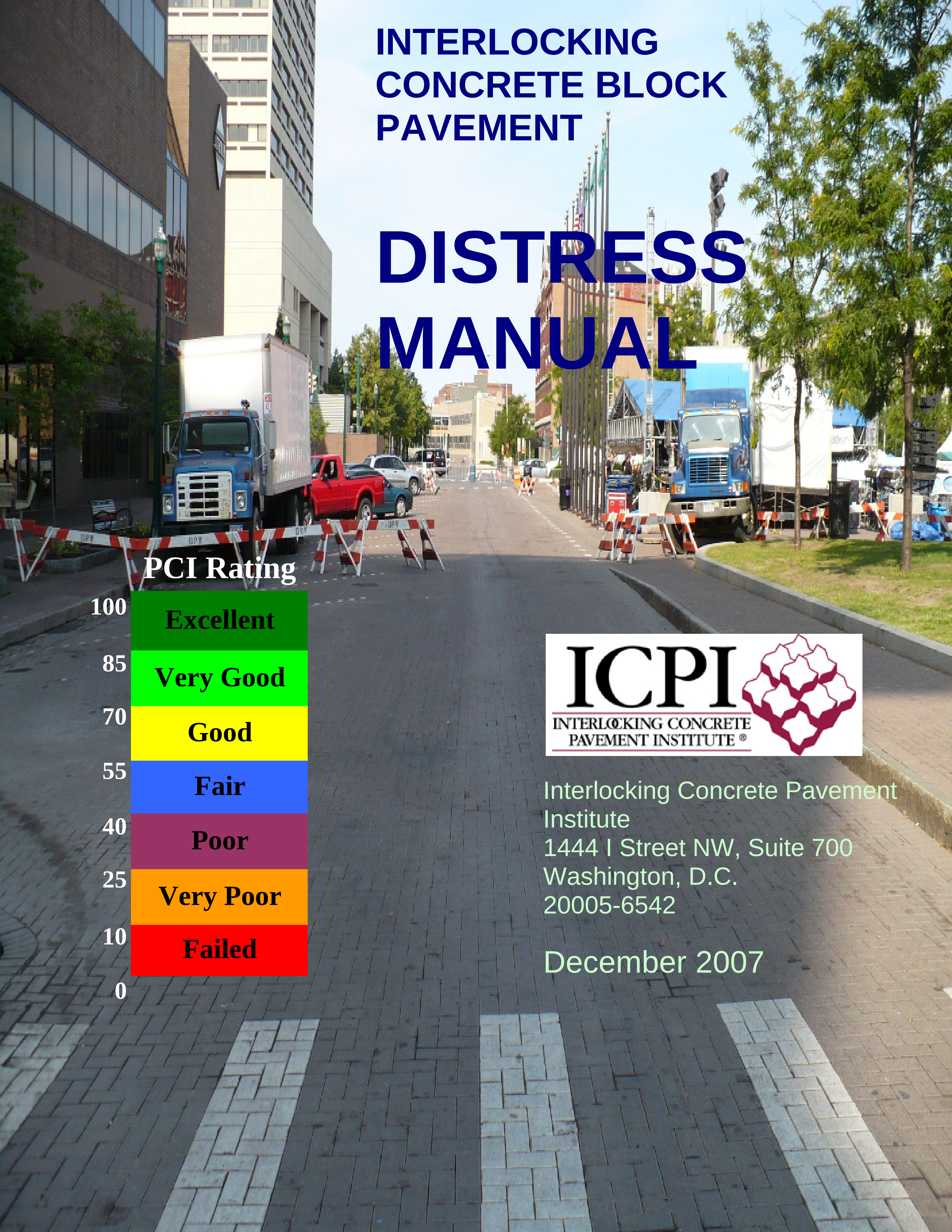


INTERLOCKING CONCRETE BLOCK PAVEMENT

DISTRESS MANUAL

PCI Rating

PCI	Rating
100–85	Excellent
85–70	Very Good
70–55	Good
55–40	Fair
40–25	Poor
25–10	Very Poor
10–0	Failed

ICPI
INTERLOCKING CONCRETE PAVEMENT INSTITUTE®

Interlocking Concrete Pavement Institute
1444 I Street NW, Suite 700
Washington, D.C.
20005-6542

December 2007

December 2007

Interlocking Concrete Block
Pavement Distress Guide

Submitted to:

Interlocking Concrete Pavement Institute

By:

Applied Research Associates, Inc.
5401 Eglinton Avenue West, Suite 204
Toronto, Ontario M9C 5K6
Telephone: (416) 621-9555 Facsimile: (416) 621-4917
Web: www.ara.com/transportation

PREAMBLE

Applied Research Associates, Inc., (ARA) was retained by the Interlocking Concrete Pavement Institute (ICPI) to develop an interlocking concrete block pavement distress guide. The guide is modeled on the U.S. Army Corps of Engineers MicroPAVER distress guide as published by the American Society for Testing Materials (ASTM). In support of this effort, ARA has completed a detailed literature survey of pavement management tools available, developed a list of typical interlocking concrete block pavement distress features, collected available photographs of these features, consulted with the original team who developed the ASTM PCI procedures for flexible and rigid pavements.

The distress guide includes a list of interlocking concrete block pavement defects which are described, and divided into three levels of severity. Photographs of the distresses at each distress severity level were gathered through site visits across North America and Europe and are included to assist pavement engineers and technicians in applying the distress guide.

A 'deduct' curve was developed for each distress type and severity to rate their impact on the overall condition of the pavement. The deduct curves were established by an expert panel using the "Delphi" approach.

Using the distress manual and deduct curves, a software model was developed to calculate a pavement condition index (PCI) from the distress type, extent and severity levels. The deduct curves were then validated through field inspections of municipal roadway type pavements constructed using concrete block paving. ARA and ICPI canvassed a number of ICPI members to identify application sections for the field investigations. A total of 43 pavement sections were inspected at the following locations throughout North America:

- Baltimore, Maryland
- Boston, Massachusetts
- Hamilton, Ontario
- North Bay, Ontario
- Portland, Oregon
- San Antonio, Texas
- Syracuse, New York
- Vancouver, British Columbia

At each of the site locations, the methodology described in the distress guide was used to assess and measure each of the distresses and to calculate the overall PCI of the pavement. Numerous photographs of representative pavement features were taken. Prior to calculating the PCI, the surveyor estimated the overall condition rating of the pavement on a scale of 0 (Poor) to 100 (Excellent). The survey crew members and ARA engineering staff then reviewed the calculated and estimated PCI values along with the photographs of the sites. Some adjustments to the deduct curves were then completed so that the PCI calculation procedure best represented the overall condition of the pavement.

TABLE OF CONTENTS

1.0 BACKGROUND

The Roman Empire was one of the first to use the concept of interlocking concrete pavements for the road system. The Romans first built pavements by tightly fitting paving units or pavers on a compacted flexible granular base. The basic paving stone concept was later revised and introduced in the Netherlands in the late 1940’s as a replacement for clay brick streets. Interlocking concrete pavements later spread to Germany in the 1960’s, and, in the 1970’s, began to emerge in the United Kingdom, Australia, South Africa, and North America. Currently, there are approximately 60 million square metres (645 million square feet) and 300 million square metres (3.2 billion square feet) of concrete pavers are produced annually in North America and Europe, respectively. Concrete pavers have been successfully used in many pavement applications such as driveways, recreational areas, parking lots, city streets, sidewalks, ports and container terminals, and airports.

Interlocking concrete block pavements provide high resistance to freeze-thaw and deicing salts, high abrasion and skid resistance, and protection from petroleum products or deformation/indentations due to high ambient temperatures. Joint sand between the individual concrete pavers facilitates vehicle wheel load transfer and controlled crack locations in order to minimize stress cracking and surface degradation. Concrete pavers are set in bedding sand, which is placed over a base material that can consist of untreated aggregate base, bituminous or cement treated base, or even Portland cement concrete. The spaces between the individual paving units is filled with clean high quality joint sand.

2.0 INTRODUCTION

This manual documents the development of an interlocking concrete block pavement distress guide based on the Pavement Condition Index (PCI) methodology. The PCI procedure for pavement evaluation has been widely accepted as it offers a method to objectively rate pavement condition. The procedure evolved from the combined experience of many pavement engineers and has been shown to fairly and consistently represent their collective ratings of a wide variety of pavements.

PCI procedures for pavement evaluation were first published by the U. S. Army Construction Engineering Research Laboratory (CERL) in the 1970s for the United States Air Force. Procedures were soon adopted verbatim by the other military branches, the American Public Works Association (APWA) and the Federal Aviation Administration (FAA). Procedures for collecting data and calculating PCI remained unchanged until 1993, when the American Society for Testing and Materials (ASTM) published D5340, “Standard Test Method for Airport Pavement Condition Index Surveys” and D6433, “Standard Test Method for Roads and Parking Lots Pavement Condition Index Surveys”. The basic flowchart for developing the PCI values for a section of pavement is shown in Figure 1.

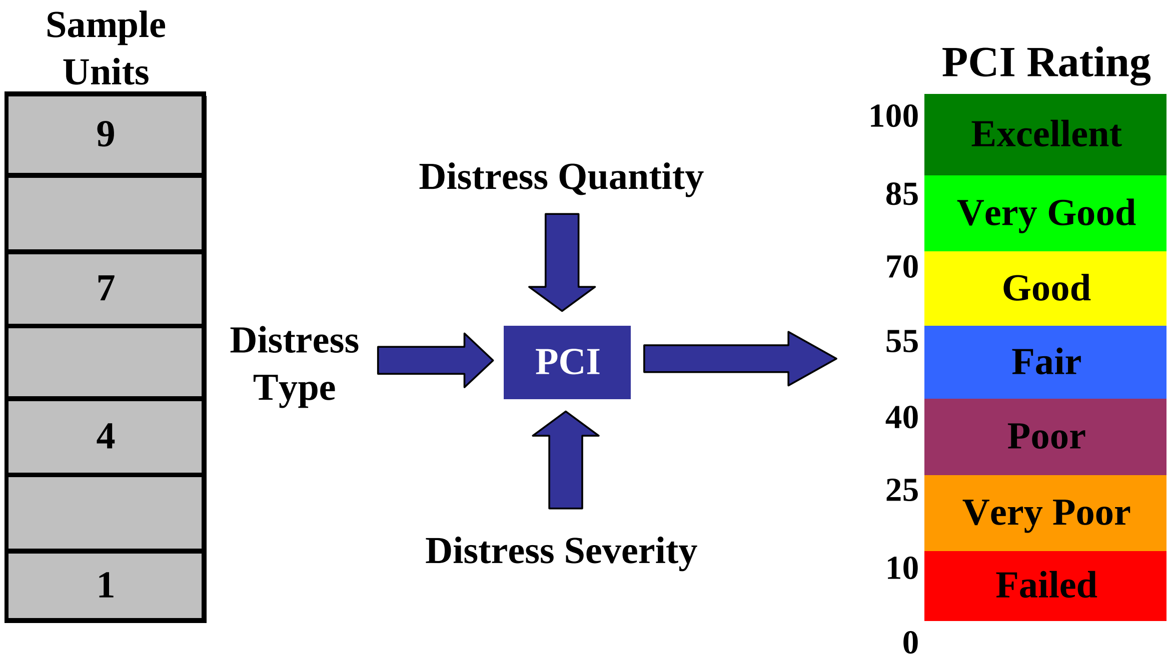


Figure 1. Flowchart for Determination of PCI.

This guide was modeled on the U.S. Army Corps of Engineers MicroPAVER distress guide as published by ASTM. The terminology and procedures used for completing the condition surveys and calculating the PCI are as per the ASTM procedures. The identification and measurement of distress are as per this guide. Calculation of PCI is based on the deduct curves presented herein.

3.0 TERMINOLOGY

Additional Sample – a sample unit inspected in addition to the random sample units to include non representative sample units in the determination of pavement condition index. This includes very poor or excellent samples that are not typical of the section and sample units. If a sample unit containing an unusual distress is chosen at random, it should be counted as an additional sample and another random sample unit should be chosen. If all sample units are inspected, then there are no additional samples.

Branch - a branch is an identifiable part of the pavement network which is a single entity and has a distinct function. For example, individual streets and parking areas are separate branches of a pavement network.

Network- a pavement network consists of all surfaced areas which provide access ways for vehicle and pedestrian traffic.

Pavement Condition Index (PCI) – a numerical rating of pavement condition that ranges from 0 to 100 with 0 being the worst possible condition and 100 being the best possible condition.

Pavement Condition Rating – a description of pavement condition as a function of the PCI value that varies from “failed” to “excellent”.

Random Sample – a sample unit of the pavement section selected for inspection by random sampling techniques.

Section - a section is a division of a branch that has certain consistent characteristics throughout its area or length. These characteristics could include: composition (thickness and materials), construction history, traffic, pavement condition, etc.

Sample Unit - A sample unit is a subdivision of the pavement section. Each pavement section is divided into sample units for the purpose of pavement inspection. The sample units for inspection shall be 225 m^2 ± 90 m^2 (2500 ft^2 ± 1000 ft^2).

4.0 SUMMARY OF PRACTICE

The pavement is divided into branches that are then divided into sections. Each section is divided into sample units. The type and severity of pavement distress is assessed by visual inspection of the pavement sample units. The quantity of distress is measured as described in Appendix A. The distress data is used to calculate the PCI for each sample unit. The PCI of a pavement section is determined based on the PCI of the inspected sample units within the section.

5.0 SIGNIFICANCE AND USE (FROM ASTM)

The PCI is a numerical indicator that rates the surface condition of the pavement. The PCI provides a measure of the present condition of the pavement based on the distress observed on the surface of the pavement, which also indicates the structural integrity and surface operational condition (localized roughness and safety). The PCI does not measure structural capacity nor does it provide direct measurement of skid resistance or roughness. It provides an objective and rational basis for determining maintenance and repair needs and priorities. Regular monitoring of the PCI is used to establish the rate of pavement deterioration, which permits early identification of major rehabilitation needs. The PCI can also provide feedback on pavement performance for validation or improvement of current pavement design and maintenance procedures.

6.0 APPARATUS (FROM ASTM)

Data Sheets, or other field recording instruments that record the date, location, branch, section, sample unit size, slab number and size, distress types, severity levels, quantities, and names of surveyors.

Hand Odometer Wheel, that reads to the nearest 30 mm (1 ¼ inches).

Straightedge or String Line, 3 m (10 foot).

Scale, 300 mm (1 foot) that reads to 1 mm (1/16 inch). An additional ruler or straightedge is needed to measure faulting.

Layout Plan, for network to be inspected.

7.0 SAMPLING AND SAMPLE UNITS (FROM ASTM)

The procedure for developing appropriate sampling intervals and sample units is as follows:

- Identify branches of the pavement with different uses such as roadways and parking on the network layout plan.
- Divide each branch into sections based on the pavements design, construction history, traffic, and general condition.
- Divide the pavement sections into sample units.

Individual sample units to be inspected should be marked or identified in a manner to allow inspectors and quality control personnel to easily locate them on the pavement surface. Paint marks along the edge and sketches with locations connected to physical pavement features is a common method of identification. GPS coordinates are becoming more popular in identifying sample unit locations. It is necessary to be able to accurately relocate the sample units to allow verification of current distress data, to examine changes in condition with time of a particular sample unit, and to enable future inspections of the same sample unit if desired.

Select the sample units to be inspected. The number of sample units to be inspected may vary from the following: all of the sample units in the section, a number of sample units that provides a 95 percent confidence level, or a lesser number.

All sample units in the section may be inspected to determine the average PCI of the section. This constitutes a 'complete' section survey. This is usually precluded for routine management purposes by available manpower, funds, and time. Total sampling, however, is desirable for project analysis to help estimate maintenance and repair quantities.

The minimum number of sample units (n) that must be surveyed within a given section to obtain a statistically adequate estimate (95 percent confidence) of the PCI of the section is calculated using the following formula and rounding n to the next highest whole number (see Eq 1).

$$n = Ns^2/((e^2/4)(N - 1) + s^2) \qquad (1)$$

where:

e = acceptable error in estimating the section PCI; commonly, $e=\pm 5$ PCI points;
s = standard deviation of the PCI from one sample unit to another within the section. When performing the initial inspection the standard deviation is assumed to be ten for interlocking concrete block pavements. This assumption should be checked as described below after PCI values are determined. For subsequent inspections, the standard deviation from the preceding inspection should be used to determine n; and,
N = total number of sample units in the section.

If obtaining the 95 percent confidence level is critical, the adequacy of the number of sample units surveyed must be confirmed. The number of sample units was estimated based on an assumed standard deviation. Calculate the actual standard deviation (s) as follows (see Eq 2):

$$s = \left(\sum_{i-1}^{n} \left(PCI_i - PCI_s \right)^2 / \left(n-1 \right) \right)^{\frac{1}{2}} \qquad (2)$$

where:

PCI_i = PCI of surveyed sample units i,
$PCIs$ = PCI of section (mean PCI of surveyed sample units), and
n = total number of sample units surveyed.

Calculate the revised minimum number of sample units (Eq 1) to be surveyed using the calculated standard deviation (Eq 2). If the revised number of sample units to be surveyed is greater than the number of sample units already surveyed, select and survey additional random sample units. These sample units should be spaced evenly across the section.

Repeat the process of checking the revised number of sample units and surveying additional random sample units until the total number of sample units surveyed equals or exceeds the minimum required sample units (n) in Eq 1, using the actual total sample standard deviation.

Once the number of sample units to be inspected has been determined, compute the spacing interval of the units using systematic random sampling. Samples are spaced equally throughout the section with the first sample selected at random. The spacing interval (i) of the units to be sampled is calculated by the following formula rounded to the next lowest whole number:

$$i = N/n \qquad (3)$$

where:

N = total number of sample units in the section, and
n = number of sample units to be inspected.

The first sample unit to be inspected is selected at random from sample units 1 through *i*. The sample units within a section that are successive increments of the interval *i* after the first randomly selected unit also are inspected.

A reduced sampling rate than the above mentioned 95 percent confidence level can be used based on the condition survey objective. The following table for selecting the number of sample units to be inspected for other than project analysis:

Given	Survey
1 to 5 sample units	1 sample unit
6 to 10 sample units	2 sample units
11 to 15 sample units	3 sample units
16 to 40 sample units	4 sample units
over 40 sample units	10 percent

Additional sample units only are to be inspected when non-representative distresses are observed. The location of these sample units is determined by the user.

8.0 INSPECTION PROCEDURE (FROM ASTM)

The definitions and guidelines for quantifying distresses for PCI determination are given in Appendix A for Interlocking Concrete Block Pavers. Using this test method, inspectors should identify distress types accurately 95 percent of the time. Linear measurements should be considered accurate when they are within 10 percent if remeasured, and area measurements should be considered accurate when they are within 20 percent if remeasured. Distress severities that one determines based on ride quality are considered subjective.

Individually inspect each sample unit chosen. Sketch the sample unit, including orientation. Record the branch and section number and the number and type of the sample unit (random or additional). Record the sample unit size measured with the hand odometer. Conduct the distress inspection by walking over the sidewalk/shoulder of the sample unit being surveyed, measuring the quantity of each severity level of every distress type present, and recording the data. Each distress must correspond in type and severity to that described in Appendix A. The method of measurement is included with each distress description. This procedure should be repeated for each sample unit to be inspected. A copy of a Blank Pavement Condition Survey Data Sheet for Sample Unit is included in Appendix B.

9.0 CALCULATION OF PCI (FROM ASTM)

Add up the total quantity of each distress type at each severity level, and record them in the "Total Severities" section. The units for the quantities may be either in square meters, linear meters, or number of occurrences, depending on the distress type.

Divide the total quantity of each distress type at each severity level by the total area of the sample unit and multiply by 100 to obtain the percent density of each distress type and severity.

Determine the deduct value (DV) for each distress type and severity level combination from the distress deduct value curves in Appendix A.

Determine the maximum corrected deduct value (CDV). The following procedure must be used to determine the maximum CDV.

If none or only one individual deduct value is greater than two, the total value is used in place of the maximum CDV in determining the PCI; otherwise, maximum CDV must be determined as follows.

List the individual deduct values in descending order. Determine the allowable number of deducts, *m*, using the following formula (see Eq 4):

$$m = 1+(9/98)(100\text{–HDV}) \leq 10 \qquad (4)$$

where:

m = allowable number of deducts including fractions (must be ≤ ten),
HDV = highest individual deduct value.

The number of individual deduct values is reduced to the *m* largest deduct values, including the fractional part. If less than *m* deduct values are available, all of the deduct values are used.

Determine maximum CDV iteratively. Determine total deduct value by summing individual deduct values. The total deduct value is obtained by adding the individual deduct values. Determine *q* as the number of deducts with a value greater than 2.0. Determine the CDV from total deduct value and *q* by looking up the appropriate correction curve (Appendix C). Reduce the smallest individual deduct value greater than 2.0 to 2.0 and repeat until q = 1. The maximum CDV is the largest of the CDVs.

Calculate PCI by subtracting the maximum CDV from 100: PCI = 100 - max CDV.

10.0 DETERMINATION OF SECTION PCI (FROM ASTM)

If all surveyed sample units are selected randomly or if every sample unit is surveyed then the PCI of the section is the average of the PCIs of the sample units. If additional sample units are surveyed then a weighted average is used as follows:

$$PCI_S = (N - A)(PCI_R)/N + A(PCI_A)/N \tag{5}$$

where:

PCI_S =	weighted PCI of the section,
N =	total number of sample units in the section,
A =	number of additional sample units,
PCI_R =	mean PCI of randomly selected sample units, and
PCI_A =	mean PCI of additional selected sample units.

Determine the overall condition rating of the section by using the section PCI.

APPENDIX A

CONCRETE BLOCK PAVEMENT INSPECTION STANDARDS

Concrete Block Pavement Inspection Standards

Distress types for concrete block pavements are listed by possible causes as follows:

Load	**Climate/Durability**	**Moisture/Drainage**	**Other Factors**
Missing Pavers	Joint Sand Loss/Pumping	Missing Pavers	Missing Pavers
Damaged Pavers	Missing Pavers	Joint Sand Loss/Pumping	Damaged Pavers
Depressions	Heave	Depressions	
Patches	Patches	Heave	
Horizontal Creep	Variable Joint Width	Patches	
Edge Restraint			
Rutting			
Variable Joint Width			

During the field condition surveys and the validation of the PCI, several questions are often asked regarding the identification and measurement of some of the distresses. The answers to most of these questions are included under the section “How To Measure” for each distress. For convenience, however, the items that are frequently referenced are listed as follows:

If multiple distresses occur in the same area, each is recorded at its respective severity level.

Distress found in a patched area is not recorded; however, its effect on the patch is considered in determining the severity level of the patch.

Measurements of differential elevation for severity determination of area distress types are made under a 3 m (10 ft) straight edge. Measurement of differential elevation at joints is made under a straight edge of 0.3 m (1 ft) length (such as the edge of a clip board).

3 mm (1/8 inch) is the smallest measurable elevation differential.

MEASURING TECHNIQUES

1. Measuring linear units of distress is usually quite straight forward. Use of a calibrated measuring wheel is the most common procedure.

2. A measuring wheel with calibration to the nearest 0.3 m (1 foot) is best for layout and measurements in excess of 30 m (100 ft). For measuring distresses, and for confirming sketch dimensions within a section, a measuring wheel with calibration to the nearest 30 mm (1.2 inches) is best.

3. Do not attempt measurements with a wheel at a pace faster than walking. At faster speeds, the wheel tends to skip over rough pavement, and can give unacceptable false readings.

4. After measuring a length, be sure the wheel has stopped turning before lifting it from the pavement.

5. Where distress occur at sample unit boundaries, record the distress at the left and forward boundary of the sample unit. Two sample units share each boundary. This technique is intended to assure equitable documentation.

6. Do not estimate the length of segments. Use the wheel. It is necessary to walk each distress to establish the correct quantity of each severity.

7. Aluminum pipe is recommended as a straightedge. Use 40 mm (1 ½ inch) inside diameter Schedule 40 aluminum pipe 3 m (10 foot) long. This type of straightedge is light in weight and resists bending better than iron or steel.

8. Vertical dimensions under a straightedge are best measured using a Calibrated Measuring Device (CMD). Other tools, such as a pencil, knife or the edge of a clipboard, may be used once their key dimensions have been verified.

9. Shadows under a straightedge are evidence of differential surface elevation, but they can be misleading. The appearance of differential elevation is exaggerated by shadows in early morning and late afternoon. Don't guess. Measure.

10. Wet or discolored pavement may imply or exaggerate the appearance of differential elevation. Don't guess. Measure.

11. Depressions, Ruts and Swell are measured to where the straight edge meets the pavement surface. Slide a knife blade under the straight edge to establish this point, and mark with spray paint or crayon.

12. On pavement with a large amount and variety of distress, an inspector can "get lost" in a sample unit. Common difficulties include measuring outside the boundaries of the sample unit, and losing track of which distresses have been measured, and which have not. When you get lost, the only acceptable procedure is to start over. Never guess or estimate.

13. In complicated sample units, minimize the difficulty by organizing the inspection. Subdivide the sample unit with chalk or dots of paint. If no obvious outlines are available, paint ticks at the pavement edge and on centerline and, if necessary, at intervals along the sample unit boundaries. The essential thing is to define manageable subdivisions to assure accurate measurements.

14. Keeping track of quantities of different distress severities while measuring can be difficult. If most of the distress is of one severity with only a minor amount of another severity, it may be possible to measure the total, keeping a running subtotal of the lesser severity on the bottom of the inspection sheet. In many instances, however, it will be necessary to measure each severity separately, marking transitions with spray paint or crayon.

15. Subdivide irregularly shaped distress areas into equivalent squares and rectangles, and mark the corners. Measure length and width of equivalent units and calculate areas.

16. Where multiple severities exist within the outer boundary of a distress, identify and mark the outline of each severity, and areas with no distress. Measure and calculate each area, and record each severity.

17. Pavement in poor to failed condition typically has large quantities of distress at multiple severities. In such pavement, meticulous documentation of quantities requires a great deal of time, and serves no useful purpose. It is important to make careful estimates that identify and record each and every distress type, severity, and density in the sample unit, pacing for linear dimensions and spot checking vertical relief with a straight edge. Inspection of a single sample unit should not take more than about 20 minutes.

DISTRESS IDENTIFICATION

101 Damaged Pavers
102 Depressions
103 Edge Restraint
104 Excessive Joint Width
105 Faulting
106 Heave
107 Horizontal Creep
108 Joint Sand Loss/Pumping
109 Missing Pavers
110 Patching
111 Rutting

101 Damaged Pavers

Description: Damaged pavers describes the condition of the paver blocks. Block damage would include paver distresses such as a chip, crack, or spall. Block damage would be indicative of load related damage such as, inadequate support causing shear breakage, etc.

Identification: Damaged pavers would include paver distresses such as a chip, crack, or spall. Cracked pavers with little to no opening will not affect performance.

How to Measure: Damaged pavers are measured in square metres (square feet) of surface area. Random individual cracked pavers are not counted. The severity is evaluated by degree of distress.

Severity Levels:

Severity Level	Item
Low	Individual cracks, spalls, or weathering
Medium	Advanced cracking, spalling, or weathering
High	Blocks are in multiple pieces or are disintegrated

Low Severity Damaged Pavers

Medium Severity Damaged Pavers

High Severity Damaged Pavers

102 Depressions

Description: Depressions are areas of the pavement surface that have elevations that are lower than the surrounding areas. Depressions are caused by settlement of the underlying subgrade or granular base. Settlement is common over utility cuts and adjacent to road hardware. Depressions can cause roughness in the pavement, and when filled with water, can cause hydroplaning of vehicles.

Identification: Visual examination is not always a reliable technique for detection of depressions, especially for low severity depressions. The most reliably method to identify depressions is to utilize a 3 m (10 foot) straight edge.

Changes in shades of color on a pavement surface can give the impression of differential elevation where none exists. The apparent depth of differential elevation is often exaggerated by shadows in the early morning and late afternoon, as well as the chamfer on the paver edges. Standing water and stains can be used to visually identify depressions, however, the boundaries and depth should be established using the straight edge. Be careful to distinguish heaves from depressions.

How to Measure: Depressions are measured in square metres (square feet) of surface area. The maximum depth of depression defines the severity. Depressions larger than 3 m (10 ft) across should be measured with a stringline.

Severity Levels:

Severity Level	Maximum Depth of Depression
Low	5 – 15 mm [0.2 to 0.6 inches]
Medium	15 – 30 mm [0.6 to 1.2 inches]
High	> 30 mm [1.2 inches]

Low Severity Depression

Medium Severity Depression

High Severity Depression

103 Edge Restraint

Description: Edge strips and curbing are forms of restraints that provide lateral support for paver pavements. Lateral restraint is considered essential to resist lateral movement, minimize loss of joint and bedding sand, and prevent block rotation. Edge strips/curbs can comprise prefabricated angle supports, concrete curbs, etc. This distress is accelerated by traffic loading.

Identification: Loss of lateral restraint is characterized by widening of the paver joints at the outer pavement edge or at the transition of pavement types. Locally pavers at the pavement edge can exhibit both vertical and horizontal rotation as well as local edge settlement. The distress is most notable within 0.3 to 0.6 m (1 ft to 2 ft) of the pavement edge.

How to Measure: Loss of edge restraint is measured in linear metres [linear feet] of pavement edge (measure the movement of the edge restraint).

Severity Levels:

Severity Level	
Low	Evidence of increased joint width, (6 – 10 mm) [0.25 to 0.4 inches] to no evidence of paver/curb rotation
Medium	Increased joint width (11 – 15 mm) [0.4 to 0.6 inches], with evidence of paver/curb rotation
High	Increased joint width (> 15 mm) [0.6 inches], with noticeable of paver/curb rotation and local settlement

Low Severity Loss of Edge Restraint

Medium Severity Loss of Edge Restraint

High Severity Loss of Edge Restraint

104 Excessive Joint Width

Description: Excessive joint width is a surface distress feature in which the joints between blocks have widened. Excessive joint width can occur from a number of factors including; poor initial construction, lack of joint sand, poor edge restraint, adjacent settlement/heave, etc. As joints get wider, the block layer becomes less stiff and can lead to overstressing the substructure layers.

Identification: Optimal block spacing is typically specified as 1.5 to 3 mm [0.05 to 0.12 inches]. As joints get wider, the individual blocks may show signs of rotation.

How to Measure: Excessive joint width is measured in square metres (square feet) of surface area. The average joint widening defines the severity. As concrete pavers are manufactured with a beveled edge, care must be taken to ensure the actual joint width is measured.

Severity Levels:

Severity Level	Average Joint Width
Low	6 – 10 mm [0.25 to 0.4 inches]
Medium	11 – 15 mm [0.4 to 0.6 inches]
High	> 15 mm [0.6 inches]

Low Severity Excessive Joint Width
(less than 5 mm [0.25 inches] wide with or without joint sand loss and performing well)

Medium Severity Excessive Joint Width

High Severity Excessive Joint Width
(greater than 5 mm [0.2 inches] with loss of joint sand and misalignment)

105 Faulting

Description: Faulting are areas of the pavement surface where the elevation of adjacent blocks differ or have rotated. Faulting can be caused by surficial settlement of the bedding sand, poor installation, pumping of the joint or bedding sand. Local roughness can reduce the ride quality. Faulting can pose a safety hazard for pedestrians. Faulting can be corrected by resetting the blocks.

Identification: Faulting is characterized by small areas of individual blocks standing proud of each. This distress is often associated with more severe distresses such as settlement, heave, rutting, etc.

How to Measure: Faulting is measured in square metres (square feet) of surface area. The maximum elevation difference defines the severity.

Severity Levels:

Severity Level	Elevation Difference
Low	4 – 6 mm [0.15 to 0.25 inches]
Medium	6 – 10 mm [0.25 to 0.4 inches]
High	> 10 mm [0.4 inches]

Low Severity Faulting

Medium Severity Faulting

High Severity Faulting

106 Heave

Description: Heaves are areas of the pavement surface that have elevations that are higher than the surrounding areas. Heaves are typically caused by differential frost heave of the underlying soils. Heaves can also occur as a result of subgrade instability and can also occur in conjunction with settlement/rutting.

Identification: Visual examination is not always a reliable technique for detection of heaves, especially for low severity depressions. The most reliably method to identify heaves is to utilize a 3 m straight edge.

How to Measure: Heaves are measured in square metres (square feet) of surface area. The maximum height of heave defines the severity. heaves larger than 3 m (10 feet) across should be measured with a stringline.

Severity Levels:

Severity Level	Maximum Height of Heave
Low	5 – 15 mm [0.2 to 0.6 inches]
Medium	15 – 30 mm [0.6 to 1.2 inches]
High	> 30 mm [1.2 inches]

Low Severity Heave

Medium Severity Heave

High Severity Heave

107 Horizontal Creep

Description: Horizontal creep is the longitudinal displacement of the pavement caused by traffic loading.

Identification: Regardless of the block bond, the pavement surface should have a uniform pattern. Shifting of the joints or pattern signify horizontal creep.

How to Measure: Horizontal creep is measured in square metres (square feet) of surface area. The deviation from the original position defines the severity.

Severity Levels:

Severity Level	Horizontal Movement
Low	6 – 10 mm [0.25 to 0.4 inches]
Medium	11 – 20 mm [0.4 to 0.8 inches]
High	> 20 mm [0.8 inches]

Low Severity Horizontal Creep

Medium Severity Horizontal Creep

High Severity Horizontal Creep

108 Joint Sand Loss/Pumping

Description: Joint sand loss/pumping is a distress feature in which the joint has been removed. Joint sand loss can occur from a number of factors including; heavy rain, sweeping, pressure washing, pumping under traffic loading, etc. Joint sand is considered essential to providing interlock and stiffness of the paver course.

How to Measure: Joint sand loss/pumping is measured in square metres (square feet) of surface area. The depth of sand loss measured from the bottom of the chamfer down defines the severity.

Severity Levels:

Severity Level	Depth of Sand Loss
Low	< 10 mm [0.4 inches]
Medium	10 – 25 mm [0.4 to 1 inch]
High	> 25 mm [1 inch]

Low Severity Joint Sand Loss

Medium Severity Joint Sand Loss

High Severity Joint Sand Loss

109 Missing Pavers

Description: Missing pavers, as the name implies, refers to sections of pavement that are missing pavers, that may have resulted from removal or disintegration/damage. Missing pavers can compromise the integrity of the pavement structure and promote surface roughness similar to potholes in flexible pavements.

Identification: Sections that are missing pavers.

How to Measure: Missing pavers are measured in square metres (square feet) of surface area. The severity is evaluated by degree of distress. Random individual paver damage would not be counted.

Severity Levels:

Severity Level	
Low	Random individual missing pavers.
Medium	Missing 2 or more pavers in one area and ride quality unaffected.
High	Missing 2 or more pavers in one area and ride quality affected.

Low Severity Missing Pavers

Medium Severity Missing Pavers

High Severity Missing Pavers

110 Patching

Description: Patching refers to sections of pavement that are missing pavers and have been reinstated with a dissimilar material. Patch quality can compromise the integrity of the pavement structure and promote surface roughness similar to potholes in flexible pavements.

Identification: Sections of dissimilar materials such as asphalt, etc. .

How to Measure: Patches are measured in square metres (square feet) of surface area. The severity is evaluated by the quality of the patch.

Severity Levels:

Severity Level	
Low	Patch is in good condition and ride quality is unaffected.
Medium	Patch is in good to fair condition and ride quality is starting to deteriorate.
High	Patch is in poor condition and ride quality is affected.

Low Severity Patch

Medium Severity Patch

High Severity Patch

111 Rutting

Description: Rutting is a surface depression in the wheel path. Depressions are areas of the pavement surface that have elevations that are lower than the surrounding areas. Rutting is typically caused by settlement of the underlying subgrade or granular base under vehicle loading. Depressions can cause roughness in the pavement and, when filled with water, can cause hydroplaning of vehicles.

Identification: Locate rutting by visual assessment and measure rutting with a straight edge. Rutting in a single wheel path is usually quite evident. However, depressions caused by static wheel loads are measured as rutting.

How to Measure: Rutting is measured in square metres (square feet) of surface area. The maximum rut depth defines the severity. To determine the rut depth, a straight edge should be placed across the rut and the depth measured in millimeters (inches). Rut depth measurements should be taken along the length of the rut. Varying severities of rutting along the length of the rut should be measured individually.

Severity Levels:

Severity Level	Maximum Depth of Rut
Low	5 – 15 mm [0.2 to 0.6 inches]
Medium	15 – 30 mm [0.6 to 1.2 inches]
High	> 30 mm [1.2 inches]

Low Severity Rutting

Medium Severity Rutting

High Severity Rutting

APPENDIX B

CONCRETE BLOCK PAVEMENT INSPECTION FORM

INTERLOCKING CONCRETE BLOCK
ROADS AND PARKING LOTS
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

ROAD ______________________________ **DATE**__________

SECTION______________________________ **SAMPLE UNIT**_______

SURVEYED BY ____________________ **SAMPLE AREA (sq m) [sq ft]** ________

DISTRESS NUMBER AND TYPE

101 Damaged Pavers	**102 Depressions**	**103 Edge Restraint**
104 Excessive Joint Width	**105 Faulting**	**106 Heave**
107 Horizontal Creep	**108 Joint Sand Loss/Pumping**	**109 Missing Pavers**
110 Patching	**111 Rutting**	

DISTRESS/ SEVERITY	QUANTITY					TOTAL	DENSITY %	DEDUCT VALUE

SKETCH

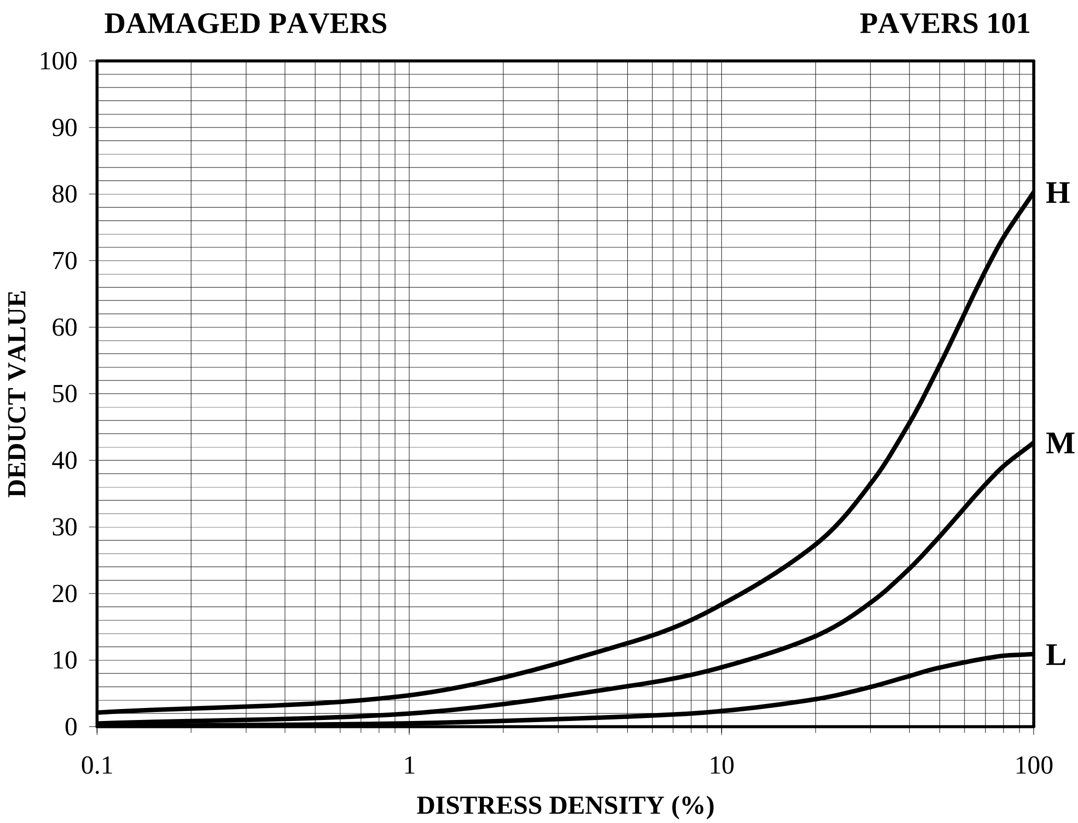
NOTES:____

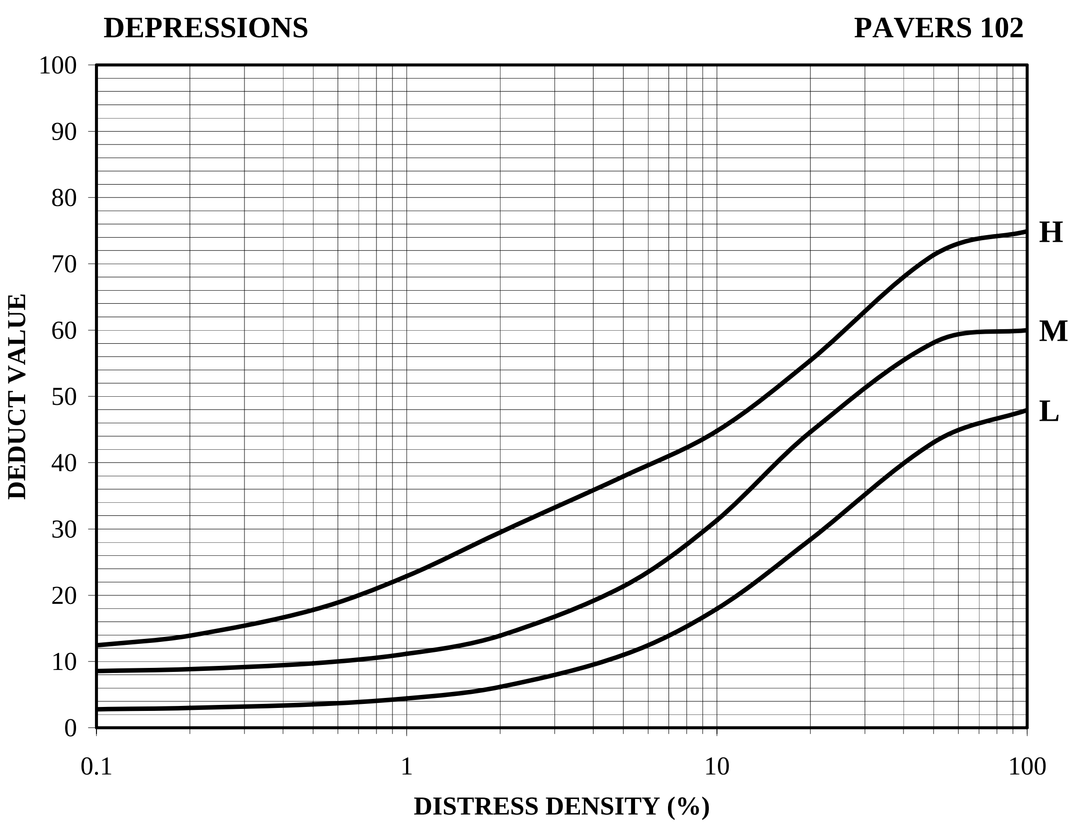
____
____
____
____
____
____

FORM ICP-ROADS

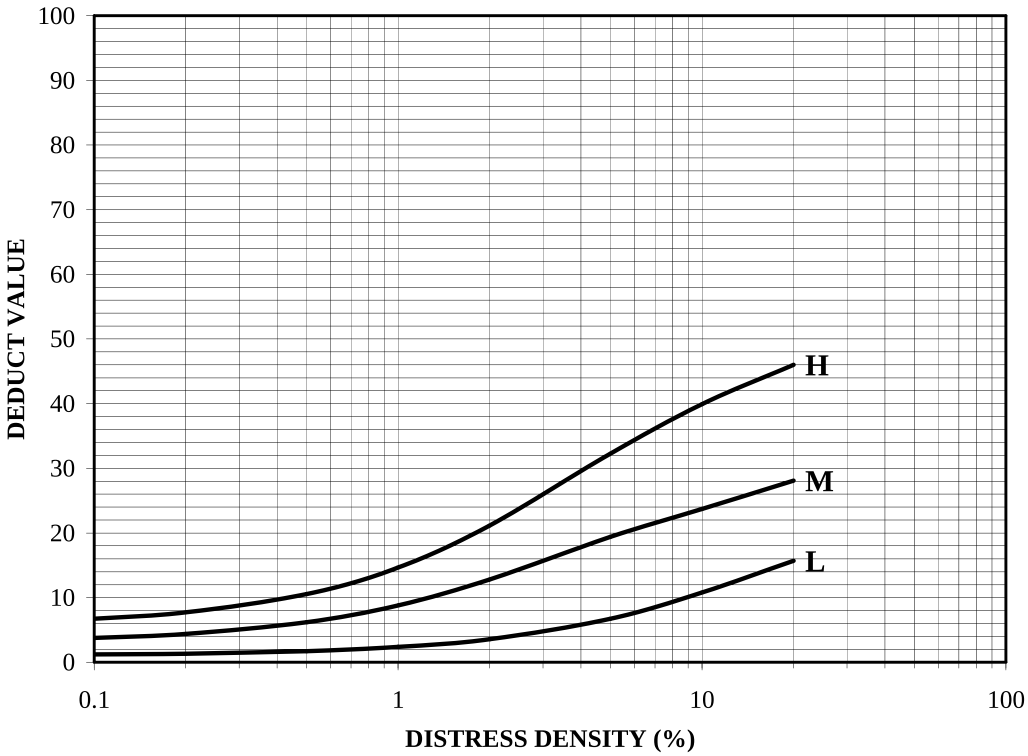
APPENDIX C

DEDUCT CURVES

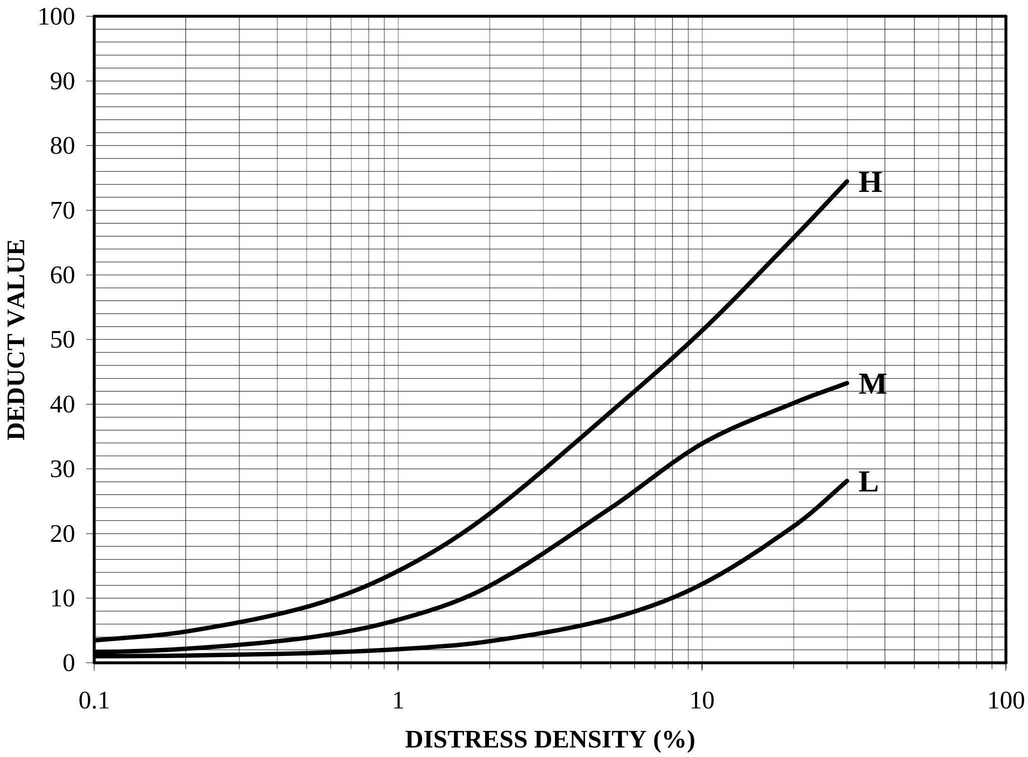

DAMAGED PAVERS
PAVERS 101
DEDUCT VALUE
0
10
20
30
40
50
60
70
80
90
100
0.1
1
10
100
DISTRESS DENSITY (%)
H
M
L


DEPRESSIONS
PAVERS 102
DEDUCT VALUE
0
10
20
30
40
50
60
70
80
90
100
0.1
1
10
100
DISTRESS DENSITY (%)
H
M
L

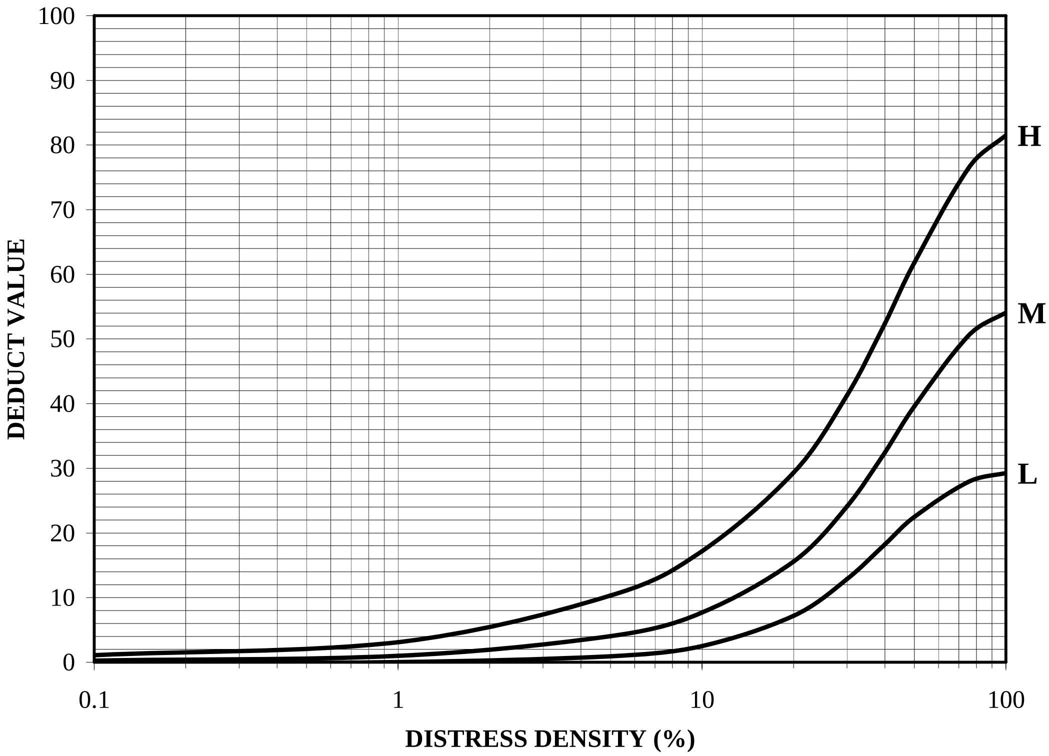
EDGE RESTRAINT **PAVERS 103**



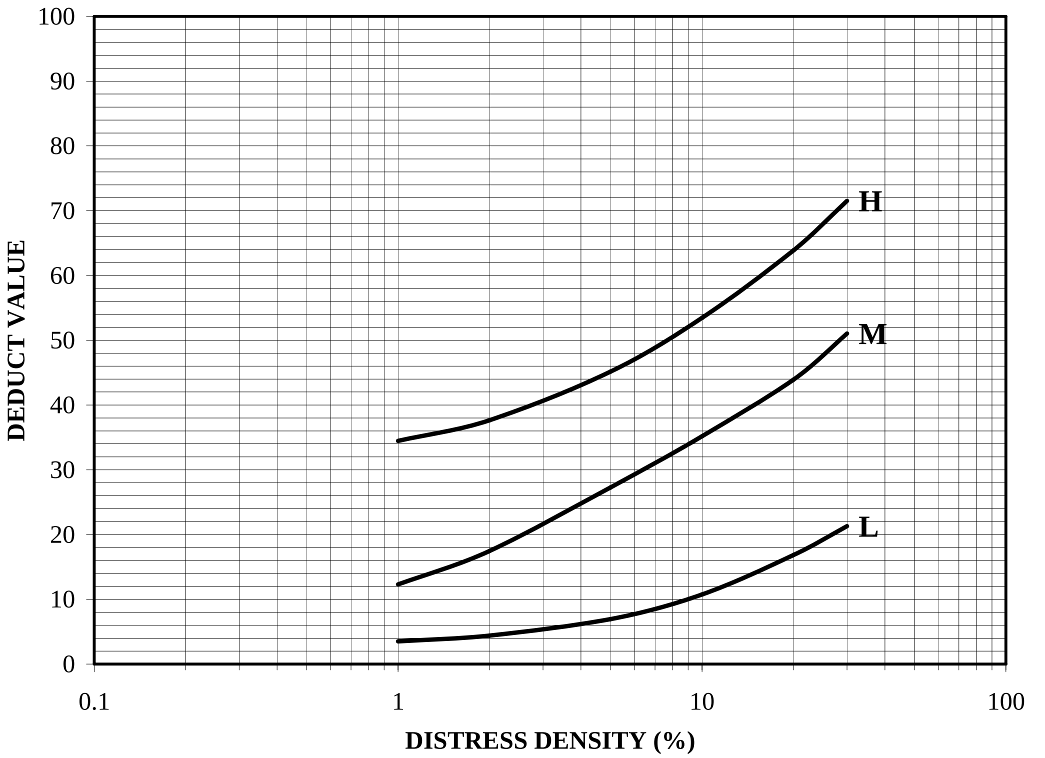
EXCESSIVE JOINT WIDTH **PAVERS 104**

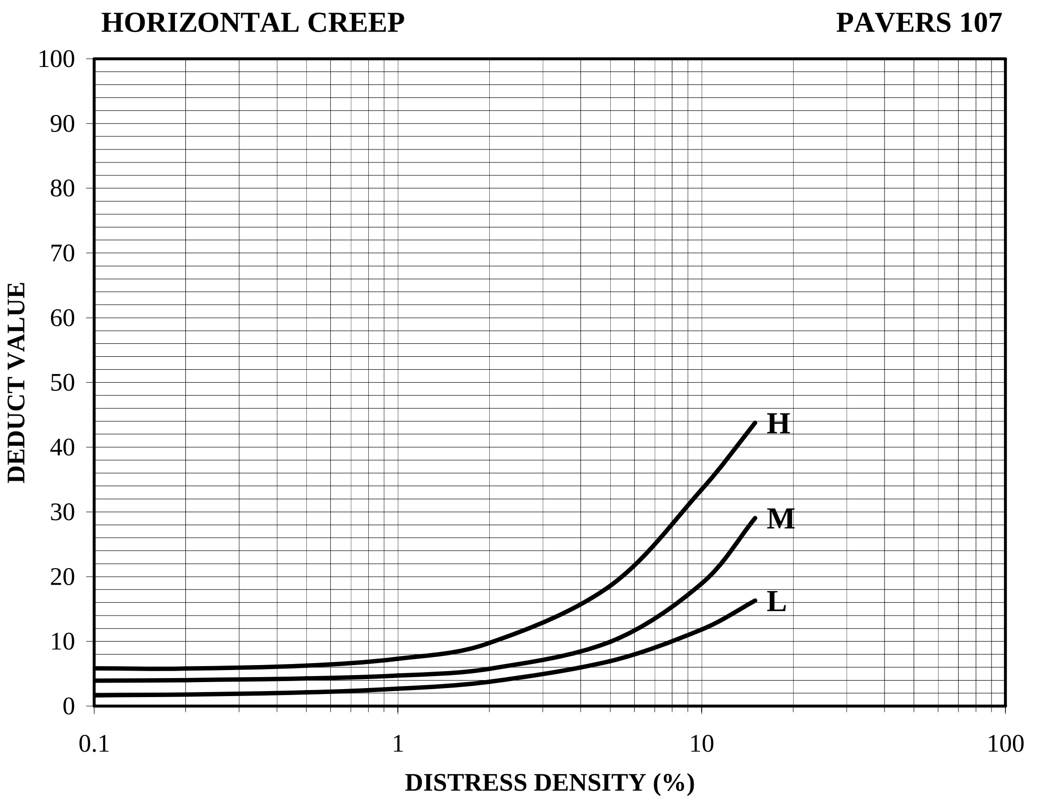


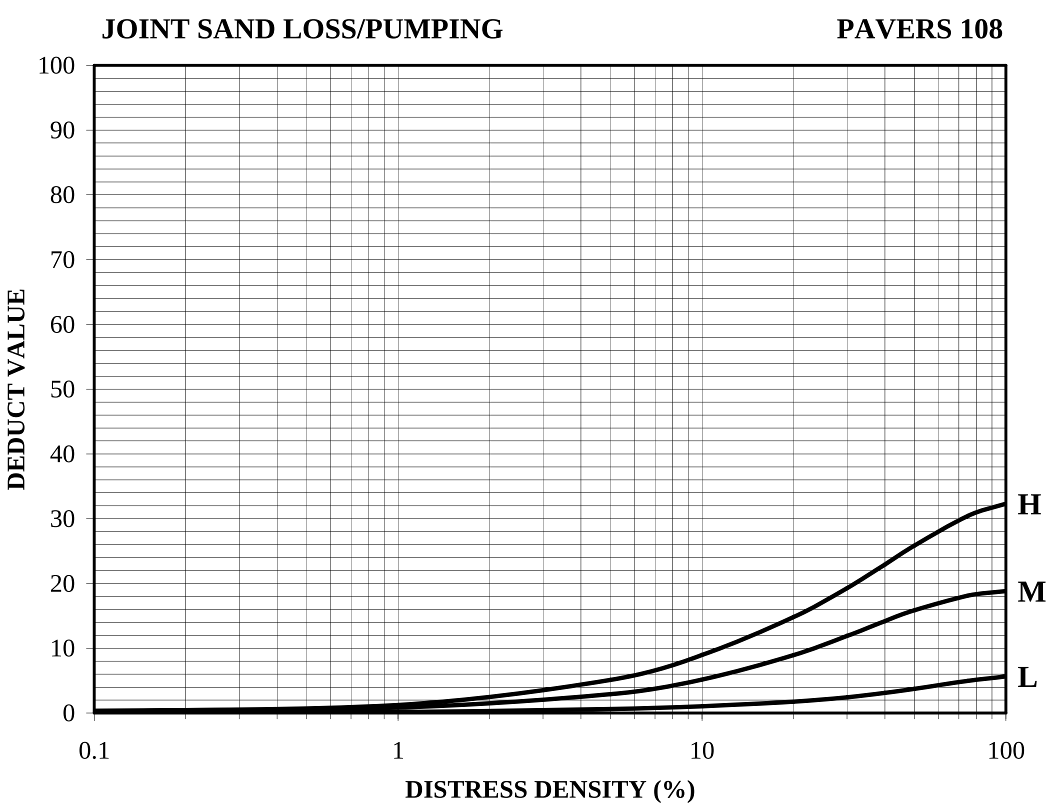
FAULTING PAVERS 105



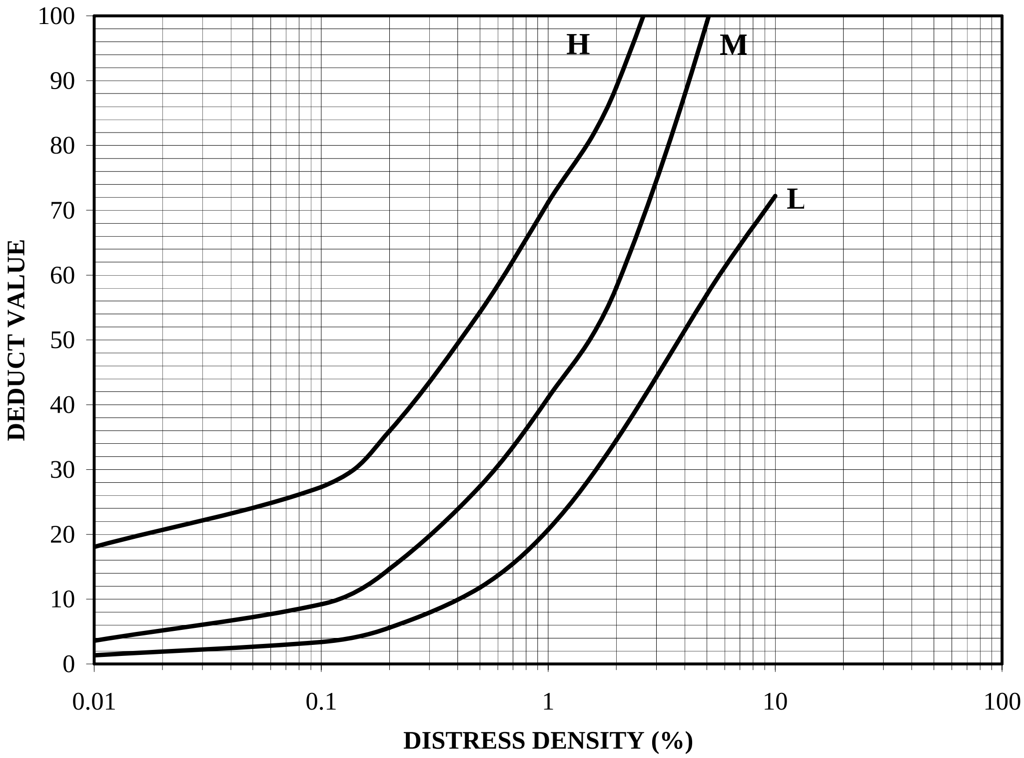
HEAVE PAVERS 106



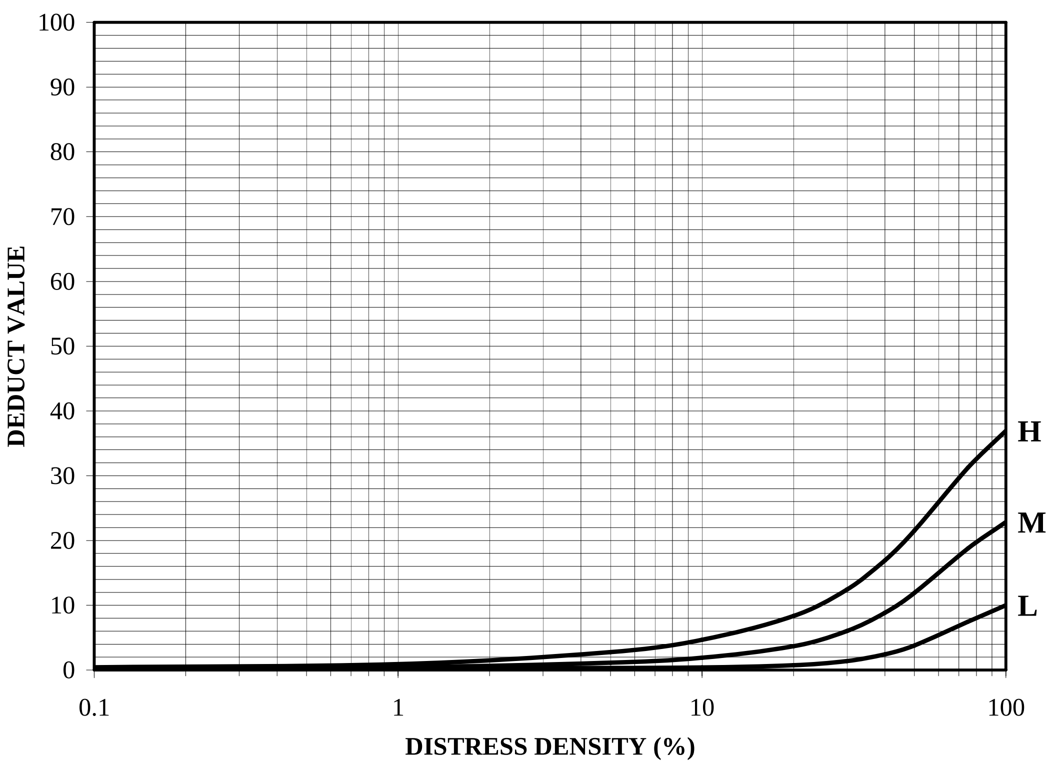

HORIZONTAL CREEP
PAVERS 107
DEDUCT VALUE
0
10
20
30
40
50
60
70
80
90
100
0.1
1
10
100
DISTRESS DENSITY (%)
H
M
L


JOINT SAND LOSS/PUMPING
PAVERS 108
DEDUCT VALUE
0
10
20
30
40
50
60
70
80
90
100
0.1
1
10
100
DISTRESS DENSITY (%)
H
M
L

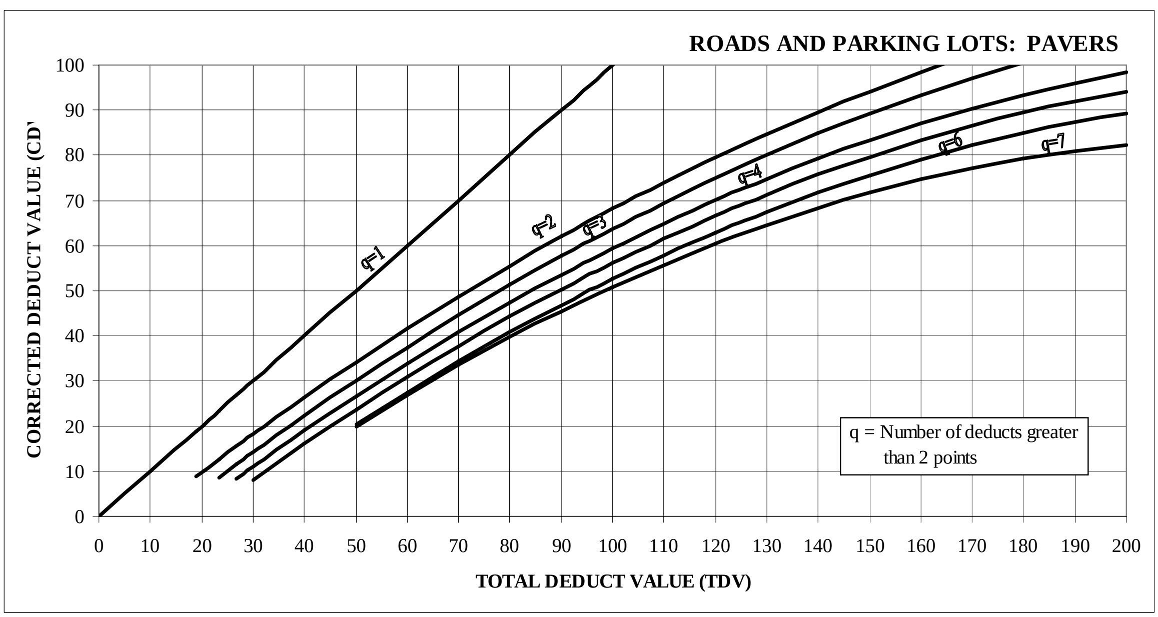
MISSING PAVERS **PAVERS 109**



PATCHING **PAVERS 110**



RUTTING
PAVERS 111
DEDUCT VALUE
DISTRESS DENSITY (%)
H
M
L
0.1
1
10
100
0
10
20
30
40
50
60
70
80
90
100



ROADS AND PARKING LOTS: PAVERS
CORRECTED DEDUCT VALUE (CDV)
TOTAL DEDUCT VALUE (TDV)
q=1
q=2
q=3
q=4
q=6
q=7
q = Number of deducts greater than 2 points
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200

APPENDIX D

EXAMPLE PCI CALCULATION FOR DEPRESSION

Example PCI Calculation for Depression

A very simple example calculation of PCI is provided in the following section.

Sample unit area = 500 m^2 (5,380 ft^2)

Distresses present = Low severity depression (102L) = 35 m^2 (375ft^2)
Moderate severity depression (102M) = 60 m^2 (645ft^2)

Density of distresses = 102L = 35/500 (375/5,380)= 7 percent
102M = 60/500 (645/5,380)= 12 percent

From deduct curve deduct value = 102L = 14
102M = 36

Total deduct value (TDV) = 14 + 36 = 50

As there are two deduct values greater than 10 percent, the PCI needs to be "corrected" to account for the superimposition of distresses.

For q = 2 and TDV = 50

Corrected deduct value = 34

PCI = 100 – 34 = 66