, it produces a short, abrupt wave in the pavement surface. This distress normally occurs only in unstable liquid asphalt mix (cutback or emulsion) pavements.

Shoves also occur where asphalt pavements abut PCC pavements; the PCC pavements increase in length and push the asphalt pavement, causing the shoving.

Severity Levels: L-Shove causes low-severity ride quality (fig B-60).

M-Shove causes medium-severity ride quality (fig B-61).

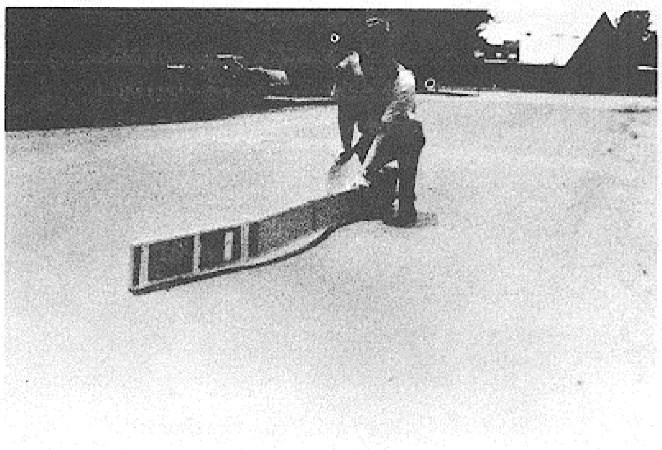


Figure B-60. Low-severity shoving.

Figure B-61. Medium-severity shoving approaching high severity.

H-Shove causes high-severity ride quality (fig B-62).

How to Measure: Shoves are measured in square feet of surface area.

Shoves occurring in patches are considered in rating the patch, not as a separate distress.

Name of Distress: Slippage Cracking.

Description: Slippage cracks are crescent or half-moon-shaped cracks having two ends pointing away from the direction of traffic. They are produced when breaking or turning wheels cause the pavement surface to slide or deform. This distress usually occurs when there is a low-strength surface mix or a poor bond between the surface and the next layer of the pavement structure.

Severity Levels: L-Average crack width is less than % inch (fig B-63).

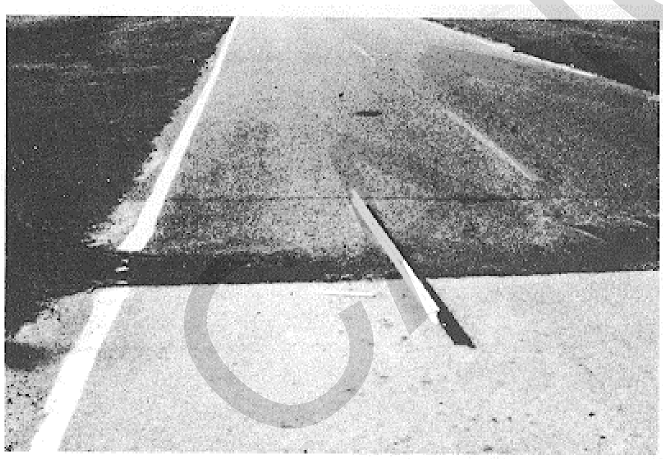


Figure B-62. High-severity shoving.

Figure B-63. Low-severity slippage cracking.

M-One of the following conditions exists (fig B-64):

1. Average crack width is between X and 1 inches.
2. The area around the crack is broken into tight-fitting pieces.

H-One of the following conditions exists (fig B-65):

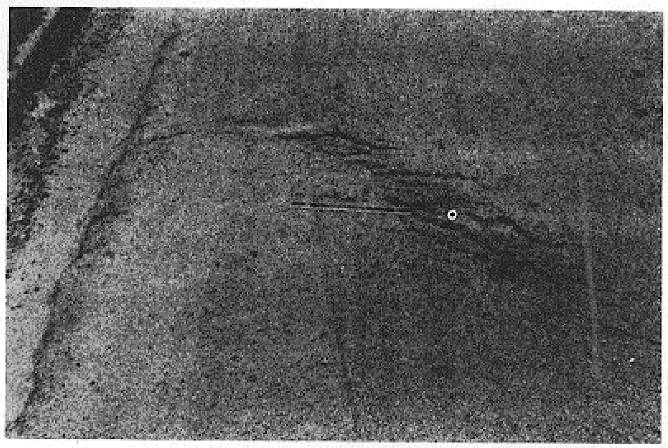


Figure B-64. Medium-severity slippage cracking.

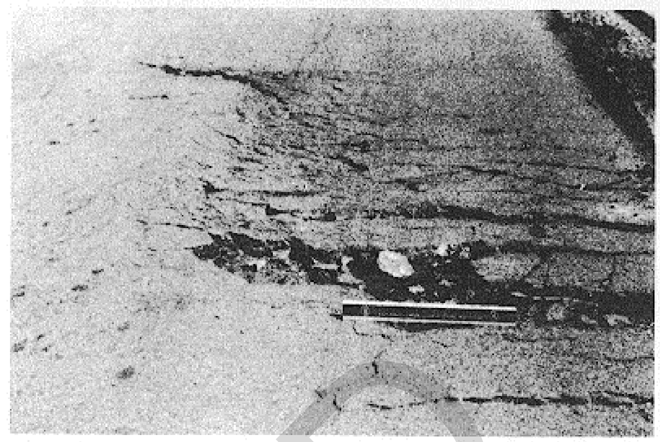


Figure B-65. High-severity slippage cracking.

1. The average crack width is greater than 1I inches.
2. The area around the crack is broken into easily removed pieces.

How to Measure: The area associated with a given slippage crack is measured in square feet and rated according to the highest level severity in the area.

Name of Distress: Swell.

Description: Swell is characterized by an upward bulge in the pavement's surface-a long, gradual wave of more than 10 feet long. Swelling can be accompanied by surface cracking. This distress is usually caused by frost action in the subgrade or by swelling soil.

Severity Levels: L-Swell causes low-severity ride quality. Low-severity swells are not always easy to see, but can be detected by driving at the speed limit over the pavement section. An upward acceleration will occur at the swell if it is present. (See fig B-66.) M-Swell causes medium-severity ride quality. (See fig B-66.) H-Swell causes high-severity ride quality. (See fig B-66.)

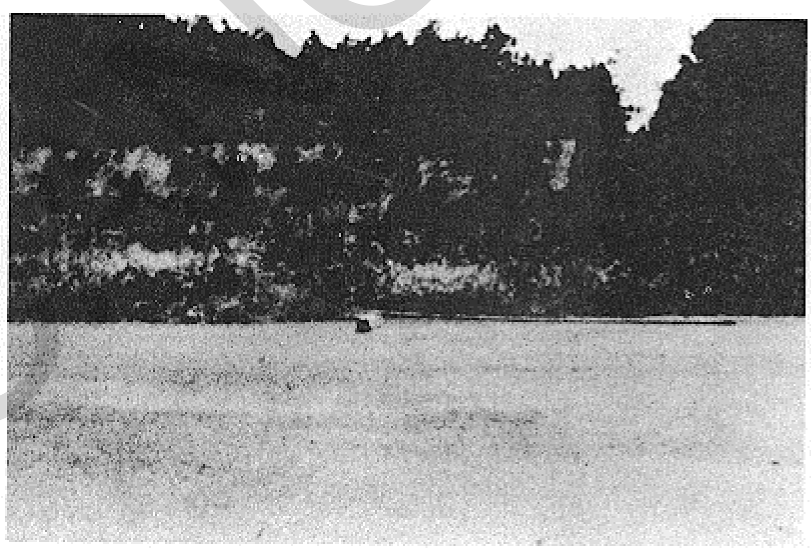


Figure B-66. Example swell; severity level is based on ride quality criteria.

How to Measure: The surface of the swell is measured in square feet.

Name of Distress: Weathering and Raveling.

Description: Weathering and raveling are the wearing away of the pavement surface caused by the loss of asphalt or tar binder and dislodged aggregate particles. These distresses indicate that either the asphalt binder has hardened appreciably or that a poor-quality mixture is present. In addition, raveling may be caused by certain types of traffic, e.g., tracked vehicles.

Severity Levels: L-Aggregate or binder has started to wear away. In some areas, the surface is starting to pit (figs B-67 and B-68).

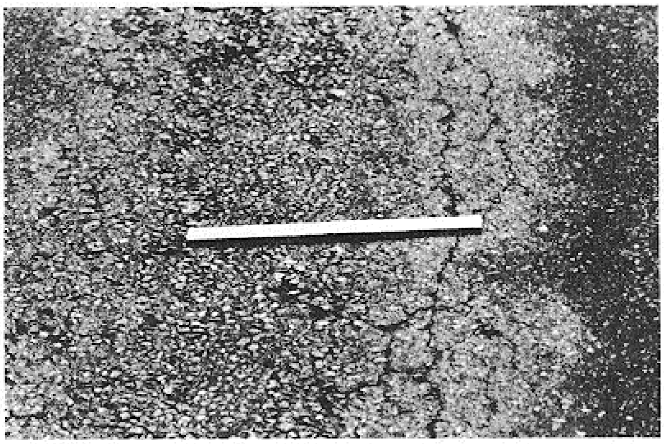


Figure B-67. Low-severity weathering and raveling.

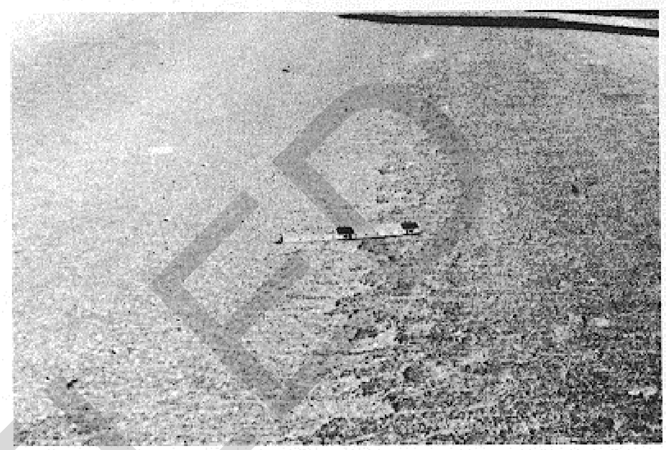


Figure B-68. Low-severity weathering and raveling caused by tracked vehicles.

M-Aggregate and/or binder has worn away. The surface texture is moderately rough and pitted (figs B-69 and B-70).

Figure B-69. Medium-severity weathering and raveling.

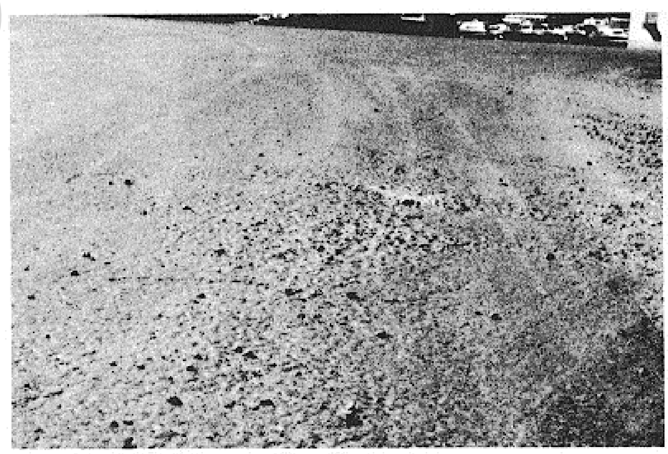


Figure B-70. Medium-severity weathering and raveling.

H-Aggregate and/or binder has been considerably worn away. The surface texture is very rough and severely pitted. The pitted areas are less than 4 inches in diameter and less than 3 inch deep; pitted areas larger than this are counted as potholes (fig B-71).

How to Measure: Weathering and raveling are measured in square feet of surface area.

ALPHABETICAL LISTING OF DISTRESS TYPES-JOINTED CONCRETE PAVEMENTS

Name of Distress: Blow-up/Buckling.

Description: Blow-ups or buckles occur in hot weather, usually at a transverse crack or joint that is not wide enough to permit slab expansion. The insufficient width is usually caused by infiltration of incompressible materials into the joint space. When expansion cannot relieve enough pressure, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blow-ups can also occur at utility cuts and drainage inlets.

Severity Levels: L-Buckling or shattering causes low-severity ride quality (fig B-72).

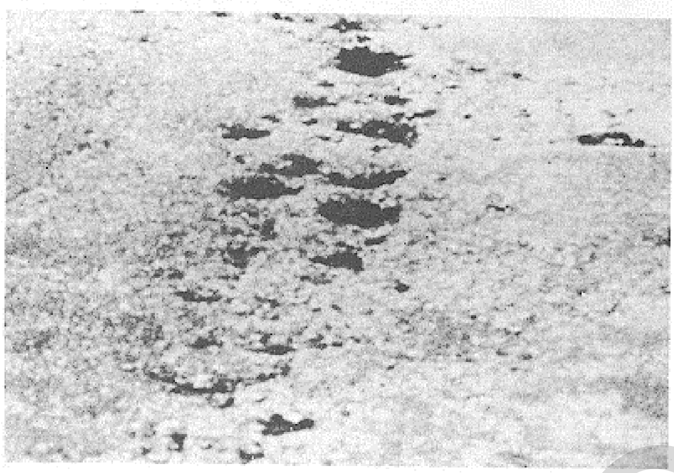


Figure B-71. High-severity weathering and raveling.

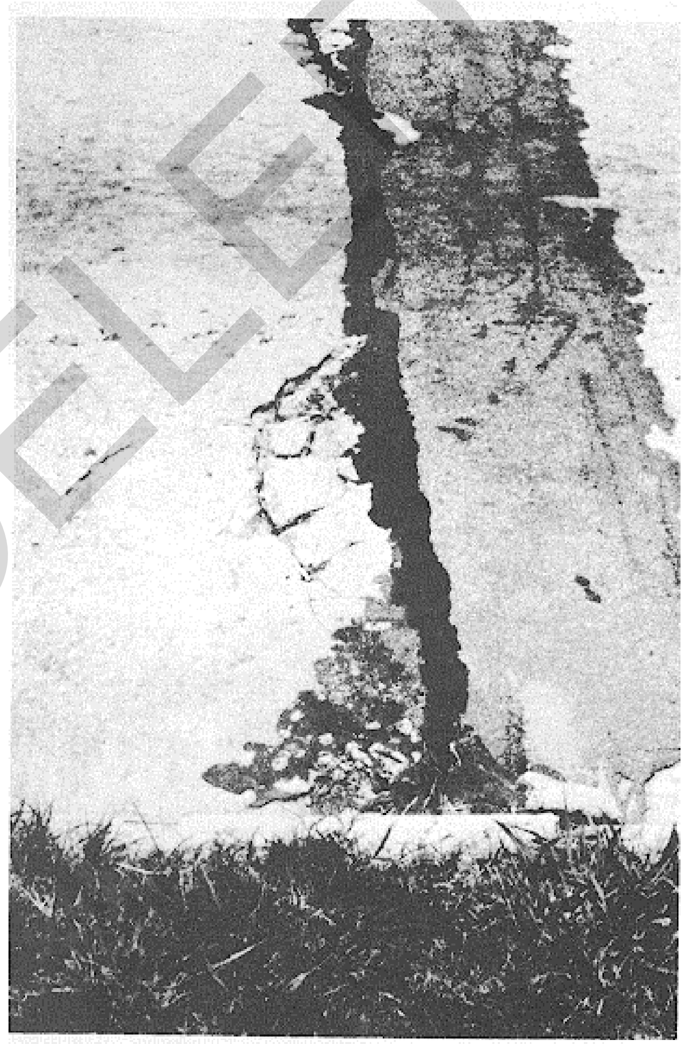


Figure B-72. Low-severity blow-up/buckling.

M-Buckling or shattering causes medium-severity ride quality (figs B-73 and B-74).

Figure B-73. Medium-severity blow-up/buckling.

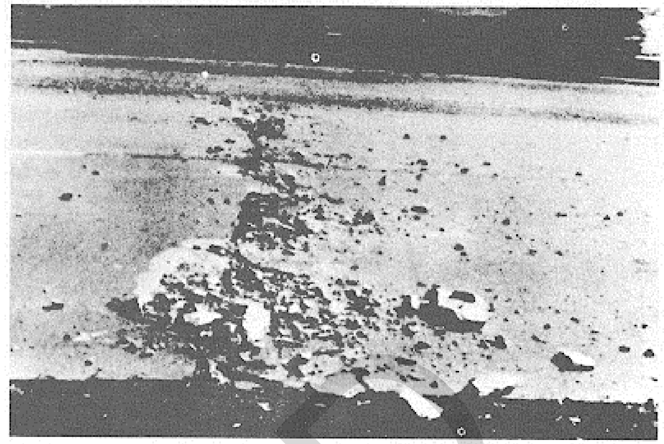


Figure B-74. Medium-severity blow-up/buckling.

H-Buckling or shattering causes high-severity ride quality (fig B-75).

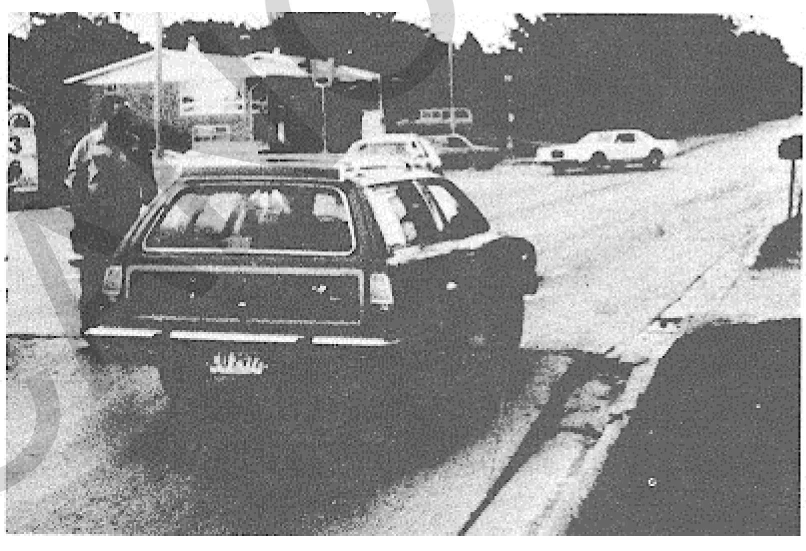


Figure B-75. High-severity blow-up/buckling approach inoperative conditions.

How to Count: At a crack, a blow-up is counted as being in one slab. However, if the blowup occurs at a joint and affects two slabs, the distress should be recorded as occurring in two slabs. When a blow-up renders the pavement inoperable, it should be repaired immediately.

Name of Distress: Corner Break.

Description: A corner break is a crack that intersects the joints at a distance less than or equal to one-half the slab length on both sides, measured from the corner of the slab. For example, a slab with dimensions of 12 by 20 feet that has a crack 5 feet on one side and 12 feet on the other side is not considered a corner break; it is a diagonal crack. However, a crack that intersects 4 feet on one side and 8 feet on the other is considered a corner break. A corner break differs from a corner spall in that the crack extends vertically through the entire slab thickness, while a corner spall intersects the joint at an angle. Load repetition combined with loss of support and curling stresses usually causes corner breaks.

Severity Levels: L*--Break is defined by a low-severity crack and the area between the break and the joints is not cracked or may be lightly cracked (figs B-76 and B-77).

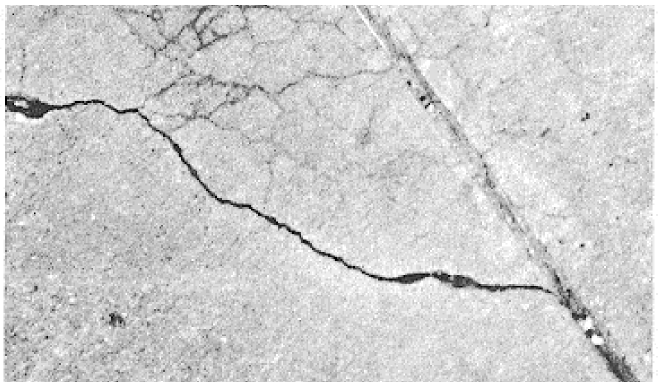


Figure B-76. Low-severity corner break.

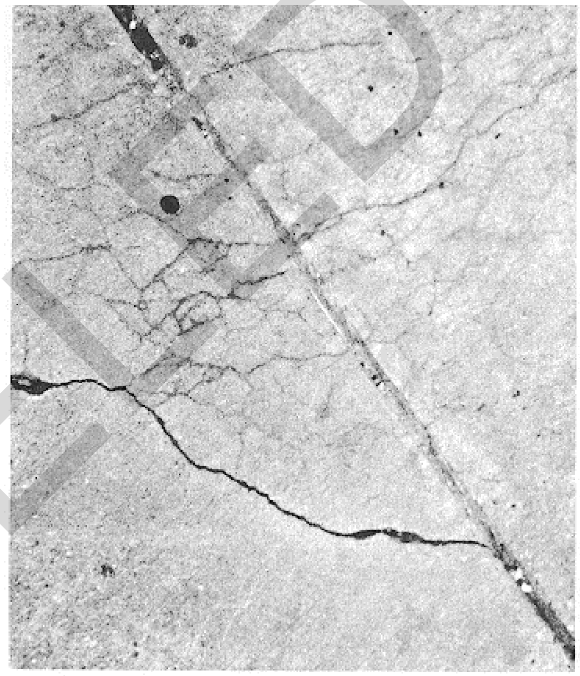


Figure B-77. Low-severity corner break.

M*-Break is defined by medium-severity crack and/or the area between the break and the joint is mediumly cracked (fig B-78).

H*--Break is defined by a high-severity crack and/or the area between the break and the joints is highly cracked (fig B-79).

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*See linear cracking for a definition of low-, medium, and high-severity cracks.

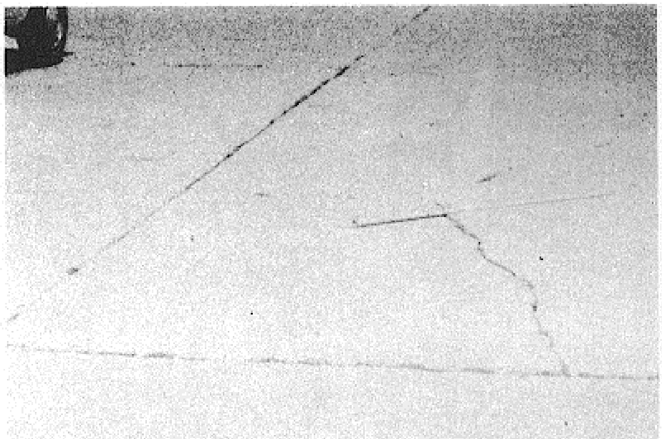


Figure B-78. Medium-severity corner break. Defined by a medium-severity crack.

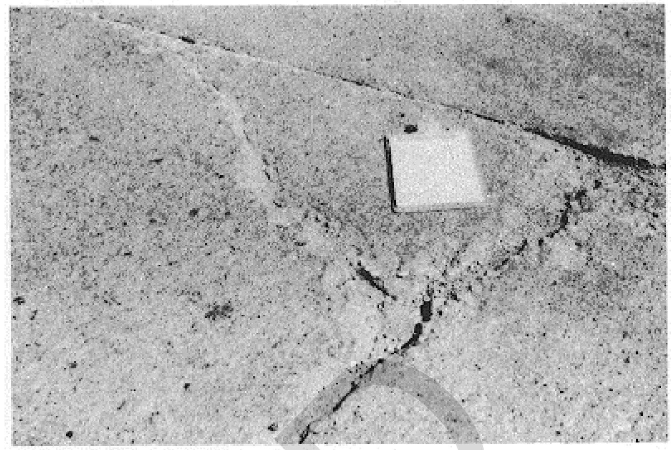


Figure B-79. High-severity corner break.

How to Count: Distressed slab is recorded as one slab if it::

1. Contains a single corner break.
2. Contains more than one break of a particular severity.
3. Contains two or more breaks of different severities.

For two or more breaks, the highest level of severity should be recorded. For example, a slab containing both low and medium-severity corner breaks should be counted as one slab with a medium corner break.

Name of Distress: Divided Slab.

Description: Slab is divided by cracks into four or more pieces due to overloading and/or inadequate support. If all pieces or cracks are contained within a corner break, the distress is categorized as a severe corner break.

Severity Levels:

Severity of majority of cracks	*Number of pieces in cracked slab*		
	4 to 5	*6 to 8*	*More than 8*
L	L	L	M
M	M	M	H
H	M	H	H

See figures B-80 through B-84.

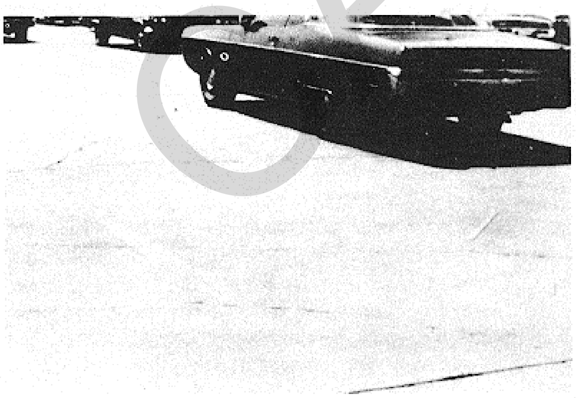


Figure B-80. Low-severity divided slab. Majority of cracks are low severity access than 1/2 inch wide and no faulting).

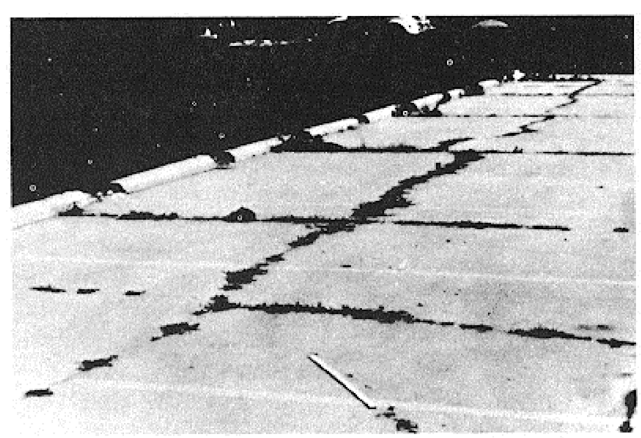


Figure B-81. Medium-severity divided slab.

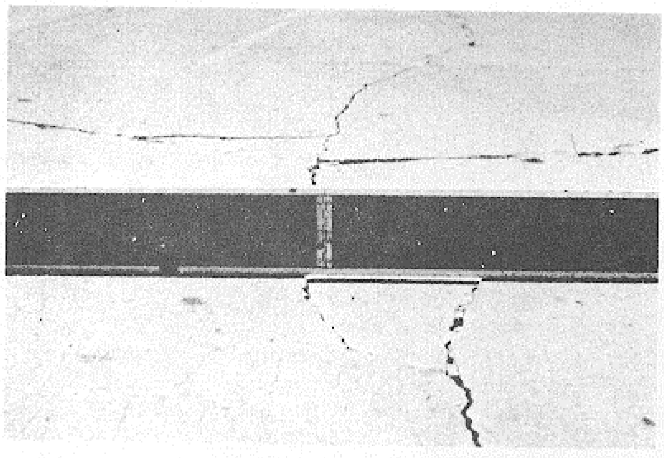


Figure B-82. High-severity divided slab caused by high-severity cracks.

Figure B-83. High-severity divided slab.

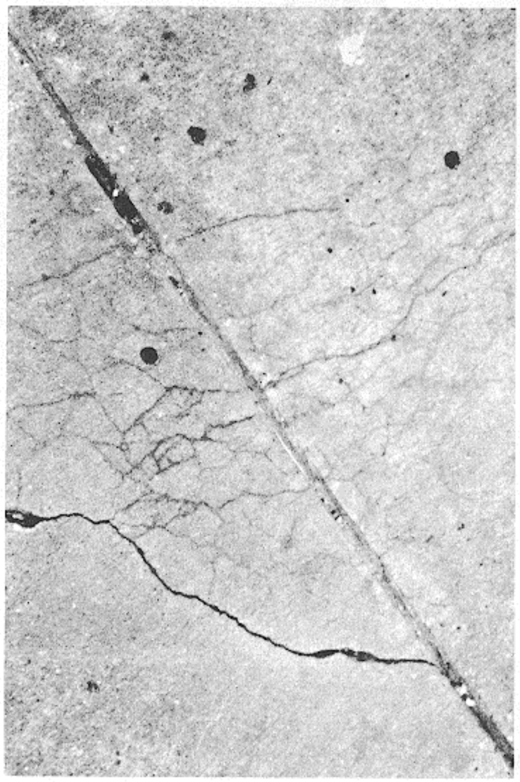
Figure B-84. High-severity divided slab.

How to Count: If the slab is medium or high-severity, no other distress is counted.

Name of Distress: Durability ("D") Cracking.

Description: "D" cracking is caused by freeze-thaw expansion of the large aggregate which, over time, gradually breaks down the concrete. This distress usually appears as a pattern of cracks running parallel and close to a joint or linear crack. Since the concrete becomes saturated near joints and cracks, a dark-colored deposit can usually be found around fine "D" cracks. This type of distress may eventually lead to disintegration of the entire slab.

Severity Levels: L-"D" cracks cover less than 15 percent of slab area. Most of the cracks are tight, but a few pieces may have popped out (figs B-85 and B-86).



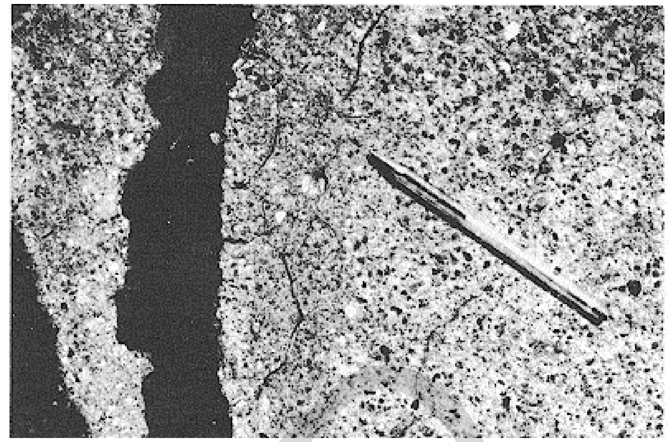


Figure B-86. Low-severity durability cracking.

Figure B-85. Low-severity durability cracking.

M-One of the following conditions exists (fig B-87):

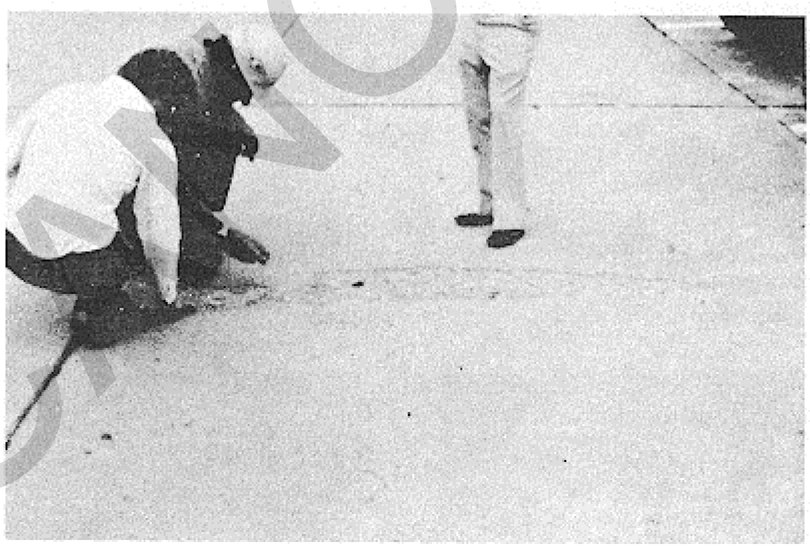


Figure B-87. Medium-severity durability cracking.

1. "D" cracks cover less than 15 percent of the area and most of the pieces have popped out or can be easily removed.
2. "D" cracks cover more than 15 percent of the area. Most of the cracks are tight, but a few pieces may have popped our or can be easily removed.

H-"D" cracks cover more than 15 percent of the area and most of the pieces have popped out or can be easily removed (see figs B-88 and B-89).

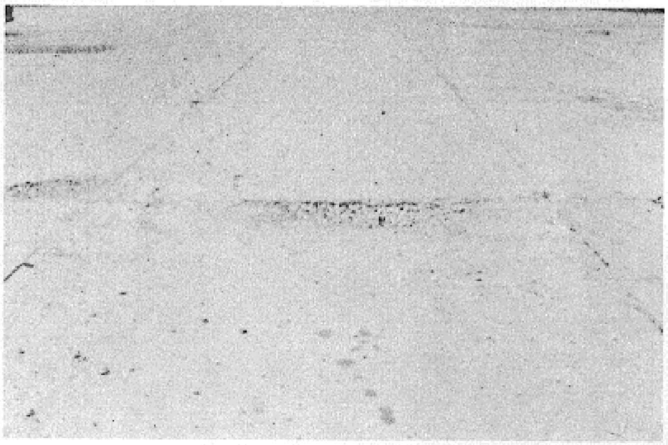


Figure B-88. High-severity durability cracking.

Figure B-89. High-severity durability cracking.

How to Count: When the distress is located and rated at one severity, it is counted as one slab. If more than one severity level exists, the slab is counted as having the higher severity distress. For example, if low and medium "D" cracking are on the same slab, the slab is counted as having medium-severity cracking only.

Name of Distress: Faulting.

Description: Faulting is the difference in elevation across a joint. Some of the common causes of faulting are:

1. Settlement because of soft foundation.
2. Pumping or eroding of materiel from under the slab.
3. Curling of the slab edges due to temperature and moisture changes.

Severity Levels: Severity levels are defined by the difference in elevation across the crack or joint.

Severity level	*Difference in elevation*
L	1/8 to 3/8 inch
M	3/8 to 3/4 inch
H	> 3/4 inch

See figures B-90 through B-93.

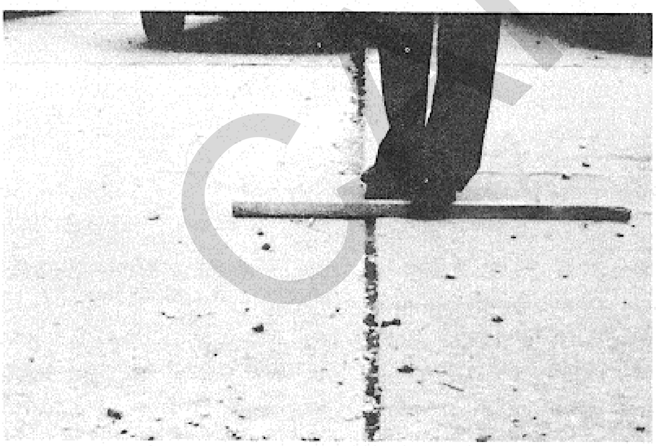


Figure B-90. Low-severity faulting.

Figure B-91. Medium-severity faulting.

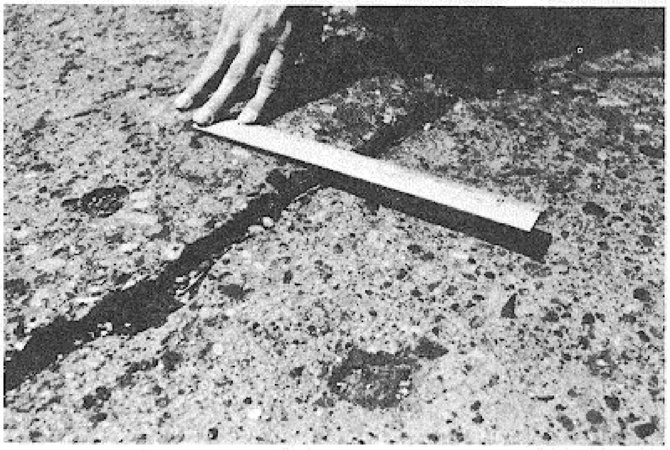


Figure B-92. Medium-severity faulting.

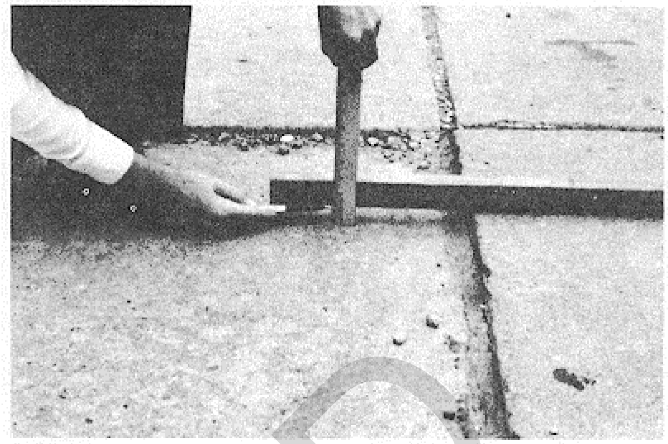


Figure B-93. High-severity faulting.

How to Count: Faulting across a joint is counted as one slab. Only affected slabs are counted. Faults across a crack are not counted as distress, but are considered when defining crack severity.

Name of Distress: Joint Seal Damage.

Description: Joint seal damage is any condition which enables soil or rocks to accumulate in the joints or allows significant water infiltration. Accumulation of incompressible materials prevents the slabs from expanding and may result in buckling, shattering, or spalling. A pliable joint filler bonded to the edges of the slabs protects the joints from material accumulation and prevents water from seeping down and softening the foundation supporting the slab.

Typical types of joint seal damage are:

1. Stripping of joint sealant.
2. Extrusion of joint sealant.
3. Weed growth.
4. Hardening of the filler (oxidation).
5. Loss of bond to the slab edges.
6. Lack or absence of sealant in the joint.

Severity Levels: L-Joint sealant is in generally good condition throughout the section. Sealant is performing well, with only minor damage (see above) (fig B-94).

M-Joint sealant is in generally fair condition over the entire section, with one more of the above types of damage occurring to a moderate degree. Sealant needs replacement within 2 years (fig B-95).

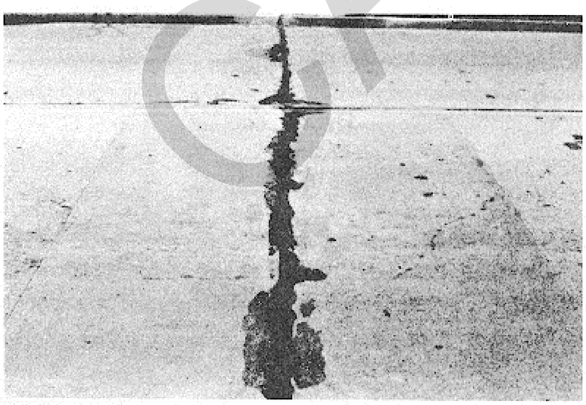


Figure B-94. Low-severity joint seal damage.

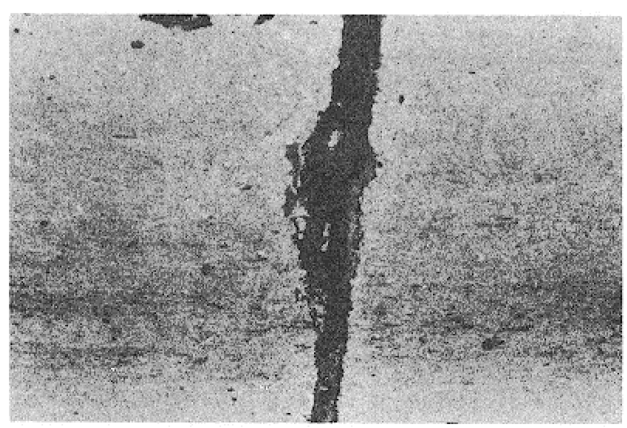


Figure B-95. Medium-severity joint seal damage.

H-Joint sealant is in generally poor condition over the entire section, with one or more of the above types of damage occurring to a severe degree. Sealant needs immediate replacement (figs B-96 and B-97).

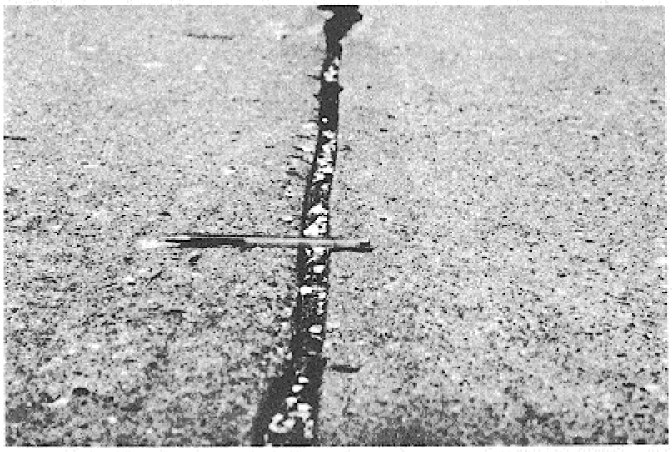


Figure B-96. High-severity joint seal damage.

Figure B-97. High-severity joint seal damage.

How to Count: Joint seal damage is not counted on a slab-by-slab basis, but rated based on the overall condition of the sealant over the entire area.

Name of Distress: Lane/Shoulder Drop Off.

Description: Lane/shoulder drop off is the difference between the settlement or erosion of the shoulder and the pavement travel-lane edge. The elevation difference can be a safety hazard; it can also cause increased water infiltration.

Severity Levels: L-The difference between the pavement edge and shoulder is 1 to 2 inches (fig B-98).

M-The difference in elevation is 2 to 4 inches (fig B-99).

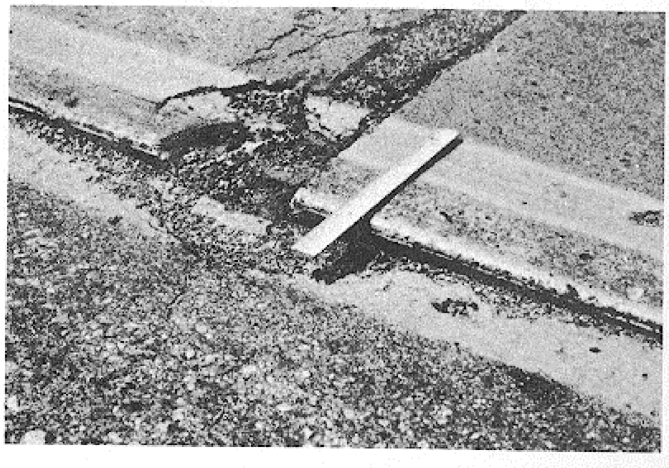


Figure B-98. Low-severity lane/shoulder drop off.

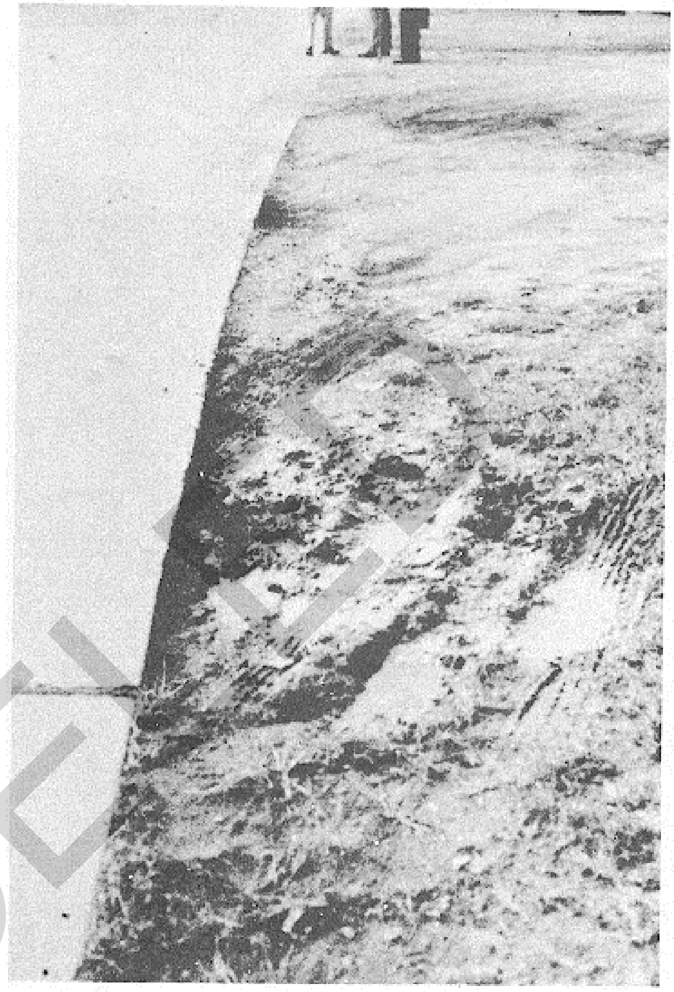


Figure B-99. Medium-severity lane/shoulder drop off

H-The difference in elevation is greater than 4 inches (fig B-100).

Figure B-100. High-severity lane/shoulder drop off.

How to Count: The mean lane/shoulder drop off is computed by averaging the maximum and minimum drop along the slab. Each slab exhibiting distress is measured separately and counted as one slab with the appropriate severity level.

Name of Distress: Linear Cracking (Longitudinal, Transverse, and Diagonal Cracks).

Description: These cracks, which divide the slab into two or three pieces, are usually caused by a combination of repeated traffic loading, thermal gradient curling, and repeated moisture loading. (Slabs divided into four or more pieces are counted as Divided Slabs.) Low-severity cracks are usually related to warp or friction and are not considered major structural distresses. Medium or high-severity cracks are usually working cracks and are considered major structural distresses (fig B-101 through B-106).

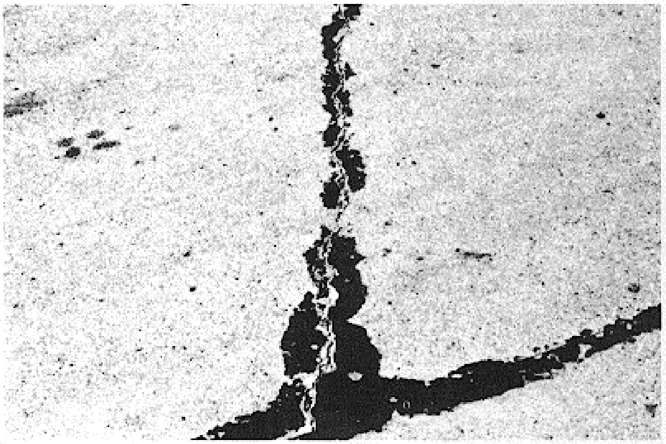


Figure B-101. Low-severity linear cracking in a nonreinforced concrete slab.

Figure B-102. Low-severity linear cracking in a nonreinforced concrete slab.

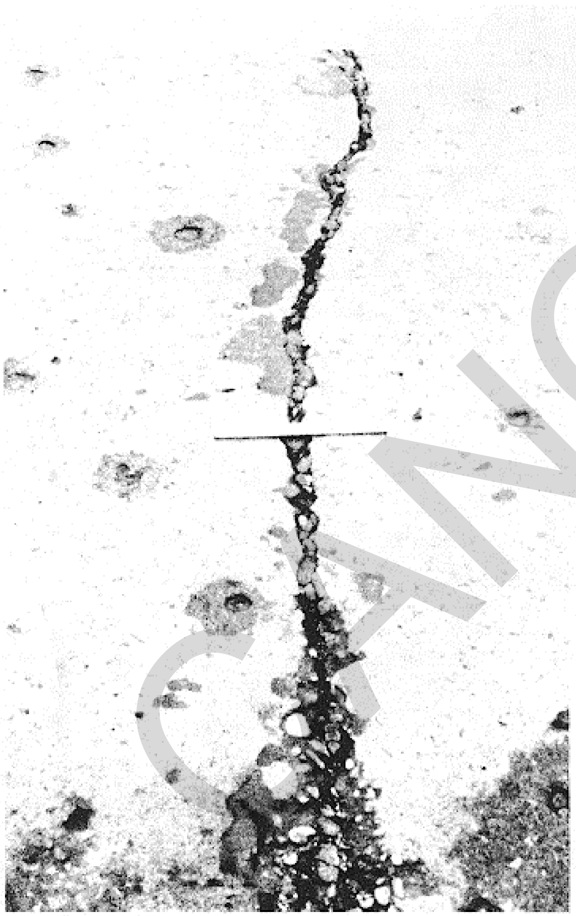


Figure B-103. Medium-severity linear cracking in a reinforced concrete slab.

Figure B-104. Medium-severity linear cracking in a reinforced concrete slab.

Figure B-105. High-severity linear cracking in a nonreinforced concrete slab.

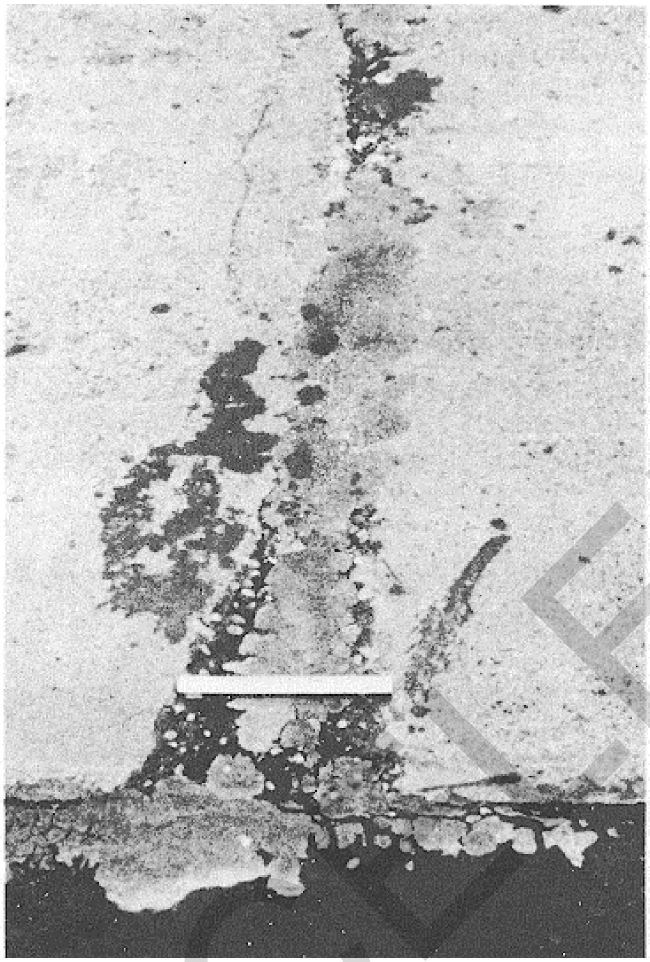


Figure B-106. High-severity linear cracking in a nonreinforced concrete slab.

Hairline cracks that are only a few feet long and do not extend across the entire slab are counted as shrinkage cracks.

Severity Levels:

Nonreinforced Slabs: L-Nonfilled* cracks less than or equal to Y inch or filled cracks of any width with the filler in satisfactory condition. No faulting exists.

M-One of the following conditions exists:

1. Nonfilled crack with a width between Y and 2 inches.
2. Nonfilled crack of any width up to 2 inches with faulting of less than X inches.
3. Filled crack of any width with faulting less than % inch.

H-One of the following conditions exists:

1. Nonfilled crack with a width greater than 2 inches.
2. Filled or nonfilled crack of any width with faulting greater than % inch.

Reinforced Slabs.

L-Nonfilled cracks with a width of Y8 to 1 inch; filled crack of any width with the filler in satisfactory condition. No faulting exists.

M-One of the following conditions exist:

1. Nonfilled cracks with a width between 1 and 3 inches and no faulting.
2. Nonfilled crack of any width up to 3 inches with up to v8 inch of faulting.
3. Filled crack of any width with faulting less than % inch.

H-One of the following conditions exists:

1. Nonfilled crack with width over 3 inches.
2. Filled or nonfilled crack of any width with faulting over % inch.

***Filed cracks where filler is unsatisfactory are treated as nonfilled.**

How to Count: Once the severity has been identified, the distress is recorded as one slab. If two medium-severity cracks are within one slab, is counted as having one high-severity crack. Slabs divided into four or more pieces are counted as divided slabs.

In reinforced slabs, cracks with a width less than X inch are counted as shrinkage cracks. Slabs longer than 30 feet are divided into approximately equal length "slabs" having imaginary joints assumed to be in perfect condition.

Name of Distress: Patching, Large (more than 5 square feet) and Utility Cuts.

Description: A patch is an area where the original pavement has been removed and replaced by a filler material. A utility cut is a patch that has replaced the original pavement to allow the installation of underground utilities. The severity levels of a utility cut are the same as those for regular patching.

Severity Levels: L-Patch is functioning well, with little or no deterioration (figs B-107 and B-108).

Figure B-107. Low-severity patching, large, and utility cuts.

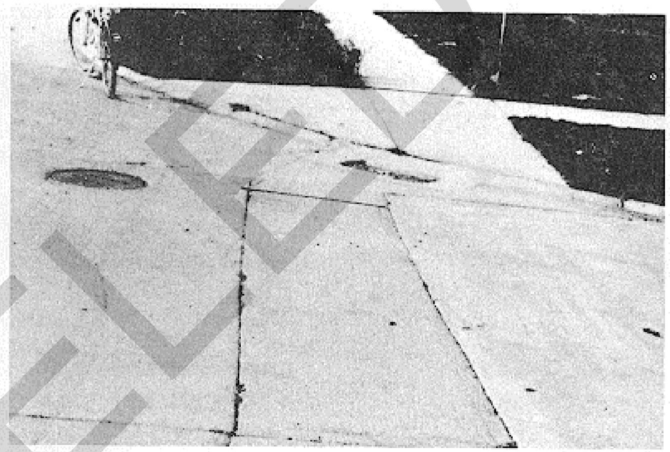


Figure B-108. Low-severity patching, large, and utility cuts.

M-Patch is moderately deteriorated and/or moderate spalling can be seen around the edges. Patch material can be dislodged with considerable effort (figs B-109 through B-111).

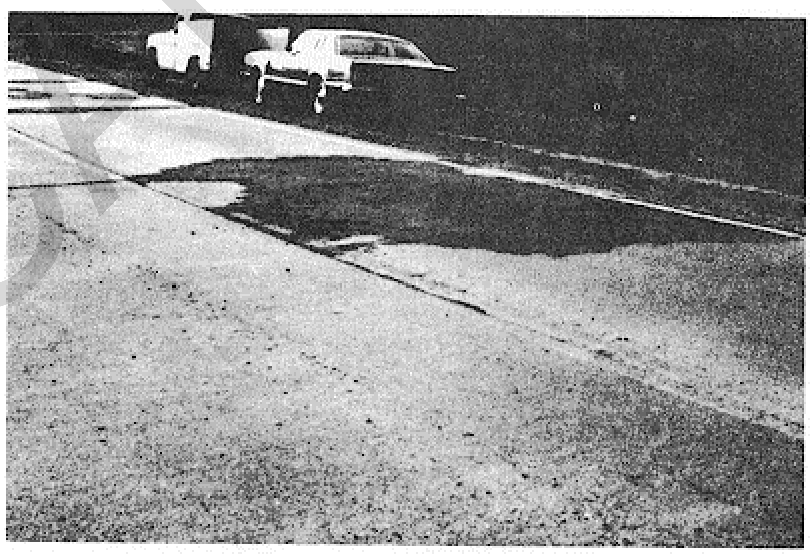


Figure B-109. Medium-severity patching, large.

Figure B-110. Medium-severity patching, large.

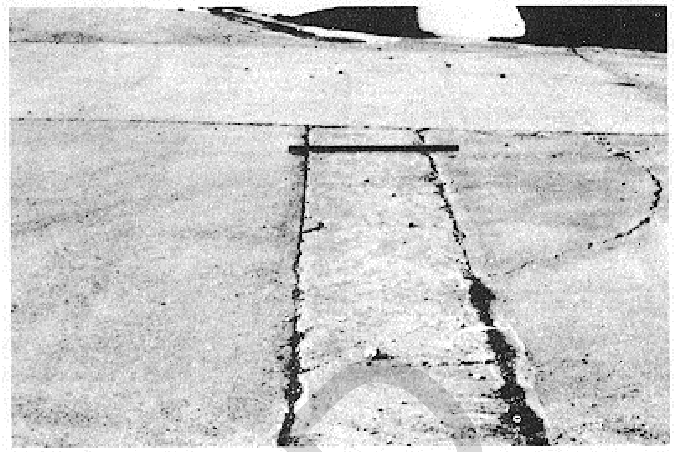


Figure B-111. Medium-severity patching, Utility cuts.

H-Patch is badly deteriorated. The extent of the deterioration warrants replacement of the patch (fig B-112).

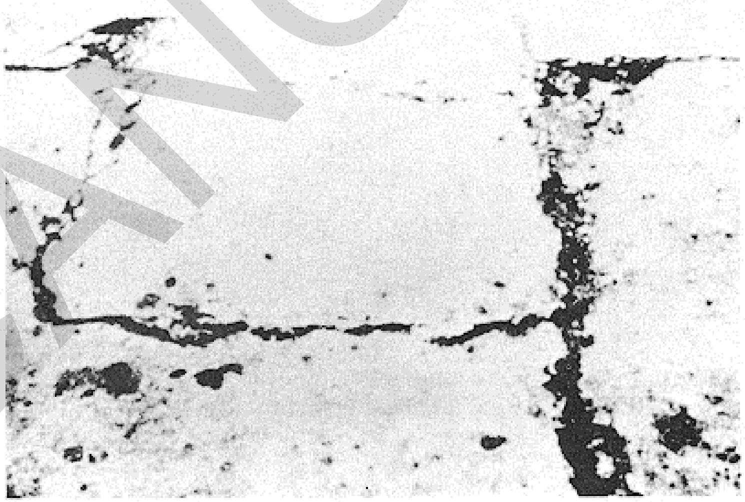


Figure B-112. High-severity patching, large.

How to Count:

If a single slab has one or more patches with the same severity level, it is counted as one slab containing that distress. If a single slab has more than one severity level, it is counted as one slab with the higher severity level.

If the cause of the patch is more severe, only the original distress is counted.

Name of Distress: Patching, Small (less than 5 square feet).

Description: A patch is an area where the original pavement has been removed and replaced by a filler material.

Severity Levels: L-Patch is functioning well with little or no deterioration (fig B-113).

M-Patch is moderately deteriorated. Patch material can be dislodged with considerable effort (fig B-114).

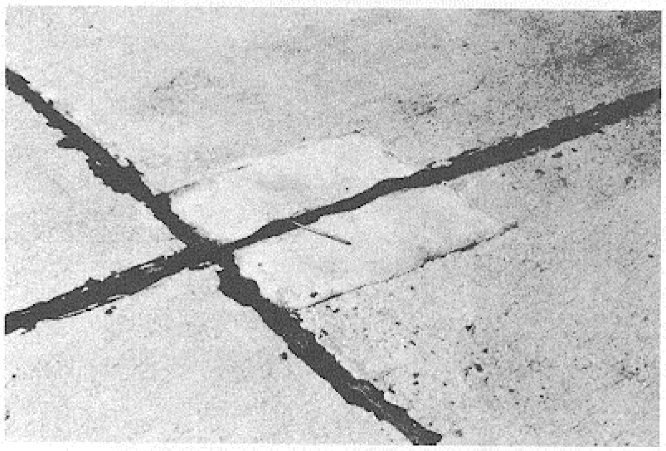


Figure B-113. Low-severity patching, small.

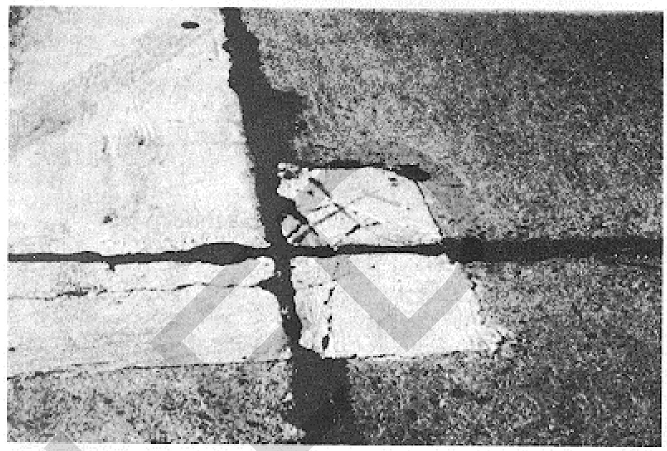


Figure B-114. Medium-severity patching, small.

H-Patch is badly deteriorated. The extent of deterioration warrants replacement of the patch (fig B-115).

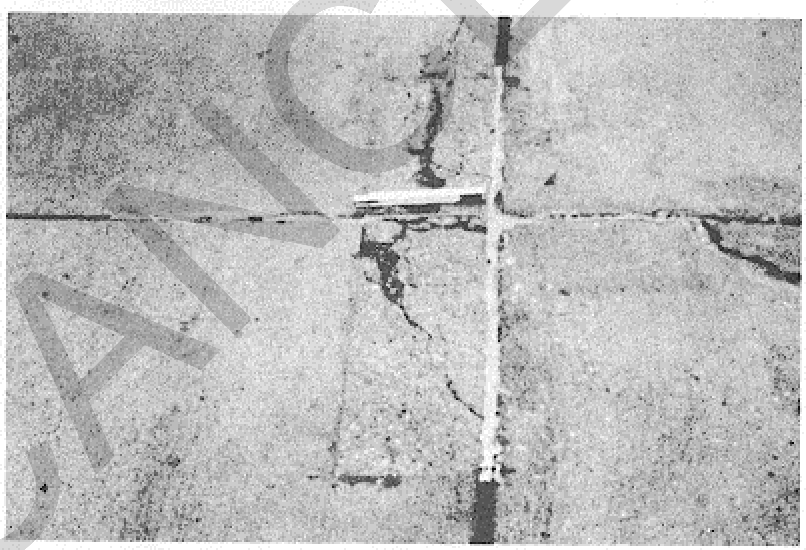


Figure B-115. High-severity patching, small.

How to Count: If a single slab has one or more patches with the same severity level, it is counted as one slab containing that distress. If a single slab has more than one severity level, it is counted as one slab with the higher severity level.

If the cause of the patch is more severe, only the original distress is counted.

Name of Distress: Polished Aggregate.

Description: This distress is caused by repeated traffic applications. When the aggregate in the surface becomes smooth to the touch, adhesion with vehicle tires is considerably reduced. When the portion of aggregate extending above the surface is small, the pavement texture does not significantly contribute to reducing vehicle speed. Polished aggregate should be counted when close examination reveals that the aggregate extending above the concrete is negligible, and the surface aggregate is smooth to the touch.

This type of distress is indicated when the number on a skid resistance test is low or has dropped significantly from previous ratings.

Severity Levels: No degrees of severity are defined. However, the degree of polishing should be significant before it is included in the condition survey and rated as a defect (fig B-116).

How to Count: A slab with polished aggregate is counted as one slab.

Name of Distress: Popouts.

Description: A popout is a small piece of pavement that freeze-thaw action, combined with aggregate expansion, causes to break loose from the surface. Popouts usually range in diameter from approximately 1 to 4 inches and in depth from M to 2 inches.

Severity Levels: No degrees of severity are defined for popouts. However, popouts must be extensive before they are counted as a distress. Average popout density must exceed approximately three popouts per square yard over the entire slab area (fig B-117).

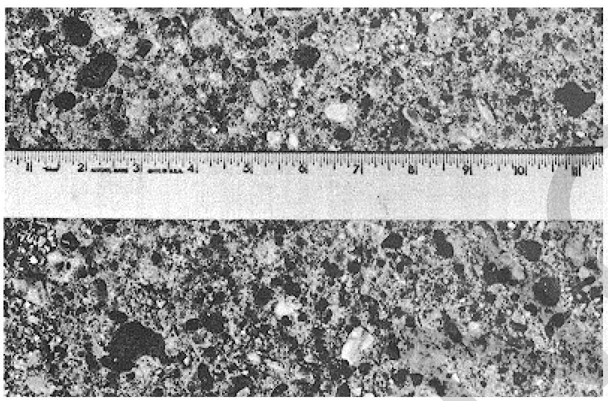


Figure B-116. Polished aggregate.

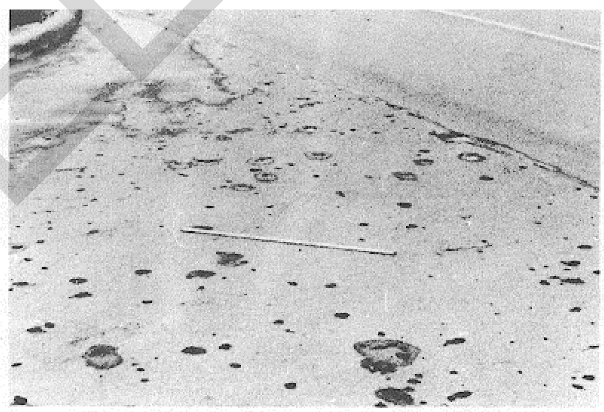


Figure B-117. Popouts.

How to Count: The density of the distress must be measured. If there is any doubt that the average is greater than three popouts per square yard, at least three random 1-square-yard areas should be checked. When the average is greater than this density, the slab should be counted.

Name of Distress: Pumping.

Description: Pumping is the ejection of material from the slab foundation through joints or cracks. This is caused by deflection of the slab by passing loads. As a load moves across the joint between the slabs, water is first forced under the leading slab, and then forced back under the trailing slab.

This erodes and eventually removes soil particles, resulting in progressive loss of pavement support. Pumping can be identified by surface stains and evidence of base or subgrade material on the pavement close to joints or cracks. Pumping near joints is caused by poor joint sealer and indicates loss of support; repeated loading will eventually produce cracks. Pumping can also occur along the slab edge, causing loss of support.

Severity Levels: No degrees of severity are defined. It is sufficient to indicate the pumping exists (figs B-118 and B-119).

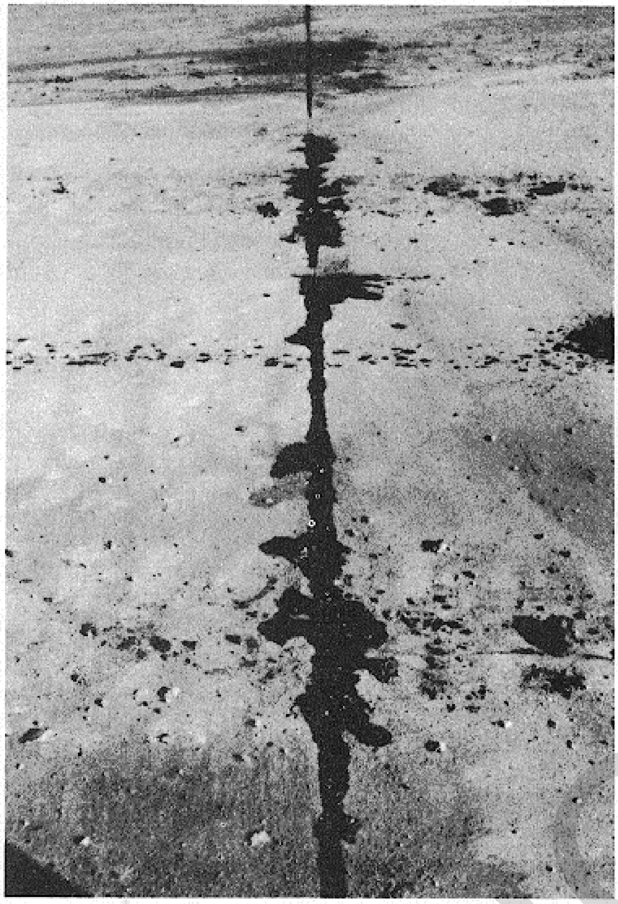


Figure B-118. Pumping.

Figure B-119. Pumping.

How to Count: One pumping joint between two slabs is counted as two slabs. However, the remaining joints around the slab are also pumping, one slab is added per additional pumping joint.

Name of Distress: Punchout.

Description: This distress is a localized area of the slab that is broken into pieces. The punchout can take many different shapes and forms, but it is usually defined by a crack and a joint, or two closely spaced cracks (usually 5 feet wide). This distress is caused by heavy repeated loads, inadequate slab thickness, loss of foundation support, and/or a localized concrete construction deficiency (e.g., honeycombing).

Severity Levels:

Majority of cracks severity	*Number of pieces* 2 to 3	4 to 5	>5
L	L	L	M
M	L	M	H
H	M	H	H

See figs. B-120 through B-122.

How to Count: If a slab contains one or more punchouts, it is counted as containing a punchout at the severity level of the most severe punchout.

Name of Distress: Railroad Crossing.

Description: Railroad crossing distress is characterized by depressions or bumps around the tracks.

Severity Levels: L-Railroad crossing causes low-severity ride quality (fig B-123).

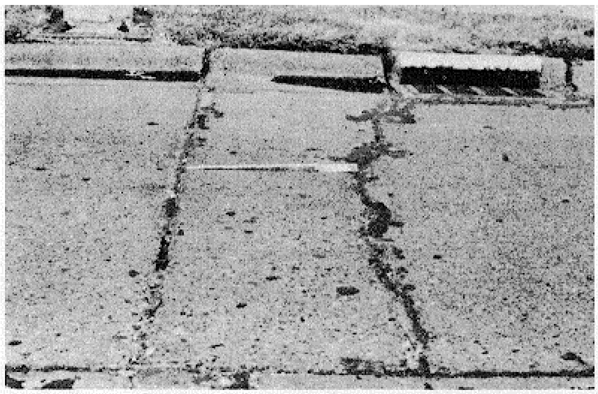


Figure B-120. Low-severity punchout.

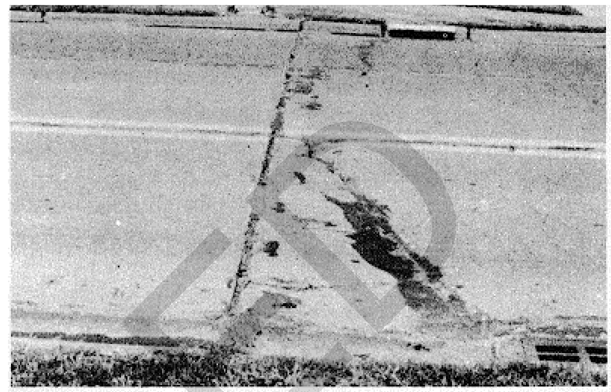


Figure B-121. Medium-severity punchout.

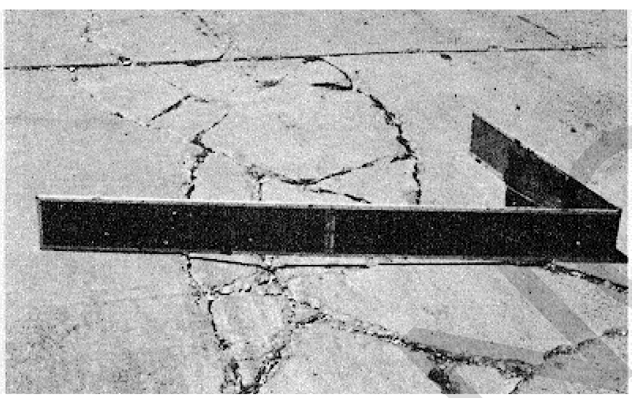


Figure B-122. High-severity punchout.

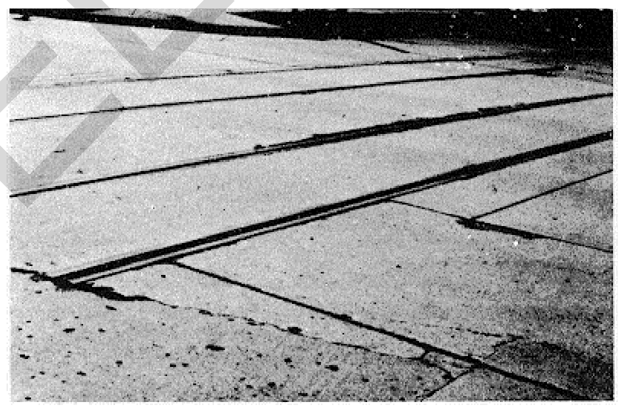


Figure B-123. Low-severity railroad crossings.

M-Railroad crossing causes medium-severity ride quality (fig B-124).
H-Railroad crossing causes high-severity ride quality (fig B-125).

Figure B-124. Medium-severity railroad crossings.

Figure B-125. High-severity railroad crossing.

How to Count: The number of slabs crossed by the railroad track is counted. Any large pump created by the tracks should be counted as part of the crossing.

Name of Distress: Scaling/Map Cracking/Crazing.

Description: Map cracking or crazing refers to a network of shallow, fine, or hairline cracks which extend only through the upper surface of the concrete.

The cracks tend to intersect at angles of 120 degrees. Map cracking or crazing is usually caused by concrete overfinishing, and may lead to surface scaling, which is the breakdown of the slab surface to a depth of approximately Y4 to 3 inch. Scaling may also be caused by deicing salts, improper construction, freeze-thaw cycles, and poor aggregate. The type of scaling defined here is not caused by "D" cracking. If scaling is caused by "D" cracking, it should be counted under that distress only.

Severity Levels: L-Crazing or map cracking exists over most of the slab area; the surface is in good condition, with only minor scaling present (fig B-126).

M-Slab is scaled, but less than 15 percent of the slab is affected (fig B-127).

Figure B-126. Low-severity scaling/map cracking/crazing.

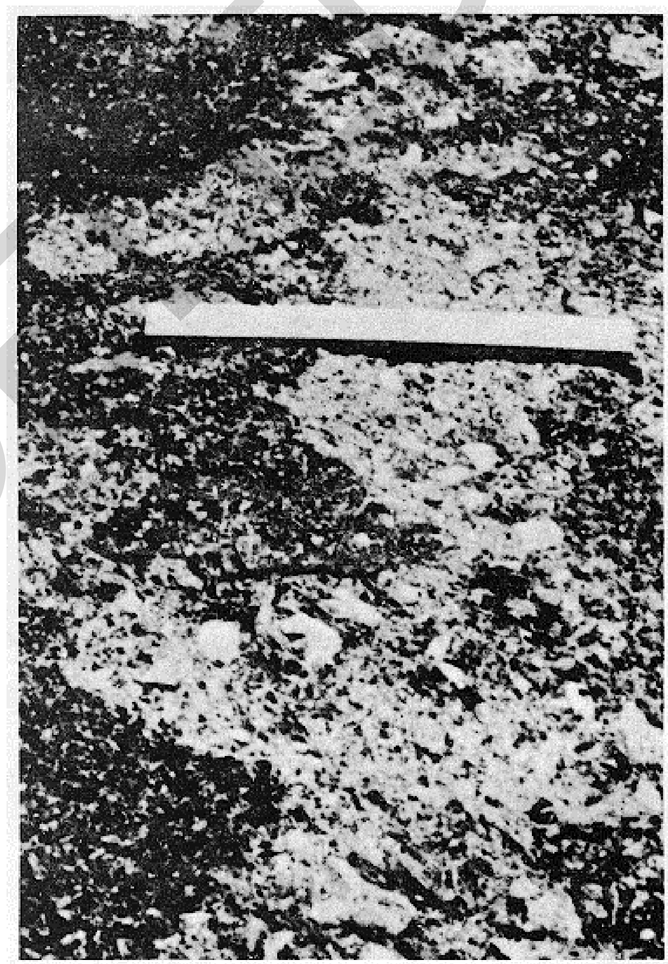


Figure B-127. Medium-severity scaling/map cracking/crazing.

H-Slab is scaled over more than 15 percent of its area (figs B-128 through B-130).

How to Count: A scaled slab is counted as one slab. Low-severity crazing should only be counted if the potential for scaling appears to be imminent, or few small pieces have come out.

Name of Distress: Shrinkage Cracks.

Description: Shrinkage cracks are hairline cracks that are usually only a few feet long and do not extend across the entire slab. They are formed during the setting and curing of the concrete and usually do not extend through the depth of the slab.

Severity Levels: No degrees of severity are defined. It is enough to indicate that shrinkage cracks are present (fig B-131).

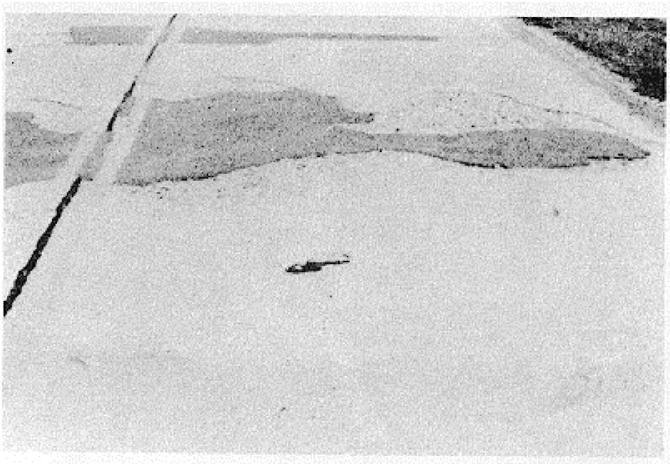


Figure B-128. High-severity scaling/map cracking/crazing.

Figure B-129. High-severity scaling/map cracking/crazing.

Figure B-130. High-severity scaling/map cracking/crazing.

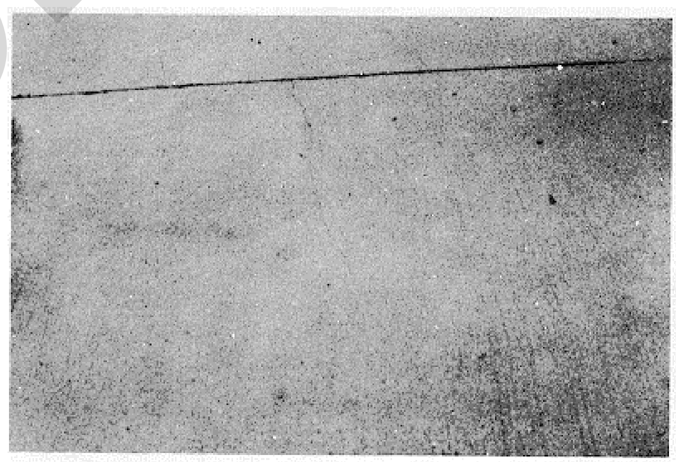


Figure B-131. Shrinkage cracks.

How to Count: If one or more shrinkage cracks exist on one particular slab, the slab is counted as one slab with shrinkage cracks.

Name of Distress: Spalling, Corner.

Description: Corner spalling is the breakdown of the slab within approximately 2 feet of the corner. A corner spall differs from a corner break in that the spall usually angles downward to intersect the joint, while a break extends vertically through the slab corner. Spalls less than 5 inches from the crack to the corner on both sides should not be counted.

Severity Levels:

	Dimensions of sides of spall	
Depth of spall	*5 x 5 inches to*	*12 x 12 inches*
12 x 12 inches		
<1 inch	L	L
1 to 2 inches.................................	L	M
>2 inches......................................	M	H

Corner spalling having an area of less than 10 square inches is not counted (figs B-132 through B-135).

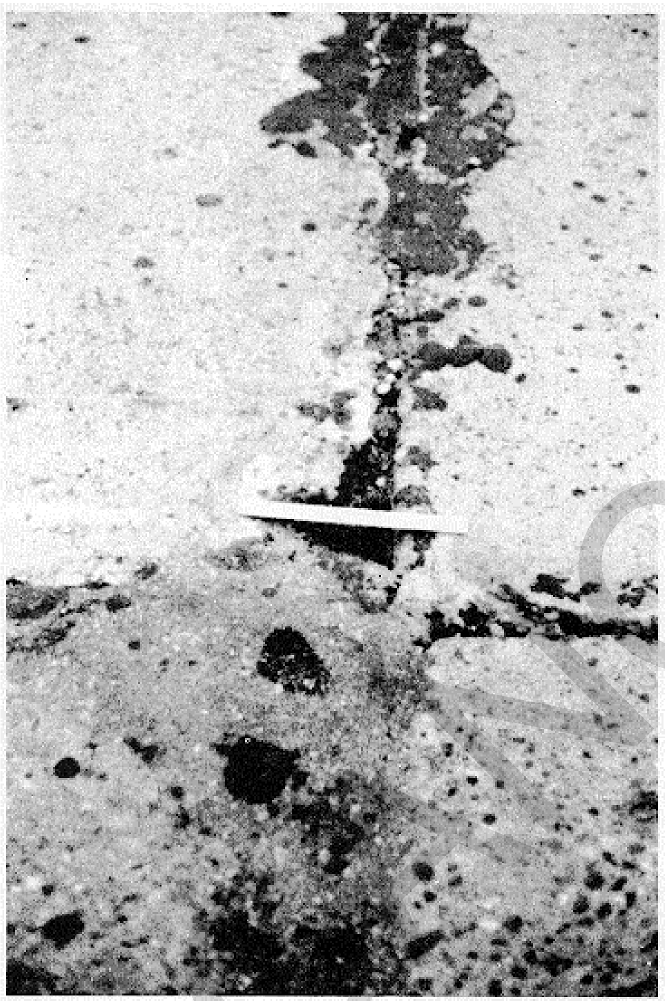


Figure B-132. Low-severity spalling, corner.

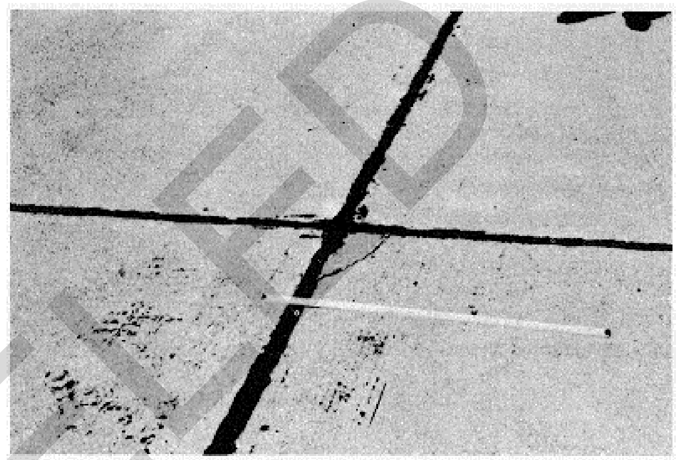


Figure B-133. Low-severity spalling, corner.

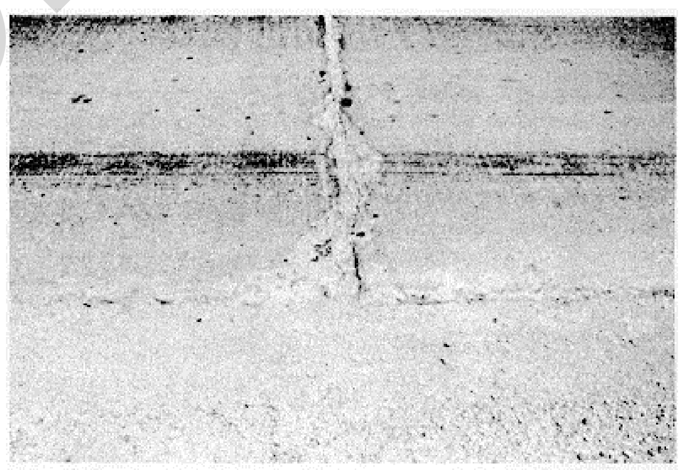


Figure B-134. Medium-severity spalling, corner.

Figure B-135. High-severity spalling, corner.

How to Count: If one or more corner spalls with the same severity level are in a slab, the slab is counted as one slab with corner spalling. If more than one severity level occurs, it is counted as one slab with the higher severity level.

Name of Distress: Spalling, Joint.

Description: Joint spalling is the breakdown of the slab edges within 2 feet of the joint.

A joint spall usually does not extend vertically through the slab, but intersects the joint at an angle. Spalling results from:

1. Excessive stresses at the joint caused by traffic loading or by infiltration of incompressible materials.
2. Weak concrete at the joint caused by overworking.
3. Water accumulation in the joint and freeze-thaw action.

Severity Levels:

Joint Spalling

Spall pieces	*Width of spall*	*Length of spall*	
		<2 feet	*>2 feet*
Tight-cannot be easily removed (may be a few pieces missing)	<4 inches	L	L
	>4 inches	L	L
Loose-can be removed and some pieces are missing; if most or all pieces are missing, spall is shallow, less than 1 inch.	<4 inches	L	M
	>4 inches	L	M
Missing-most or all pieces have been removed	<4 inches	L	M
	>4 inches	M	H

See figures B-136 through B-138.

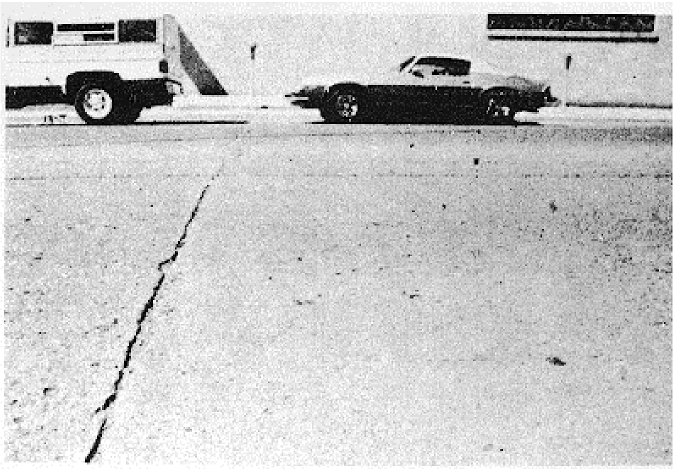


Figure B-136. Low-severity spalling, joint.

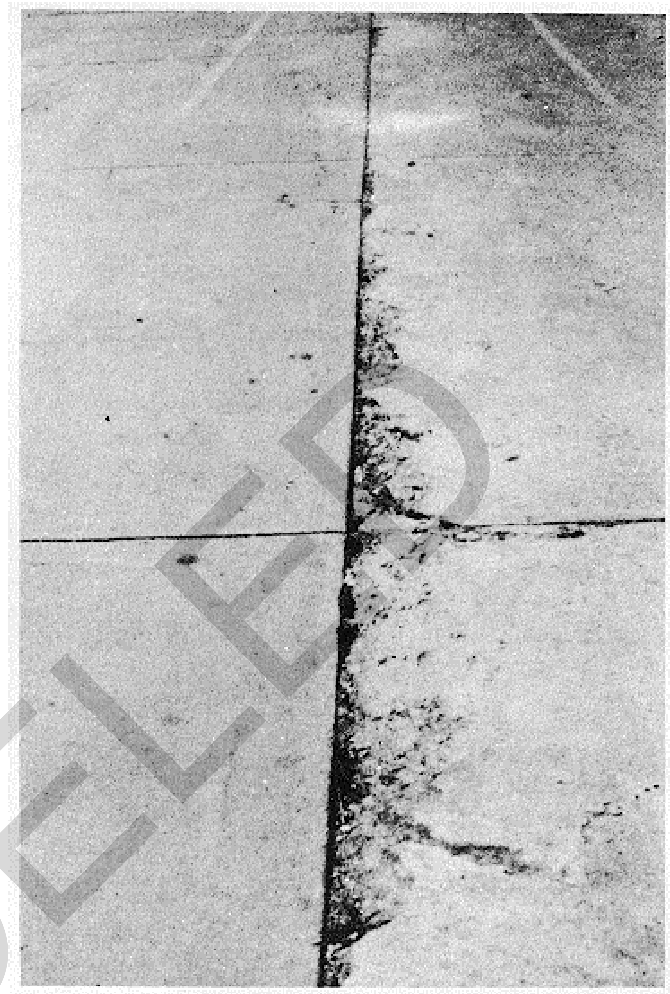


Figure B-137. Medium-severity spalling joint.

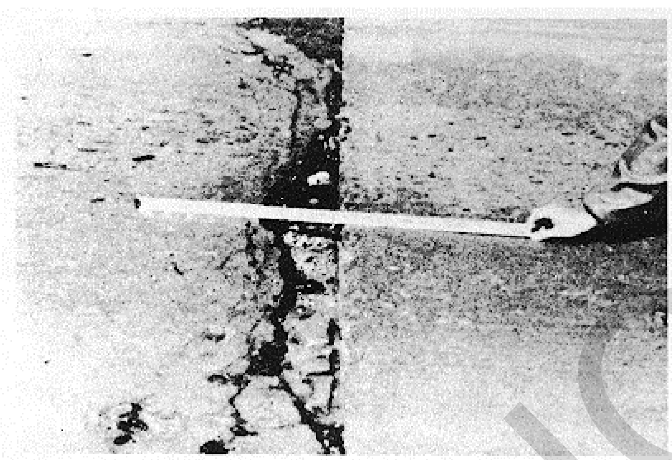


Figure B-138. High-severity spalling, joint.

A frayed joint where the concrete has been worn away along the entire joint is rated as low severity.

How to Count: If the joint is along the edge of one slab, it is counted as one slab with joint spalling. If spalling is on more than one edge of the same slab, the edge having the highest severity is counted and recorded as one slab. Joint spalling can also occur along the edges of two adjacent slabs. If this is the case, each slab is counted as having joint spalling.

APPENDIX C
DEDUCT VALUE CURVES-ASPHALT SURFACED JOINTED CONCRETE PAVEMENT

C-1. Introduction
In this appendix is furnished the deduct value curves essential for computing the PCI of a pavement sample unit as used in the manual PAVER system (figs C-1 through C-40).

C-2. Type of pavements
The curves are provided in alphabetical order according to distress types, covering first asphalt surfaced pavement, then concrete pavements.

C-3. User instructions
As explained in chapter 3, the following five steps are involved in calculating the PCI for a sample unit::

a. 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.

b. Step 2. The deduct values are determined from the deduct value curves in this appendix. The following examples are given for a sample unit 25 feet by 100 feet (2500 square feet):

(1) For 6 square feet of distress type 1 (alligator cracking) low severity, the density equals

$$\frac{6 \times}{2500} 100 = .24.$$

Using figure C-1, find .24 on the distress density line. Proceed vertically to the L (Low Severity) curve, then horizontally to the left to read a deduct value of 4.

(2) For 16 square feet of distress type 1 (Alligator Cracking) Medium Severity the density equals

$$\frac{16 \times}{2500} 100 = .64.$$

Using figure C-1, find .64 on the distress density line. Proceed vertically to the M (Medium Severity) curve, then horizontally to the left to read a deduct value of 17.

(3) For 50 square feet of distress type 15 (Rutting) Low Severity, the density equals

$$\frac{50}{2500} \times 100 = 2.0.$$

Using figure C-15, find 2.0 on the distress density line. Proceed vertically to the L (Low Severity) curve, then to the left to read a deduct value of 13.

c. Step 3. A total deduct value is computed by summing all individual deduct values in the sample unit.

d. Step 4. The corrected deduct value (CDV) is computed. In the example given in figure 3-3, the total deduct value (the sum of all deduct values) was found to be 45. The value of q (the number of individual deducts whose value is greater than 5) was found to be 2. Using figure C-20 find 45 on the TDV line. Proceed vertically to the line q equals 2, then to the left to read a CDV of 33.

e. Step 5. The PCI is computed using the relation PCI = 100CDV. In the example, PCI= 100-33 = 67; the rating is good.

C-4. Deduct value curves
The deduct value curves and the corrected deduct value curves provided in this appendix are needed to solve steps 2 and 4 above.

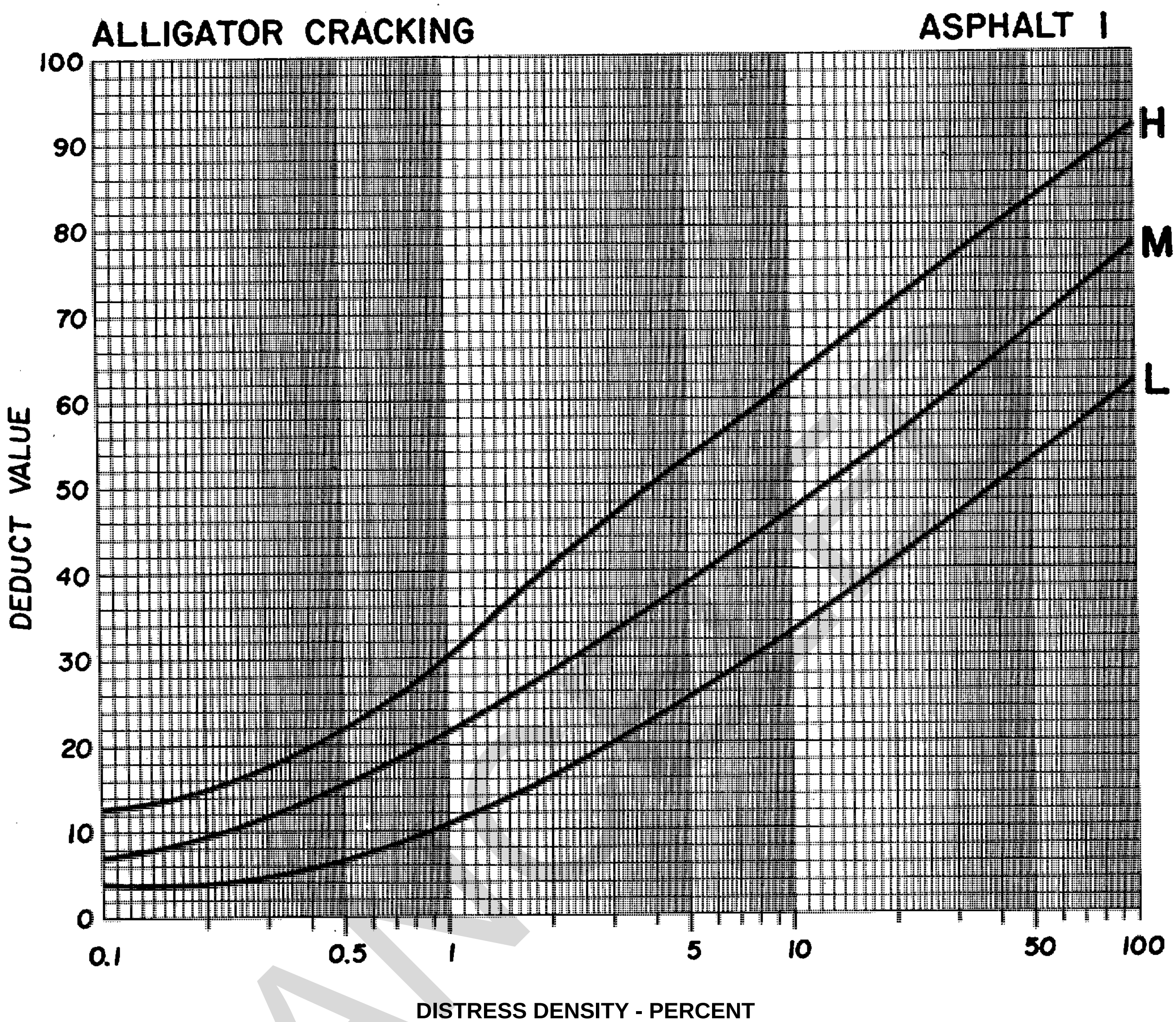
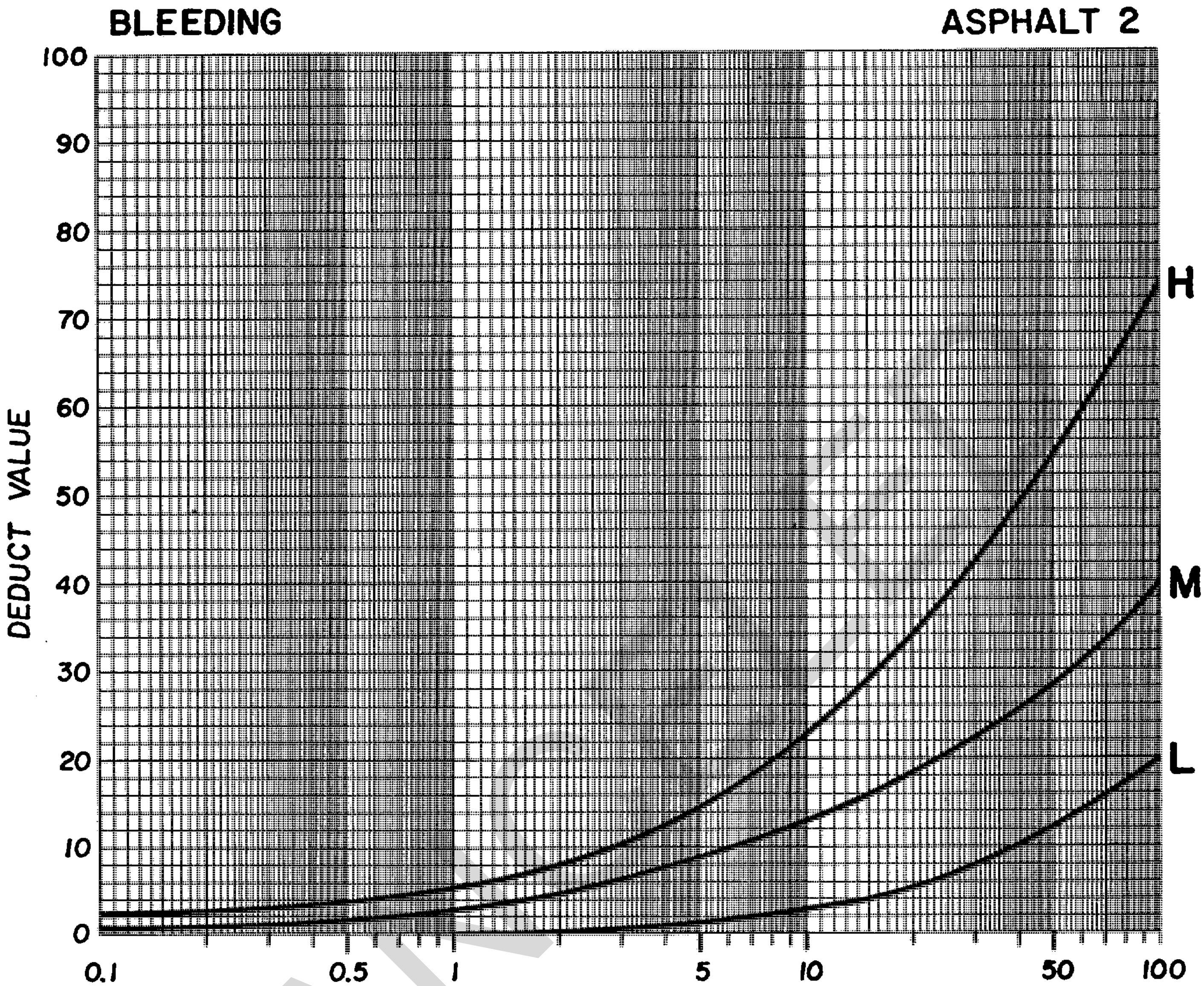
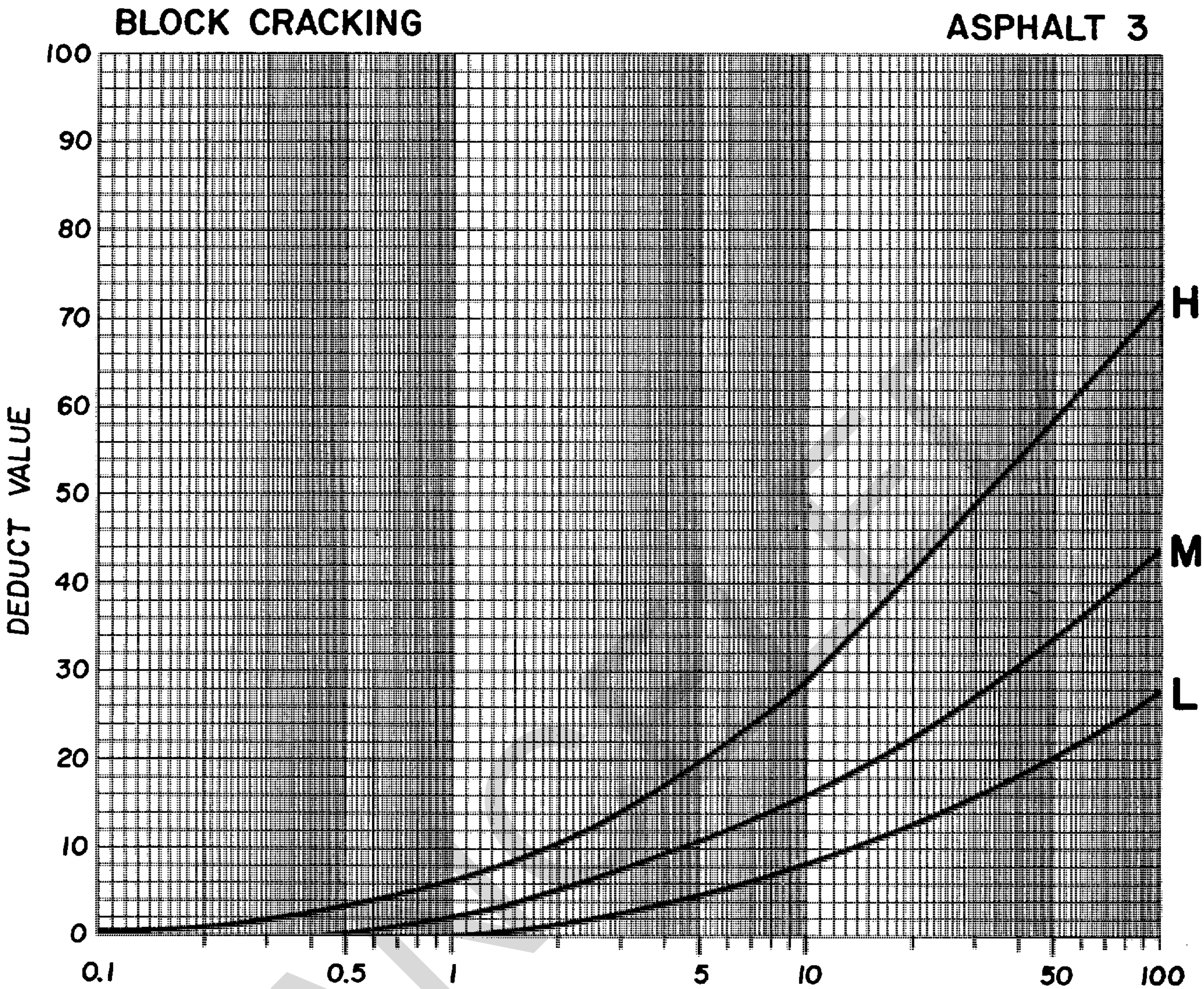


Figure C-1. Deduct value curves for alligator cracking.



DISTRESS DENSITY -PERCENT

Figure C-2. Deduct value curves for bleeding.



DISTRESS DENSITY -PERCENT

Figure C-3. Deduct value curves for block cracking.

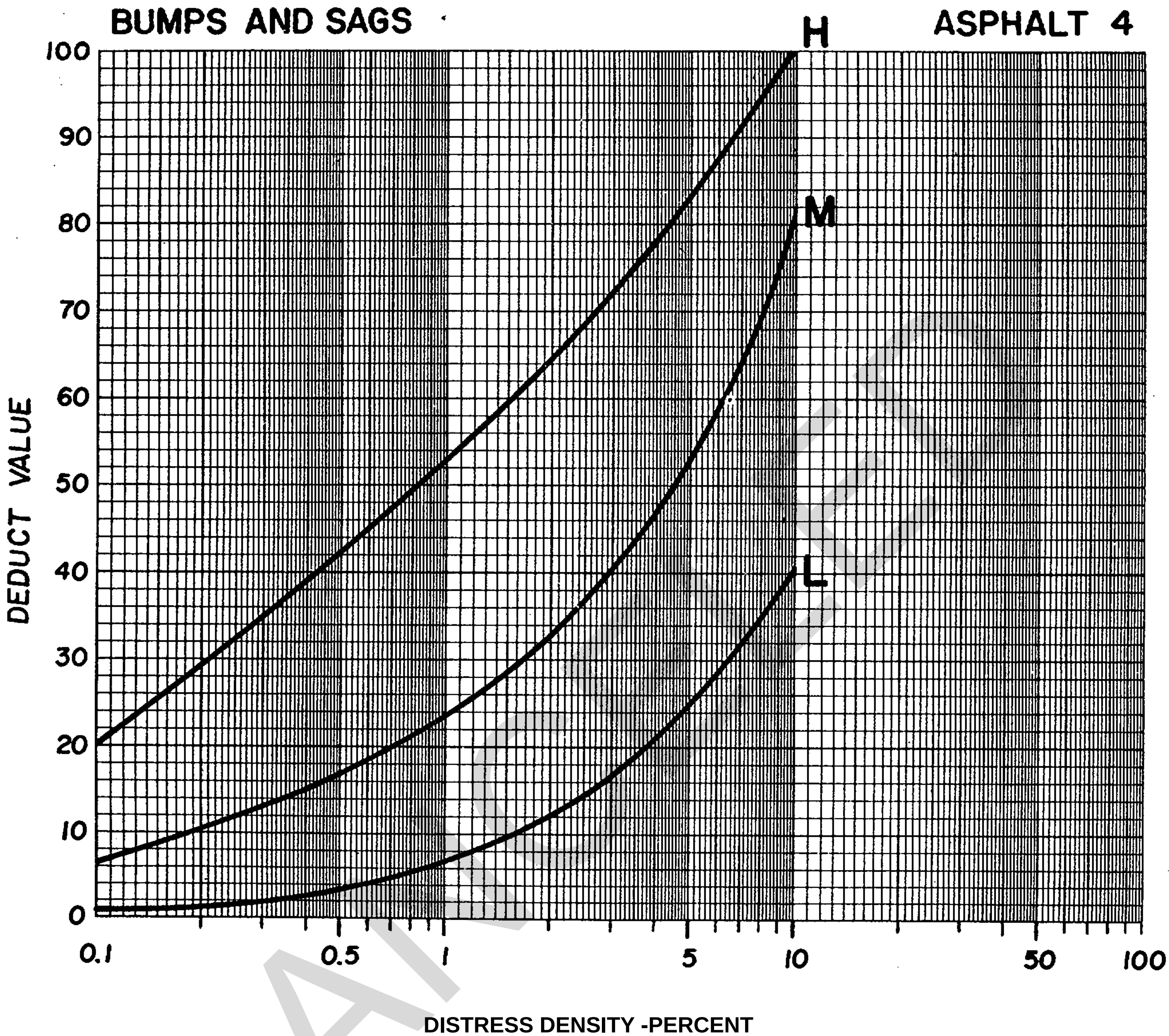
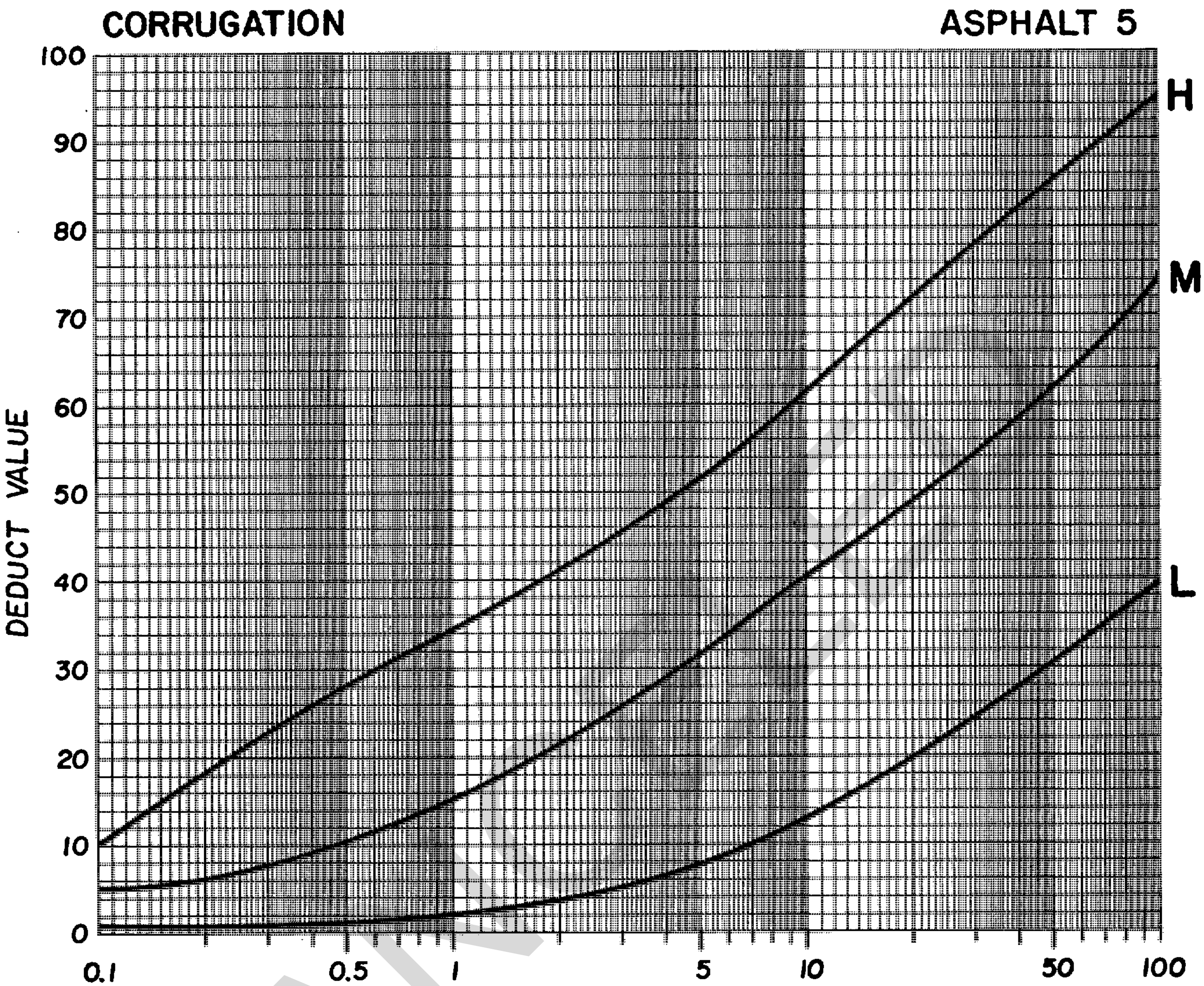
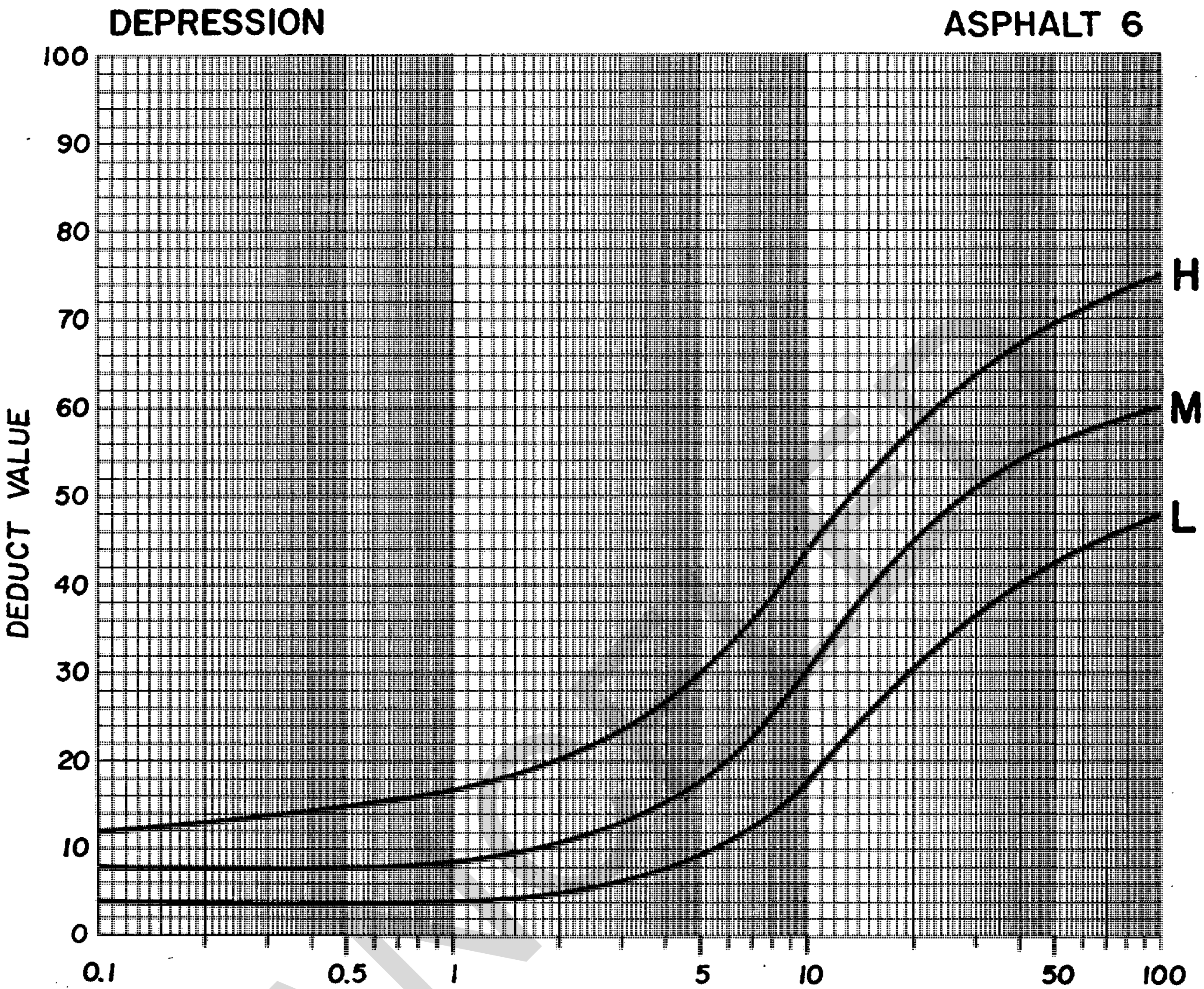


Figure C-4. Deduct value curves for bumps and sags.



DISTRESS DENSITY -PERCENT

Figure C-5. Deduct value curves for corrugation.



DISTRESS DENSITY -PERCENT

Figure C-6. Deduct value curves for depression.

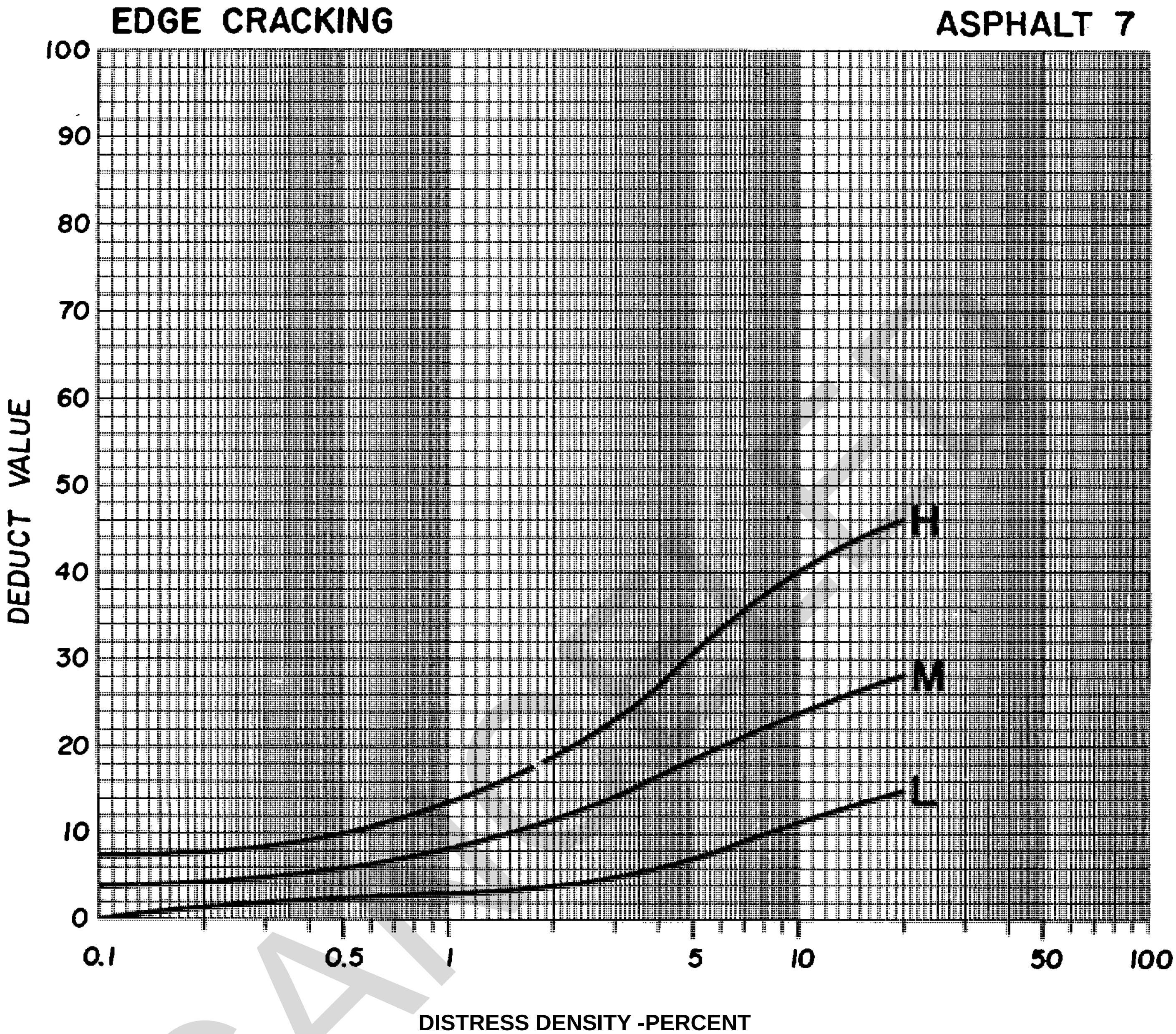


Figure C-7. Deduct value curves for edge cracking.

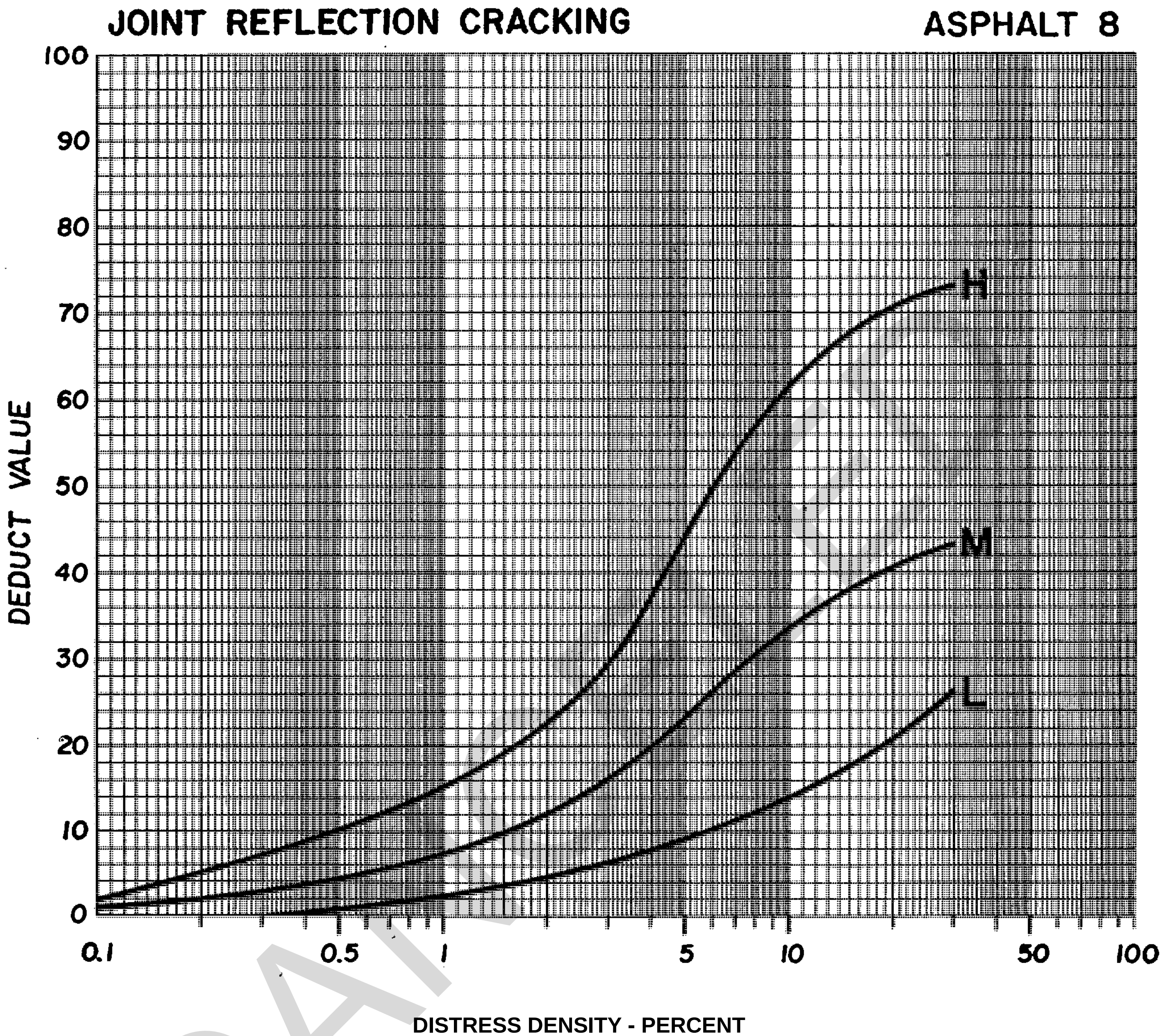
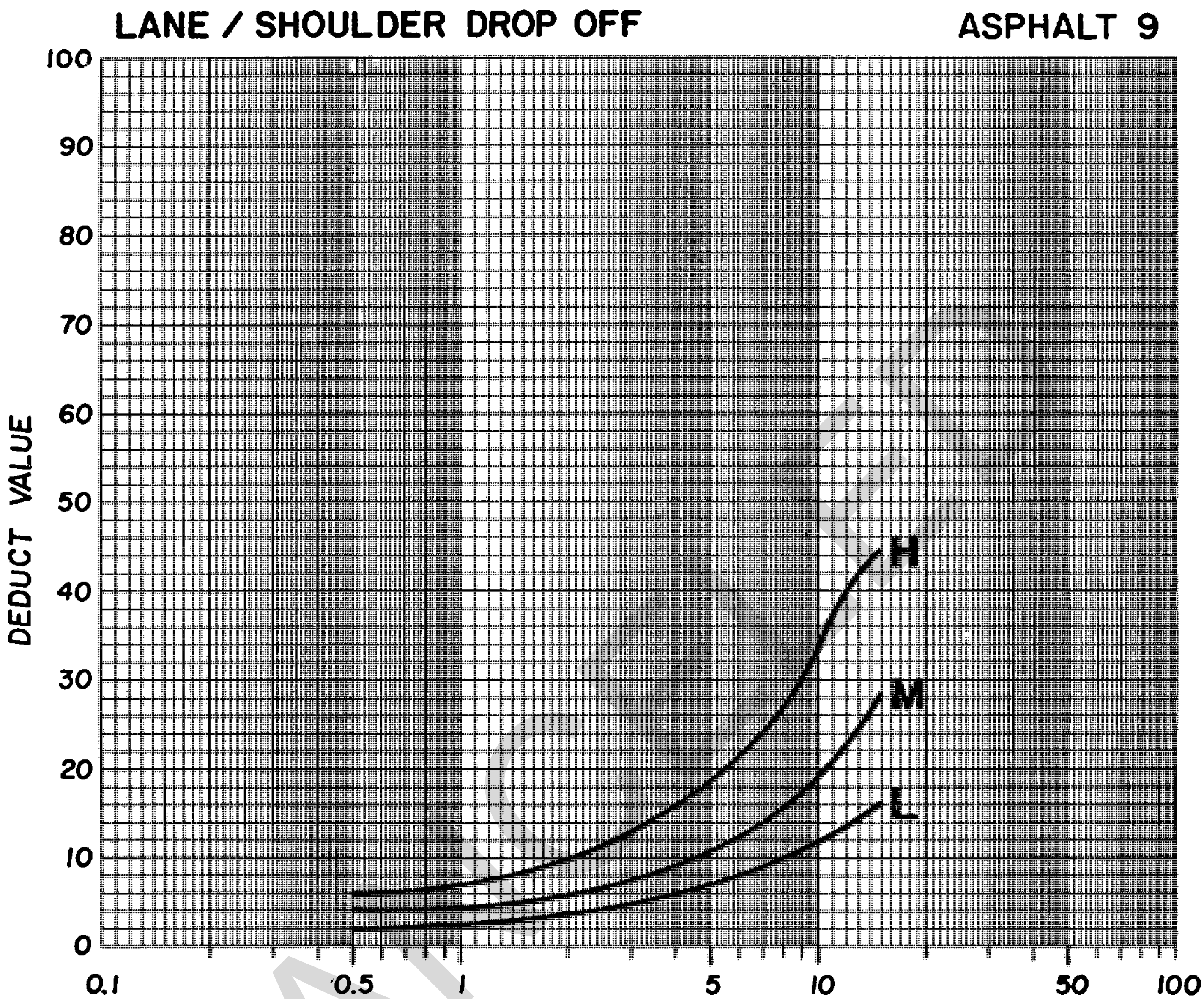
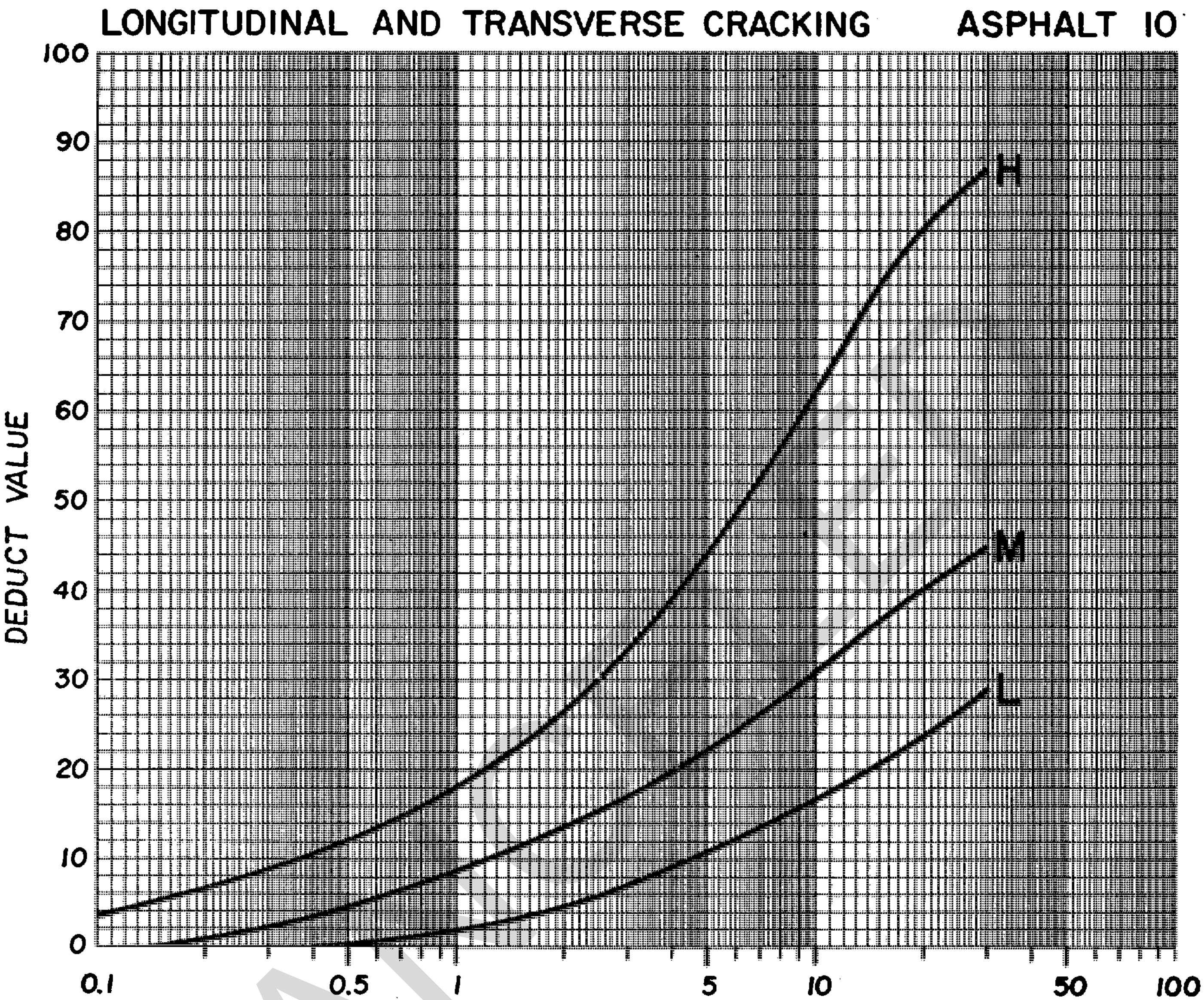


Figure C-8. Deduct value curves for joint reflection cracking.



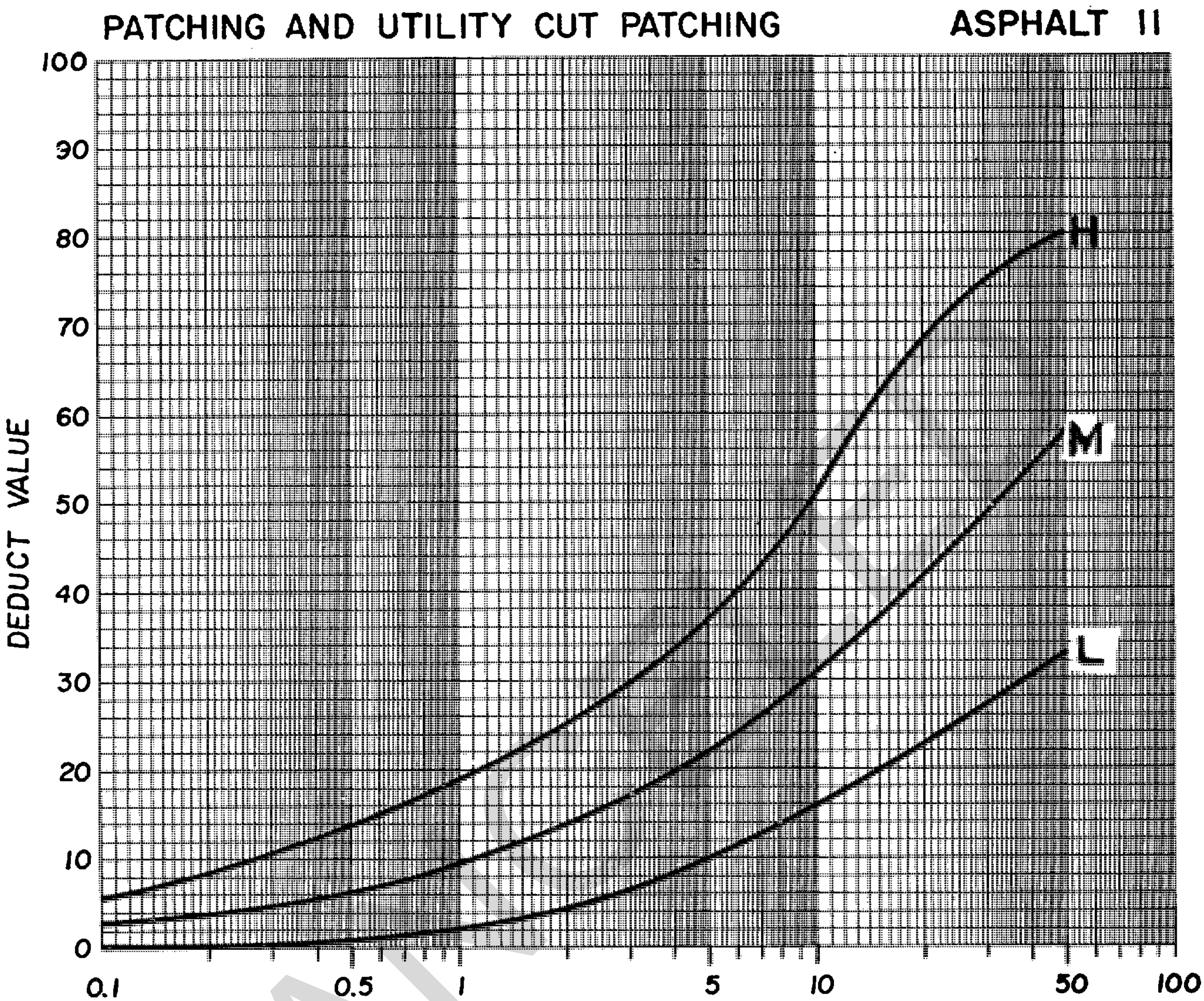
DISTRESS DENSITY - PERCENT

Figure C-9. Deduct value curves for lane/shoulder drop off



DISTRESS DENSITY - PERCENT

Figure C-10. Deduct value curves for longitudinal and transverse cracking.



DISTRESS DENSITY -PERCENT

Figure C-11. Deduct value curves for patching and utility cut patching.

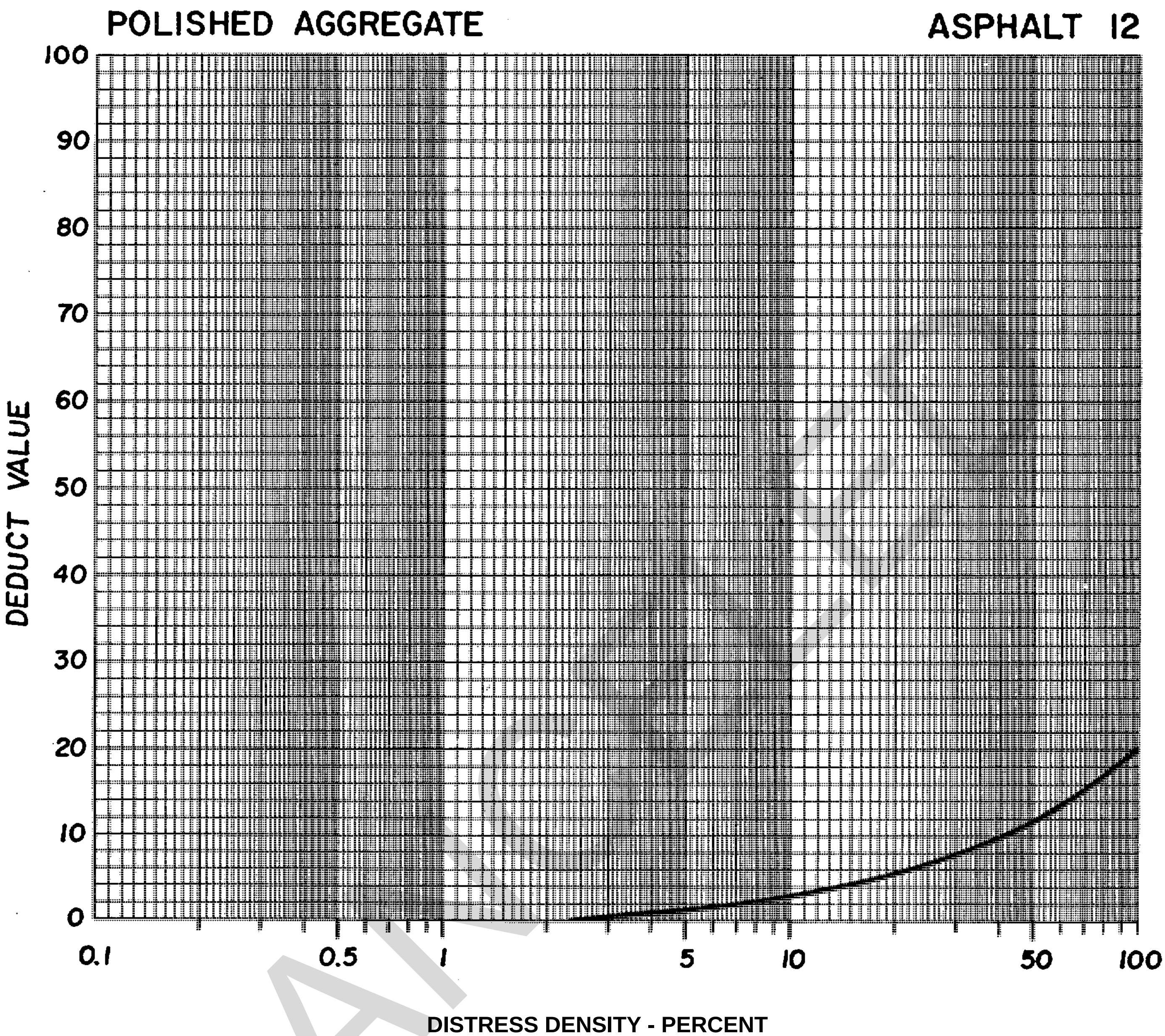
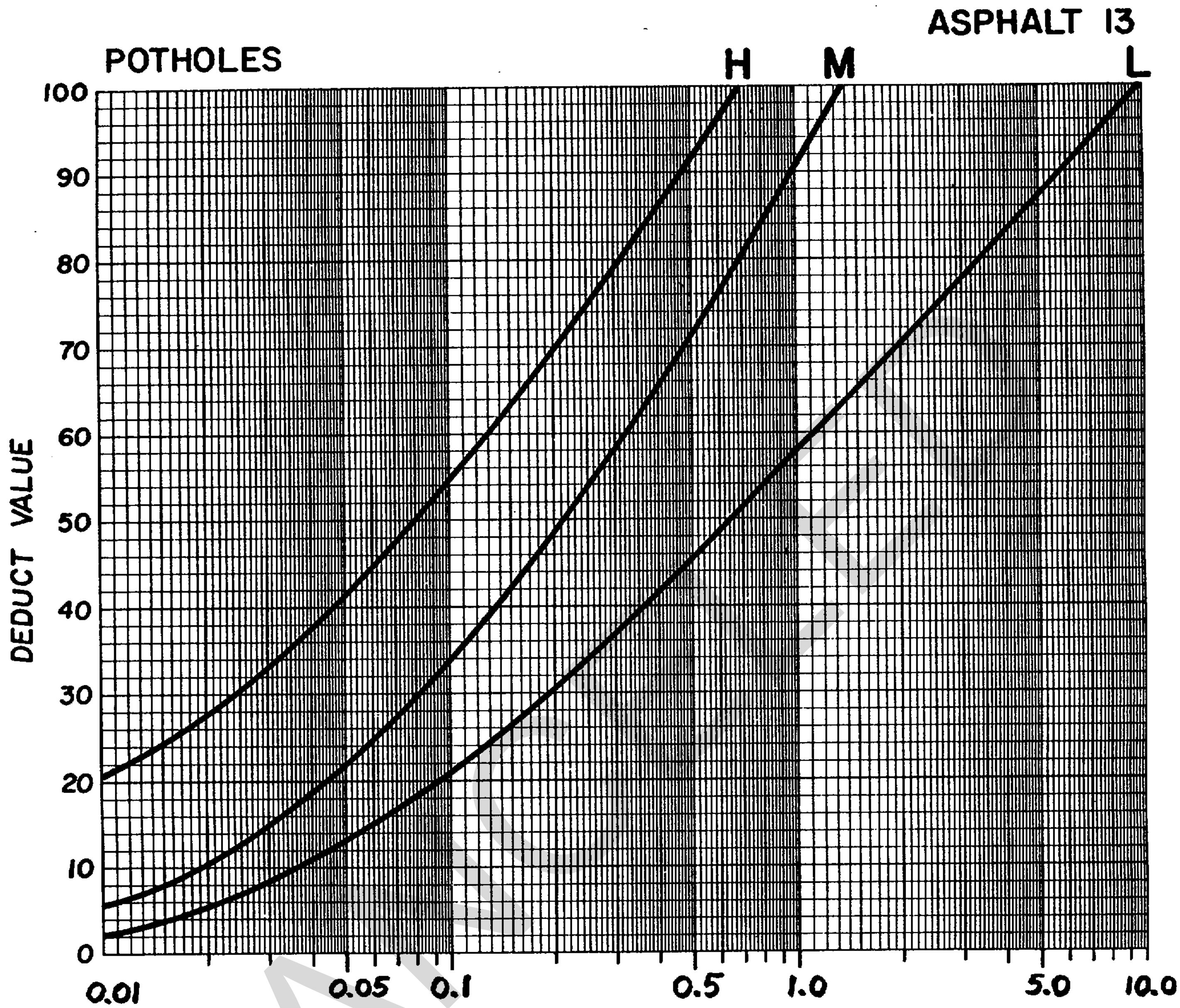
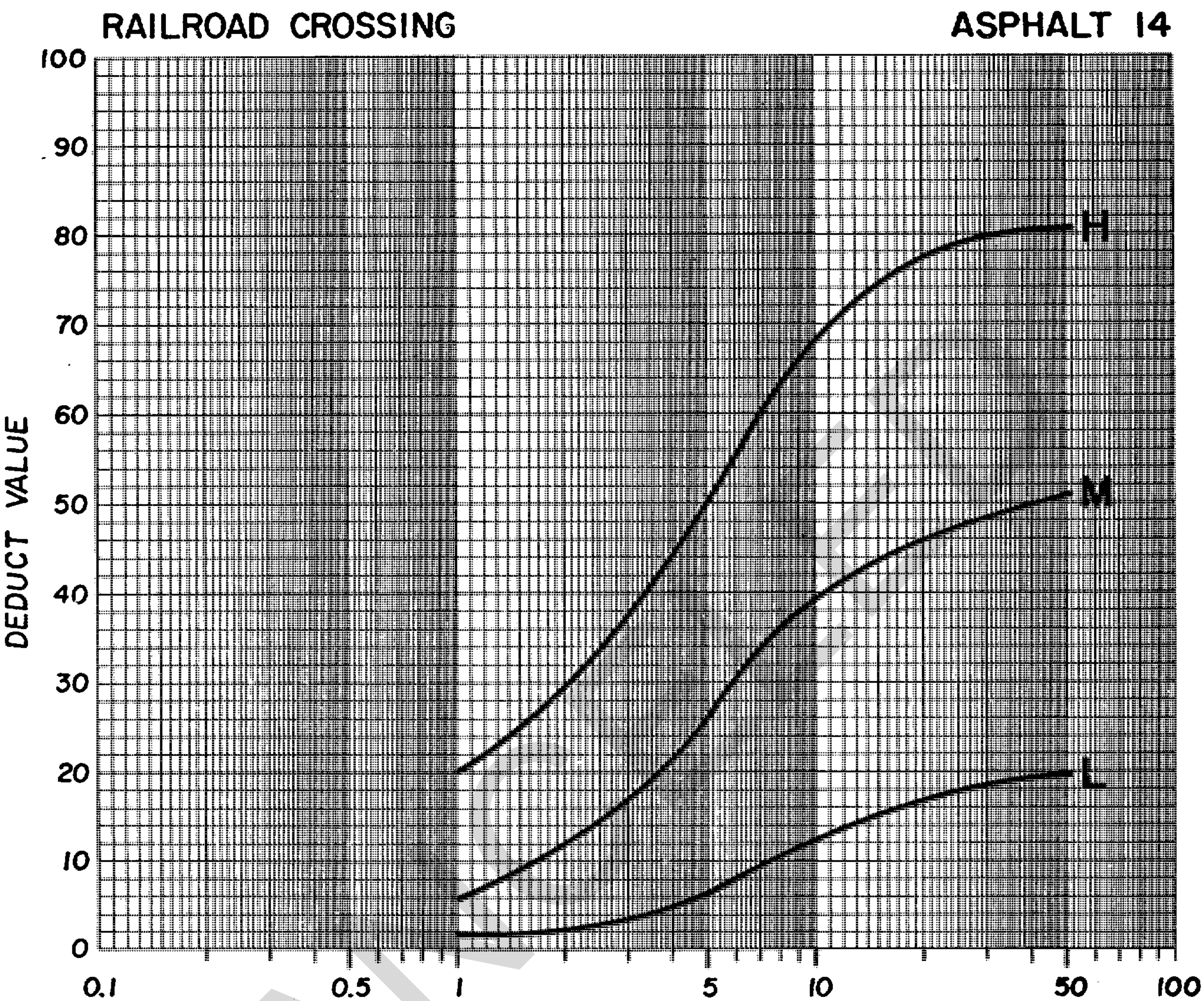


Figure C-12. Deduct value curves for polished aggregate.



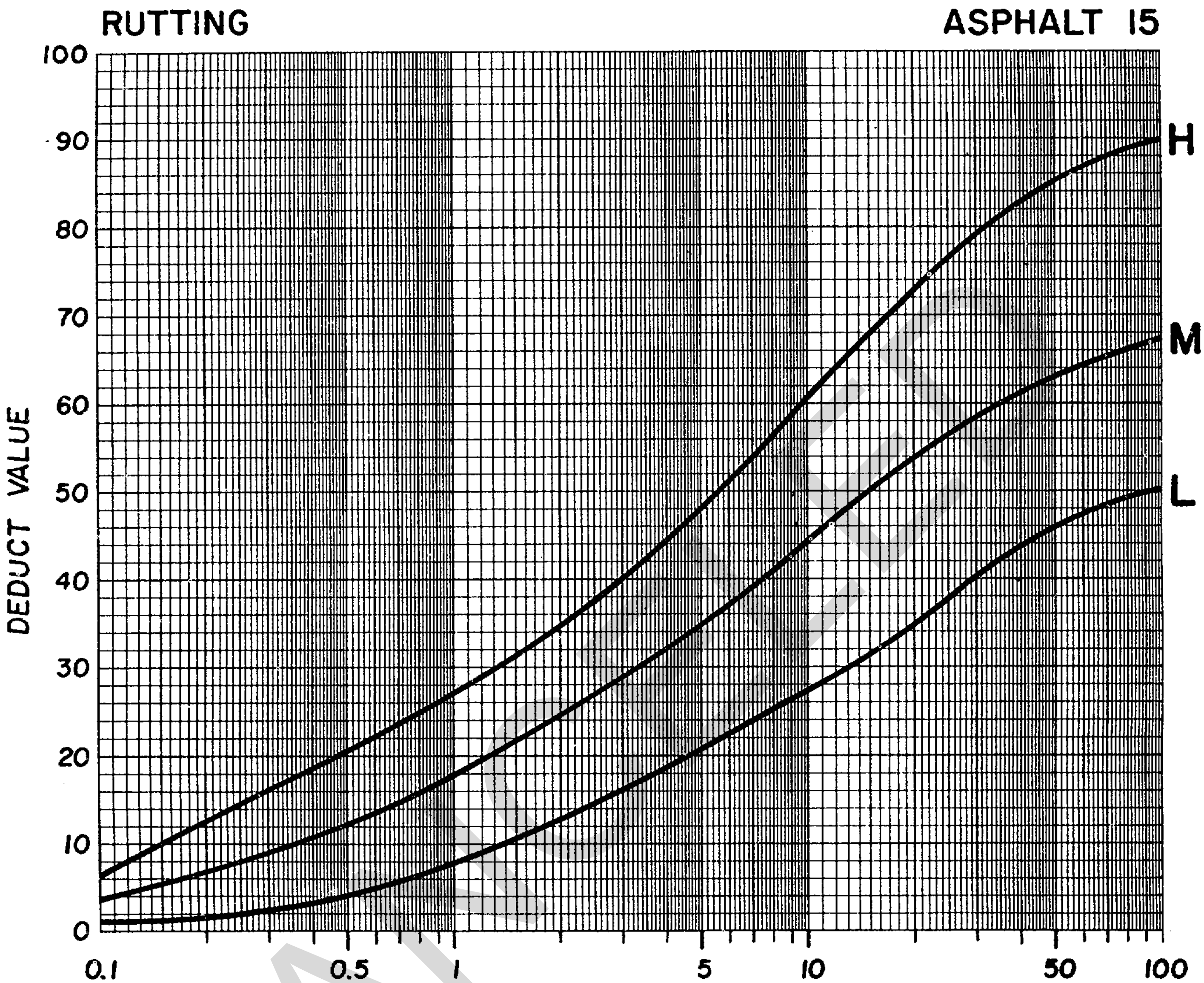
DISTRESS DENSITY -PERCENT

Figure C-13. Deduct value curves for potholes.



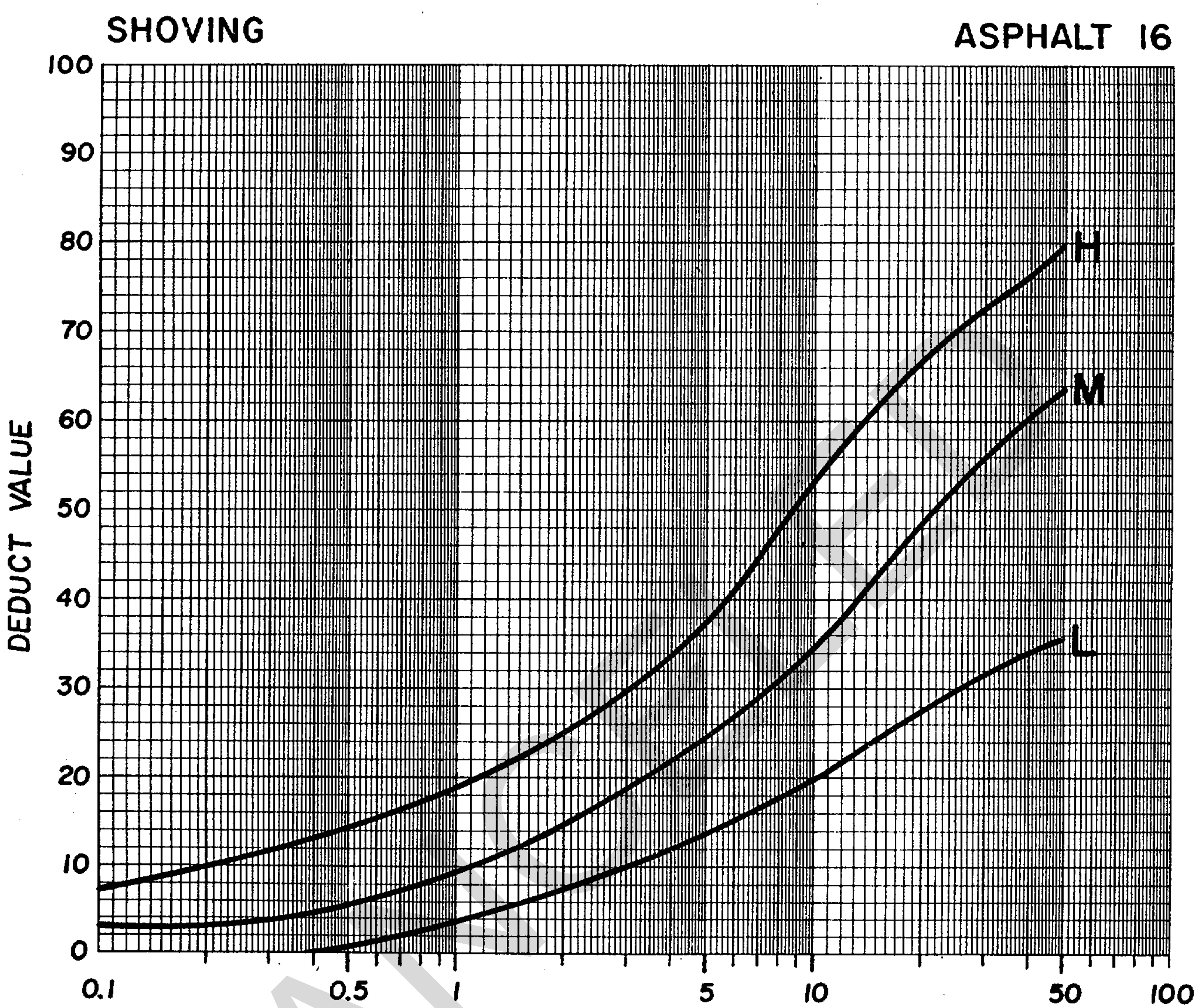
DISTRESS DENSITY - PERCENT

Figure C-14. Deduct value curves for railroad crossing.



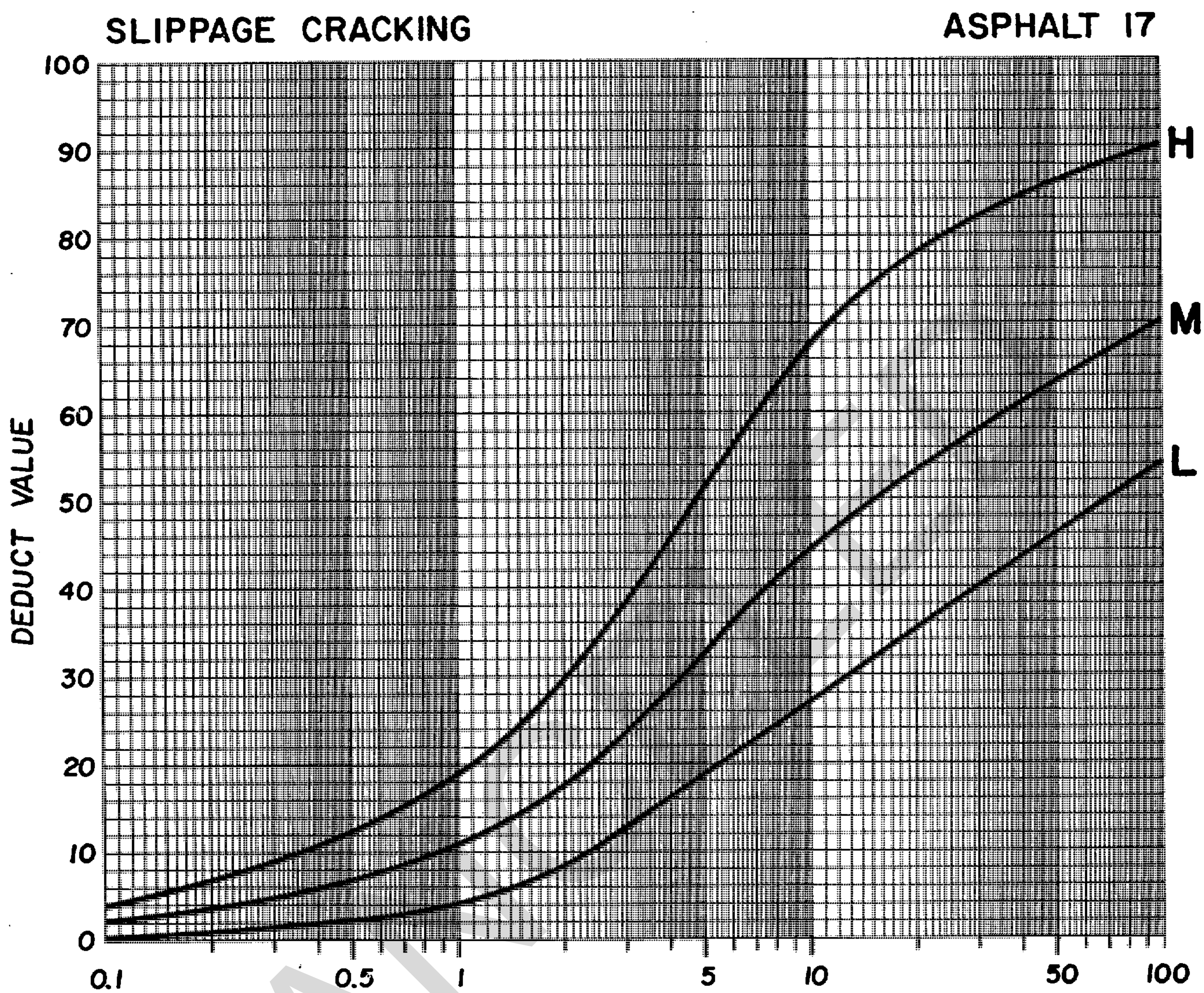
DISTRESS DENSITY - PERCENT

Figure C-15. Deduct value curves for rutting.



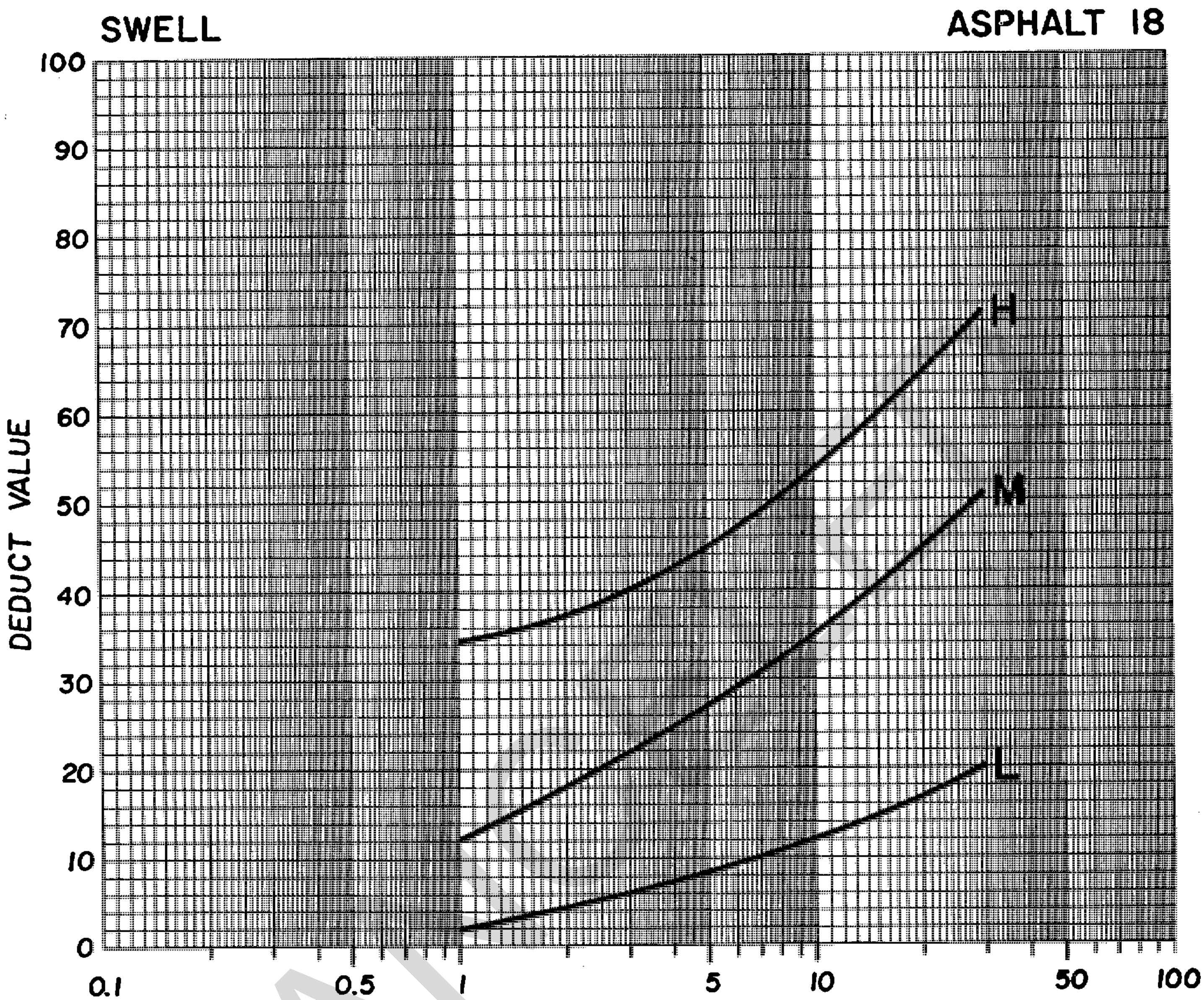
DISTRESS DENSITY - PERCENT

Figure C-16. Deduct value curves for shoving.



DISTRESS DENSITY - PERCENT

Figure C-17. Deduct value curves for slippage.



DISTRESS DENSITY - PERCENT

Figure C-18. Deduct value curves for swell.

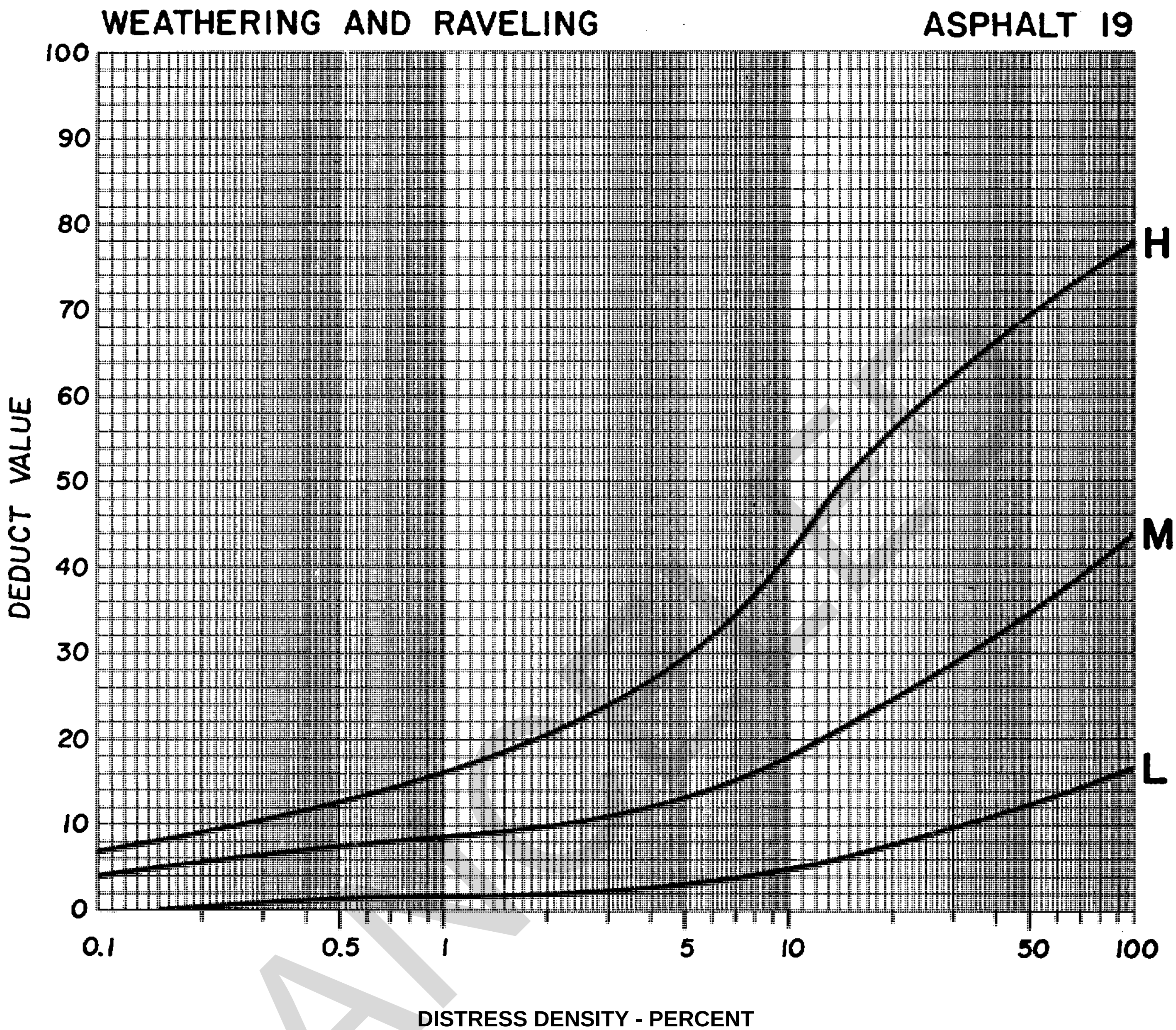
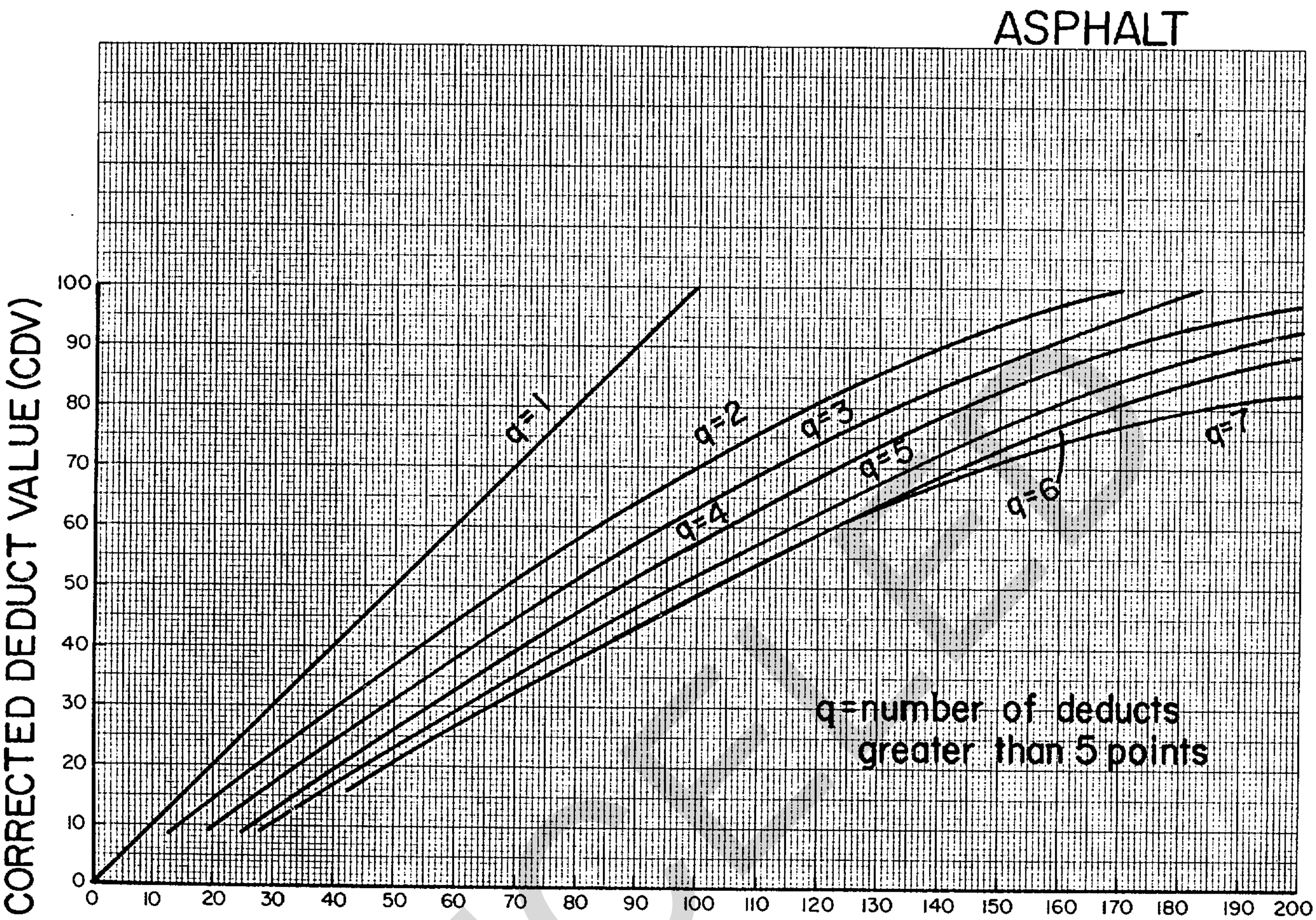


Figure C-19. Deduct value curves for weathering and raveling.



TOTAL DEDUCT VALUE (TDV)

Figure C-20. Corrected deduct value curves for asphalt-surfaced pavements.

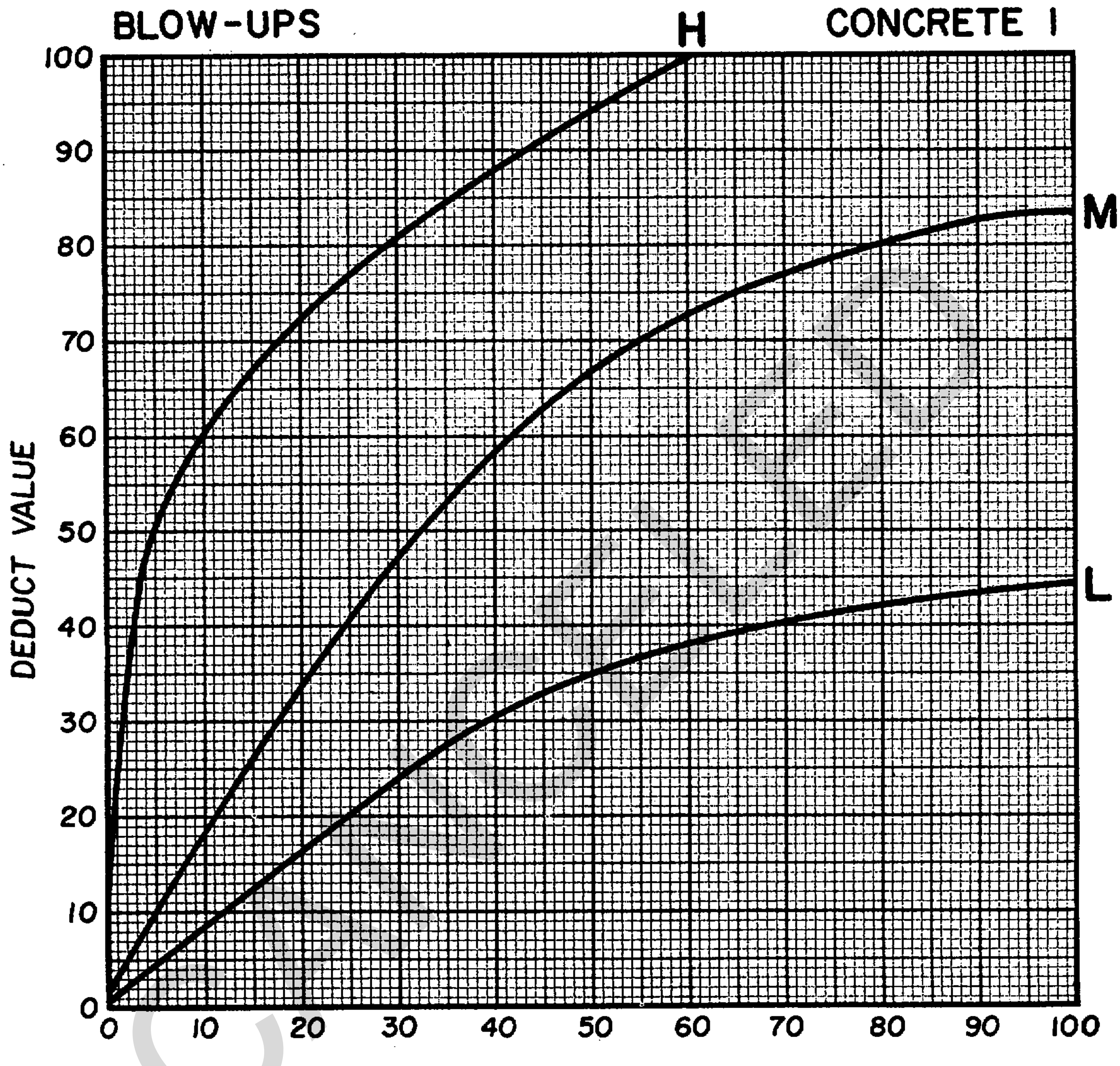
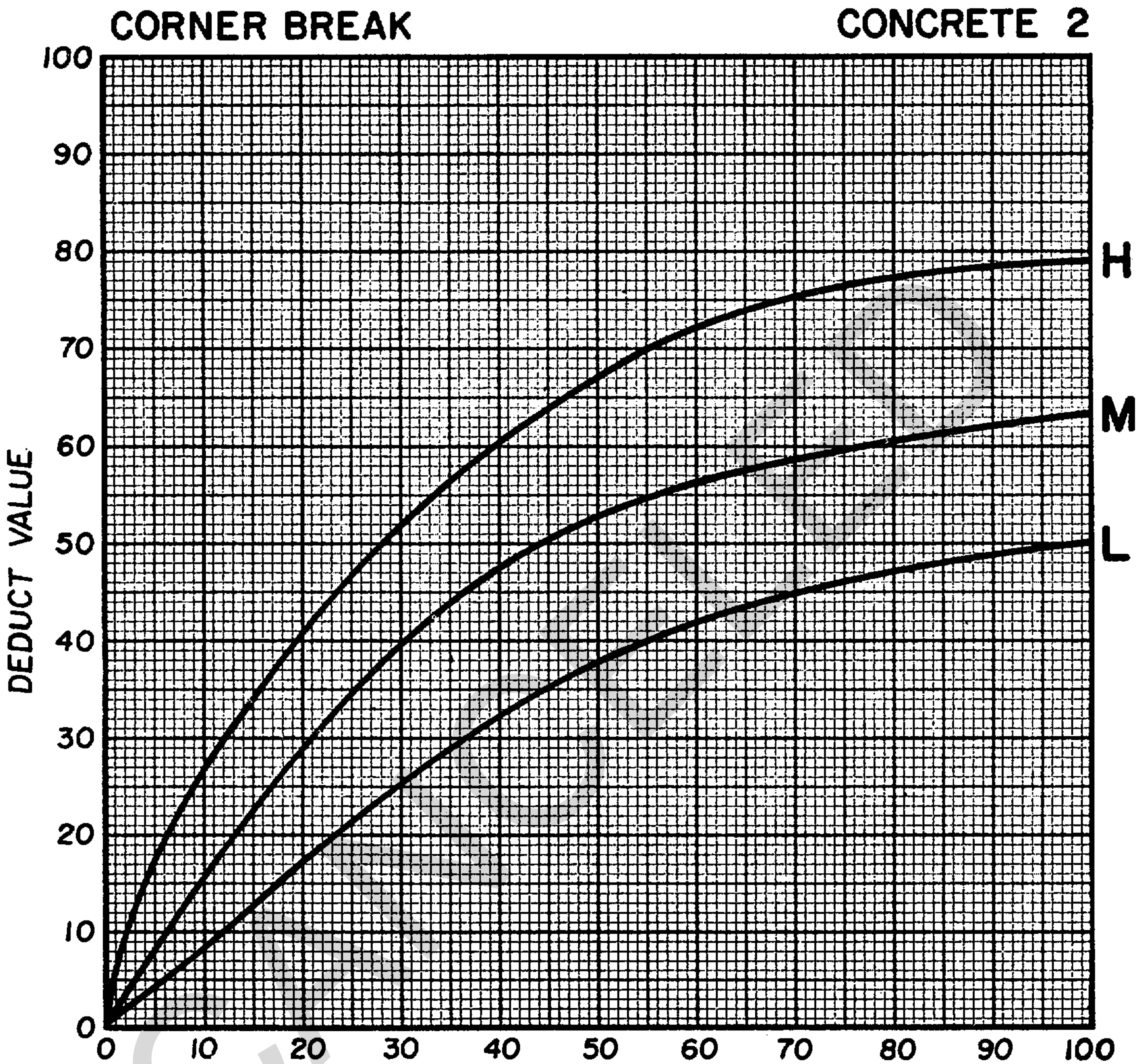
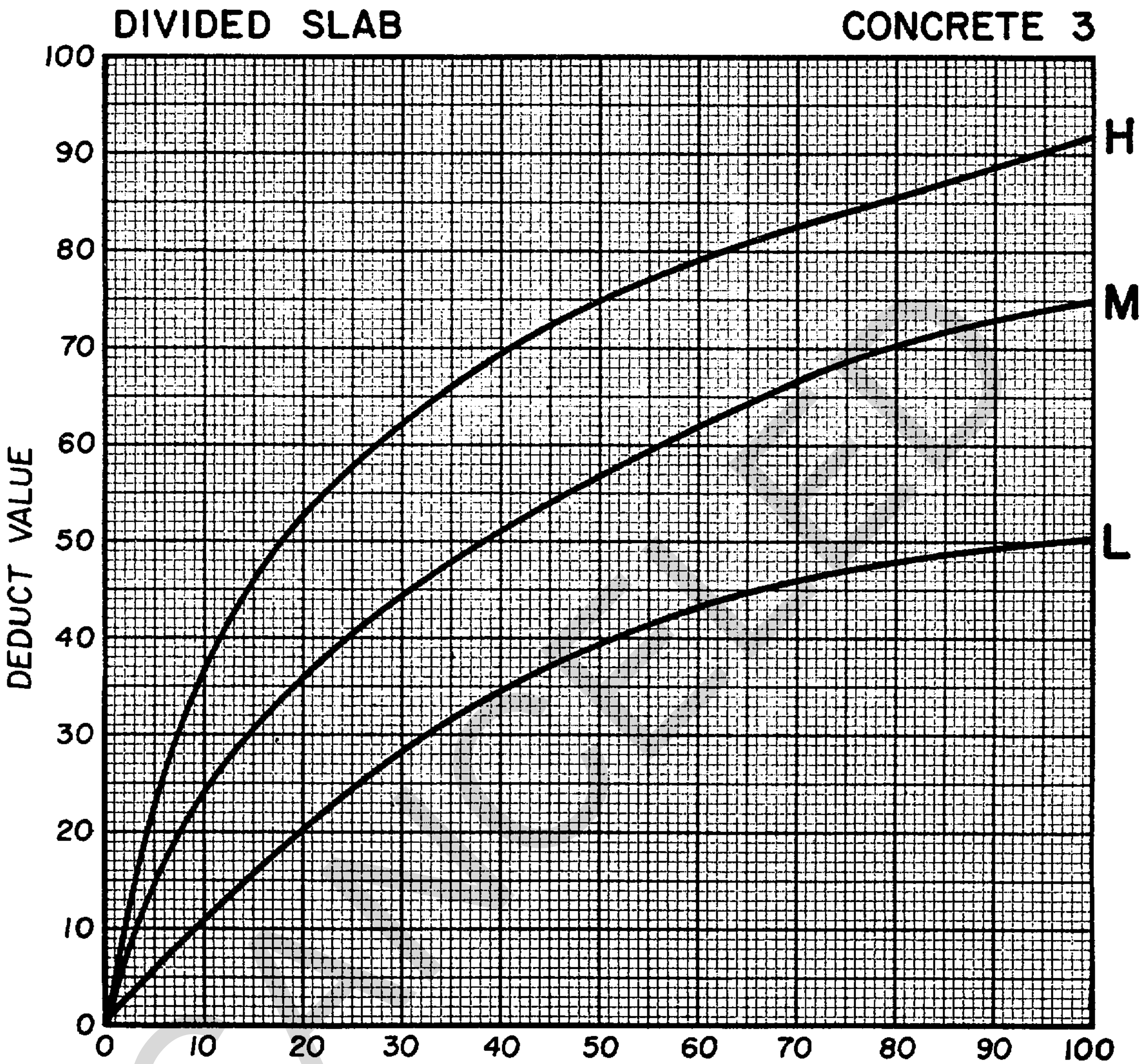


Figure C-21. Deduct value curves for blow-ups.



DISTRESS DENSITY - PERCENT

Figure C-22. Deduct value curves for corner break.



DISTRESS DENSITY - PERCENT

Figure C-23. Deduct value curves for divided slab.

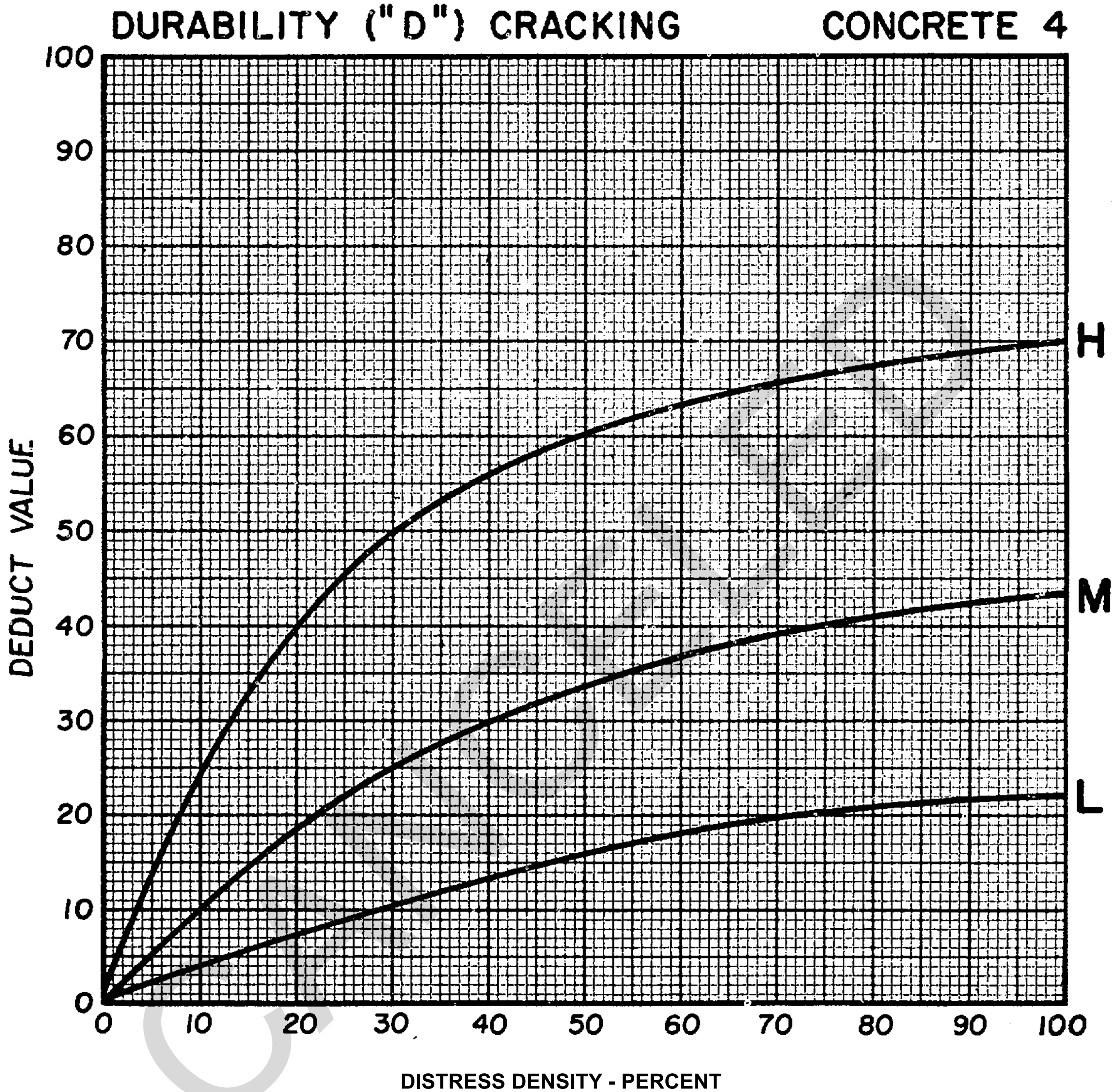
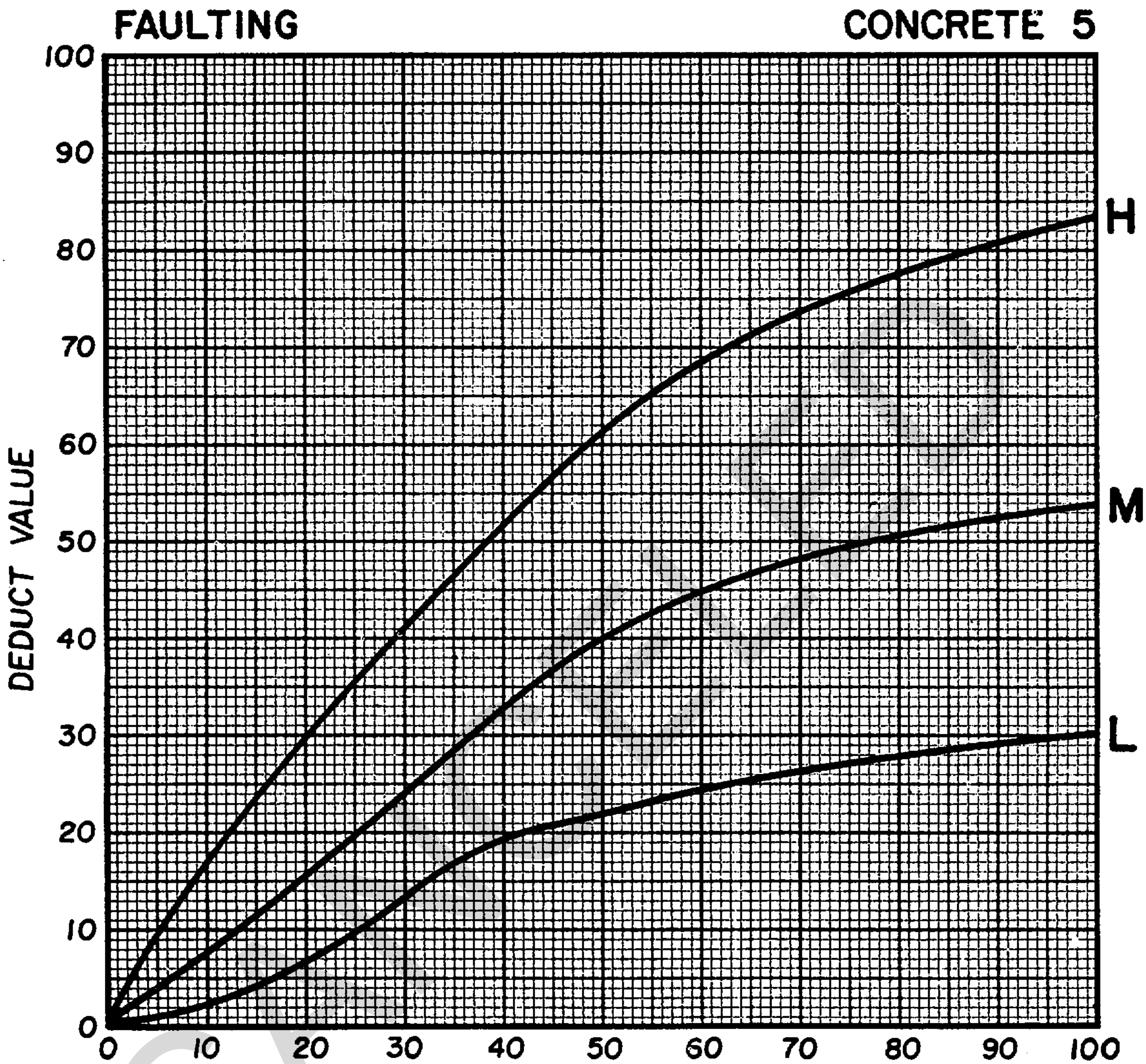


Figure C-24. Deduct value curves for durability ("D") cracking.



DISTRESS DENSITY - PERCENT

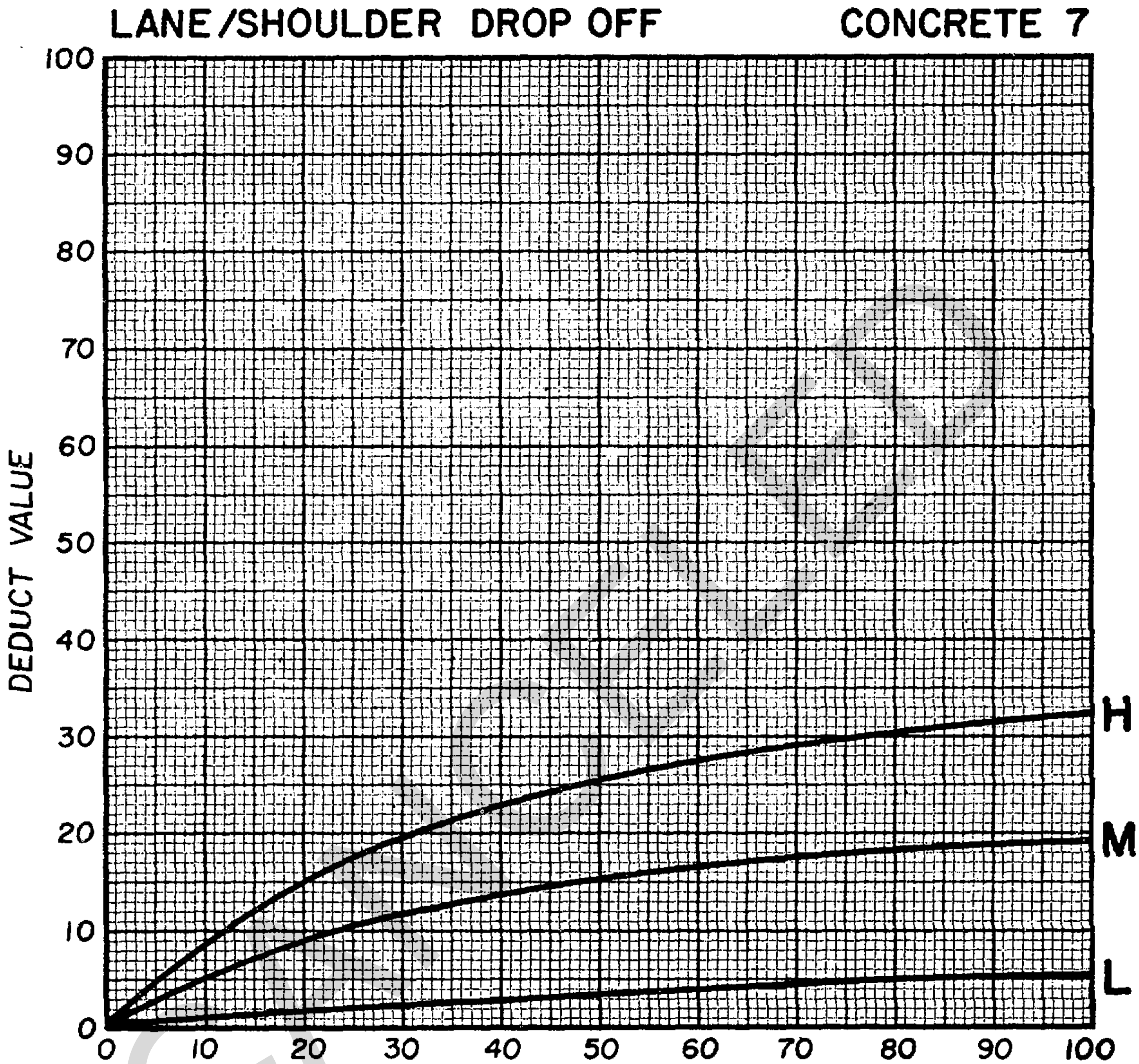
Figure C-25. Deduct value curves for faulting.

The deduct values for the three levels of severity are:

LOW	2 points
MEDIUM	4 points
HIGH	8 points

Joint seal damage is not rated by density. The severity of the distress is determined by the sealant's overall condition for a particular sample unit.

Figure C-26. Deduct values for joint seal damage.



DISTRESS DENSITY - PERCENT

Figure C-27. Deduct value curves for lane/shoulder drop off

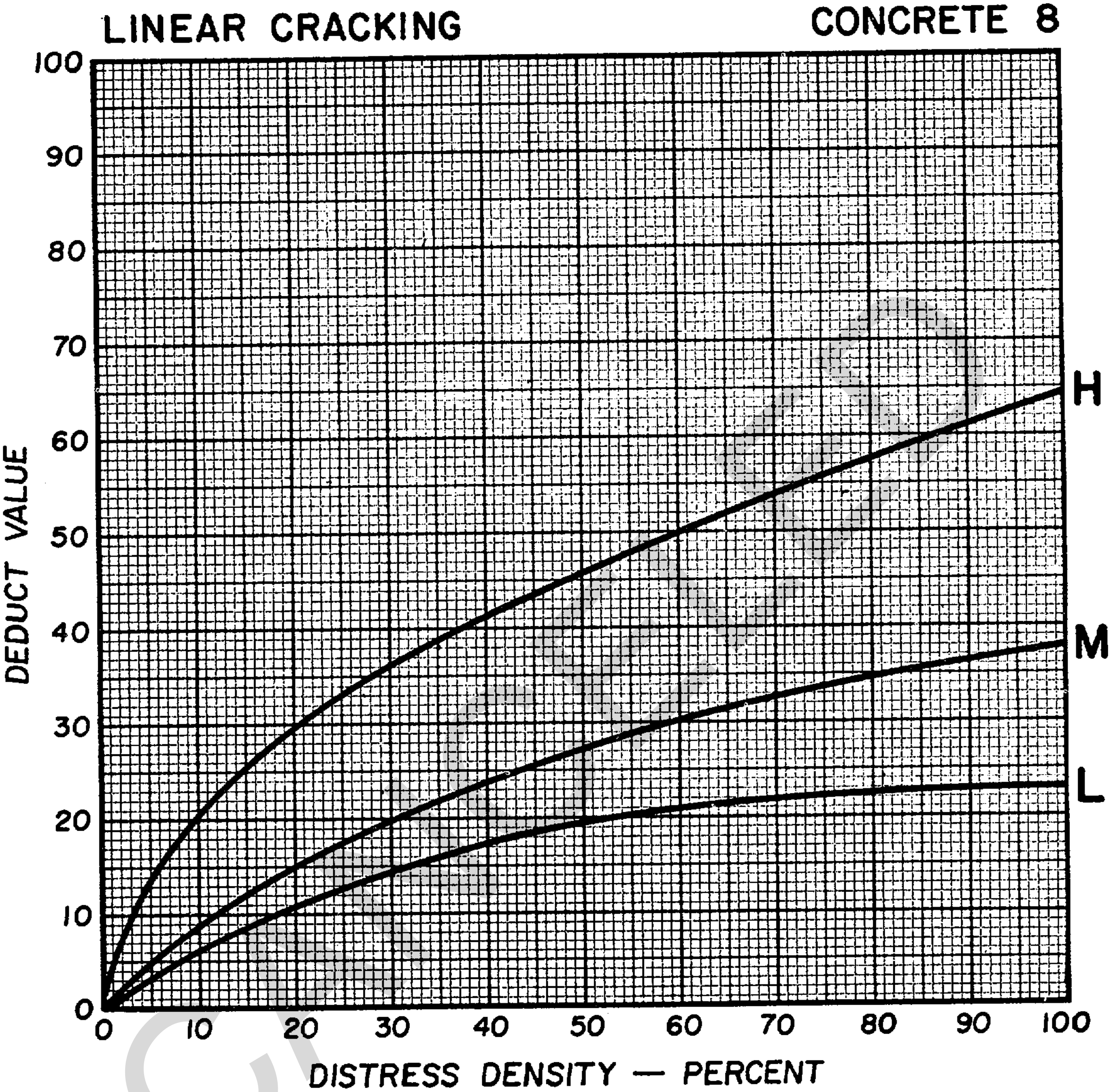


Figure C-28. Deduct value curves for linear cracking.

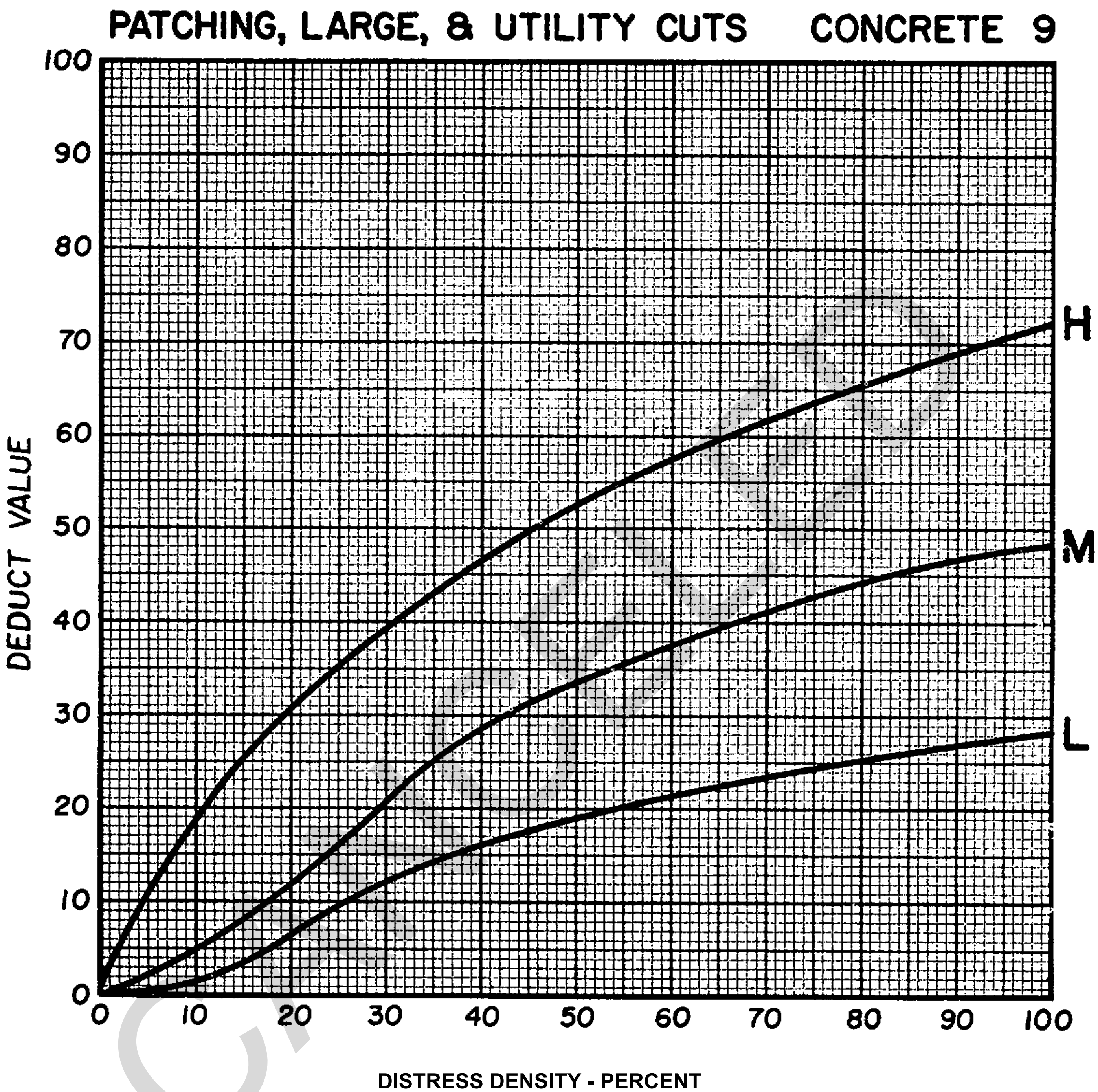
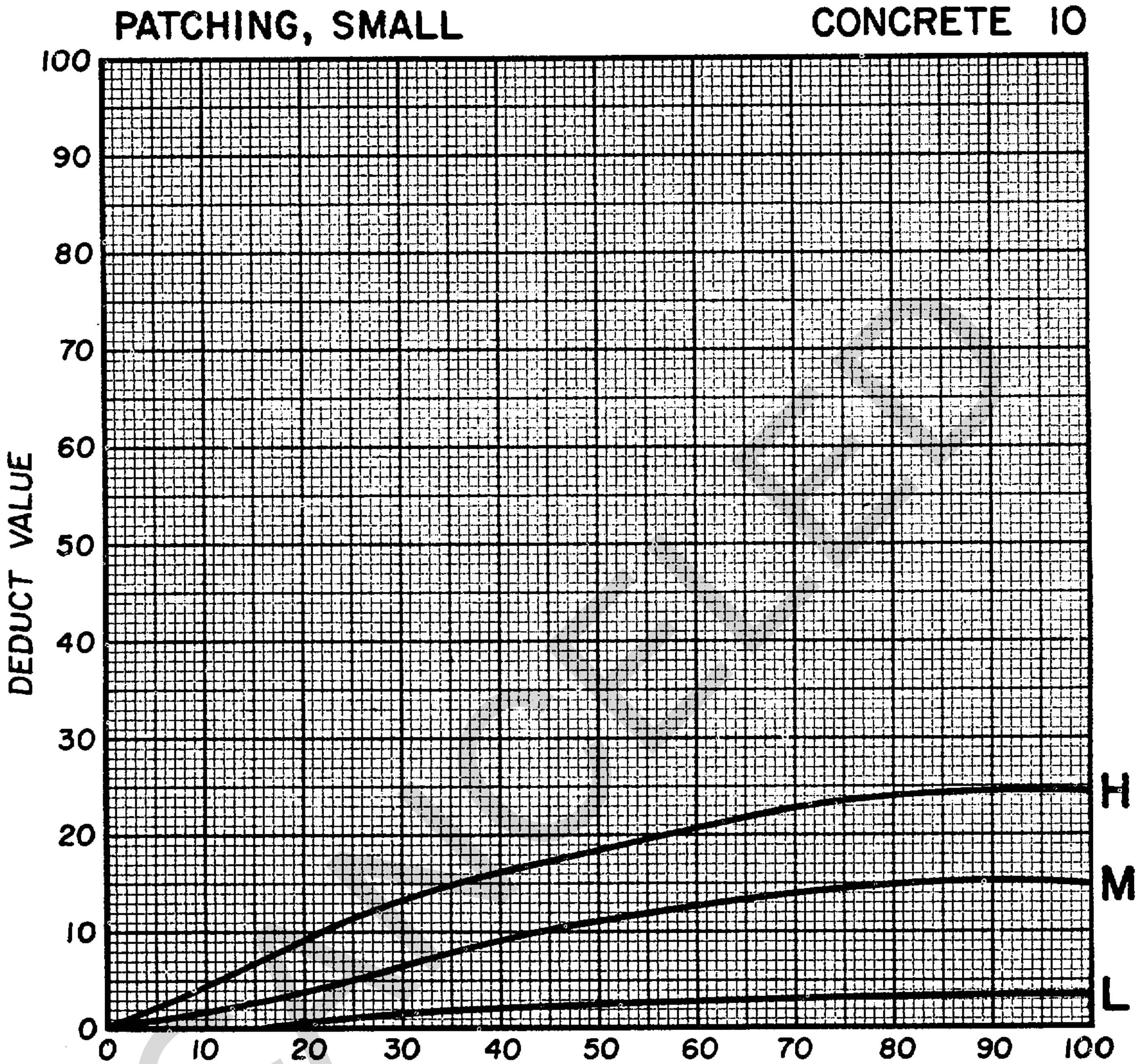


Figure C-29. Deduct value curves for patching large and utility cuts.



DISTRESS DENSITY - PERCENT

Figure C-30. Deduct value curves for patching small.

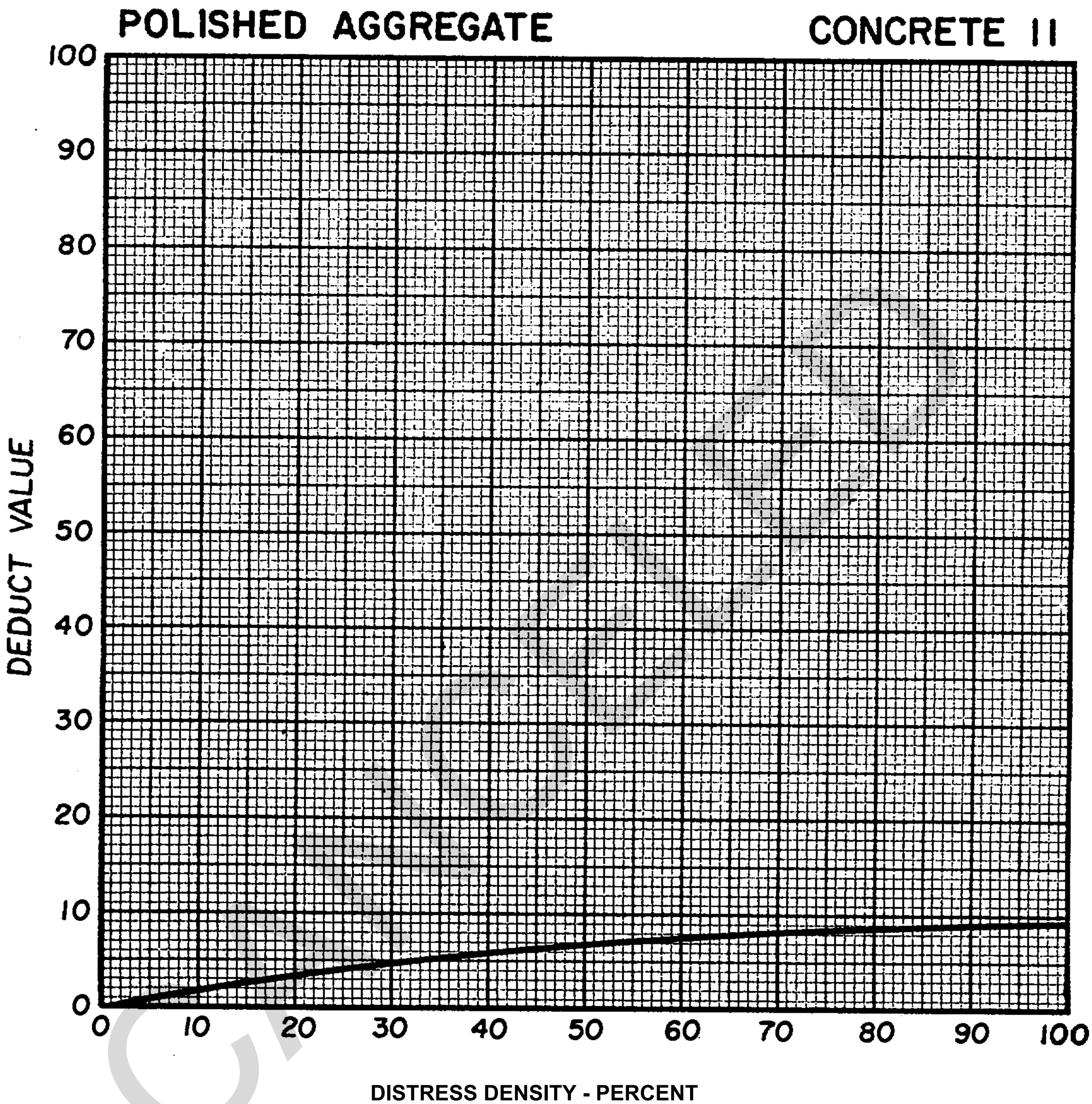


Figure C-31. Deduct value curve for polished aggregate.

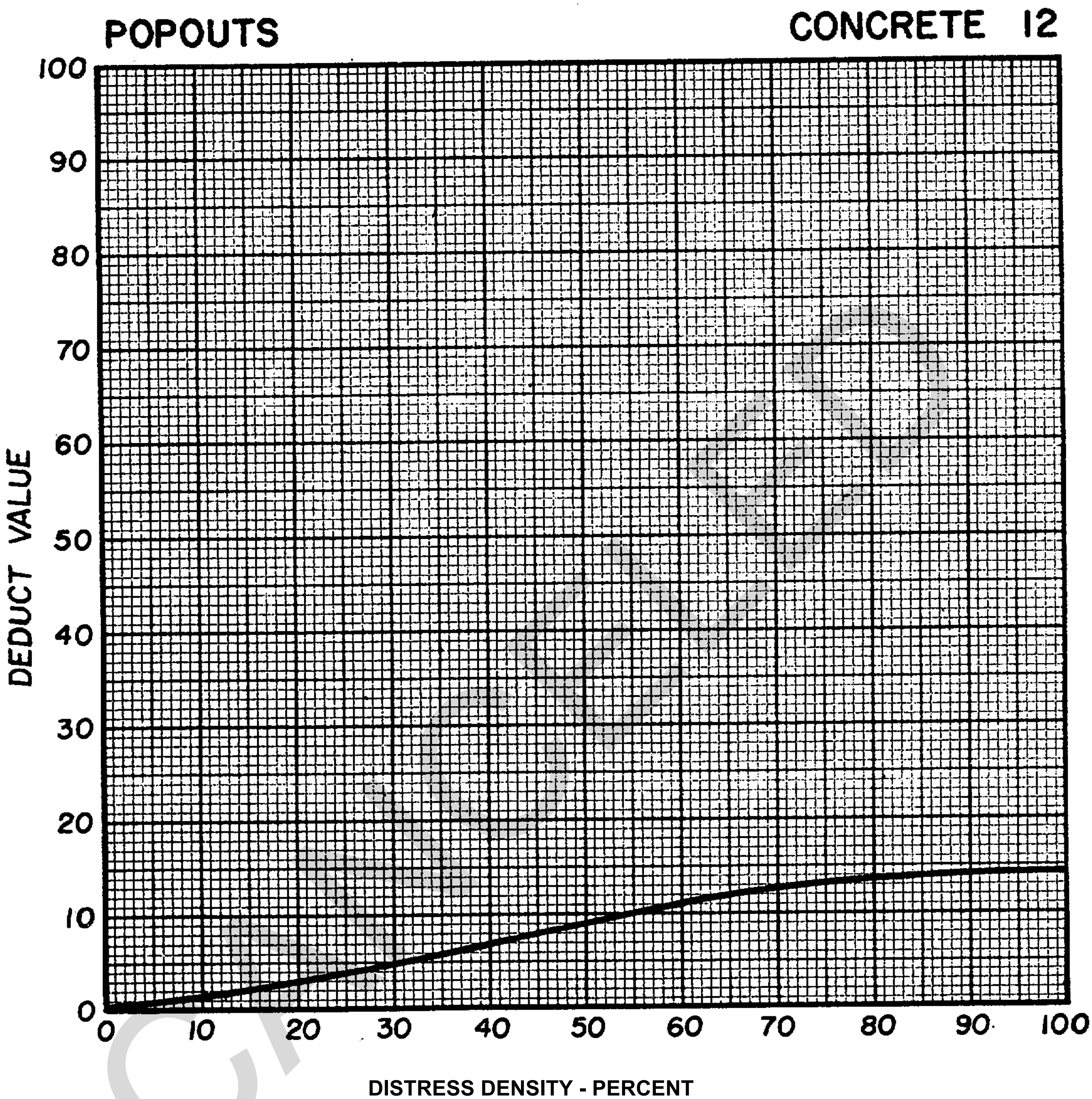
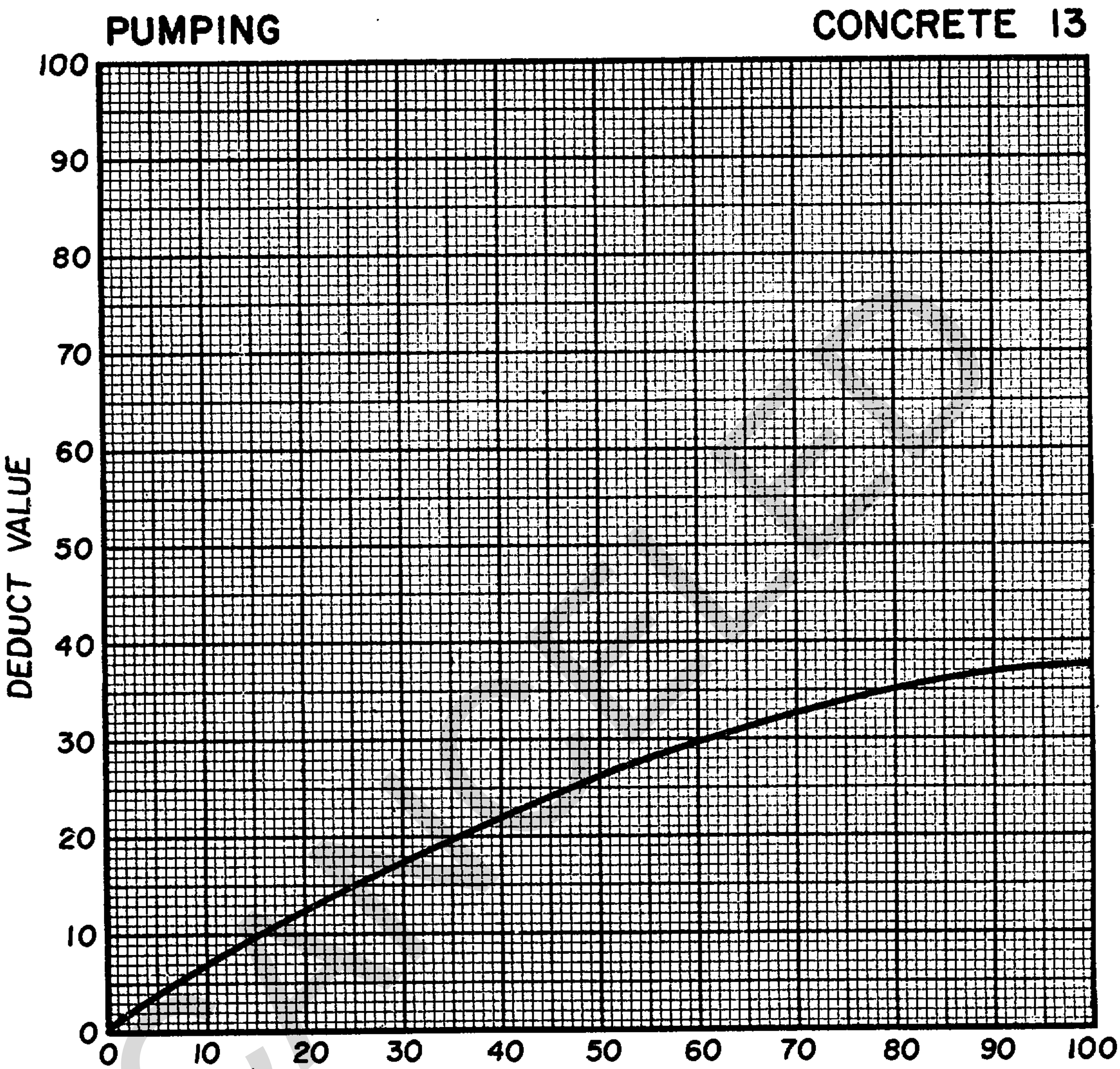


Figure C-32. Deduct value curves for popouts.



DISTRESS DENSITY - PERCENT

Figure C-33. Deduct value curve for pumping.

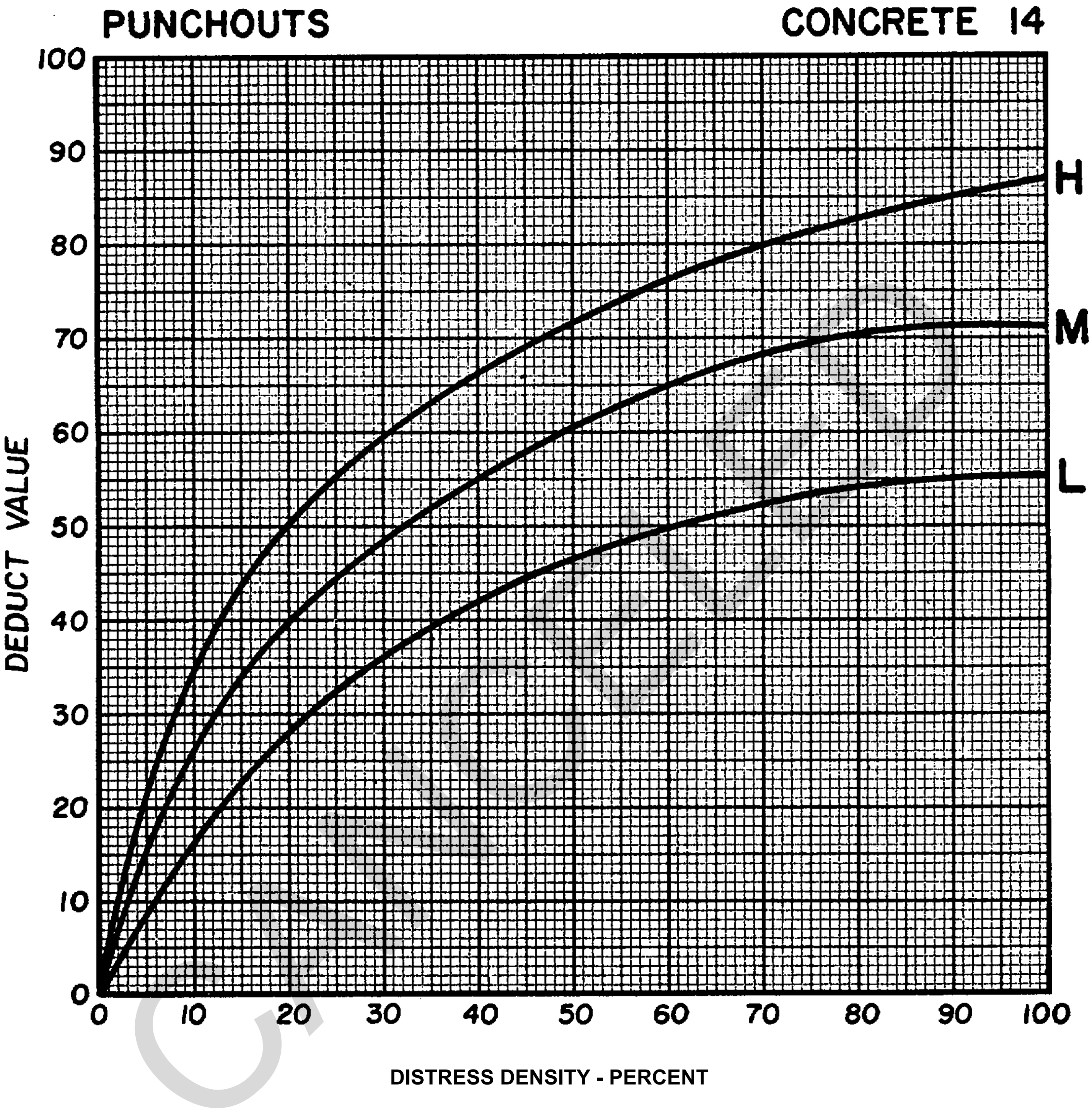


Figure C-34. Deduct value curves for punchouts.

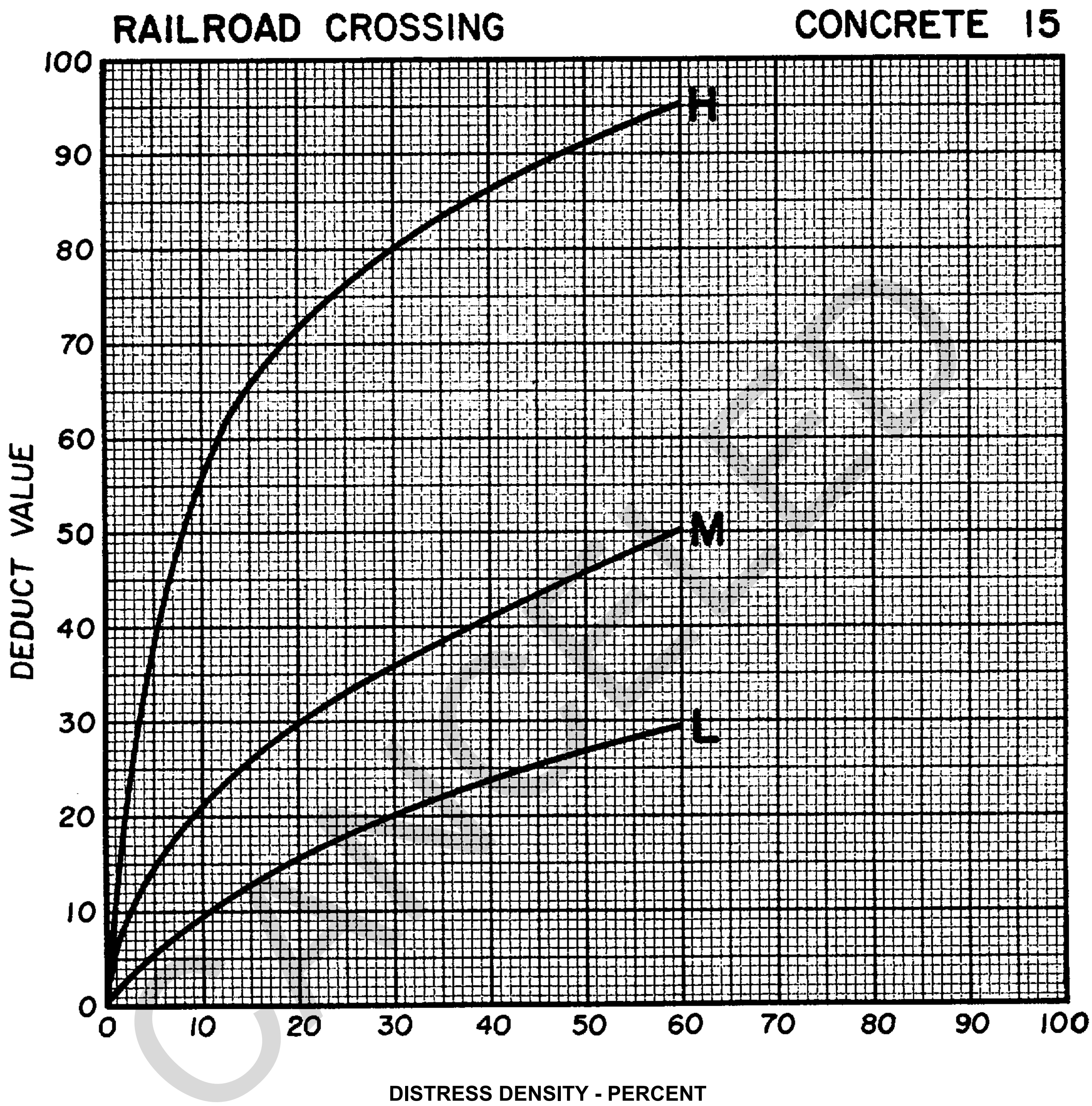


Figure C-35. Deduct value curves for railroad crossing.

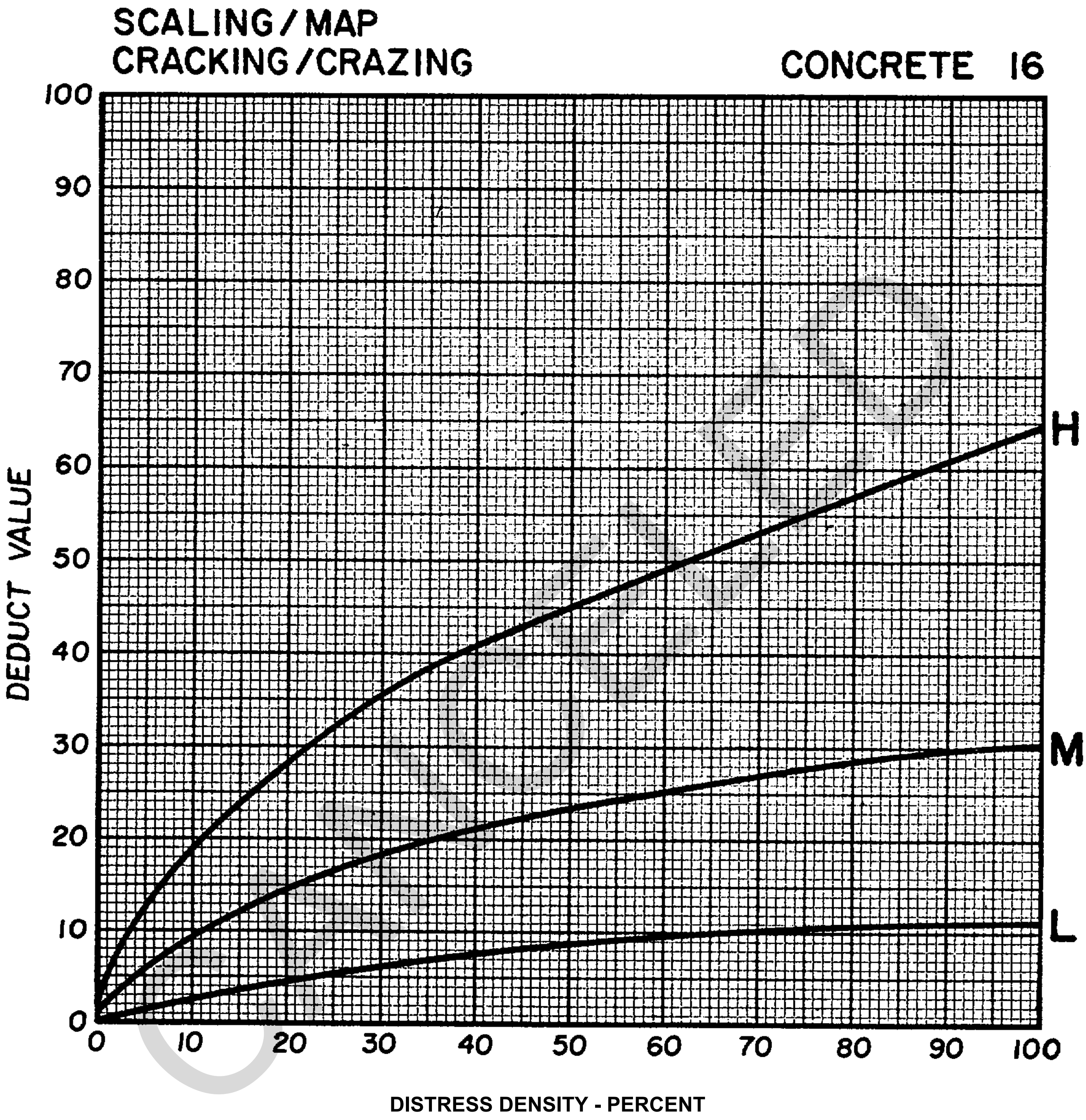


Figure C-36. Deduct value curves for scaling/map cracking/crazing.

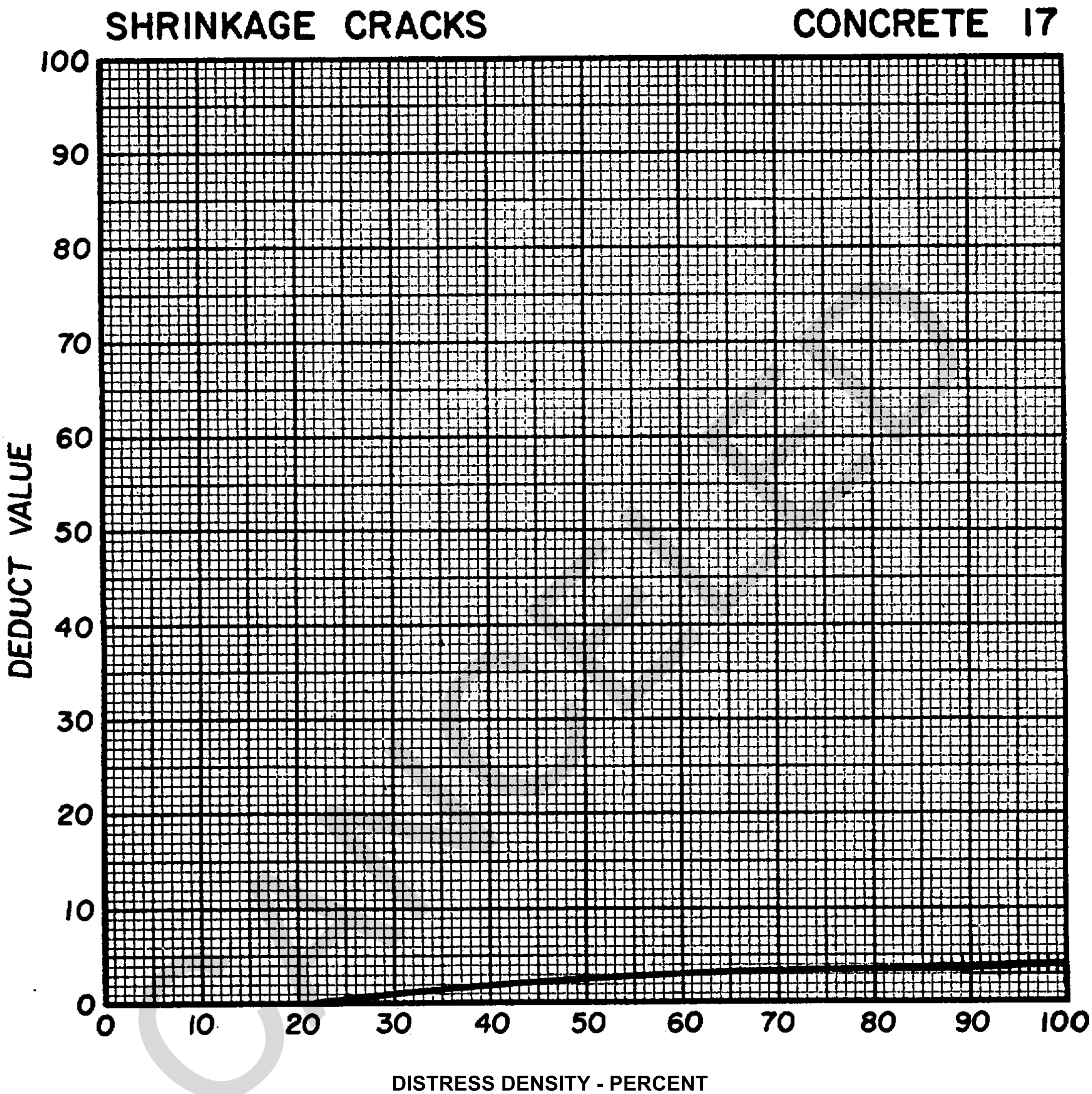


Figure C-37. Deduct value curve for shrinkage cracks.

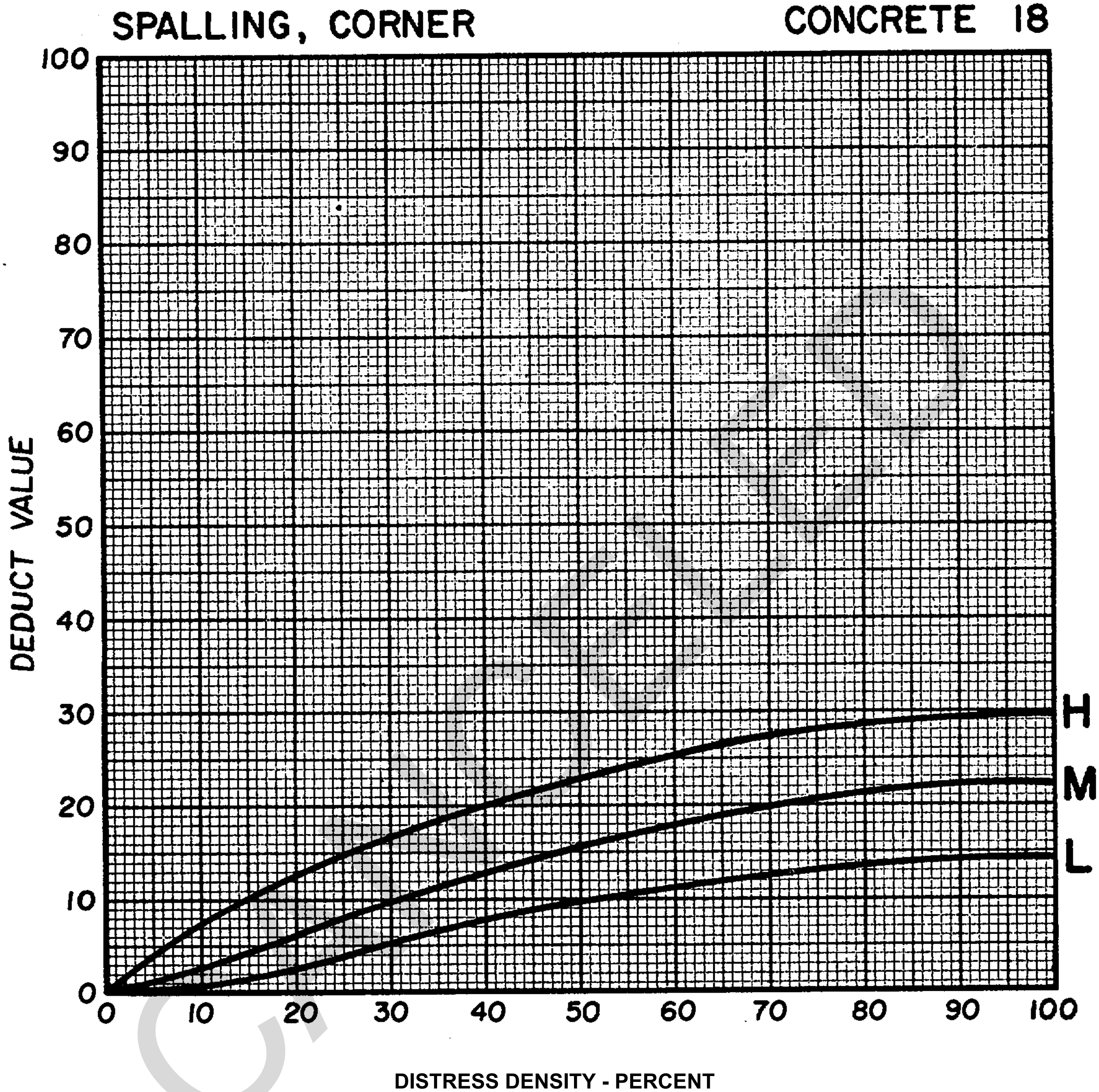


Figure C-38. Deduct value curves for spalling, corner.

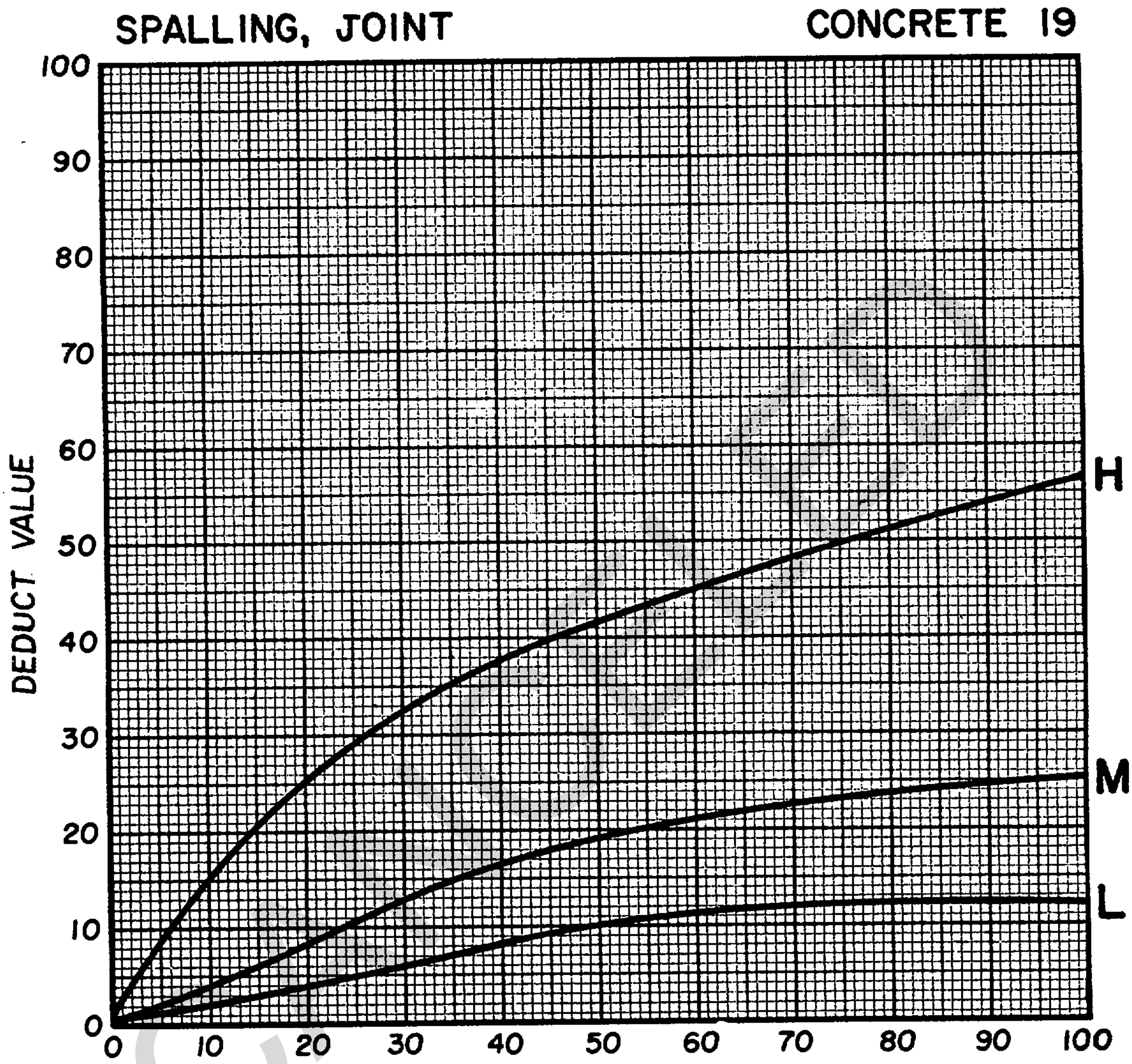


Figure C-39. Deduct value curves for spalling, joint.

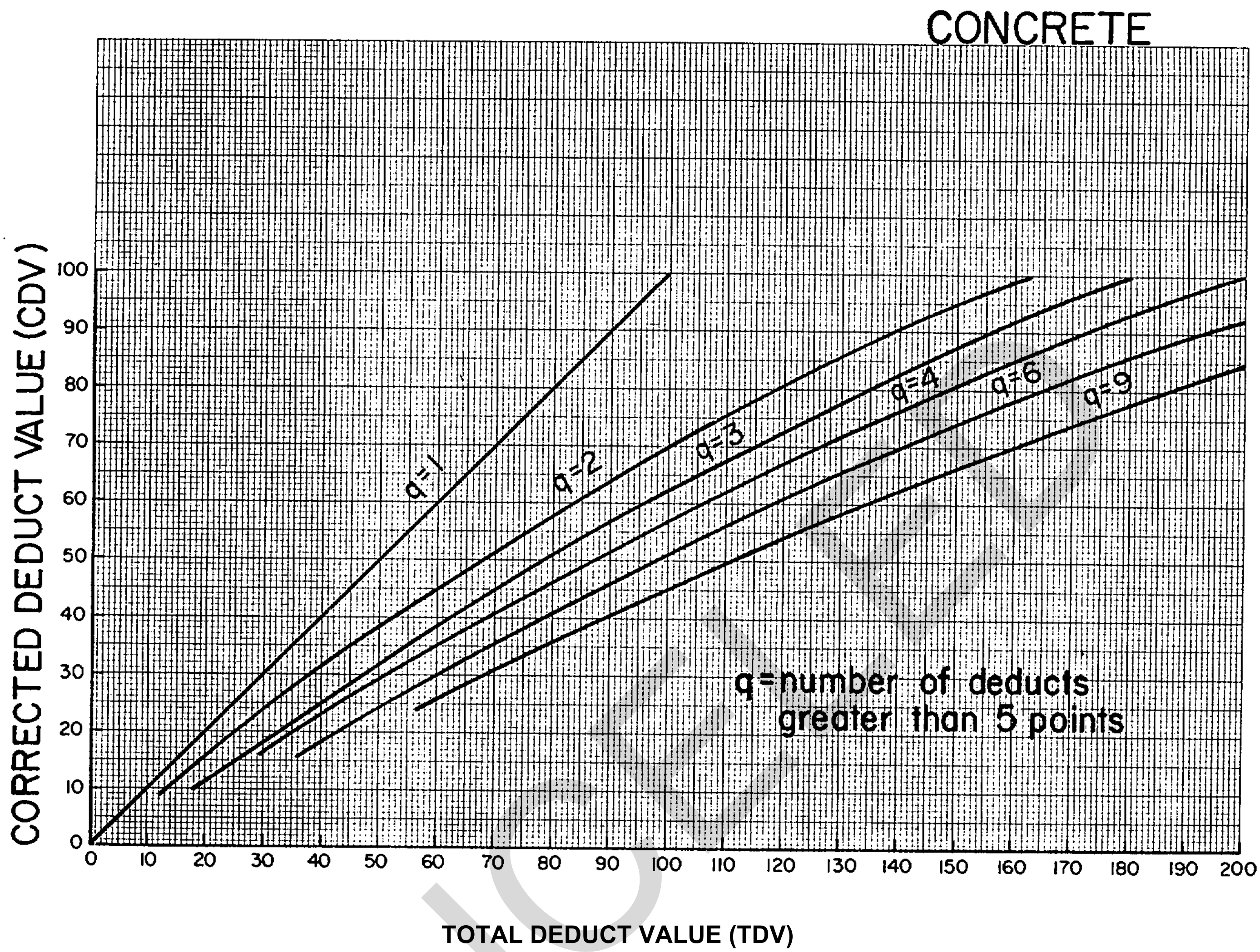


Figure C-40. Corrected deduct value curves for jointed concrete pavements.

APPENDIX D

AUTOMATED PAVER REPORTS

DESCRIPTION AND USE

D-1. Report title: LIST

a. Description. The LIST report is a printout of the names and numbers for the branches of the pavement network in alphabetical order by branch name.

b. Contents. The report contains branch numbers, branch names, and number of sections for each branch.

c. Uses. The report is used to determine what branch number has been assigned to a particular street, and the number of sections for any branch.

D-2. Report title: INV

a. Description. This report provides an inventory of pavement sections for a given network.

b. Contents. The report identifies each section and provides section location, surface type, branch use, pavement rank, area and total branch area.

c. Uses. The report is used to obtain general information about a section, including the beginning and ending points and total area for a given branch.

D-3. Report title: RECORD (Format 1)

a. Description. This report provides comprehensive information about a selected pavement section.

b. Contents. The report contains section identification, section dimensions, shoulder identification, drainage identification, secondary structure identification, work history, pavement structure, layer material properties, results of surveys, and proposed future work for the pavement section.

c. Uses. The report is used to obtain detailed information necessary when considering repair work to be performed in the section.

D-4. Report title: RECORD (Format 2)

a. Description. This report provides specific information about a number of pavement sections, such as structural drainage, or shoulder information.

b. Contents. The report may contain, depending on the record selected, full section identification and dimensions with pavement structural information; or drainage information; or traffic or layer material property information; or a work history for the pavement.

c. Uses. The report is used to obtain information needed for scheduling and planning major work efforts or whenever specific information about all sections of a facility is needed.

D-5. Report title: INSPECT

a. Description. The report contains section identification, PCI value, inspection date, distress type, severity, and quantity for the entire section.

b. Contents. The report contains section identification, PCI value, inspection date, distress type, severity, and quantity for the entire section.

c. Uses. The report is used to determine pavement condition and distress types, severities, and quantities for a given pavement section(s) and/or to determine history of pavement condition for the pavement in order to perform a desk estimate of needed maintenance and repair costs for a given pavement.

D-6. Report title: SAMPLE

a. Description. This report is used to obtain inspection results for each section detailed by sample units.

b. Contents. The report contains sample unit number, sample type, distress type, severity, quantity, density-percent, sample size, sample PCI, and overall PCI and distress for the pavement section.

c. Uses. The report is used to determine where a distress type exists in a pavement section; to monitor change in condition for a given sample unit; and to identify variation in condition within a given pavement section.

D-7. Report title: PCI & PCIA

a. Description. This report provides a list of sections and PCI values based on last inspection results for selected pavements. The PCI report lists the sections in order of increasing PCI. The PCIA report lists the sections in alphabetical order.

b. Contents. The report identifies each pavement section and provides section location, section number, PCI value, date of last inspection, surface type, section area, and pavement rank.

c. Uses. The report is used to identify pavement sections in a given PCI range; to determine priorities of maintenance and repair; to develop annual and long range work plan.

D-8. Report title: PCI DISTRIBUTION

a. Description. The report provides the user with a frequency diagram of the PCIs for specific branch uses, pavement rank, and surface type. A listing of the sections is also available. The distribution can be of the current year or any year in the future. If future years are selected the PCI is predicted by straight line extrapolation assuming no overlays or reconstruction are performed.

b. Contents. The report contains branch use(s), pavement rank(s), and surface type(s) PCI prediction year and PCI range.

c. Uses. The report is used to justify budget requests. Report presents distribution of PCI of pavement sections selected; the change of this distribution over a period of time, assuming no overlays or reconstruction can be seen by selecting the year(s) into the future desired.

D-9. Report title: PAVEMENT CONDITION HISTORY

a. Description. The report provides the condition history for a specific pavement section. It plots the PCI-time curve. The PCI is projected 5 years into the future beyond the last inspection date.

b. Contents. The report contains the branch name, pavement rank, section number, section area, and PCI-time plot.

c. Uses. The report is used to assist in justification of a repair project for a specific pavement section.

D-10. Report title: WORKHIS

a. Description. This report provides a record of past maintenance and repair performance on any pavement section.

b. Contents. The report contains a list of work completed with description, manner of accomplishment of that work, material code for the material used, date work was completed, in place unit cost and total repair cost.

c. Uses. The report is used to find what past work has been performed on a pavement section, and to determine the past cost invested in repair of a pavement section.

D-11. Report title: POLICY

a. Description. This report provides lists of maintenance policy proposed for all sections, including estimated unit costs for work proposed, material to be used, distress and repair types, distress severity, and total estimated cost of repair.

b. Contents. The report contains distress type, severity, repair type, material used, unit costs, and total cost of repair.

c. Uses. The report is used to schedule maintenance and repair work; to develop annual and long range work plans; and to estimate budget requirements.

D-12. Report title: WORKREQ

a. Description. This report provides lists identifying maintenance and repair requirements for specified sections. Included are time and cost estimates, and priority for the work required.

b. Contents. The report contains type of work proposed and distress to be repaired, quantity of work, estimated labor and material costs, material to be used, estimated total cost, priority, fiscal year for work proposed, and whether work has been financed.

c. Uses. The report is used to keep inventory of work proposed and completed; to develop estimates for financing future work; and to develop annual work plans, and long range work plans.

D-13. Report title: BUDGET

a. Description. This report provides the user with a 10-year projected budget level for any combination of branch use, pavement rank, and surface type selected. The budget level is projected based on an average cost of repair for the surface type (i.e., AC or PCC). The year to repair is determined by projecting the minimum PCI level specified by the user.

b. Contents. The report contains branch use, surface type, pavement rank, and cost of repair for each fiscal year (10 years from present). A listing of sections projected to be repaired each year can also be obtained.

c. Uses. The report is used to provide an estimate of the budget level necessary to maintain the pavement system above an acceptable minimum condition, based on an average cost.

APPENDIX E

BLANK SUMMARY AND RECORD FORMS

(DA Forms 5145-R to 5156-R used for PAVER will be reproduced locally on 8 1/2 - by 11-inch paper.)

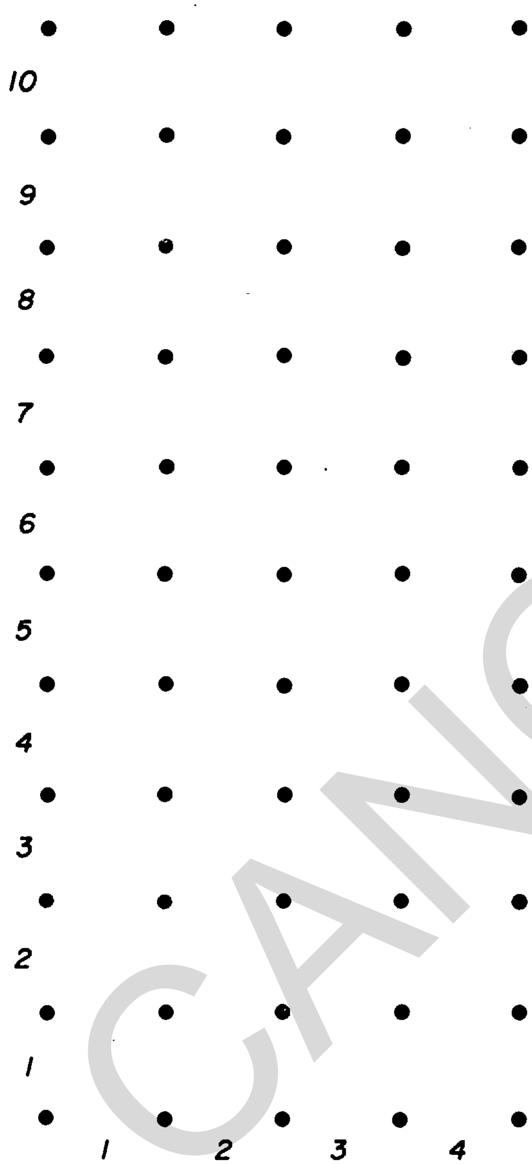
CONCRETE PAVEMENT INSPECTION SHEET

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

BRANCH ____________________ SECTION ____________

DATE ________________________ SAMPLE UNIT ______________

SURVEYED BY _________________ SLAB SIZE ______________



Distress Types

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

DIST. TYPE	SEV.	NO. SLABS	% SLABS	DEDUCT VALUE
26*				
q=	TOTAL DEDUCT VALUE			
CORRECTED DEDUCT VALUE (CDV)				

PCI = 100 - CDV = ____________

RATING = ____________

* 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 E-1.

ASPHALT PAVEMENT INSPECTION SHEET

For use of this form, see TM 54-623; the proponent agency is USACE.

BRANCH ____________________ SECTION ____________________

DATE ____________________ SAMPLE UNIT ____________________

SURVEYED BY ____________________ AREA OF SAMPLE ____________________

Distress Types

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

SKETCH:

EXISTING DISTRESS TYPE, QUANTITY & SEVERITY

TYPE →						
QUANTITY & SEVERITY						
TOTAL SEVERITY L						
TOTAL SEVERITY M						
TOTAL SEVERITY H						

PCI CALCULATION

DISTRESS TYPE	DENSITY	SEVERITY	DEDUCT VALUE
q=	TOTAL DEDUCT VALUE		
CORRECTED DEDUCT VALUE (CDV)			

PCI = 100 − CDV = ____________

RATING = ____________

* 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 E-2.

Section Evaluation Summary

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

1. Overall Condition Rating - PCI ________

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 — ____percent deduct value

   Climate/Durability Associated — ____percent deduct value

   Other (____) Associated Distress — ____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 E-3.

PRESENT WORTH COMPUTATION

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

M & R ALTERNATIVE ______________________________

____

ANALYSIS PERIOD ________ YEARS INTEREST RATE _____ %

DIFFERENTIAL INFLATION RATE _____ %

YEAR	M & R WORK DESCRIPTION	COST $	f	PRESENT WORTH $
			TOTAL	$

DA FORM 5148-R, NOV 82

Figure E-4.

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.			4.			
						2.			5.			
									3.			

Branch Code					Branch Name	Branch Use	Number of Sections	Branch Area Sq. Yd.

Remarks: ____

DA FORM 5149-R, NOV 82

Figure E-5.

BRANCH IDENTIFICATION SUMMARY
CONTINUATION SHEET

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

Branch Code					Branch Name	Branch Use	Number of Sections	Branch Area Sq. Yd.

Remarks: ____________________

DA FORM 5149-1-R, NOV 82

Figure E-6.

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.
			_____ ft.x _____ ft. _____ sq. yd		

Traffic Types And Uses				General Information		
				Curb And Gutter	Sidewalks	Surface Type
○ Aircraft ○ Fixed Wing ○ Rotary Wing	○ Runway ○ Taxiway ○ Parking or Pads ○ Apron ○ Other	○ Vehicular ○ Real Property ○ Family Housing	○ Primary ○ Secondary ○ Tertiary ○ Parking - Storage ○ Other	○ Left ○ Right ○ None	○ Left ____ ft. ○ Right ____ ft. ○ None ____	○ PCC ○ AC ○ Surface Treatment ○ Other

Sketch:

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

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Figure E-7.

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

		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)								
Overlays	Overlay (3)								
	Overlay (2)								
	Overlay (1)								

		Material	Material Code			Thickness (in.)	Date Const.	Comments
Initial Construction	Surface							
	Leveling							
	Base							
	Subbase							
	Select							
	Compacted Subgrade							
	Natural Subgrade							

**New Section of Branch Must Then Be Identified.*

DA FORM 5151-R, NOV 82

Figure E-8.

SECTION MATERIALS PROPERTIES RECORD

For use of this form, see TM 5623; the proponent agency is USACE.

Installation Name	Date			Branch Name	Section Number

Pavement Layer	Material Properties	Value / Unit	Comments

DA FORM 5152-R, NOV 82

Figure E-9.

SECTION TRAFFIC RECORD

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

Installation Name	Date			Branch Name	Section Number

Roads or Streets																								
Date of Survey																								
Traffic Type	a	b	c	d	e	f	a	b	c	d	e	f	a	b	c	d	e	f	a	b	c	d	e	f
Volume Index																								

Parking Lots – Airfields – Other	
Date of Survey	Description

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Figure E-10.

SECTION CONDITION RECORD

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

Installation Name	Branch Name	Date			Section Number

Average PCI ______________________ Condition Rating ______________________

Ride Quality G____F____P____Safety G____F____P____Drainage G____F____P____

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

No. of Additional Units Surveyed ______________________

PCI Range ______________________ Minimum of Units to be Surveyed ______________________

Pavement Type
◯AC ◯PCC

Section Area
______ ft. x ______ ft.
______ sq. yd.

Section Distress Data
◯ Extrapolated Quanities ◯ Actual Quantities

Distress Type	Severity Level	Quantity	Section Density	Deduct Value	Comments
			Total		

Percent Deducts Structural Related ________ Environmental ________ Other ________

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Figure E-11.

BRANCH MAINTENANCE & REPAIR REQUIREMENTS

For use of this form, see TM 5o623; the proponent agency is USACE.

Installation Name	Date	Branch Name	Total No. of Sections

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

Remarks ______________________________

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Figure E-12.

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
	Mo.	Da.	Yr.		

Work Performed					
Date of M&R	Description of Work	Location	Thickness	Quantity/Unit	Cost

Remarks: ____

DA FORM 5156-R, NOV 82

Figure E-13.

The proponent agency of this publication is the Office of the Chief of Engineers. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) direct to HQDA(DAEN-MPO-B), WASH DC 20314.

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General, United States Army.
Chief of Staff

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Major General, United States Army
The Adjutant General

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U.S. ARMY CORPS OF ENGINEERS (Preparing Activity)

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location
1	17 May 2006	Revised Foreword

This UFC supersedes TM 5-623, dated 1 November 1982. The format of this UFC does not conform to UFX 1-300-1; however, the format will be adjusted to conform at the next major revision. The body of this UFC is a document of a different number.

FOREWORD

\1\
The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD(AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the more stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

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