2nd Edition
More Than 200 Photos

AIRPORT PAVEMENT INSPECTION by PCI

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$40.00

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by

P C I

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SECOND EDITION

published by

ECKROSE/GREEN ASSOCIATES
Madison, Wisconsin

Cover design by

Nautilus Printing & Publishing Co., Inc.
Madison, Wisconsin

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PREFACE

The Pavement Condition Index (PCI) method of documenting pavement conditions was developed by the United States Army Corps of Engineers in the decade of the 1970s. It may prove to be the most revolutionary breakthrough in Civil Engineering technology in this century.

The PCI inspection and evaluation technique makes possible, for the first time, an objective assessment of pavement condition based on visual examination. The concept is based on easily recognized distress types, each influencing the condition index according to an emphirical standard developed from collective judgements of a large group of experienced pavement engineers.

The real value of PCI, as a pavement management tool, is that the condition of a pavement section can be confirmed, within reasonable limits of accuracy, by any qualified pavement inspector. With this confidence in reported data, engineers can predict deterioration rates, forecast serviceability, program maintenance and improvement actions, and estimate costs with accuracy never before possible.

Because rating results are objective (repeatable), evaluation of pavement dynamics over time is made possible by comparing condition ratings from subsequent years during the life of the pavement. This can lead to an ever improving knowledge of a pavement's "personality" with a corresponding increase in ability to accurately program maintenance and improvements.

The PCI method of condition rating is extremely important to persons responsible for management of pavement systems. It is a giant step forward in Civil Engineering technology at a time when preservation of pavement systems is more crucial than ever before.

However, PCI is a new technology, being implemented for the first time by most users. As with nearly all new technologies, there is room for improvement. PCI procedures need to be refined, from time to time, by persons who have used them extensively, and have tested and examined them in detail.

This manual is such a refinement. The intent and purpose of initial PCI standardization is retained in every sense. PCI standards have been strengthened and refined to improve consistency of data collection and to provide guidance to users in preparing for and conducting inspections. By use of this manual, repeatability and quality assurance can be increased substantially. Minimum standards established herein have never before been achievable using PCI inspection procedures.

This manual has been developed for use by inspectors trained in PCI inspection techniques by Eckrose/Green Associates. It presents the collective judgements, interpretations and techniques of the authors, and inspectors working under supervision of the authors, in five years of extensive field inspections on more than 275 airports. With proper training and supervision, any maintenance technician, pavement designer, construction supervisor, or surveyor can expect to achieve standards established by this manual.

This SECOND EDITION of "Airport Pavement Inspection by PCI" has significant improvements over the initial publication. There are more than 200 photographs in this edition to support the text. A picture, in distress identification, is worth at least 1000 words, and these photographs represent a veritable library of value. We have further refined many of our "Additional Criteria" in response to questions and requests from our field crews. Chapter 2 has been revised to provide a direct comparison of the MicroPAVER computer program with Eckrose/Green's AIRPAV software. We have expanded Chapter 3, "Site Layout Procedures", to further amplify our records research and pavement layout techniques. And, we have added Chapter 6, "Drainage Condition Index Procedures", to introduce a new technology we are developing for evaluation of drainage conditions associated with pavement.

It is a rare privilege to work in a field which is evolving as rapidly as pavement management is today. Each day presents exciting new challenges, and there are countless opportunities for innovation and improvement. But there is a special responsibility, also. In this emerging technology, with few established standards and virtually no traditions, one must be especially careful not to "oversell" a concept, or to mislead the using public. We believe this manual is a responsible contribution to pavement management technology.

The Authors

CHAPTER I

PAVEMENT MANAGEMENT

BACKGROUND

Pavement is nearly as important to our way of life as are food and shelter. Next to assuring the means to sustain life, mobility is, perhaps, the most fundamental essential of our society. To enhance mobility, we have developed vehicles to transport us on land and water and in the air. Ground transportation, as we know it, would not be possible without our vast networks of paved streets and highways. Air transportation, as well, requires paved airports at origin and destination points.

A pavement system reflects the needs of society for mobility. Large population centers are supported by complex pavement systems. Small town and rural areas have more simple needs, and supporting pavement systems reflect those needs. Pavement has but one purpose - to support and provide a smooth all weather surface for wheeled vehicles.

Pavement composition is dictated by many factors. Kinds and volumes of traffic are primary. Terrain, climate and soil conditions are also important. Other factors include political and engineering preference, availability of raw materials and construction expertise.

POLITICAL FACTOR

In any pavement system, political leaders are most concerned about safety, service and appearance. The system must serve society. It must provide access where people want to go, with safety, and in harmony with its environment. When a pavement system fails in any of these areas, responsible elected and appointed officials get complaints from their constituents.

PLANNING FACTOR

The ability of a pavement system to serve society is largely a function of planning. Before any pavement system, or system expansion, can be built it must be integrated conceptually with other expectations and demands of the people. Planners dictate the character of a pavement system by identifying existing needs and forecasting future needs. Planning provides a transition between political and engineering concerns. Planners anticipate and respond to the needs of society by conceptualizing the evolving pavement system within constraints of financing, environment, politics and engineering.

ENGINEERING FACTOR

Engineers design pavement to be safe, serviceable, economical, durable and attractive. Their concerns are of drainage and materials. They establish load and volume capacity, pavement type, composition and thickness. They build, maintain and rehabilitate the pavement system for as long as it is needed by society.

CONTROLLING FACTOR

Funding is the means by which society achieves the support systems it demands. Society pays taxes to finance water and sewer systems, parks, schools, streets and highways and airports. Some taxes are dedicated, but most are entrusted to elected representatives. These political leaders must then apportion funds among all the support systems in place. The process keeps the systems in balance and assures efficient evolution of our quality of life.

CATALYSTS

Society is made up of special interest groups who compete for available tax dollars. These groups provide political leaders with awareness of need, potential benefits and consequences to society associated with funding of individual support systems. Their contribution is invaluable in making tax apportionments.

This competition for public funds is the foundation upon which our support systems are built. It provides checks and balances to assure that funds will be used where they are most needed. It encourages public awareness and participation. It requires each special interest group to critically examine and justify its needs.

Since credibility is so very important, it demands competent use of allocated funds and proof thereof. It requires management.

MANAGING THE PAVEMENT SYSTEM

Responsibilities.

A manager's first responsibility is to make best possible use of public funds entrusted to him. He must expand the pavement system, as authorized, to serve society's needs. He also must maintain the system in safe and serviceable condition. When there are not enough funds provided to do all the things that are needed, he must decide which needs are most important. And he must document his needs and support his decisions to justify future funding. Fulfilling these responsibilities is what pavement management is all about.

Overview.

The first step in pavement management is to determine what the needs are. This is done by critically examining all pavement in the system. This will require at least a comprehensive visual inspection and analysis of the importance of various pavement sections to the function of the system.

Ultimately, priorities will be established based on pavement condition, function and available resources. Once priorities are set, it is important to decide the best way to deal with the pavement and what it will cost. It is then necessary to finance the work.

When the work starts it is important to supervise to insure full value for the investment. Finally, activities must be documented to measure progress, improve techniques, and ensure program continuity.

In summary, pavement management requires regular inspections, periodic reevaluation of priorities, deciding among action alternatives, a continuing campaign for financial support, supervision of project activities, and documentation of results.

Inventory.

Visual inspection is a very good evaluation technique. It is simple and inexpensive and provides a great deal of valuable information about pavement conditions. However, it is often wise to make additional tests to identify conditions not definable by visual inspection.

The most traditional method is to obtain samples for laboratory testing. Advantages are that actual materials can be examined and tested. Disadvantages are that a piece of pavement is destroyed in taking the sample, costs can be quite high, and results represent only conditions at the spot of the sample.

In recent years several alternative testing techniques have been developed, many of which are nondestructive in nature and allow examination of considerably broader expanses of pavement than is practical with physical sampling. Among nondestructive testing techniques are nuclear meters, electronic devices, radar units, impact and dynamic loading devices, and friction measuring equipment. Each can provide valuable information of conditions and each has certain limitations. In practice, it is appropriate to select from nondestructive techniques to fulfill specific investigative requirements.

Priorities.

In order to establish functional priorities, pavement should be divided into sections in such a way that each section represents a single operational function. Within functional areas, pavements should be further subdivided into areas of like construction. All pavement in a system should be included.

Priorities should be based on operational importance to the system, use demand, rate of deterioration and condition. Assigning of priorities and allocating of funds should always be done in the interest of achieving a more balanced pavement system. The objective must be to maintain well defined minimum service levels throughout the system.

Evaluations.

If identifying problems was all a manager had to do, management would be easy. The real challenge is to formulate solutions and orchestrate them to successful completion. Formulating solutions in pavement management requires analyzing pavement conditions, defining alternative corrective actions and assessing the consequences of those actions. Credible alternative actions will vary with the function of a pavement section and its condition.

Finding the best solutions to pavement problems is very important. It deserves professional input, and the credibility of any program may well depend upon the manager's ability to justify his approach to this process.

Financing.

Before any preservation or expansion can take place, it is necessary to obtain funding for the work. Selling the program on its merits to public officials is an ongoing management responsibility.

Pavement management tools can provide a tremendous advantage in the competition for public funds. They provide hard evidence of the condition of pavement in the system and the benefits to be expected. By comparing remaining service life projections of a "do nothing" option with service life projections of recommended solutions, it is possible to predict consequences of any failure to finance the program.

Implementation.

With the budget approved and the money available, what more can be expected of a manager? The answer to this question is simple. Fulfilling those expectations is not.

It is a manager's responsibility to use public funds in the most effective manner possible. This requires preparing precise instructions for the use of those funds and supervising the work in progress to insure that value received is equal to value given. Here, again, professional assistance is almost always a wise course of action.

Documentation.

It is important to keep accurate records of accomplishments. Records are necessary not only to respond to criticism, but to assure continuity. Accurate documents of improvements, to include construction and equipment warranties, detailed descriptions of accomplishments, dates of completion, and names and addresses of engineers and contractors involved, will be invaluable in making the pavement management program even more effective in the future.

CHAPTER 2

PAVEMENT EVALUATION AND MANAGEMENT SYSTEMS

INTRODUCTION

Public officials are becoming more aware of a need to manage pavement systems systematically and objectively. As facilities age and as their condition deteriorates, it is apparent that scarce available funds must be appropriated wisely if the systems, which represent a major capital investment, are to be preserved in serviceable condition.

There has been a rapid growth in Pavement Management Systems (PMS) being offered. While each offers certain positive characteristics, many are limited in scope, flexibility and adaptability to individual needs. Some are based extensively on proprietary processes, further limiting their long term usefulness.

In order to achieve maximum long term utility, a PMS should be flexible enough to incorporate services specifically selected to meet the User's needs. A PMS should be specifically designed for an individual pavement system. In addition, when a private vendor or consultant is involved, the supplier of the PMS must be able to provide professionals with experience and expertise to select appropriate courses of action and appropriate specialized services from the PMS field. This approach assures that the User will not pay for more or less than is required, and that the right technology and management tools are acquired for the system. Further, a PMS should consist of widely accepted procedures which can, to the greatest possible extent, be updated and maintained by the User. Design of an appropriate pavement management system is a process of integration of all applicable elements.

In overview, a comprehensive PMS is a complex integration of technologies which should encompass at least the following elements, molded into a program that is right for the User.

* System Inventory
* Visual Inspection
* Nondestructive Testing
* Other Testing
* Integration and Evaluation of Data
* Capital Expenditure Planning
* Maintenance Programming

A brief discussion of each of these elements follows.

SYSTEM INVENTORY

This critical element of a PMS consists of assembling a historical record of pavement including type, age, construction characteristics and major traffic considerations. Information is usually available in Owner's files, but historical records of pavement systems are often incomplete. Supplemental information may be available from engineers who have designed projects, and from the FAA District or Regional Engineering Office.

The inventory leads to identification of discrete pavement "sections" having generally similar characteristics. This process of subdividing pavement allows inspection, testing and evaluation work to be focused more effectively, and facilitates identification of unusual or uncharacteristic conditions.

The system inventory will frequently include a preliminary visual inspection by an experienced pavement engineer to verify conditions and to identify areas of pavement which may require special attention in the inspection or testing phases.

VISUAL INSPECTION

Visual inspection is, in reality, an element of the data collection phase of a system inventory. It is the oldest form of pavement condition evaluation. Engineers have been evaluating pavement by this method since shortly after the first pavement was constructed. The greatest difficulty with visual examination has always been the subjective nature of the process.

In recognition of this limitation, an objective system of examination has been introduced which is rapidly becoming a "de facto" standard for visual inspection. This data gathering procedure is a visual inspection system called the Pavement Condition Index (PCI). The procedure was developed for the U.S. Air Force by the Army Corps of Engineers. It has been adopted by the Federal Aviation Administration (FAA) for use on civil airports. The system has also become the recommended PMS of the American Public Works Association (APWA) as part of its "PAVER" program for municipalities.

A PCI inspection is conducted on a statistically selected number of samples of each pavement section. While this technique does not give 100% area coverage, the process does provide measured distress information for a large selection of distress types in the system. This allows reassessment in future years and offers a positive means of determining rate of pavement deterioration. Accordingly, the longer the PMS is used, the greater will be confidence in the projected life and in the Capital Planning Program.

The PCI is based on a number of distinct distress types commonly found in pavements, as follows:

RIGID PAVEMENTS

1. Blowup
2. Corner Break
3. Longitudinal, Transverse, Diagonal Cracking
4. Durability ("D") Cracking
5. Joint Seal Damage
6. Patching, Small
7. Patching, Large
8. Popouts
9. Pumping
10. Scaling, Map Cracking, and Crazing
11. Settlement or Faulting
12. Shattered Slab
13. Shrinkage Cracks
14. Joint Spalling
15. Corner Spalling

FLEXIBLE PAVEMENTS

1. Alligator Cracking
2. Bleeding
3. Block Cracking
4. Corrugation
5. Depression
6. Jet Blast Erosion
7. Joint Reflection Cracking
8. Longitudinal and Transverse Cracking
9. Oil Spillage
10. Patching
11. Polished Aggr
12. Raveling and Weathering
13. Rutting
14. Shoving by PCC Slabs
15. Slippage Cracking
16. Swell

The PCI procedure objectively defines the type, quantity and severity of these distress types in pavement. This data is converted by formula to a numerical rating between zero and 100, with 100 being a perfect pavement and zero being a totally failed pavement. Accordingly, the procedure affords the User a standard index of pavement condition not available in any of the more subjective inspection procedures.

There are three primary objectives for a pavement condition survey. The first of these is to provide a measure of existing conditions based on apparent structural adequacy and surface characteristics. With training, an observer can learn much about the causes of pavement distress by evaluating the different types, quantities and severities of distress. The second objective is to standardize procedures to a degree which will allow the process to be repeated with consistent results, and to assess effectiveness of maintenance programs. The third objective is a common index for comparison of pavement sections in a system, and to provide a sound basis for maintenance and rehabilitation decisions.

The PCI procedure fulfills these objectives and, in addition, indirectly measures several primary determinants of pavement condition, including:

1. Structural adequacy
2. Roughness
3. Friction characteristics
4. Rate of deterioration
5. Maintenance effectiveness

This objective distress information can be used directly in maintenance planning and it provides a basis for much of the evaluation procedure discussed later.

PCI inspection is an important activity that provides data for alternative analysis, service life forecasts, reinspection comparisons, and evaluation of pavement deterioration over time. PCI data also provides definitive information of pavement condition for use in capacity analysis.

NONDESTRUCTIVE TESTING

There are many kinds of nondestructive testing. In fact, many PMS systems are based nearly exclusively on nondestructive testing procedures. Each type of nondestructive testing has specific application and different types are frequently used to supplement one another. No single technique, however, can provide all the data necessary for a comprehensive, effective PMS.

In a comprehensive PMS program, selection of type and extent of nondestructive testing should only be made following a review of program objectives and a visual examination of the pavement system. This permits selection of testing procedures tailored to User needs and observed conditions, and assures that the User pays only for testing programs which are appropriate and necessary.

Among nondestructive techniques frequently employed in pavement evaluation/management programs are deflection testing, ground penetrating radar, infrared thermography and friction testing. Each has a specific function and each should be selected according to the specific needs of the pavement system. A summary review of some of the most commonly used nondestructive testing techniques is presented here.

DEFLECTION TESTING

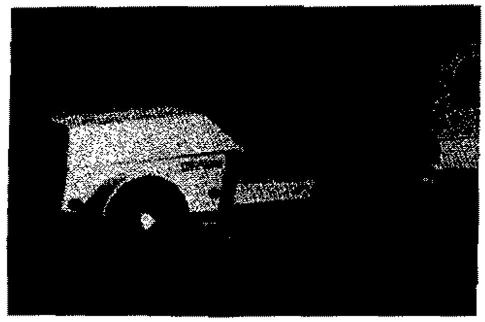
Equipment

Several types of deflection testing devices are in current use. In broad terms, they fall into one of three categories: static devices, dynamic devices and impulse devices.

Static devices, typified by the "Benkleman Beam" are simplest to use and are least costly in terms of capital expense. Unfortunately, they are also most limited in application, most inconvenient, and most labor intensive of the alternatives. Simply put, use of a static device consists of placing a long fixed beam which extends from outside the test area into the area where deflection will be measured. A load is placed in the test area, typically a loaded truck, the measuring devices are zeroed, the truck is removed, and the "rebound" of the pavement is measured. The process may also be used in the reverse direction. While there is a considerable body of literature attending this process, it is rapidly disappearing from use because of its labor cost, lack of repeatability in results, and the need to disrupt traffic.

Dynamic devices are those which apply a repeated or cyclical load to the pavement surface and measure pavement response (deflection) with a series of sensors similar to those used in seismic work. Dynamic devices fall into two categories, mechanical and hydraulic.

Mechanical systems have been in use longer, and they function by rotating an eccentric mass about a shaft, imparting a repetitive load to the pavement surface through a wheel, shoe or plate. Typical of these is the "Dynaflect" machine. Up to this point, there has been more research and more applications completed with this type of device than with any other. It is in fairly wide use by many public agencies and private firms.



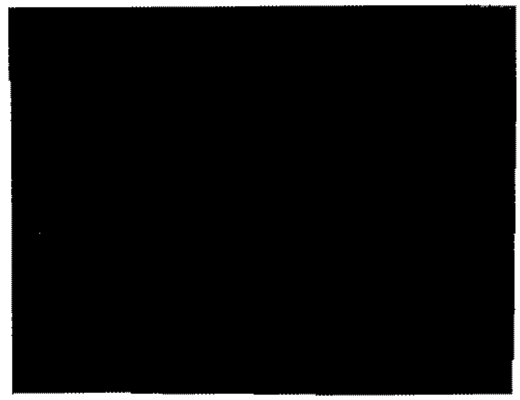
Dynaflect Machine
Figure 2-1

Though widely used, the machine has some limitations which inhibit its application. One of these is that it employs a small load, typically 2 Kips or less. While there have been many studies which indicate correlation of pavement response to this type of load with higher loads, the fact is that for many heavier pavement sections, the device is not capable of generating enough deflection to secure reliable, repeatable data.

Another limitation centers on data analysis. Most applications apply empirical methods which result in "inches of overlay", or linear elastic layer models which analyze materials properties in terms of resilient modulus. With most common empirical methods, the recipient is usually provided with an end product which provides no clear indication of the method by which a particular result was generated. In either case, in-situ characteristics may exist, relative to load or frequency response, which will result in spurious data. This type of machine, unfortunately, does not have a capability to vary either load or frequency of application. Since pavements are, in actuality, neither elastic, linear in response, or independent of harmonic influence, it is important to Users to understand these variables and to understand precisely how results were obtained.

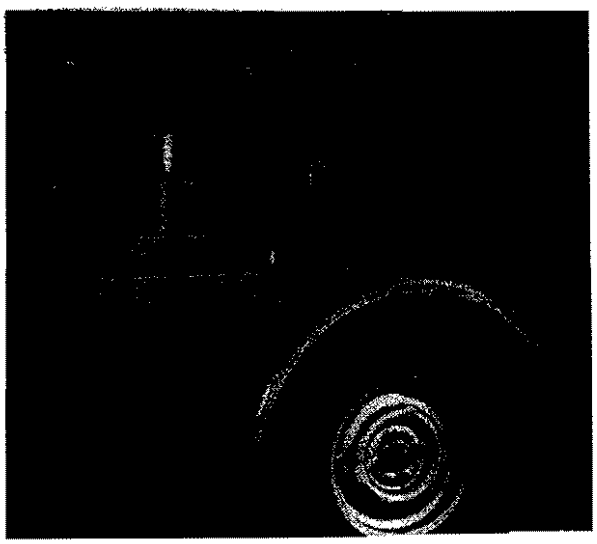
In spite of these limitations, this type of deflection device may well be the one of choice for relatively light pavement systems because of ready availability and low cost.

In recognition of these limitations, another type of dynamic device has been developed, typified by the "Road Rater". With this machine, load is applied hydraulically to the pavement, through a plate or shoe, and response is measured through a series of sensors, spaced at uniform distances from the point of load. The advantages of this type of device are: larger imparted loads (up to 1Ø Kips); ability to vary load and to "sweep" loads across a range to examine linearity of response; and ability to vary frequency of load application to eliminate harmonic effect from the final data. Data analysis is typically either on empirical or elastic layer basis, as with the mechanical devices.



Road Rater
Figure 2-1

The newest of the devices employed for deflection testing operates on a somewhat different principle. This device is of the "impulse" type which makes a single application of load by dropping a mass and transmitting the load to the pavement through a plate or shoe. As with the "Road Rater", response is measured through a series of sensors. These impulse type devices are categorized as "falling weight deflectometers"(FWD). Applied load is variable, determined by the height of the drop, and reaches up



Falling Weight Deflectometer
Figure 2-3

to 30+ Kips in some machines, although 20-22 Kips is a more typical upper range. The larger load, at least in theory, more closely approximates heavy wheel loads, an obvious advantage. Applications of this type of deflection test are far fewer than applications of dynamic devices, but the system is enjoying a fast growing popularity. There is also a considerable amount of research being conducted with this type of device to develop more sophisticated analytical models.

While there is considerable variation in deflection test devices, each can be effective if appropriately applied as an engineering tool based on a thorough understanding of the data generated, and not on a "black box" cure-all for pavement evaluation. A rule of thumb for applicability might be as follows:

Light flexible pavements:	Mechanical dynamic
Medium to heavy flexible or medium rigid pavements:	Hydraulic dynamic
Heavy rigid pavements:	Falling weight deflectometer

with the understanding that each device can be used for lighter weight pavements depending on cost and availability.

Methodology

Two primary analytical methodologies are used in computer programs which predict materials strength based on deflection data. Most comparative results indicate that either "elastic layer" or "finite element" analysis can produce reliable results. The two approaches are significantly different but, from a practical standpoint, either can be used with confidence. Other proprietary, or strictly empirical "inches of overlay" analyses based on deflection testing alone should be used with great caution.

The recommended procedure for strength analysis and materials characterization is to combine deflection data and pavement layer thickness information into an elastic layer evaluation to establish a dynamic elastic modulus for each pavement layer. Elastic layer analysis is preferred because of the extensive body of research data available in support of results, and because this type of analysis approximates design standards and criteria of a majority of public agencies and trade institutions. Microcomputer programs are available which produce consistent results with demonstrated accuracies well within tolerances required for pavement applications.

From a technical standpoint, results obtained from appropriately applied elastic layer and finite element analyses have been shown to be comparable within limits of accuracy of deflection sensors.

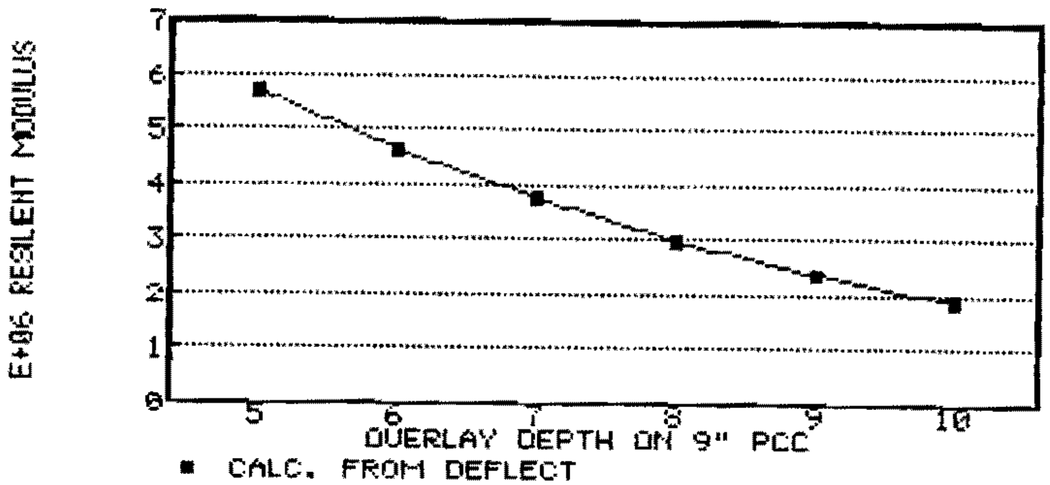
Users of deflection testing techniques should not be overly concerned about the complexity of analytical models, except in research applications. It is far more important to achieve a high level of accuracy in testing and analysis by use of available complementary procedures, and to have competent consultation in application of results.

GROUND PENETRATING RADAR

One of the most critical elements in the accurate interpretation of deflection test results is accurate pavement layer thickness data. Elastic layer analysis is very sensitive to layer thickness. Moduli may vary by several hundred percent, based on the thickness value used. In fact, under extreme circumstances, the moduli produced by such analysis can vary up to one hundred percent with a thickness variation of only one inch.

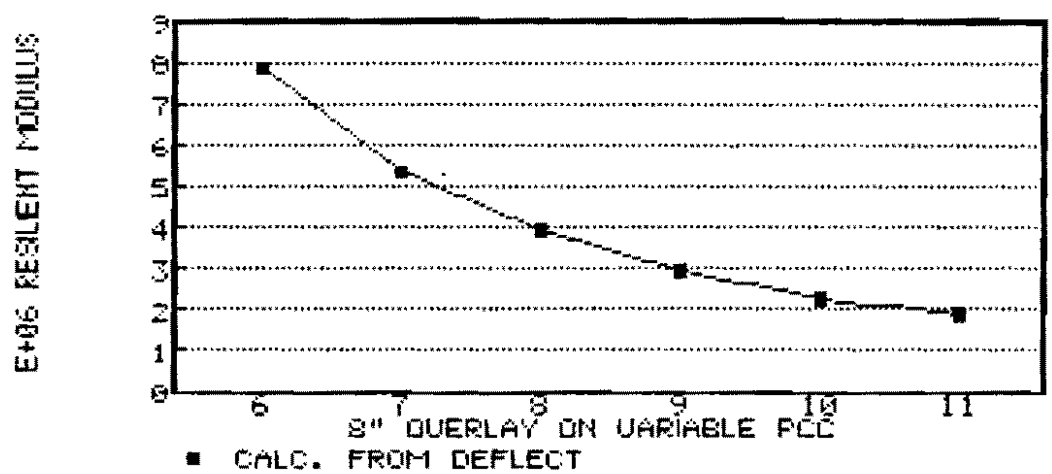
This sensitivity is illustrated in the following figures taken from an actual field project. In each case deflection data is real and thickness data is varied in one inch increments. The impact of inaccurate thickness information can be readily seen. As these figures are viewed, keep in mind that actual layer thickness may differ significantly from dimensions shown on record drawings. Variations of five inches and more are common.

Figure 2-4 shows the effect of varying overlay thickness on a fixed PCC slab which is 9" thick.



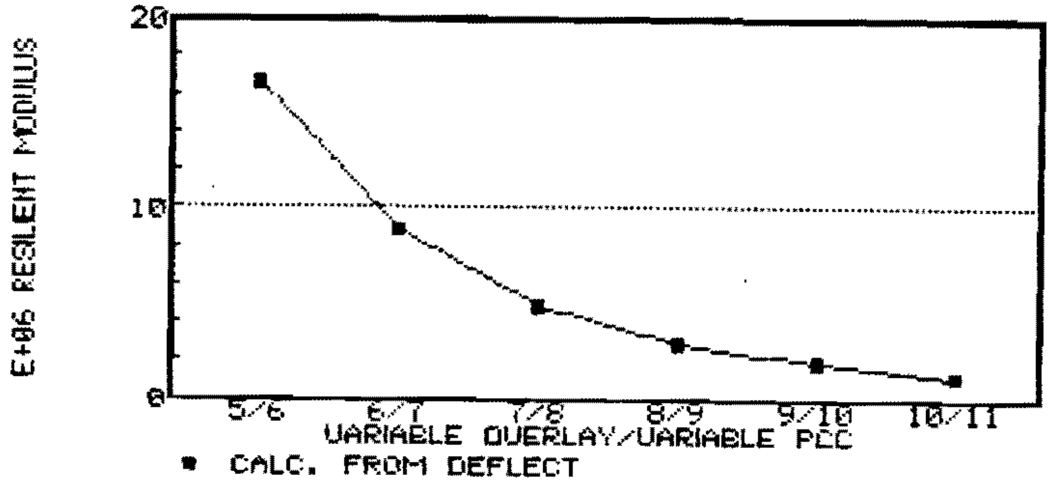
Variable Overlay on Fixed PCC
Figure 2-4

Figure 2-5 shows a similar effect when the overlay is held to a fixed thickness and the underlying PCC slab thickness is varied.



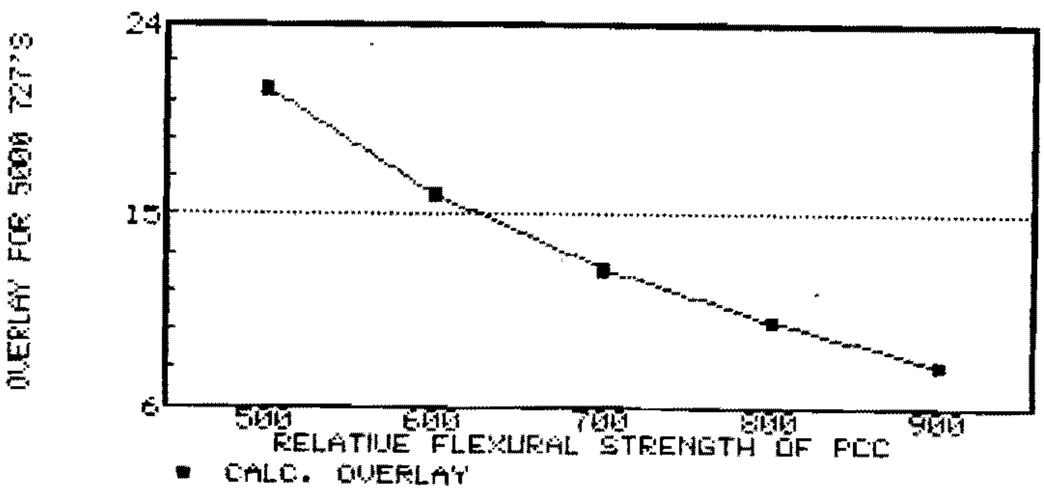
Fixed Overlay on Variable PCC
Figure 2-5

The composite effect with both overlay and PCC slab thickness being varied (a typical field condition) is shown in figure 2-6.



Variable Overlay on Variable PCC
Figure 2-6

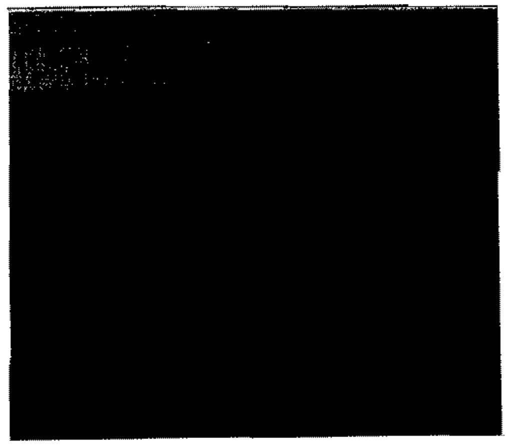
Since resilient modulus and flexural strength bear a site/material specific relationship to one another, the total potential effect of either an overdesign or under-design can be shown in Figure 2-7, in which overlay thickness is determined according to FAA standards, using the approximate range of flexural strengths which correspond to the previous results.



Combined Effect of Errors in Thickness Estimates
Figure 2-7

Ground Penetrating Radar (GPR), supplements deflection testing by providing accurate layer thickness information for use in the computer model. This technique should be used to complement deflection data unless historical information is known to be consistently accurate, or where data is being used only to evaluate subgrade characteristics.

GPR Antenna Configuration
Figure 2-8



GPR Recorded Output
Figure 2-9

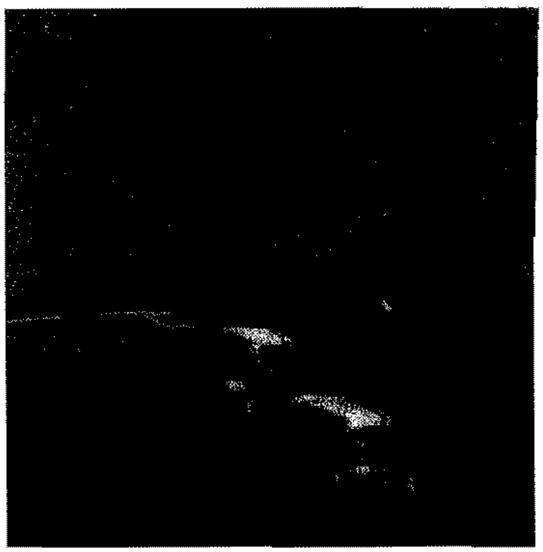
In addition to its application as a supplement to deflection testing, ground penetrating radar should be the primary tool for locating and mapping voids under pavement. When used in a ground-coupled mode at high center frequencies, it is acknowledged to be the most accurate nondestructive technique available for identifying and quantifying voids in and under pavement. Accurate dimensional information is available with GPR and, further, the equipment is capable of discriminating between actual voids and areas where weak or minimal base or subgrade support is present.

Other devices frequently promoted for voids detection are unable to make this distinction. Further, if and when voids can be detected by other means such as deflection testing, estimation of void size is limited to interpretation of the "deflection basin" defined by sensor measurements. Such estimates are quite unreliable in horizontal dimension, and the technique is incapable of estimating vertical dimensions of a void. Although some research is being conducted in this area, Users should be aware that these limitations render void detection by deflection testing as a speculative and currently unproven methodology.

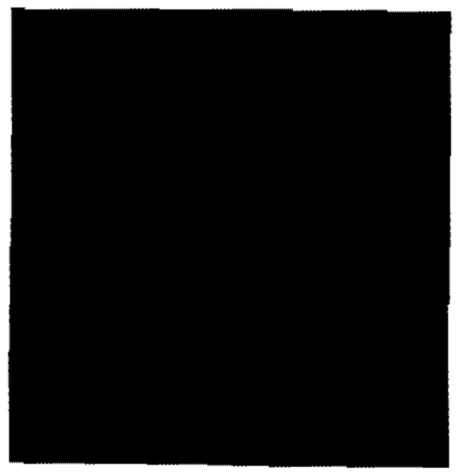
Finally, where load transfer is an important consideration, GPR provides a direct reading of joint deterioration characteristics such as durability failure versus keyway failure.

THERMAL INFRARED THERMOGRAPHY

Yet another nondestructive technique which has application in pavement evaluation is infrared thermography (IR). Although IR was developed primarily for rapid, accurate detection of delamination in bridge decks, the technology has found more general application on pavement for several years.



IR Camera Configuration
Figure 2-10



IR Image on Pavement
Figure 2-11

The major application in pavement evaluation has been detection of corrosion induced delamination in reinforced concrete pavements, particularly on continuously reinforced concrete pavement (CRCP). Recently, however, IR has been successfully employed in such diverse projects as mapping asphalt overlay debonding, and location of bond failures in porous friction courses. Primary advantages of this technique are rapid data acquisition, minimum traffic interference, and a degree of accuracy not attainable by manual or mechanical acoustical means.

SKID RESISTANCE (FRICTION) TESTING

Mu-Meter
Friction Testing Device
Figure 2-12

Skid testing is one of the oldest forms of nondestructive testing for airfield pavements. Much of the current equipment has been in use and continued development for years. This procedure is designed to provide a numerical assessment of the friction characteristics of the pavement/tire interface under both wet and dry conditions. The most typical characteristics under a wetted or flooded condition, and continuously over time following wetting, to assess friction charactgeristics as the pavement dries. The same devices can be, and often are, used to measure braking qualities under icing conditions. There is a large body of existing literature on this procedure.

OTHER TESTING

Depending on specific project requirements, other types of testing may be required. These may include laboratory testing of pavement core samples, subsurface exploration, and field or laboratory determination of bearing capacities. It is important to employ such techniques only after preliminary analysis of data gathered in the visual inspection and nondestructive testing phases of the project, and to a limited extent, for calibration of nondestructive test results. This procedure assures the User that such additional testing will be properly focused and attendant costs will be held to a minimum.

COMPUTERIZED EVALUATION

The dominant analytical tool in pavement evaluation/management systems is the microcomputer. Many programs being offered today present a single maintenance or rehabilitation strategy which may be accepted or rejected by the User. This limited approach is typical of early attempts at computer analysis.

The most highly publicized recent entry into the PMS computer systems environment is MicroPAVER. MicroPAVER is a modification of mainframe PAVER software developed by the Corps of Engineers for the Federal Aviation Administration and the Air Force. MicroPAVER software operates on desktop computers. The most attractive feature of MicroPAVER is that it is inexpensive and available, by subscription, to anyone.

Disadvantages, however, may be more important to the User. First, MicroPAVER is canned software. Written in the 1970s, programming techniques are dated and cumbersome. Programs are generic, so interaction required by the User is extensive. Potential for modification to meet the Users needs is very limited, as software is "off the shelf" to PMS consultants, not written by them. Second, MicroPAVER software is memory intensive and time consuming. The MicroPAVER program alone, exclusive of memory or data requirements, uses in excess of eight megabytes of storage capacity. Although the Corps has developed some techniques to make MicroPAVER more efficient and "user friendly", implementation of a pavement system PMS requires considerable expertise and time commitment by the User.

Eckrose/Green's AIRPAV pavement evaluation & management software, on the other hand, is menu driven and modular, allowing the user to acquire only those portions desired for in-house use. Use of the software does not require high levels of computer expertise or memorization of unique commands. AIRPAV software was developed using most recent innovations in programming technique so that computations are fast, and storage and memory requirements are minimized.

Basic AIRPAV module classifications are: (1) PCI data storage and calculation; (2) analysis of pavement characteristics and development of improvement options; and (3) creation and interactive use of Capital Improvements recommendations for individual airports and the state network. Since these functions are not carried on simultaneously, the user only needs memory capacity for one activity at a time. A summary of memory requirements for these three functions follows:

ACTIVITY REQUIREMENT	PROGRAM REQUIREMENT	OVERHEAD REQUIREMENT	TOTAL
PCI CALC.	73 KB	58 KB	131 KB
ANALYSIS	70 KB	58 KB	128 KB
CAP. IMP.	81 KB	58 KB	139 KB

As can be seen, any of the AIRPAV programs can operate in a 256 KB RAM environment. However, we recommend a minimum of 512 KB, with 640 KB preferred, for fastest and most convenient operation of the system.

Mass data storage is another consideration in viewing hardware requirements. AIRPAV software is designed to use mass storage for only the data portion actually required to support the function. This assures minimum operator inconvenience, particularly where the system configuration relies on diskettes for mass data storage.

A third disadvantage of MicroPAVER is that it does not have the degree of sophistication in evaluation that is evident in Eckrose/Green AIRPAV software. Comparisons are offered below.

MicroPAVER forecasts pavement deterioration based on straight line analysis from date of construction to date of inspection to date of forecast. In contrast, AIRPAV forecasts are made using fourth order forecast curves representing actual inspection data within the airport system under evaluation. If insufficient data is available from the system evaluation for reliable curve development, the AIRPAV generic data base consisting of more than 300 airport inspections may be utilized.

MicroPAVER programs corrective actions and estimates using unit prices provided by the user, and recommendations based on Pavement Condition Index ranges. AIRPAV recommendations and estimates are based on a matrix of actual distress types, severities and densities, not PCI values. The results are much more compatible with pavement conditions.

MicroPAVER prepares Capital Improvement Programs based on maintenance and rehabilitation actions specially input by the user. MicroPAVER does not offer alternative actions unless such actions are specifically input by the user. In effect, MicroPAVER manages a data base and performs some mathematical calculations. AIRPAV software, on the other hand, anticipates needed actions based on pavement conditions as indicated by recorded distress information. Using the matrix described above, the program recommends a best corrective action, and presents all alternative actions which will result in increased service life for the pavement, from among the following potential alternatives. Each flexible pavement action is independent. However, four of the rigid pavement actions may be chosen in combination. Therefore, seventeen options are actually evaluated for rigid pavement.

FLEXIBLE PAVEMENT	RIGID PAVEMENT
Reconstruction	Reconstruction
Structural Overlay	Reseating/Overlay
Resurfacing	*Slab Replacement
Surface Treatment	*Patching Crack
Repair	*Joint/Crack Repair
No Action	*Undersealing
	No Action

*Combination actions.

In addition to evaluating rehabilitation options, Eckrose/ Green AIRPAV software forecasts service life extensions and estimates costs for each action presented.

AIRPAV software is much faster in operation than MicroPAVER. This difference can best be appreciated by working with the software, but some comparisons can be made in hard numbers. First, AIRPAV makes extensive use of RAMDISK to speed applications. RAMDISK is typically 90-120 times faster than hard disk in a typical XT class microcomputer. The size of the MicroPAVER program does not permit use of RAMDISK in most computers, even though they may have been designed for such use.

A second factor which contributes significantly to the speed of AIRPAV is in disk file efficiency. The more times a computer program must access the hard disk, the slower it will run. By comparison, using data from a small Indiana airport, MicroPAVER required 1241 disk access operations just to generate a maintenance report on the screen. AIRPAV used only 1144 disk access operations to access data, analyze each feature, select viable alternatives, project service life for each, optimize project years, and store resultant information into the Capital Improvements Program.

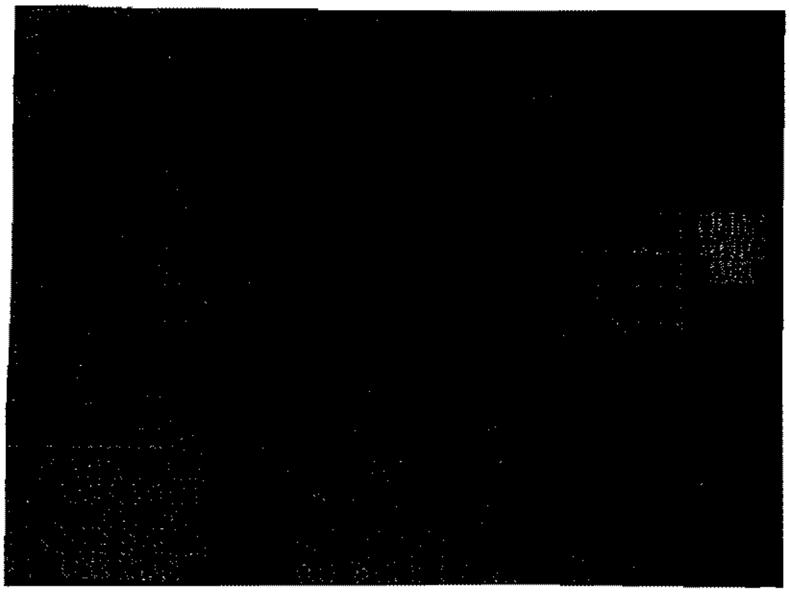
A similar task-to-task comparison was conducted for a single feature on the airport to retrieve maintenance and repair information. MicroPAVER required 866 disk access operations. AIRPAV required only 161, of which 92 were to the highly efficient RAMDISK.

To reduce these comparative statistics to terms which can be immediately appreciated by any pavement manager, the following example is presented. Identical inspection data from a small general aviation airport was input to MicroPAVER and AIRPAV computer programs. The same computer was used, and data was entered by the same operator, who is experienced in use of both systems. Time required by MicroPAVER, to obtain PCI values for pavement on the airport, was two hours and thirty minutes. Time required by AIRPAV, to accomplish the same task, was less than thirty minutes.

Use of AIRPAV software does not require high levels of computer expertise or memorization of unique commands. Complete operating manuals are provided for individual modules or for an integrated system, dependent on user selection. The modules used in preparation and installation of a Pavement Management system are briefly described as follows:

AIRPCI - This module reduces field inspection notes to standard PCI reporting sheets and creates an electronic record of all inspection activities. Provisions are made in the program for distress types, severities, quantities, resultant deduct values and calculated PCI values. The program is used to create a pavement condition data base. This data base is maintained independently from all successive uses, in order that future updates of inspection data will not be adversely affected by other activities.

AIRPMS - This program automatically reads pavement condition data from the PCI file, accumulates data by facility and feature, and produces a working data base format. Pavement ratings are calculated by feature and extrapolated distress quantities are developed. The program provides for additional storage of data such as construction history, test results, etc. Supplemental data storage can be tailored to the User's needs and desires. This program is also the basic analytical tool, providing either on-screen graphic analysis or hard copy presentation of recommended alternatives, as noted in the software descriptions. Analysis may be conducted for any year and the results will be added to the data base at the user's option. Analysis can be done for a variety of Minimum Service Levels. Transfer to the AIRCIP module is done by simple menu selection.



Graphic Display of AIRPMS Alternatives
Figure 2-13

AIRCIP - This is the "standard" recommended module for user installation. This program uses the alternative recommendations from the AIRPMS analysis for development of Capital Improvement Programs for a six year period. The User controls such items as unit costs and inflation factors in the development of these programs. Further, the User can move projects from year to year, with automatic cost recalculation and service life revision, and can upgrade or downgrade project scope, within the limits of viability established in the AIRPMS analysis, again with automatic recalculation of cost and expected service life. AIRCIP provides access to Master File data to perform the following functions.

1) Maintain up to 10 alternative CIP scenarios
2) Review data file
3) Display data in any of several categories
4) Review and change unit prices
5) Review and change rate of inflation
6) Evaluate action alternatives
7) Evaluate consequences of delayed action
8) Develop projects of like action among sections
9) Move projects to alternate years
10) Display six years of recommended improvement
11) Add user-selected projects not previously analyzed
12) Combine several airport programs into a statewide CIP
13) Print any of the above displays

AIRCIP On-Screen Display
Figure 2-14

Transfer back to the AIRPMS module is by simple menu selection, if that module is installed. In addition to construction of improvement programs, the program provides for pavement ranking by age, by condition, or by condition relative to minimum service level. Other ranking formats can be made available.

AIRMIP - This Maintenance Improvement Program is the newest addition to the Eckrose/Green library of computer software. AIRMIP reads distress information and formulates maintenance strategies for implemention by airport personnel. Only distress types correctable "in-house" are considered. The scope of AIRMIP is based on capailities of maintenance personnel and the maintenance philosophy of management. Distress types normally considered are reflective and shrinkage cracks in flexible pavement, and joints and cracks in rigid pavement. Patching may also be included where maintenance personnel have capability to work with hot mixed asphalt concrete and Portland cement concrete in small quantities. Less frequently, surface treatments are considered in AIRMIP where equipment and expertise are available on staff. AIRMIP estimates distress quantities, calculates amount and cost of materials required, and estimates manhours and equipment. Maintenance activities are subdivided into "restorative", "sustaining", and "interim" categories. Each has different specifications and resource requirements. Activities are also divided by type, including "crack repair", "joint repair", "asphalt patching", "PCC patching", and where appropriate, "surface treatment". Slab replacement might also be included at the discretion of airport management. AIRMIP presents maintenance opportunities, by pavement facility, and by maintenance category and type, in the form of a Maintenance Work Plan. Maintenance Work Plans are designed to become Maintenance Work Orders when authorized by maintenance supervisors.

AIRCAP - Where indicated, especially in pavement at commercial service airports, capacity analysis, may be included in the comprehensive evaluation. Capacity analysis is a predesign function which allows the User to rapidly view structural capacity of pavement under existing or forecast traffic. For such pavements, use of a microcomputer based program which provides rapid assessment of capacity is essential.

AIRCAP designs a theoretical structural overlay for each section of pavement using existing in-place materials as the foundation, and actual, or forecast, traffic loads. The result may be a "plus", "minus", or "zero" value. A zero indicates existing pavement is exactly balanced to aircraft loads. A plus overlay indicates pavement which is not structurally adequate, and a minus overlay indicates pavement which has capacity in excess of aircraft loads.

This approach to capacity analysis allows a design engineer to visualize the degree of "imbalance" in a pavement system, and to plan and design projects to restore that balance.

Ultimately, the AIRCAP program makes possible a most economical design for rehabilitation of airfield pavement. Each pavement section is analyzed separately, taking maximum advantage of known conditions. Pavement sections are then compared for load vs. capacity imbalance. A rehabilitation strategy can then be developed to provide just the right capacity for each pavement section while making best use of existing material strength. This approach is equally beneficial for all pavement types.

The AIRCAP program has many features which can be particularly useful to a design engineer. They include:

* Automatic calculation of design aircraft. The program allows for entry of any combination of aircraft types and departures. Up to 45 types of aircraft can be used in determination of a design aircraft, and the library of landing gear configurations and weights can be customized to reflect

special aircraft on any airfield. This feature allows a rapid evaluation of potential impact of changes in air traffic mix, as well as anticipated changes in ground movements.

* Consideration of subgrade strength. Where known values for subgrade strength are available they can be used. In other cases, this information can be provided through conventional or nondestructive testing. Since the program uses approved design procedures, sensitivity of pavement to subgrade conditions can be readily assessed and a cost effective program of additional testing can be developed based on need.

* Incorporation of Pavement Condition. The program essentially designs a pavement and an overlay, if required, using existing materials and based on existing pavement conditions. Therefore, the capacity analysis accurately reflects pavement condition and traffic loads. The program is capable of using pavement condition information from PCI surveys and from both nondestructive and destructive testing programs. An important capability is the ability to couple capacity analysis with service life forecasts from analytical programs to assess future pavement capacity under various rehabilitation strategies.

* Operational Considerations. Critical operation patterns and loadings can be compared to pavement capacity. This allows for rapid identification of pavement areas which may require load restrictions, and provides an ability to relate potential short-term and long-term traffic flow changes to pavement capacity and rate of deterioration.

* Program Timing. Pavement does not deteriorate at a constant rate. Most evaluation programs do not recognize this fact, or do so only in a limited fashion. A realistic analysis must be able to analyze the effect of project timing on costs and on ability of pavement to withstand traffic loads. This capability will provide the User with a most meaningful long-term improvement plan.

SUMMARY

A Comprehensive Pavement Evaluation/Management Program is a complex and interdisciplinary activity. Each program should be tailored to User needs. Fortunately, procedures and technologies are rapidly being developed which can assist the User to implement such a program. Current microcomuter technology permits easy integration of these techniques.

CHAPTER 3

SITE LAYOUT AND INSPECTION

Authors' Note:

Detailed descriptions of pavement distresses and an outline of PCI procedures are presented in FAA Advisory Circular 150/5380-6, "Guidelines and Procedures for Maintenance of Airports". Anyone proposing to implement, supervise or administer PCI procedures on an airport should study the Advisory Circular carefully.

PAVEMENT CONFIGURATION AND HISTORY

The first essential step in defining a pavement system for evaluation is to establish its boundaries and dimensions. Best sources for this information are Airport Layout Plans (ALP), record drawings of construction projects, and aerial photographs. FAA "5010" inspection sketches may be useful if drawn to approximate scale. If previous surveys of the pavement system have been done, a pavement layout sketch may be available.

The records review must also include an investigation of the construction history of the pavement system. Much of this information is available from records mentioned above. These records may normally be found at the airport or at State and FAA offices. Important information includes locations and dimensions of pavement construction projects, including description and thickness of layers placed; and year of last construction. In addition to records research, it may be necessary to visit with local officials to complete the inventory.

At commercial airports serving larger than commuter aircraft, a traffic study may also be required. This may consist of interviews with airport operations personnel, Air Traffic Controllers and Airline (including cargo carriers) Station Agents. The purpose, initially, is to establish traffic flow patterns to and from runways, and to gates and parking.

PAVEMENT LAYOUT

Before a PCI survey can begin, it is important to make a layout sketch of the airport pavement, subdividing it by type, composition and function to establish a management network. A layout sketch of the network shows pavement defined by Facilities, Features and Sample Units. This sketch will be a primaryguide for inspectors and will become a record of the survey.

PCI procedures require that pavement be subdivided into Facilities, Features and Sample Units. The purpose, and our technique, of subdividing pavements are as follows.

Facilities.

A Facility is a readily identifiable pavement segment such as a runway, taxiway or apron. Facilities should be named pavement segments where so identified. For instance, "Runway 8-26", "Taxiway A" and "Terminal Apron" are examples of individual Facilities on an airport.

We number Facilities using four digit identifiers coded by function. For example, taxiway Facilities might be numbered according to letter identifier as follows:

Taxiway A = 1ØØ
Taxiway B = 2ØØ
Taxiway C = 3ØØ, etc.

Aprons would begin with a higher series of numbers such as:

Terminal Apron = 41ØØ
General Aviation Apron = 42ØØ
Transient Parking = 43ØØ, etc.

Finally runways would receive a still higher series of numbers such as:

Runway 13-31 = 61ØØ
Runway 4-22 = 62ØØ, etc.

With this system, the pavement function is immediately recognizable. Taxiways are 1ØØ's through 2ØØØ's, aprons are 4ØØØ's, and runways are 6ØØØ's.

Anyone who works with the system will soon come to recognize individual Facilities by number. And, in a state airport system, numbers can be assigned so that primary runways and terminal aprons are identifiable at a glance.

This numbering system may be expanded to incorporate new Facilities or to redesignate existing Facilities without disrupting the logic of the system.

Features.

A Feature is a pavement section with uniform function, age, composition and condition. A Feature is always contained within a single Facility. Its purpose is to identify a segment of pavement which can be expected to perform and deteriorate uniformly in service.

Feature boundaries are located at Facility boundaries, construction lines, major traffic intersections, and where pavement conditions change noticeably. A Feature can be as small as a single Sample Unit (described below) or as large as a Facility.

The search for new Feature boundaries continues throughout the inventory and evaluation process. It begins with investigation of pavement history of the airport. Feature boundaries are located at each construction limit and at each change in pavement type and cross section configuration. Pavement composition and year of construction are recorded for each Feature. Feature boundaries are noted on the layout sketch.

Next, at commercial airports, traffic patterns are examined. Additional Feature boundaries are located at taxiway intersections having significant convergence or divergence of traffic. Feature boundaries may also be located on aprons where traffic routes are dictated by gate positions or designated taxi lanes.

A data summary sheet is prepared for each Feature in a pavement system. Information includes construction history, pavement area and whether the pavement is used by larger than commuter aircraft. These Feature summary sheets may be used by inspectors during the survey to analyze probable causes of pavement distress. When new Features are created, or when Features are modified during a field survey, Feature summary sheets must be updated, accordingly. A sample Feature summary sheet is presented at Appendix A.

The following guidelines will assist in designating Feature boundaries.

1. Construction Feature boundaries have precedence over traffic Feature boundaries. Where a construction boundary exists within 200 feet of a traffic boundary, designate the construction boundary and ignore the traffic boundary.

2. Feature boundaries for traffic are not necessary on airports which do not serve larger than commuter airplanes or cargo type military aircraft. General Aviation aircraft usually have little impact on pavement condition.

3. Do not locate traffic Feature boundaries at little used connecting taxiways.

4. Analyze ground support vehicle lanes as part of the traffic analysis at general aviation airports. Snow plows and fuel tankers often cause more damage on pavement at small airports than do aircraft.

5. When in doubt about establishing a traffic Feature boundary, leave it out. If traffic impact is significant, pavement condition will be affected, and a condition boundary will be established during the survey.

Additional Feature boundaries are established during the PCI survey where distinct changes in pavement condition are found.

The final review of Feature boundaries is made during evaluation when PCI values are analyzed. If a sequence of Sample Unit PCI reveals a significant change in condition within a Feature, a new Feature boundary will be established to separate the two conditions.

Features are identified using the last two digits of the Facility number. For instance, 1525 is Feature number 25 in Facility 1500. When Features are identified on the pavement sketch, they should not be numbered consecutively, but in increments of 3, 5 or 10 so that Features can be added in sequence as the study progresses, and in future surveys.

Sample Units.

Sample Units are the building blocks of PCI pavement management. Sample Units provide control for the PCI survey. They divide pavement into equal or similar size segments and they define specific areas to be inspected. If 100 percent of a pavement system were to be examined, Sample Units would theoretically not be required. However, an advantage of the PCI method of evaluation is that an entire pavement system can be represented while inspecting only a portion of the pavement.

The entire pavement system is subdivided into Sample Units. Then a representative sampling of those units is inspected. Feature PCI are obtained by averaging Sample Unit PCI within the Feature.

A Sample Unit should contain about 5000 square feet of flexible pavement, or approximately 20 slabs of rigid pavement. Sample Unit size can vary from these standards, but should be of uniform size within a Feature to the extent possible. Uniformity of sample size is especially important for rigid pavement.

Sample Units are laid out and numbered following initial pavement inventory and traffic review. Sample Units may be numbered consecutively in direction of stationing by Facility or, when a Facility is segmented by Features which vary widely in size and shape, by Feature. When Sample Units form adjacent columns within a Facility, numbering begins at the left column with number 100. As numbering of each column is completed, the next adjacent column is numbered beginning with the next multiple of 100 (i.e. second column begins with 200, third column with 300, etc). This technique offers continuity while providing for addition of Sample Units in sequence following expansion, or when field adjustment of Facility dimensions is necessary.

On a very large Facility, such as an apron with several columns of Sample Units, an adjustment may be necessary in the numbering procedure. Where the sequence described above is inadequate to supply all Sample Units in a Facility with a number, the apron should be divided along a Feature line and the sequence repeated.

On flexible pavement, Sample Units are normally laid out by stationing in units of 50 or 100 feet. Where width is optional, as on an apron, it is established at 50 feet and length is 100 feet to achieve the 5000 square foot standard. Where width is dictated by Feature or Facility boundary, length is established in the 50 foot multiple which will provide an area approaching or equal to the 5000 square foot standard but at least 2500 square feet. Taxiways and runways up to 100 feet wide, except where longitudinal Feature boundaries control, are subdivided as follows:

Facility Width (in feet)	Sample Unit Length (in feet)
up to 25	200
25 to 50	100
50 to 100	50

Runways and taxiways wider than 100 feet are subdivided longitudinally, usually in thirds for operational reasons unless longitudinal construction boundaries, such as a widened pavement, prevail.

Fillets and radii pavement should be defined as separate Sample Units, if their area exceeds 2500 square feet, but such odd Sample Units should not normally be selected for inspection unless they are independent Features prescribed by composition, age or traffic. Where the inspector detects a significant difference in pavement condition at a radius or fillet, he may establish a separate Feature for that pavement, or inspect it as an additional Sample Unit.

On rigid pavement, Sample Unit layout is dictated, to some degree, by individual slab configuration. The standard is 20 slabs per Sample Unit. However, adjustments may be necessary to achieve a balanced layout. For statistical purposes, it is important that all slabs in a Sample Unit be of uniform size to the extent possible.

Different Sample Units within a Feature may be of different size and contain different slab count, but the size of each and number of slabs in each must be known.

A Sample Unit should not normally have more than 28 or fewer than twelve slabs.

Sample Unit numbers are referred to on layout sketch and in conversation as integers, such as "Sample Unit 226", but they are combined in analysis with Facility and Feature identifiers as decimals. For instance, Sample Unit number 226 on a Terminal Apron would be identified in analysis as 4110.226, immediately associating the Sample Unit with Feature 10 in Facility 4100.

LAYOUT SKETCH.

All pavement in a system should normally be included in the layout sketch. A client may not wish to have all pavement inspected in the initial program, but the outline should be included where possible.

In developing a layout sketch for a pavement system, the following suggestions will be helpful.

1. Designate airport name and the date information is current.
2. A scale of 1" = 200' is about the smallest size which permits "half-sizing" for field work.

3. Orient the drawing with a north arrow.

4. Complete pavement outline from aerial photos, Airport Layout Plan (ALP) drawings, or construction drawings. FAA 5010 sketches may sometimes be used for pavement outlines. Exact scale is not required in the pavement outline, but the proportions must be near enough to scale to assure the proper orientation of Features, and the proper number of Sample Units in a Feature.

5. Subdivide all pavement into Facilities. Use heavier lines to differentiate Facilities from Sample Units.

6. Subdivide Facilities into Features referring first to construction history, then to traffic.

7. Establish reference lines for control. Mark stationing lightly on the sketch. (This will be helpful in laying out sample units). All Feature and Sample Unit boundaries must be referenced from lines which are clearly identifiable on the site, such as pavement edges or extended centerlines of taxiways or runways so that they can be located in the field.

8. Lay out Sample Units from reference lines. Number Sample Units consecutively from one end of a Facility to the the other.

9. Number all Features.

10. Identify runways by number identifier (i.e. Runway 8-26) and taxiways by appropriate letter or number if so designated.

11. Incorporate all odd sized pavement remnants into Sample Units as follows.

    a. Fillets and radii constructed as components of surrounding pavement - include with adjacent Sample Unit if smaller than 2500 square feet (flexible pavement) or fewer than ten equivalent size slabs (rigid pavement). Otherwise designate as a separate Sample Unit.

    b. Fillets and radii constructed separately, as at widened sections - designate separate Feature.

c. Remnant pavement at end of Sample Unit column - Include with adjacent Sample Unit if less than 2500 square feet. Otherwise designate separate Sample Unit.

12. Dimension odd sized remnants carefully.

13. Dimension all Sample Units. (A single dimension representing typical Sample Units in a Facility is fine.)

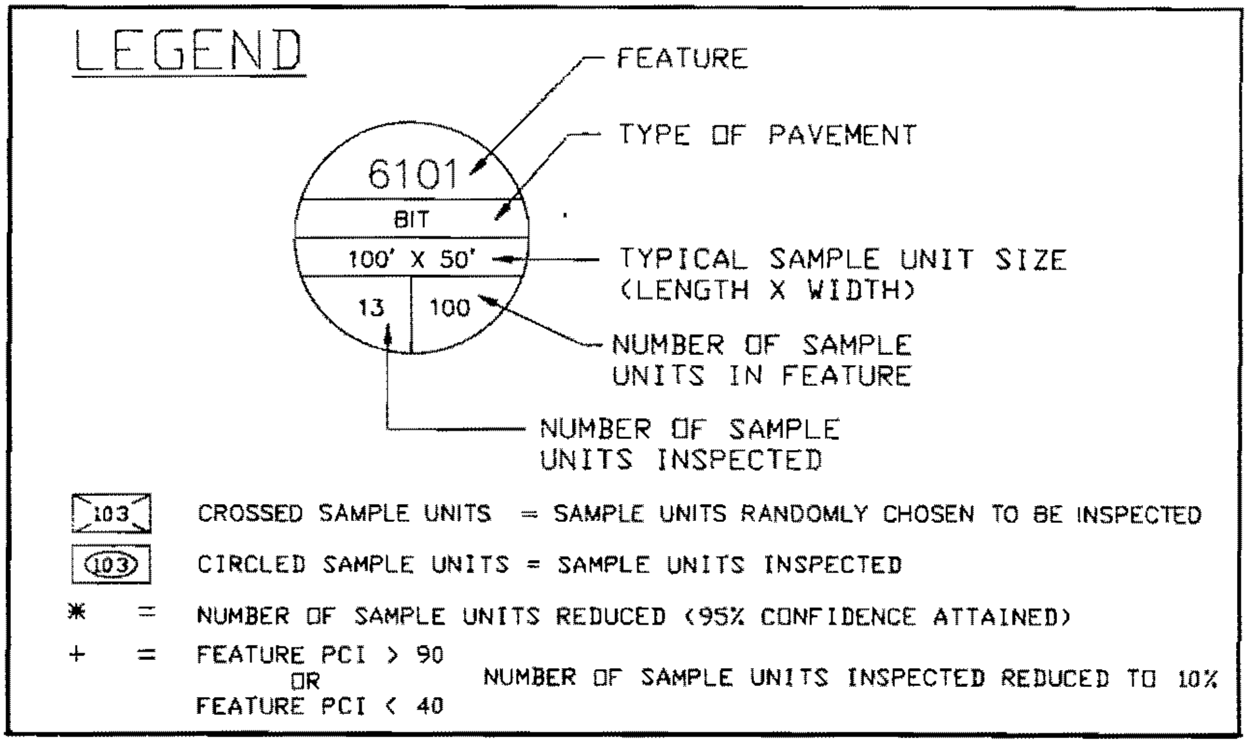
14. Measure all stationing around taxiway curves on centerline. On flexible pavement make Sample Unit lines perpendicular to centerline.

15. Make all notations large enough to be readable on reduced size reproductions.

16. At Facility crossings, Sample Units of the prominent Facility are shown. Sample Units of the secondary Facility continue through the prominent Facility, but are not shown. (Numbering continues with stationing as well, as if the secondary Facility is covered by the prominent Facility.) The prominent Facility is identified by construction continuity. If an intersection is an independent construction Feature, prominence is established by operational preference.

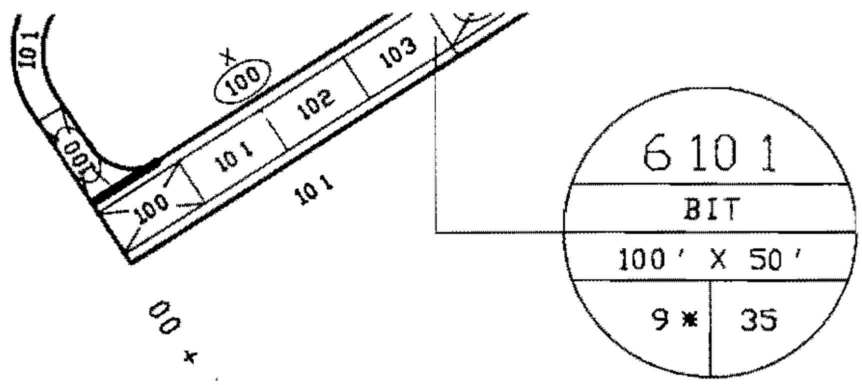
17. On rigid pavement, show joint configuration and spacing. If consistent, dimensions may be shown at pavement boundaries as typical. If internal variations occur, detailed drawings must be made to show the variations and their relationship to Sample Units.

Several examples of layout sketch details are presented on the following pages.



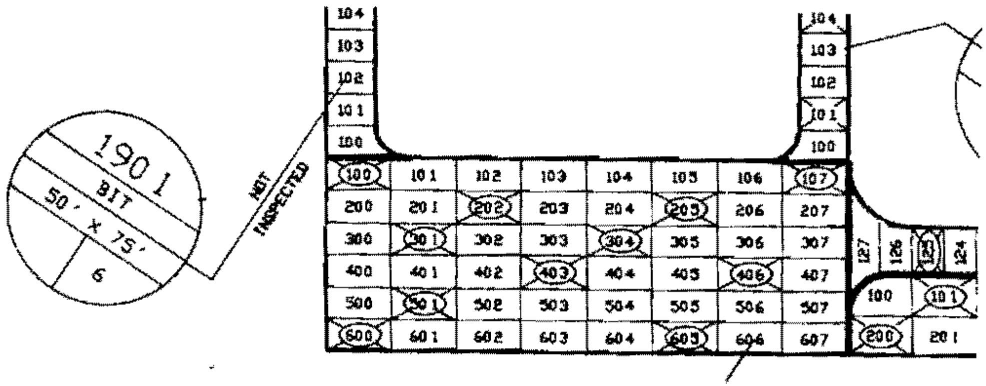
Legend
Figure 3-1

This is a typical legend for a layout sketch. The information "balloon" presents data needed to plan the field layout and inspection. Symbols used to identify reduced inspection density represent circumstances described below in the section titles "Representative Sampling".



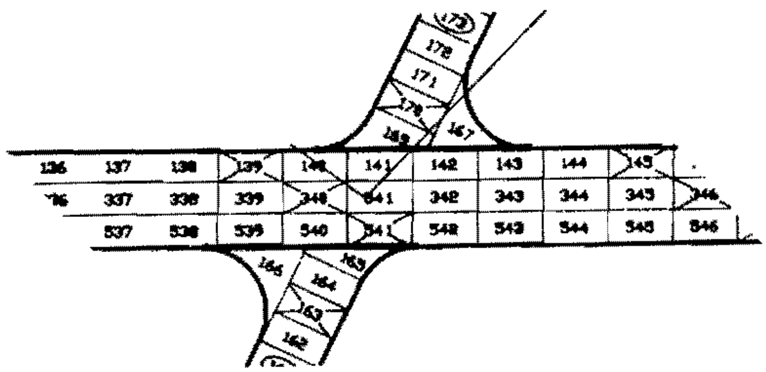
Sample Unit Layout - Runways and Taxiways
Figure 3-2

Runway Facility number is 6100. Feature number shown is 01. Sample Units begin at end of runway with number 100 and are numbered consecutively. Taxiway Sample Units are numbered from edge of runway pavement. This permits layout and inspection of taxiway pavement within the runway safety area concurrent with runway inspection, minimizing downtime.



Sample Unit Layout - Aprons
Figure 3-3

Sample Units are numbered consecutively in columns, with each column beginning with a multiple of 1ØØ. This offers numbering continuity in event of apron expansion. Note that taxiway 19Ø1 (new pavement) was not inspected.



Sample Unit Layout - Secondary Runway
Figure 3-4

Sample Unit layout continues "under" the prominent runway. Since Sample Units are dimensioned in 5Ø or 1ØØ foot increments, runway stationing can be determined from Sample Unit numbers. For example, the beginning of Sample Unit <u>139/339/539</u> on the prominent runway is at Station 39. Note that the beginning of Sample Unit <u>164</u> on the secondary runway is at Station 32, since these Sample Units are only 5Ø feet long. The prominent runway, which is 15Ø feet wide is divided into 5Ø foot wide Features. The secondary runway, which is 1ØØ feet wide, has a single Feature full width. Note, also, that small fillets at the intersection are incorporated with adjacent Sample Units and large fillets are designated as separate Sample Units.

REPRESENTATIVE SAMPLING

The PCI procedure requires a thorough, searching inspection. This can be time consuming and expensive. However, the procedure was developed to provide for representative sampling of pavement to reduce time and cost. The degree of confidence in the survey is a function of sampling density. It remains, then, to decide how many Sample Units to inspect, and in what distribution.

Distribution can be accomplished by random selection or systematic sampling. Random selection, as the name implies, relies on formulas and tables for selection of units to be inspected. In systematic sampling, a pattern is established within each Feature to provide even distribution of units to be inspected. In systematic sampling it is important to randomly select the first Sample Unit in the pattern to be inspected.

Sampling density is another matter. The confidence level to be expected is a function, not only of density, but of number of total samples and consistency of pavement condition. These are statistical truths.

Two levels of confidence are commonly mentioned in pavement management. Project level confidence requires a high degree of assurance upon which financing and design decisions can be made. Network level confidence is satisfactory for more general management decisions such as selecting among candidate projects and budgeting for future work.

Project level confidence is generally established at 95 percent. A chart is provided in FAA AC 150/5280-6 to establish sampling density required for Features relative to total number of Sample Units and condition of pavement. Project level confidence requires a high sampling density in small areas.

The FAA does not offer a guideline for Network level sampling. However, the following sampling schedule has been very satisfactory in Airport Pavement Evaluations. This schedule normally results in a sampling density on large airports of 15 to 25 percent, and on small airports of 25 to 35 percent.

TABLE 3-1
Recommended Sampling Density

Total Samples	Samples Inspected Good Condition	Poor Condition
1-2	All	All
3-4	2	3
5-7	3	4
8-10	4	5
11-14	5	6
15-19	6	7
20-25	7	7
26-30	8	8
31-37	9	9
38-45	10	10
46-55	11	11
56-80	12	12
Over 80	15%	15%

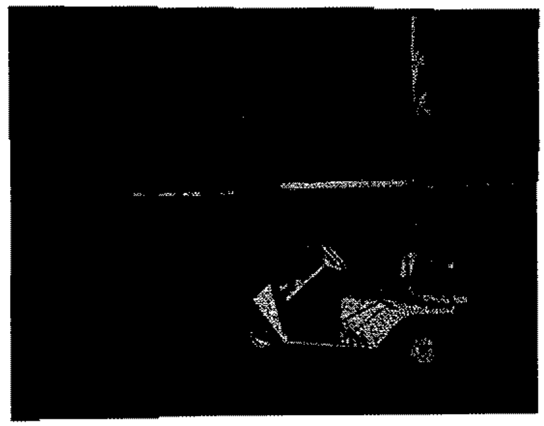
Assignment of pavement condition in this schedule is subjective and can usually be provided by the airport engineering staff. Although this schedule does not statistically assure 95 percent confidence, a very representative survey is achieved.

Time required to inspect a sample unit, particularly on flexible pavement, is a function of pavement condition. Measuring and recording multiple distress conditions on pavement which is obviously below the established minimum acceptable service level can be costly, and serves no meaningful purpose. We recommend that, when pavement can be shown to be below a threshold PCI, say PCI = 40, inspection be terminated in that Feature. Conversely, there is little to be gained from meticulous inspection of very new pavement. We recommend that pavement constructed within two years prior to the year of survey not be inspected unless there is knowledge of premature deterioration. Finally, on inspected pavement, we recommend that inspection be terminated when PCI can be shown to be above a designated level, say PCI = 90.

INSPECTION

A team of two persons works well for pavement inspection. Team members may work independently or together. Each person or team needs a vehicle for mobility on airport and each person should be within hearing distance of an air-to-ground radio receiver set to the designated frequency. On controlled airports, each person or team must maintain radio contact with the Air Traffic Control Tower (ATCT).

Inspection Team
Figure 3-5

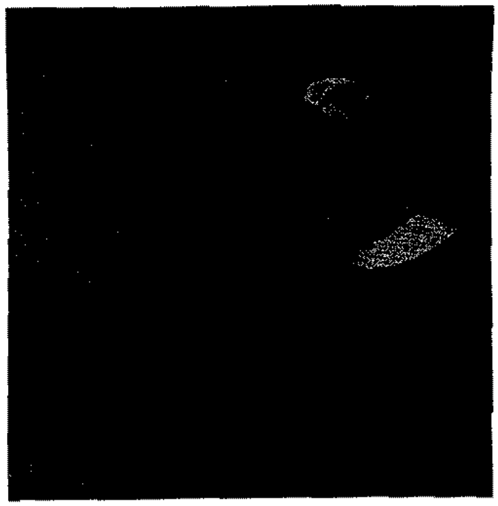


Survey Vehicle
Figure 3-6

The team approach offers several advantages. Traffic disruption is minimized. Surveillance for airport traffic is improved. Inspectors can discuss types and severities of distress, and can check each others work to assure best results. A disadvantage is that the team approach is less time efficient than independent operation.

Inspectors should work as a team during the early stages of a project (at least one or two days) to assure standardization. Thereafter, experienced inspectors may work independently, with periodic consultation to assure consistency. When there is an inexperienced inspector on the project, the team must stay together until full standardization is achieved.

Inspectors record data on data sheet forms. Data sheets must be reviewed by inspectors before leaving an airport to assure that all required Sample Units are represented and to recheck any data entry which appears out of place (inspectors check each other's work). Copies of sample unit data sheets for flexible and rigid pavement are presented at Appendix B.



Recording Data
Figure 3-7

Sample Units designated on the layout sketch for inspection are located and identified on pavement by the team. The survey vehicle and a measuring wheel are normally used to locate designated Sample Units, and spray paint is used to mark Sample Unit Boundaries.

Layout Procedure
Figure 3-8

Sample Unit Markings
Figure 3-9

A high degree of precision is not required for layout of Sample Units. Required standards are presented in Table 3-2.

TABLE 3-2
Site Layout Standards

Distance (in feet)	Tolerance (in feet)
100	1
1,000	5
10,000	10

Inspectors add Feature boundaries and modify Sample Unit configuration where necessary. If site dimensions are at variance with the layout sketch, the inspector establishing control makes appropriate adjustments. The inspector must not, however, delete Feature boundaries from a sketch. Features are often outlined from pavement which has been overlayed by a subsequent project.

Inspectors must be alert to notice changes in pavement appearance or condition on the airport. Where traffic, poor drainage or other phenomenon has caused a section of pavement to deteriorate more rapidly than surrounding pavement, that condition must be recognized. If the area is significantly larger than a single Sample Unit, a new Feature should be established. If the area can be contained within, or be fairly represented by a single Sample Unit, it should be inspected as an Additional Sample Unit. If the abnormal condition exists on less than one quarter of a Sample Unit area, it will not have a significant impact, and should be recorded as part of the distress pattern for the Sample Unit. The confidence level of sampling is enhanced significantly by this procedure.

Inspectors have to work in a variety of weather conditions including extremes of heat and cold and rain. Protection from the elements is an important responsibility of each inspector, and especially the Team Chief. Proper clothing is essential.

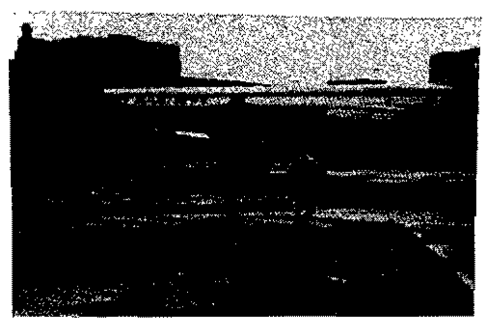
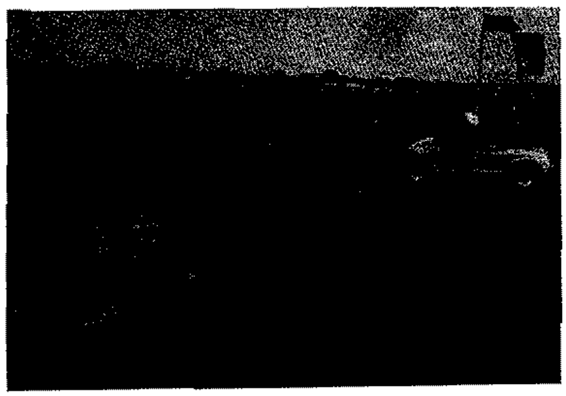


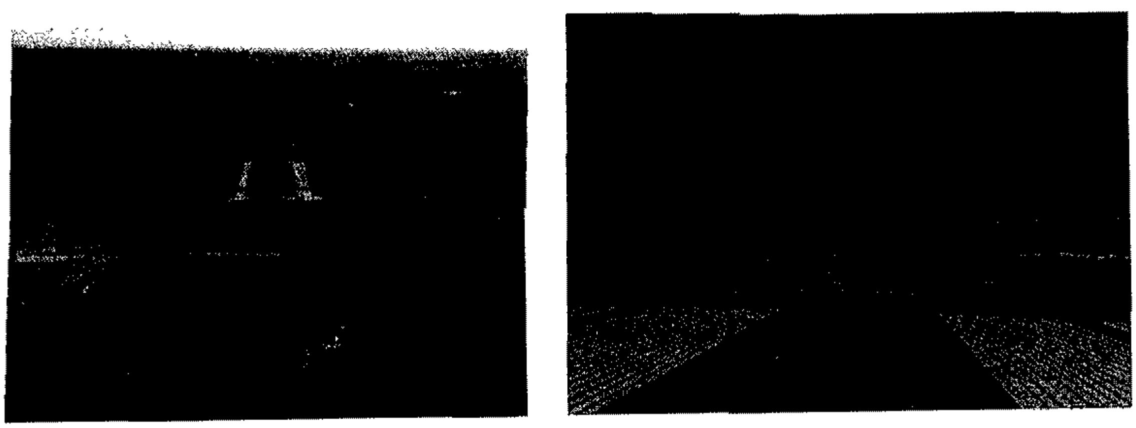
Figure 3-10

All inspectors must be carefully oriented to what we call "airside etiquette". When they are on an airport, they must monitor the appropriate airport UNICOM frequency. They must be familiar with traffic patterns and the importance of wind direction to traffic flow. They must not leave equipment unattended on air traffic surfaces, and when they clear a runway for departing or landing aircraft, they must clear to a distance equal to the holding line offsets. Aircraft traffic should never be disrupted at uncontrolled fields.



Waiting For Traffic To Clear the Runway
Figure 3-11

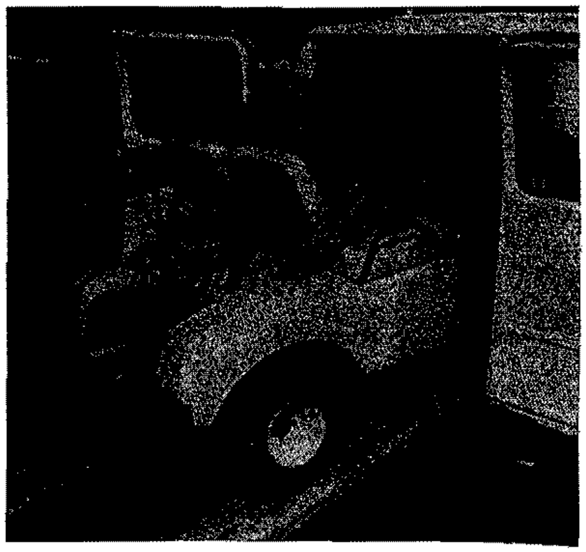
Pilots preoccupied with landing procedures may not notice a single person or small vehicle on the runway. The inspector must be alert to presence of air traffic.



Runway As Seen From Final Approach
Figure 3-12

Inspectors must respond immediately to Controller instructions at controlled airports, and they must comply with one absolute rule. Aircraft ALWAYS have the right-of-way.

Not all potential hazards are associated with air traffic. Working around motorized equipment offers ample opportunity for the unwary to be injured.



WATCH YOUR HEAD!!
Figure 3-13

Detailed instructions for identification of distress types and severity, and for measuring distresses are given in Chapter 5.

CHAPTER 4

PAVEMENT CHARACTERISTICS

WHAT IS PAVEMENT

Pavement provides an all weather surface for wheeled vehicles and it distributes wheel loads to subgrade. This function of distributing loads is not widely understood outside the engineering profession, but it is of vital importance in the study of pavement characteristics. Chapter 2 of AC 150/5380-6, provides an excellent review of the load distribution function of rigid and flexible pavements, along with a discussion of their composition and structure.

Theoretically, virtually any material which can perform the two functions outlined above can be pavement. In fact, many materials have been used, including stones, wood, metal plates and various other materials and mixtures. An ideal pavement would be strong, smooth yet with an excellent surface for braking, durable, attractive and inexpensive. Nearly all pavement types offer some of these virtues, but so far, none are ideal. The best material or mixture is one which gives the greatest combination of these virtues.

Modern highways and airports are paved with the best materials we can provide in sufficient quantities at acceptable cost. Materials and mixtures vary widely as functions of climate, cost, availability and choice, but to most of us, pavement can be broadly subdivided into two types classified as rigid and flexible. The most common ingredients are stone and a product to bind the stones together.

TYPES OF PAVEMENT

Rigid pavements are usually bound with Portland cement, a by-product of limestone, which reacts with water to produce a very hard rock-like substance called concrete. Flexible pavements are usually bound with asphalt cement, a petroleum by-product with very low viscosity, or flow rate, at atmospheric temperatures. Portland cement and asphalt cement have one very important characteristic in common. Under mixing conditions, they are easily transported, placed and shaped, and in service they are stable and durable.

As has been mentioned, load distribution is a vital function of pavement. Both rigid and flexible pavements perform this function, but in very different ways. Rigid pavement distributes loads by its internal ability to resist bending, called flexural strength. It acts as a bridge, and imposed wheel loads are distributed uniformly to subgrade from within the slab. Flexible pavement distributes loads through layers of materials designed to resist compression. The result is the same, but the process is very different, and evidence of failure is determined by the process.

PAVEMENT DETERIORATION

Pavement begins to deteriorate from the moment it is placed. Deterioration is a very complex process accelerated by environmental factors and use. Chemical and physical effects of sun, wind, water and changing temperatures work constantly to destroy pavement. Loading and surface abrasion from traffic further accelerate the process. Materials and procedures are carefully selected by engineers to build pavements capable of resisting this process. Deterioration, then, is a function of environment, traffic, and materials/ procedures.

ENVIRONMENTAL FACTORS

Environmental factors include erosion and the effects of thermal and chemical reactions. Erosion is a physical result of wind, water and sunlight. Wind and water cause abrasive action which wears, dislodges and carries away exposed materials.

Erosion is accelerated by stresses created when confined water freezes and expands. Sunlight contains ultra-violet rays which attack and destroy microscopic components of exposed pavement. Thermal changes cause materials to expand and contract, setting up stresses and movements which lead to separation of pavement particles, and eventual disintegration of the structure.

Chemical reactions take place between pavement materials and through outside influences which change physical characteristics of components.

Not all of these reactions are bad. For instance, Portland cement continues to hydrate, and therefore to gain strength, through most of its useful life. And the "kneading" action of traffic on flexible pavement actually helps to preserve its vitality.

However, most environmental reactions in pavement work against it. Asphalt in flexible pavement oxidizes, causing hardening and loss of elasticity. Water and air in contact with material particles cause chemical reactions which change the physical characteristics of the particles resulting in loss of pavement integrity. Foreign products such as fuel, alcohol, exhaust by-products, and varied air and water pollutants tend to accelerate the process.

TRAFFIC FACTORS

Traffic causes deterioration through wheel loads and by abrasion. Wheel loads cause pavement to yield, or flex. Even rigid pavement will flex slightly under load. Pavement reacts in one of two ways to this flexing action. It recovers to its original position, called elastic motion, or it remains deformed, called plastic motion. Most flexing under loads is elastic, and movement is very slight. Deterioration takes place when repeated flexing movement begins to loosen bond between particles. In time, more particles separate, an increment of integrity is lost, the flexing increases and deterioration accelerates. Eventually, cracks appear at the surface.

Plastic motion can result from a single heavy load or from repeated loadings. It can begin with the first wheel load or it can result from fatigue caused by elastic motion. At any rate, plastic motion results in surface irregularities which, in time, can be observed. Rigid pavement is very resistant to plastic deformation. Consequently, when its elastic limit is reached, rigid pavement will break, leaving clearly visible cracks at the surface.

Moving wheels also cause abrasive deterioration. High point loads can actually crush stones in pavement. Turning and braking movements create high shear stresses which can dislodge and displace particles.

Airplane propellers and jet engines create air turbulence which has an abrasive effect on pavement. Engine exhaust gases can be very hot and, when combined with blast effects, can significantly damage a pavement surface.

ENGINEERING FACTORS

A pavement can only be as durable as the materials and procedures used in its construction. Modern pavements are made from natural materials which vary considerably in quality. Engineers take these variations into account during design, but even so, inferior materials are often used.

The way in which materials are combined and placed is also very important to durability. Improper procedures can reduce service life significantly. Inferior materials, defective design and improper construction procedures cause pavement deterioration which can be observed in distresses visible on the surface.

RESURFACING FACTORS

Old pavements are often rehabilitated by overlayment. This is a very attractive procedure because it is relatively inexpensive and it "restores old pavement to serviceable condition". In fact, overlayment does not restore old pavement. It merely covers old pavement with new pavement.

Overlays do reinstate roadways and airport pavements to serviceable condition. Pavement irregularities are reduced or eliminated and new surfaces are provided. A new wearing surface presents an attractive appearance and may easily lead one to believe that the pavement has been restored. However, distresses, and many causes of those distresses, still exist in the old pavement. Unless they are carefully neutralized in design, they will affect the overlay, contributing to premature deterioration. Cracks soon reflect to the surface. Surface irregularities gradually return because the underlying cause was not corrected, and the new surface eventually takes on the appearance and shape of its predecessor. Many surface distresses in overlayments reflect conditions inherited from the old pavement.

EVALUATING PAVEMENT CONDITION

As a pavement structure begins to fail, evidence of that failure often shows up at the surface. Pavement distress is represented by cracks, deformations, material loss and changes in appearance. These anomalies are called distresses and, to a trained analyst, they tell a great deal about the condition of the pavement.

Our ability to judge pavement condition by distress analysis is a function of how well we can predict the underlying cause of each distress. Every visible distress in pavement is a result of one or more of the factors identified above. Fortunately, it is possible, in most cases, to associate a distress with an underlying cause. This is the basic premise of the PCI concept.

CHAPTER 5

DISTRESS IDENTIFICATION AND MEASUREMENT

INTRODUCTION

The reason the PCI procedure for pavement evaluation has been so widely accepted is that it offers a method to objectively rate pavement condition. The procedure evolved from the combined experience of many pavement engineers and has been shown, in prototype projects, to fairly and consistently represent their collective ratings of a wide variety of pavements.

Advisory Circular 150/5380-6 provides descriptions and photograph examples of 31 distresses used in the PCI procedure to represent pavement condition. They are listed alphabetically by pavement type in Chapter 2. These descriptions and photographs are the foundation of objectivity of the Pavement Condition Index method of pavement condition survey.

The strength of PCI depends on consistent identification and measurement of pavement distresses in the field. Descriptions and photographs developed by the Corps of Engineers seem, at first glance, to identify all distress conditions clearly. However, in practice it is evident that considerable interpretation and judgment are required of inspectors to achieve a level of consistency necessary for reliable forecasting. A basic knowledge of pavement characteristics (Chapter 4), and a thorough understanding of what each distress type represents, are essential.

PCI inspection is much like any other investigation or scientific research. The inspector must not accept an apparent condition until he is convinced of the reason for the condition. Some distresses are easy to read. Others are not so obvious. The inspector has not successfully completed the survey until all distresses have been correctly identified, interpreted for severity, and accurately measured and recorded.

This chapter presents our performance standards for PCI survey. In order to achieve these standards, we have formalized our interpretations of distress types, severities and measurement procedures.

Integrity of our work is imperative. Therefore, descriptions provided in AC 150/5380-6 are strictly observed. Each distress is introduced herein by reproducing and underlining the Corps of Engineers description, presented word for word from AC 150/5380-6.

Additional criteria and measurement standards provided represent collective judgment of the authors. They were first published, in draft, in 1986, and were tested on 36 airports in Wisconsin and 20 airports in Indiana. The first edition of this manual presented several refinements to the criteria and standards based on PCI inspection experience on those airports. This second edition presents further refinements and additions based on inspections at an additional 100 airports.

Survey party chiefs who participated in the field tests, and who have contributed to continuing improvement of descriptions and inspection techniques, are experienced inspectors who have worked with the authors on airport surveys for more than three years and have attended our annual PCI training course at least four times.

Performance standards were established following an extensive quality review process consisting of duplicate inspections by the authors of selected sample units on many airports. The standards are achievable with 80 percent consistency when duplicate inspections are made of any sample unit of pavement by inspectors trained and supervised by the authors.

The most significant result of these standards is that repeatability of survey data can now be focused at sample unit level. Our standards are based on distress identification and measurement, not PCI values. The corrected deduct curves used in PCI calculation can change a PCI value for a sample unit of pavement by several points in response to a very small change in distress density. For instance, if only one distress on a sample unit registers a deduct value exceeding five points, the total deduct is equal to the sum of deduct values, say 40, and the PCI = 60. However, if a second distress type, by incremental increase, becomes a "greater than five point" distress, the total deduct would be increased by only one point, but the resulting corrected deduct value would be 26. Unless the deduct value for a single distress exceeded 26, the apparent change in PCI would be 14 points.

This is an extreme example of the fallibility of PCI computation, and such variations tend to "damp out" at feature level, but it is obvious that standards based on PCI values, as a determinant of data collection consistency, is pointless. That is why we have developed the following performance standards for PCI inspections on airports.

PERFORMANCE STANDARDS

Certified PCI inspectors are expected to consistently achieve inspection results on any designated sample unit within the following tolerances:

Distress Type Identification. No variance.

Severity Identification. One variance in three.

Measurement. (Sum of units of multiple severity distresses.)

Linear	- 10 percent variance.
Area (except patches)	- 20 percent variance.
Patches	- 5 percent variance.

IDENTIFICATION AND MEASUREMENT STANDARDS

Flexible Pavement.

General Comments.

1. Record alligator cracking and rutting independently. These distresses are caused by loads and often exist together in the same pavement area, but with different densities.

2. Bleeding and polished aggregate are distresses which represent loss of friction properties on a pavement surface. When both occur on the same pavement, record only bleeding.

3. Block cracking is an advanced form of longitudinal/

transverse cracking. Block cracking is measured by area and incorporates all longitudinal/transverse cracking within that area.

4. Cracking reflected from an underlying rigid pavement has different origins than block cracking, and is recorded separately when found on the same pavement. Reflection cracks from pavement joints are recorded as Joint Reflection Cracks, and reflection cracks from cracks in underlying pavement are recorded as Longitudinal and Transverse Cracks.

5. Measurements of differential elevation for severity determination of area distress types are made under a ten foot straight edge. Measurement of differential elevation at cracks in flexible pavement, and for all distress types in rigid pavement, is made under a straight edge of one foot length.

6. A ten foot long by 3/4 inch I.D. water pipe makes a good straight edge. Check the straightedge frequently by sighting through the pipe or by rolling it slowly along the pavement.

7. Distresses located within one foot of a pavement edge adjacent to an unstabilized shoulder are ignored in the survey. These distresses are normally caused by weak subgrade conditions at edge of pavement. Cracks at pavement edge are recorded in street/highway surveys, but no defined distress type is provided for airport surveys. The reason is that runway and taxiway pavement are wide enough that the outer edges are not critical to serviceability.

8. 1/8 inch is the smallest measureable dimension in identifying area boundaries and in establishing distress severity.

9. Structures in pavement, and designed pavement geometry, are not used to measure for determination of distress severity and area.

10. Surface treatments are not structural components of a pavement structure. They protect the pavement in much the same way that paint protects wood. They tend to obscure distress conditions at the pavement surface. To the extent possible, it is important to "read through" a seal coat and rate the underlying distress types and severities.

11. A PCI survey provides a record of the condition of pavement at an instant in time. Record what you <u>see</u>, not what you <u>believe</u>, or think <u>will be</u>.

12. Pavement in excellent condition can be fairly represented with a reduced sampling rate. When authorized by the Owner, pavement with PCI above 90 may be inspected at a 10 percent sampling rate. This requires that all inspected sample units have PCI above 90. Inspectors must visually confirm that inspected sample units are, in fact, representative of the pavement.

13. Pavement in advanced stages of deterioration is very difficult to inspect quantitatively. Time required to measure multiple distress types at various levels of severity is not justified on pavement which is obviously in failed condition. When authorized by the Owner, pavement with PCI below 40 may be inspected at a 10 percent sampling rate. This requires that all inspected sample units have PCI less than 40. Inspectors must visually confirm that inspected sample units are, in fact, representative of the pavement.

14. When authorized by the Owner, inspection may be terminated in a sample unit when any distress listed at Table 5-1 exceeds the density shown. Distresses indicate failed pavement correctable only by reconstruction or overlay. Density values correspond to deducts of 60 points or more, assuring PCI less than 40.

TABLE 5-1
Maximum Distress Density

Distress Type	Severity	Density (%)
Alligator Cracking	Medium	20
	High	10
Block Cracking	High	50
Corrugation	Medium	20
	High	10
Depression	Medium	50
	High	20
Rutting	Medium	50
	High	10
Slippage Cracking	-	20
Swell	Medium	50
	High	20

Cracking Distress.

The most common distress type encountered in PCI inspection is cracking. Criteria for determining crack severity is the same for all distress types based on cracking. Therefore, standards for crack severity are presented below. These standards apply for block, reflective, and longitudinal/transverse cracking distress types, and for evaluating severity of alligator cracks and patches.

Standard Text.

a. Low severity level (L). Cracks have either little or no spalling with no loose particles. The cracks can be filled or nonfilled. Nonfilled cracks have a mean width of 1/4 in. or less. Filled cracks are of any width, but their filler material is in satisfactory condition.

Additional Criteria

1. Filler is in satisfactory condition if it prevents water from entering the crack and if it is pliable. Both conditions are necessary.

It is not uncommon for filler to completely obscure a low severity crack from view for a short distance. On the other hand, filler is often "dribbled" on pavement where there is no crack. Try to establish whether a crack actually exists under filler material, but, when in doubt, record as low severity cracking.

Water access is evidenced if a knife blade can be inserted between filler and either crack face without meeting resistance. Water access may be evident by visual examination. Growing vegetation in a crack is evidence of unsatisfactory filler, but do not be fooled by mower clippings in the crack.

Sand in a crack is not evidence of unsatisfactory filler. If sand is present, it must be removed to expose filler before a determination can be made.

Depth of filler below pavement surface is not a factor in determining filler condition.

2. Spalling is represented by loss of material at the crack face. Spalling results from pavement particles (of one square inch or larger surface

area) breaking away from the surface due to impact of traffic loads or by compressive forces within the pavement. A frayed edge (as if rounded by sandpaper) does not constitute a spalled crack.

Little, light or minor spalling means no spalled particles are larger than four square inches, and less than ten percent of the crack face is spalled.

3. Mean width is the predominant width in any one foot crack segment. Severity is rated foot by foot along the crack length, except spalls less than one foot long are considered incidental.

Standard Text.

b. Medium severity level (M). One of the following conditions exists.

(1) Cracks are moderately spalled with few loose particles and can be either filled or nonfilled of any width.

(2) Filled cracks are not spalled or are only lightly spalled, but the filler is in unsatisfactory condition.

(3) Nonfilled cracks are not spalled or only lightly spalled, but mean crack width is greater than 1/4 inch.

(4) Light random cracking exists near the crack or at the corners of intersecting cracks.

Additional Criteria

1. Filled cracks with unsatisfactory filler are subject to width criteria described above. If 1/4 inch wide or less, and meeting spall criteria, a crack with unsatisfactory filler is rated at low severity. Pavement condition is not reduced by Owner maintenance.

Cracks wider than 3 inches are rated at high severity. Three inches is the maximum trench width allowed on airport traffic surfaces for safe operations.

If there is evidence of measurable (1/8") subsidence of pavement edges into the void at a crack face, record the crack at medium severity.

2. When a small piece of pavement with one face at a crack separates full depth of the surface course, the separation is a result of secondary cracking which isolates the small piece from the pavement mass. The isolated piece may range in size from a fist-size chunk, to a long thin strip adjacent to the crack. This condition is aggravated by traffic loads and/or loss of subgrade support. As this condition deteriorates, the associated crack is rated accordingly. The following definitions are consistent with standard criteria which describe such separations as moderate spalling.

Spalling may be evident over the entire length of the crack. Spall chunks may be of any size but must be securely attached to the pavement. Isolated chunks smaller than 25 square inches in surface area may be loose in place, but not missing. Loose pieces may not represent potential voids in pavement wider than three inches in smallest dimension. Isolated particles means along less than ten percent of the crack length.

A light random crack outlines a moderate spall in an early stage of development.

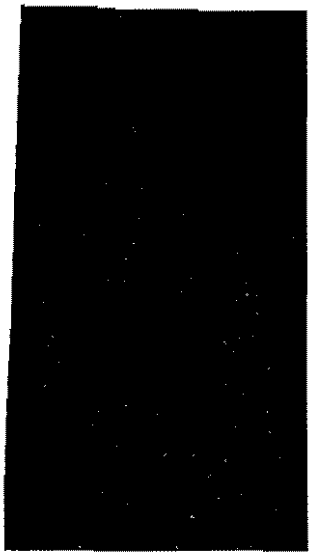
Standard Text.

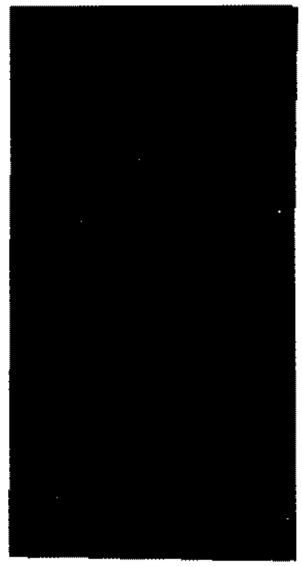
c. High severity level (H). Cracks are severely spalled with loose and missing particles. They can be either filled or nonfilled of any width.

Additional Criteria

1. Severe spalling is any degree of spalling exceeding criteria outlined above.

2. A spall may be rated severe due to subsidence of associated pavement particles into the crack void. This condition can exist even though secondary cracking may not be visible. Record a crack at high severity if subsidence associated with the crack exceeds 1/2 inch.

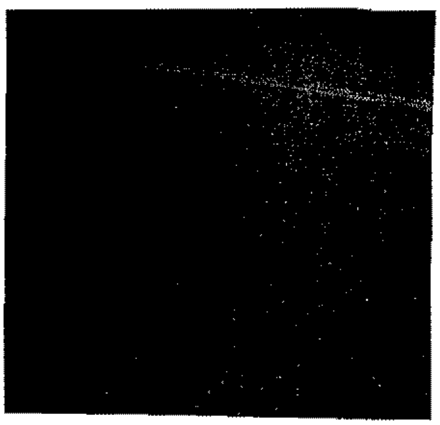


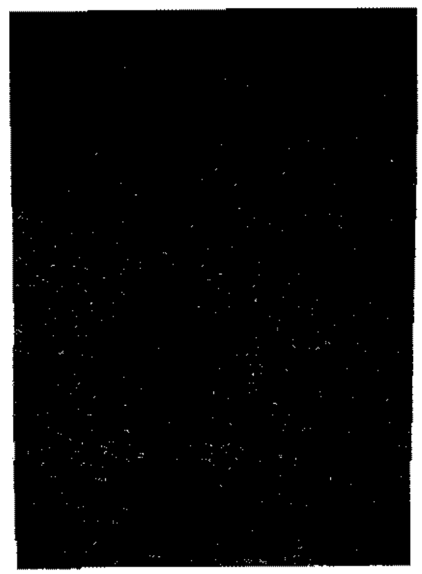


NO DISTRESS

Edge Cracking
Figure 5-1

Good Butt Joint
Figure 5-2



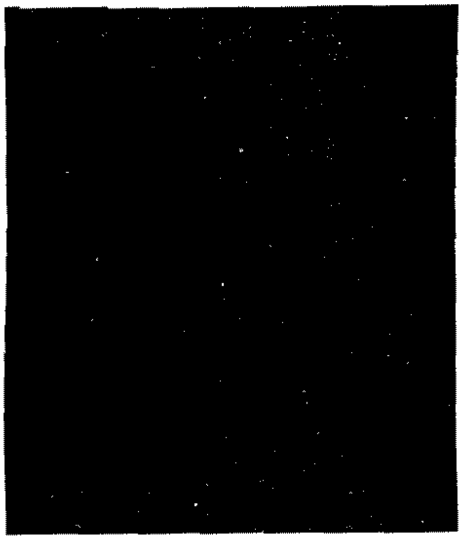


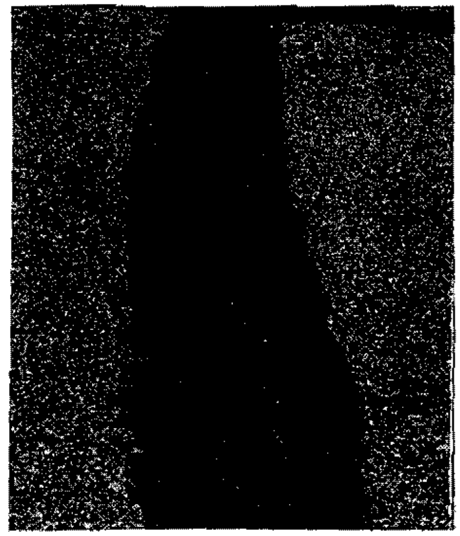
LOW SEVERITY CRACKS

Paving Butt Joint
Figure 5-3

Joint Reflection Crack
Figure 5-4

Figure 5-3 is a low severity crack close in, closes to a good butt joint at center, then reappears at medium severity due to moderate spalling near the top. Figure 5-4 is a low severity crack with frayed edges. The spalled area at the bottom is incidental (less than 10 percent of the crack length.)



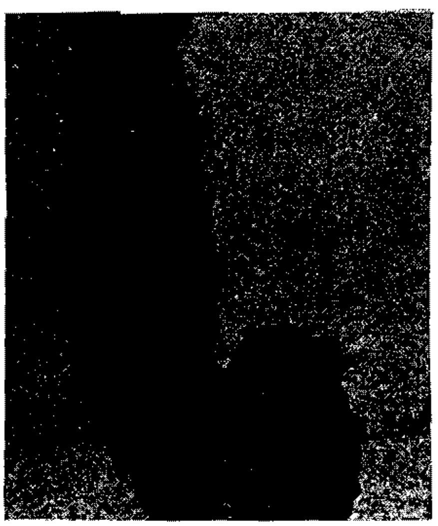


LOW SEVERITY CRACKS

Figure 5-5

Figure 5-6

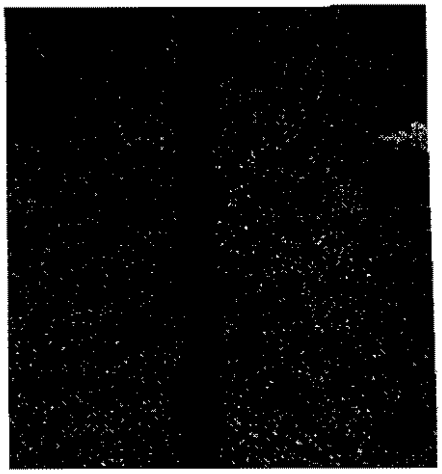
At Figure 5-5, sealer stops, but the crack continues. Measure the crack, not the sealer. At Figure 5-6, Sealer is in satisfactory condition.

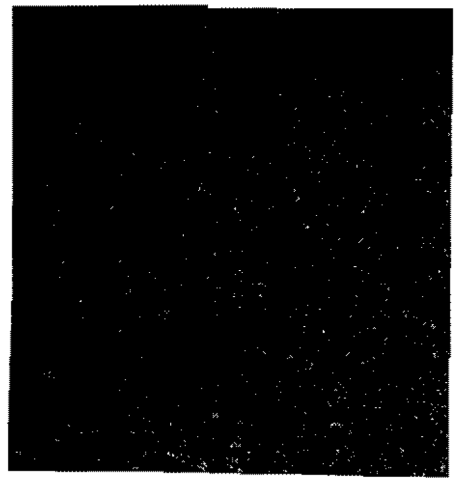


Low Severity Crack
Figure 5-7

Medium Severity Crack
Figure 5-8

Sealer in crack at Figure 5-7 is more than one inch below the surface, but is it in satisfactory condition. Sealer in crack at Figure 5-8 is also satisfactory, but the crack is moderately spalled.

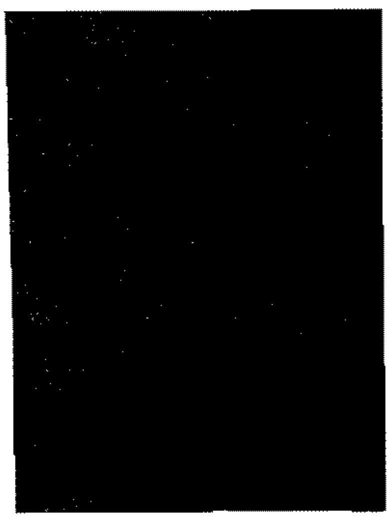


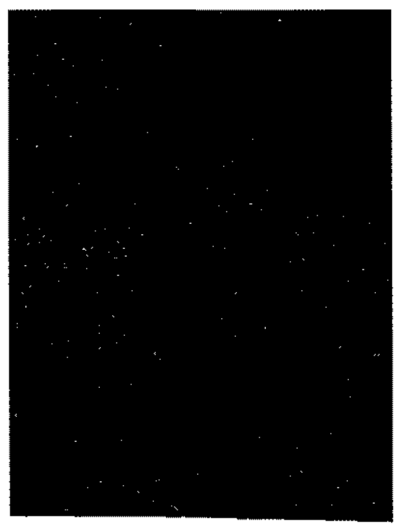


MEDIUM SEVERITY CRACKS w/ SPALLS

Figure 5-9 Figure 5-10

Crack at Figure 5-9 is moderately spalled. Crack at Figure 5-10 is wider than 1/4 inch. Spall in Figure 5-10 is incidental, but is considered "loose" since aggregate interlock at the face is lost.





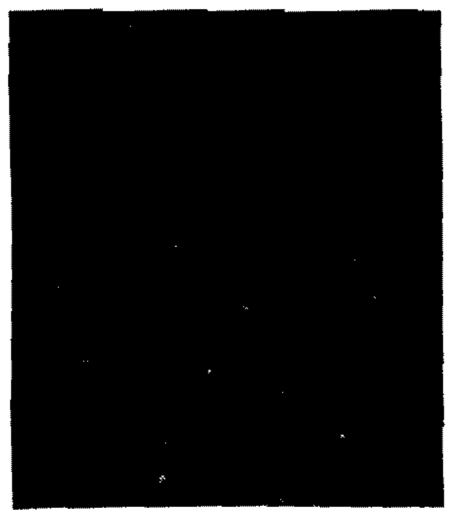
MEDIUM SEVERITY CRACKS w/SECONDARY CRACKING

Figure 5-11 Figure 5-12

Crack at Figure 5-11 is rated at medium severity due to secondary cracking. Note that secondary cracks are within 6 inches of the primary crack. Figure 5-12 shows a crack at medium severity, wider than 1/4 inch, with secondary cracking close in. Secondary cracks develop into severe spalls (aggregate interlock lost and wider than 3 inch void potential) at top of picture, changing severity to high.

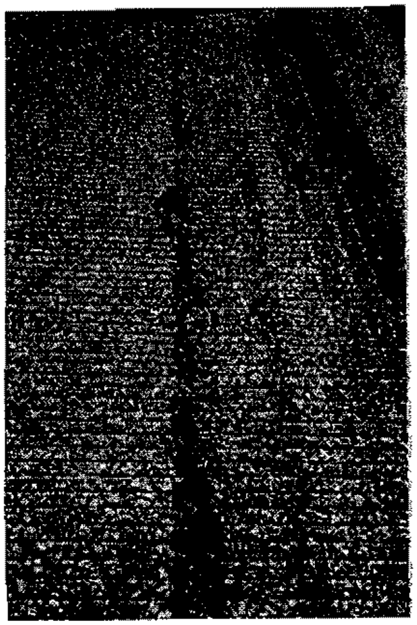
MEDIUM SEVERITY CRACKS w/SUBSIDENCE
Figure 5-13 Figure 5-14

Subsidence is measurable (1/8"), but less than 1/2 inch, and is localized within 6 inches of the crack. If measurable subsidence exists beyond 6 inches from the crack, measure and record "depression" (in absence of secondary cracks or spalls) or "rutting" (if secondary cracking or spalling are present).



HIGH SEVERITY CRACKS w/ SUBSIDENCE
Figure 5-15 Figure 5-16

Subsidence at pavement edge (be careful not to measure into the crack) is at 1/2 inch or more.



HIGH SEVERITY CRACKS w/SPALLING

Figure 5-17 Figure 5-18

The joint reflection crack at Figure 5-17 is severely spalled close in with missing pieces. Near the top, the crack changes to low severity. Figure 5-18 shows a severely spalled crack with loose pieces (aggregate interlock lost) over virtualy the full length.

HIGH SEVERITY CRACK
Figure 5-19

Although the sealer in this crack is in satisfactory condition, crack width measures in excess of 3 inches. Before rating a crack at high severity for width, be sure to locate, and measure between, vertical faces of the crack with a knife blade. Sealer may be misleading.

Measuring Techniques.

Calibrated Wheel
Figure 5-20

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

2. When longitudinal crack patterns are limited to paving lane joints and transverse cracks extend across the pavement, experienced inspectors can accurately estimate quantities by multiplying the number of longitudinal and transverse cracks by length and width of sample unit, respectively. This technique must never be attempted in sample units with complex crack patterns, or until accuracy can be clearly demonstrated by duplicating measurements with a calibrated wheel. Inspectors should cross check each other's work frequently when this procedure is being used. If published standards are not met consistently, the calibrated wheel must be used.

3. Measuring joint reflection cracks and longitudinal and transverse cracks can be difficult. There is a tendency to lose track of the Sample Unit boundary. This difficulty will diminish with experience.

4. Where there is a large amount of cracking, it is easy to get "lost" in the Sample Unit, forgetting which cracks have been measured. Overcoming this difficulty requires subdividing the sample unit into clearly definable segments. If paving lane joints are visible, cracks can be measured one lane at a time. Occasionally, prominent transverse cracks can be used for reference. If no visible references are available, it may be necessary to mark segment corners with paint or crayon. It is, however, imperative to maintain positive points of reference in the sample unit.

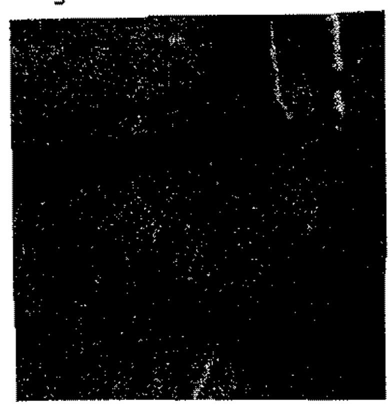
5. Keeping track of different crack severities while measuring can also be difficult. If most of the cracking is of one severity with just a minor amount of another severity, it may be possible to measure the total, keeping track of the minor quantity mentally. In most cases, however, it will

be necessary to measure each severity separately, marking transitions with spray paint or crayon.

6. It is best to measure alligator and block cracking first. With these areas marked, the remaining sample unit area will be smaller. Then subdivide the sample unit into segments, and measure the remaining cracks as described above.

7. Small areas of distress can be estimated by visualizing a rectangular area of equivalent size, and calculating the area of the rectangle.

8. When an area is large or of irregular shape, it is necessary to physically mark boundaries on the pavement. A lumber marking crayon or spray paint is recommended for this purpose. As limits of an area are identified, small marks are made with crayon to define the boundaries. Boundaries of multiple severities of a distress are outlined in the same manner. When the area has been defined by intermittent crayon marks, measuring proceeds as described above.



Marking Area Boundary
Figure 5-21

9. When multiple severities of a distress exist in the same area, each severity must be isolated and measured. The most common technique is to define and measure the entire area and then define and measure the least extensive severity of distress within the overall area. Where three severities are involved,the process is repeated, measuring severity of least area, then severity of next greater area, and subtracting each, in turn, from the next.

10. All distress types, except joint reflection and longitudinal and transverse cracking, require area measurements. Techniques for obtaining area measurements of various distresses are presented here.

a. Area boundaries of Alligator Cracking are defined at 6 inches beyond the outermost visible crack in the pattern. When a single crack is visible, width is one foot. Area boundaries should be marked intermittently with crayon or paint.

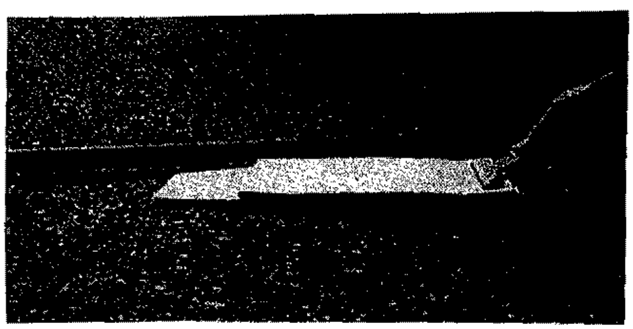
b. Area boundaries of Bleeding are defined at 25 percent coverage of pavement surface.

c. Area boundaries of Block Cracking ~~are defined 5 feet beyond the~~ outermost crack in the pattern. 4-24-91

d. Area boundaries of Jet Blast Erosion, Oil Spillage, Patching, Polished Aggregate, Raveling and Weathering, and Slippage Cracking are defined at the outer edges of visible distress.

e. Area boundaries of other distress types are defined where minimum measurable (1/8") differential elevation is reached.

11. Measuring width of cracks, depth of depressions and rutting, and height of swells can be expedited by calibrating tools and equipment on hand to the key dimensions, which are 1/8", 1/4", 1/2", 1" and 3". For example, a clip board may be 1/8" thick, a pencil may be 1/4" thick, etc. Fingers can be calibrated to close tolerance. A pocket knife can be an excellent measuring device in addition to its value in examining crack filler and condition of pavement surface. Examples of efficient measuring techniques are shown below.



Measuring 1/8 Inch
Figure 5-22

Measuring 1/2 Inch
Figure 5-23

12. With practice, the 3/4 inch cast pipe straight edge can be maneuvered quite efficiently with a foot, as demonstrated below.

Rolling Forward
Figure 5-24

Sliding Laterally
Figure 5-25

ALLIGATOR OR FATIGUE CRACKING - DISTRESS NO. 1.

Standard Text.

Description.

a. Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphaltic concrete (AC) surface under repeated traffic loading. The cracking initiates at the bottom of the AC surface (or stabilized base) where tensile stress and strain are highest under a wheel load. The cracks propagate to the surface initially as a series of parallel 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 ft on the longest side.

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

Severity Levels.

a. Low severity level (L). Fine, longitudinal hairline cracks running parallel to one another with none or only a few interconnecting cracks. The cracks are not spalled.

b. Medium severity level (M). Further development of light alligator cracking into a pattern or network of cracks that may be lightly spalled.

c. High severity level (H). Network or pattern cracking has progressed so that the pieces are well defined and spalled at the edges; some of the pieces rock under traffic.

Measuring Procedure.

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

Additional Criteria

1. Alligator cracking can have a circular or linear pattern. On thicker pavement sections, cracks may appear random rather than linear or circular.

2. Alligator cracking may initially appear in wheel tracks as linear parallel cracks when associated with rutting.

3. Pavement overloads on weak subgrade by rollers during construction can cause alligator cracking of new pavement. These cracks must be distinguished from blemishes caused by tearing of pavement surface by rollers sliding on, or pushing, the hot mix. Alligator cracks extend through the pavement surface course.

4. Some surface treatments, and paint, develop surface blemishes with linear or rectangular patterns similar in appearance to alligator cracks. Usually, the distinction will be obvious to a trained inspector. When in doubt, check the depth of crack. Surface blemishes do not extend into the pavement more than about 1/4 to 1/2 inch. Alligator cracking extends through the surface course.

5. A single crack may be load related, and therefore, an alligator crack. When identified as such, single alligator cracks are measured by length times one foot.

6. Cracks which define blocks larger than 2 feet on a side are not Alligator Cracks. Measure and Record L & T Cracking.

7. Establishing between severities of this distress type may be difficult, especially since multiple severities are common in a single distressed area. Two factors help to identify low severity alligator cracks. (a) There is no pattern of interconnecting cracks, although there may be an occasional random crack connecting two parallel cracks. (b) The individual cracks rate at low severity as defined elsewhere in this Chapter.

Medium severity alligator cracking is defined by

(a) a well defined pattern of interconnecting cracks, (b) the block pattern is generally rectangular, (c) all pieces are securely held in place (good aggregate interlock between pieces).

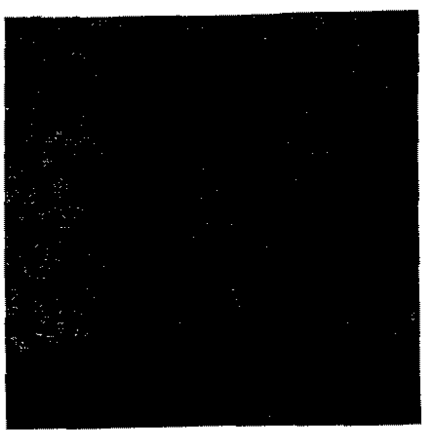
High severity alligator cracks are identified by (a) blocks which are approximately equally sided, and smaller than 6 inches on a side, (b) individual cracks rate at medium or high severity, (c) individual pieces are missing or loose in place (aggregate interlock lost). Loose or missing pieces is a positive indication of high severity alligator cracking.

8. In areas of multiple severities, isolate areas by severity and measure each separately. Areas smaller than five square feet may be included with adjacent distressed areas.

9. For purposes of area definition, intermittent crack segments may be considered continuous if gaps do not exceed 20 percent of the total crack length. This provision is not to be used in determining distress severity.

10. Any uncertainty about severity defaults to the higher severity.

11. The following photographs illustrate alligator cracking criteria.

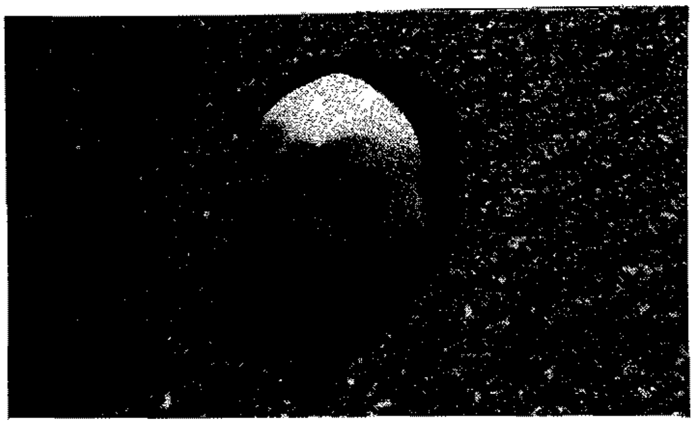


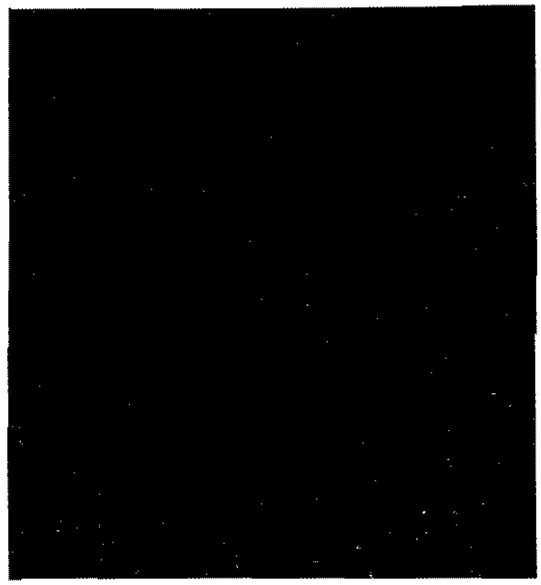
NO DISTRESS

Figure 5-26

Figure 5-27

Paint and tar based surface treatments have different thermal properties than asphalt. Consequently, they develop surface cracks similar to the alligator pattern. Figures 5-26 and 5027 illustrate such cracks, known as blemishes. They are not distresses.

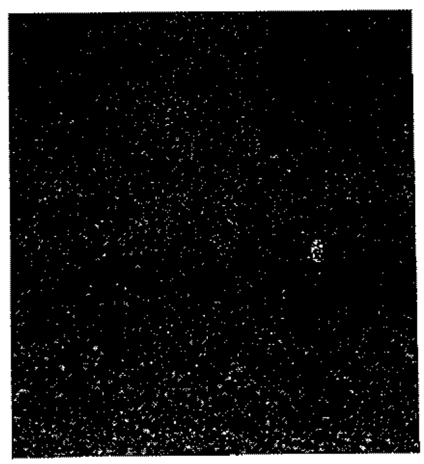




NO DISTRESS

Figure 5-28 Figure 5-29

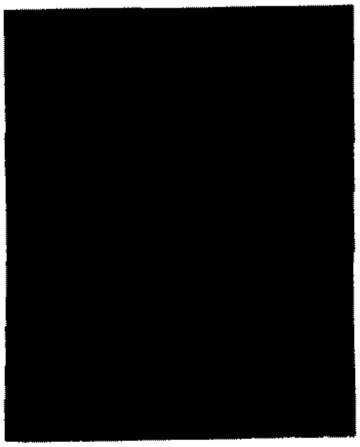
Figure 5-28 shows pavement grooved for better drainage to prevent hydroplaning. Figure 5-29 shows a roller mark simulating alligator cracking. However, these cracks do not extend full depth of pavement, except for one short crack at the center of the photo which is too small to be significant.



LOW SEVERITY ALLIGATOR CRACKING

Figure 5-3Ø Figure 5-31

Roller marks at Figure 5-3Ø extend through the pavement and meet low severity criteria. Secondary cracks at Figure 5-31 extend more than 6 inches from the primary crack and are measured as low severity alligator cracking. The primary crack is included in the area measurement and is not measured separately.



LOW SEVERITY ALLIGATOR CRACKING

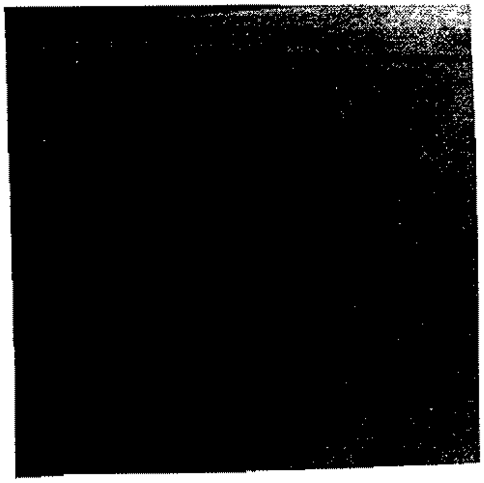
Figure 5-32 Figure 5-33

Cracks in Figure 5-33 are well defined, but lateral cracks are more than two feet apart.

LOW SEVERITY ALLIGATOR CRACKING

Figure 5-34 Figure 5-35

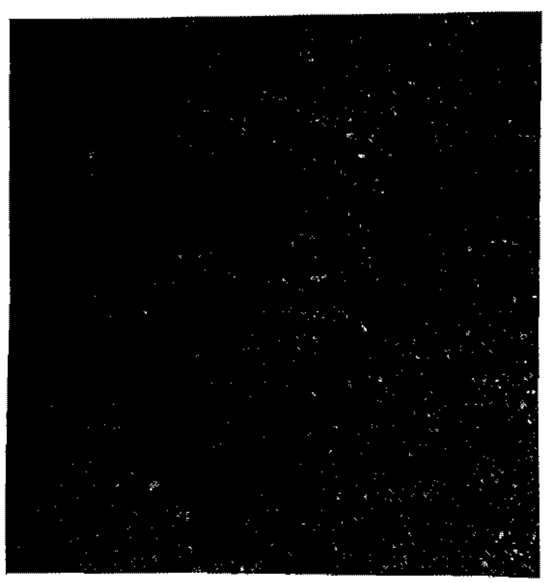
Cracks at Figure 5-34 are approaching medium severity. Lateral cracks are beginning to form a pattern. Cracks at Figure 5-35 result from a soft spot in subgrade.



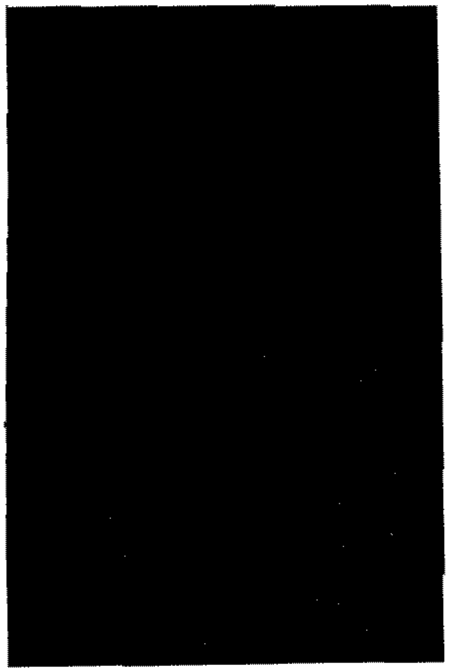
LOW SEVERITY ALLIGATOR CRACKING

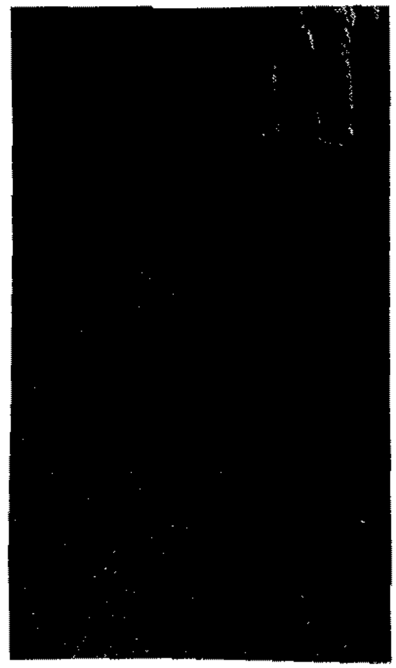
Figure 5-36 Figure 5-37

Cracks at Figure 5-36 might be rated as longitudinal except for the traffic lane indicated by wheel marks. Crack at Figure 5-37 results from a localized weakness within the pavement structure. It is characterized by a random pattern seemingly from nowhere and going nowhere. The crack often takes the shape of a tree branch and the origin of the crack is at the fork. Single cracks are measured by length times one foot.



Closeup of "Tree Branch" Alligator Crack
Figure 5-38





MEDIUM SEVERITY ALLIGATOR CRACK

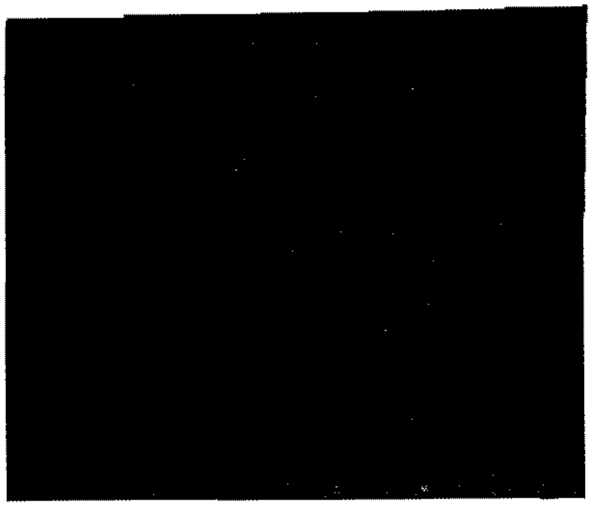
Figure 5-39 Figure 5-40

Figures 5-39 and 5-40 present classic alligator cracking at medium severity. Pattern is well established and rectangular in shape, and pieces are firmly secure in place (good aggregate interlock).

MEDIUM SEVERITY ALLIGATOR CRACKING

Figure 5-41

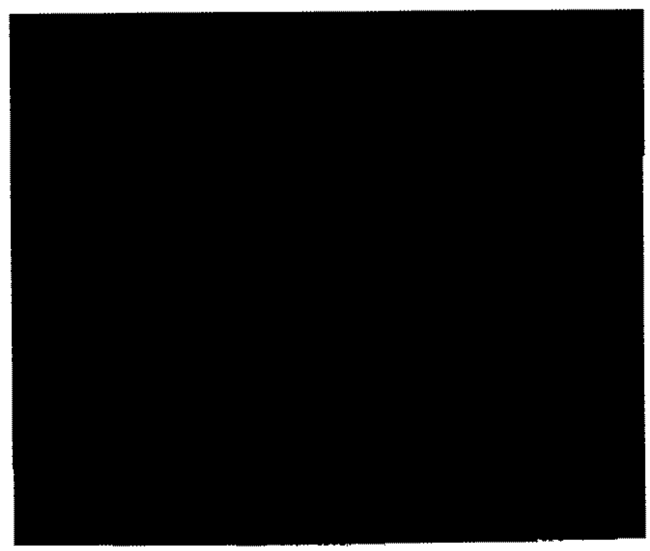
Figure 5-41 shows classic medium severity alligator cracking in a circular pattern.



MEDIUM SEVERITY ALLIGATOR CRACKING

Figure 5-42 Figure 5-43

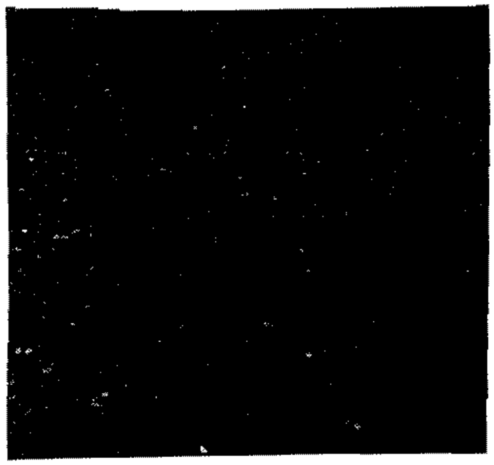
Crack patterns are often obscured by dirt and debris, making identification more difficult. Crack pattern and severity must be determined before a rating is assessed.



MEDIUM SEVERITY ALLIGATOR CRACKING

Figure 5-44 Figure 5-45

Alligator cracking is common near cracks where moisture softens subgrade, weakening pavement support. Figures 5-44 and 5-45 are examples. In Figure 5-45, the primary crack defines high severity alligator cracking one foot wide. Adjacent cracks are at medium severity. Cracks further out are measured as transverse cracks, since they define pieces larger than two feet on a side.

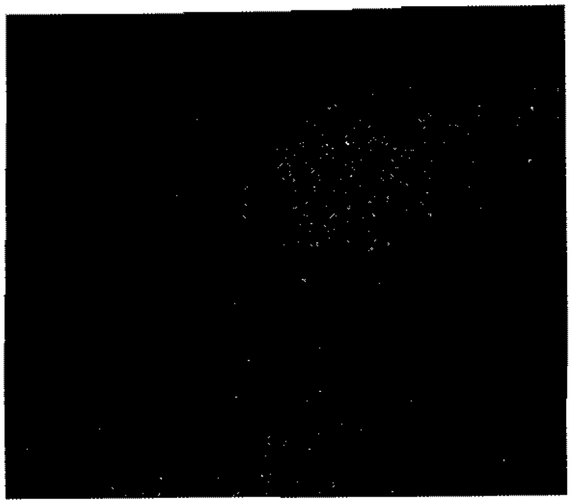


LONGITUDINAL AND TRANSVERSE CRACKING (L & T)
Figure 5-46

Cracks at Figure 5-46 resemble alligator cracking except that they define pavement pieces larger than two feet on a side. Pieces this large provide considerable bearing strength and defining cracks are rated as L & T.

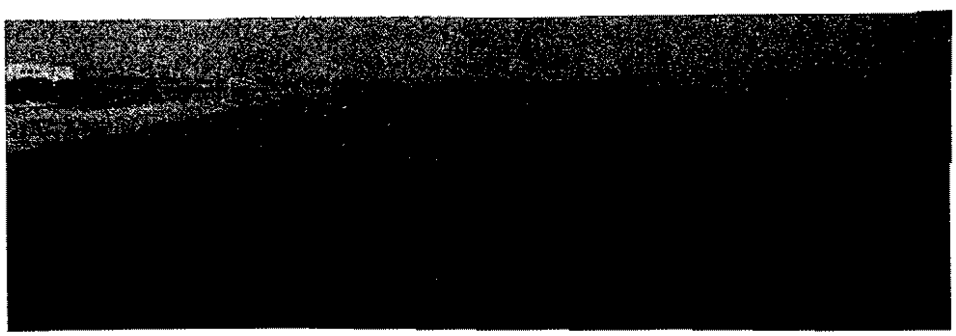
HIGH SEVERITY ALLIGATOR CRACKS
Figure 5-47 Figure 5-48

These figures present classic high severity alligator cracking patterns. Individual pieces are small and nearly square, aggregate interlock is lost, and bearing strength of pavement is virtually lost. Figure 5-47 shows a small amount of missing pieces, and is actually the more severe. Cracks at Figure 5-48 appear more severe because they are wet. Rating on wet pavement must be done with special care.



HIGH SEVERITY ALLIGATOR CRACKING
Figure 5-49 Figure 5-50

These photos represent alligator cracking in most advanced stages. The patch in Figure 5-49 is ignored, as the original distress is more serious. The pothole at Figure 5-50 is the ultimate alligator crack pattern.



ALLIGATOR CRACKS IN WHEEL TRACKS
Figure 5-51

Figure 5-51 shows a classic pattern of alligator cracking in wheel tracks on a taxiway. They are not centered because the taxiway was recently widened, shifting centerline to the right.

BLEEDING - DISTRESS NO. 2.

Standard Text.

Description.

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

Severity Levels.

No degrees of severity are defined. Bleeding should be noted when it is extensive enough to cause a reduction in skid resistance.

Measuring Procedure.

Bleeding is measured in square feet of surface area.

Additional Criteria

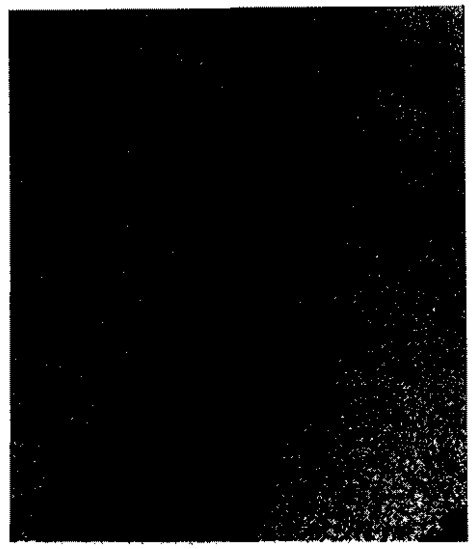
1. Bleeding usually appears as spots or "pools" of bitumen on the surface, but may be concentrated along a crack when permeating from a base layer since the crack offers least resistance. Bleeding associated with cracks may be difficult to distinguish from crack filler. If the area is large enough to be recorded, it is almost certainly bleeding.

2. Fresh bleeding is shiny and sticky. However, in a dormant condition, bitumen may be dull from oxidation, dust and pollutants. Fresh bitumen may be exposed using a knife blade. A knife blade can also help in distinguishing a dome of bleeding bitumen from a coated aggregate particle.

Bleeding may also be camouflaged by rubber deposits from tires of landing aircraft. Bleeding bitumen under rubber deposits may be very difficult to detect. Use a knife blade to expose the body of material. Fresh bitumen is shiny and will stick to the knife blade.

3. If boundaries of the distressed area are not obvious, locate a one square foot area approximately 25 percent covered by exposed bitumen. This area represents the appearance of pavement at the boundaries of the distressed area.

4. Distressed areas smaller than 25 square feet are not recorded.



BLEEDING

Figure 5-52

Figure 5-53

Classic Bleeding pattern is shown at Figure 5-52. This photo shows the distress at about 50 percent coverage. Figure 5-53 shows a Bleeding pattern at a paving lane construction joint. This is much less common, caused by excess bitumen in an underlying layer.

BLOCK CRACKING - DISTRESS NO. 3.

Standard Text.

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 ft to 10 by 10 ft. When the blocks are larger than 10 by 10 ft, they are classified as longitudinal or transverse cracking. 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. The occurrence of block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large portion of pavement area, but sometimes will occur only in nontraffic areas. This type of distress differs from alligator cracking in that the 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, located only in traffic areas (i.e., wheel paths).

Severity Levels.

(Severity levels are presented under General Comments, item 9, page 5-5).

Measuring Procedure.

Block cracking is measured in square feet of surface area, and usually occurs at one severity level in a given pavement section. Any areas of the pavement section having distinctly different levels of severity, however, should be measured and recorded separately.

Additional Criteria

1. Size of block is not a factor in rating severity. Severity of the distress is the same as severity of the defining cracks. If crack severity changes from one area of a sample unit to another, record both severities of block cracking. If crack severity changes within a pattern, record block cracking at the dominant severity (more than 50 percent).

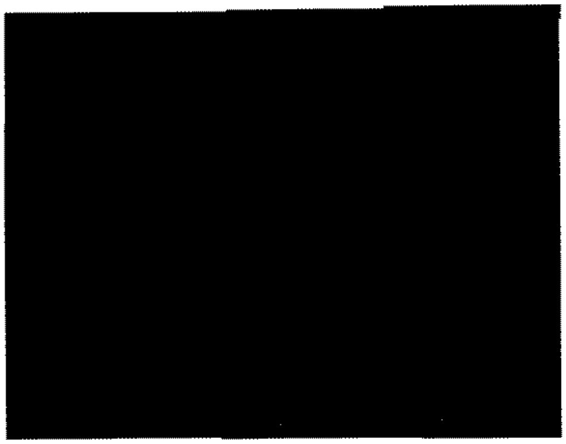
2. Cracks caused by pavement construction joints are used in establishing a block pattern, but reflection cracks from underlying rigid pavement are not included. This distinction is important in properly identifying, measuring and recording the block cracking distress type.

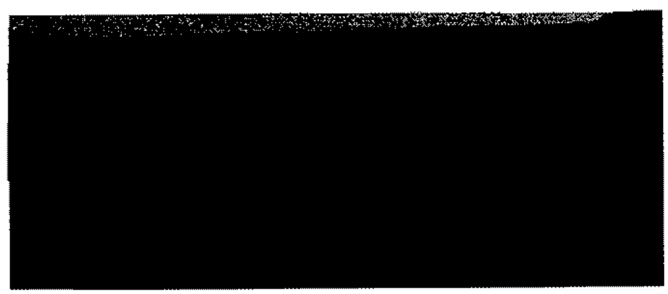
3. Block cracking should not be recorded when crack separation exceeds ten feet. If in doubt, measure and record longitudinal/transverse cracking.

4. If the block pattern is contained in an area smaller than 100 square feet, measure and record longitudinal/transverse cracking.

5. For visualization of block crack pattern, consider intermittent cracks on line to be continuous if gaps do not exceed 20 percent of total crack length.

6. Where block cracking and longitudinal/transverse cracking are both identified in a Sample Unit, measure block cracking first and outline areas of block cracking with paint or crayon. This will reduce potential for inadvertently measuring the same crack for both distress types.





BLOCK CRACKING

Figure 5-54

Figure 5-55

BLOCK CRACKING
Figure 5-56

CORRUGATION - DISTRESS NO. 4.

Standard Text.

Description.

Corrugation is a series of closely spaced ridges and valleys (ripples) occurring at fairly regular intervals (usually less than 5 ft) along the pavement. The ridges are perpendicular to the traffic direction. Traffic action combined with an unstable pavement surface or base usually causes this type of distress. Corrugation is not commonly found on airport pavement.

Severity Levels.

a. Low severity level (L). Corrugations are minor and do not significantly affect ride quality (see measurement criteria below).

b. Medium severity level (M). Corrugations are noticeable and significantly affect ride quality (see measurement criteria below).

c. High severity level (H). Corrugations are easily noticed and severely affect ride quality (see measurement criteria below).

Measuring Procedure.

Corrugation is measured in square feet of surface area. The mean elevation difference between the ridges and valleys of the corrugations indicates the level of severity. To determine the mean elevation difference, a 10-ft straightedge should be placed perpendicular to the corrugations so that the depth of the valleys can be measured in inches. The mean depth is calculated from five such measurements.

Severity	Runways and High-Speed Taxiways	Taxiways and Aprons
L	<1/4 in.	<1/2 in.
M	1/4 - 1/2 in.	1/2 - 1 in.
H	>1/2 in.	>1 in.

Additional Criteria

1. Corrugations are caused by repeated braking of vehicles in a concentrated area, as at a stop sign on a down grade. If corrugations occur on an airport surface, they are most likely, on taxiways, near holding lines and, on runways, approaching exit taxiways.

2. More common distress types, which might be mistaken for corrugations, are swell caused by ice crystals under paint stripes, and depressions caused by parked vehicles which appear as "moguls" or waves in pavement.

3. Corrugations result from horizontal forces on the surface which exceed the ability of the pavement structure to resist movement.

DEPRESSION - DISTRESS NO. 5.

Standard Text.

Description.

Depressions are localized pavement surface areas having elevations slightly lower than those of the surrounding pavement. In many instances, light depressions are not noticeable until after a rain, when ponding water creates "birdbath" areas; but the depressions can also be located without rain because of stains created by ponding of water. Depressions can be caused by settlement of the foundation soil or can be built during construction. Depressions cause roughness and, when filled with water of sufficient depth, could cause hydroplaning of aircraft.

Severity Levels.

a. Low severity level (L). Depression can be observed or located by stained areas, only slightly affects pavement riding quality, and may cause hydroplaning potential on runways (see measurement criteria below).

b. Medium severity level (M). The depression can be observed, moderately affects pavement riding quality, and causes hydroplaniex potential on runways (see measurement criteria below).

c. High severity level (H). The depression can be readily observed, severely affects pavement riding quality, and causes definite hydroplaning potential (see measurement criteria below).

Measuring Procedure.

Depressions are measured in square feet of surface area. The maximum depth of the depression determines the level of severity. This depth can be measured by placing a 10-ft straightedge across the depressed area and measuring the maximum depth in inches. Depressions larger than 10 ft across must be measured by either visual estimation or by direct measurement when filled with water.

Maximum Depth of Depression

Severity	Runways and High-Speed Taxiways	Taxiways and Aprons
L	1/8 - 1/2 in.	1/2 - 1 in.
M	1/2 - 1 in.	1 - 2 in.
H	≥ 1 in.	≥ 2 in.

Additional Criteria

1. Depressions are often detectable by visual examination of the pavement surface, especially by sighting along the surface from a prone position. Depressions can also be identified with a ten foot straightedge.

2. Standing water and stains do not outline the boundaries of a depression. When present, they merely confirm its presence. Do not rely on these indicators as evidence of depressions. The straightedge is a much more reliable tool.

3. Visual examination for presence of depressions on aprons and taxiways is usually sufficient. Visual examination is not adequate for detection of the presence of depressions on a runway. Use a straightedge and examine at least 20 percent of the Sample Unit surface to confirm the presence or absence of depressions. If depressions are present, investigate the entire surface.

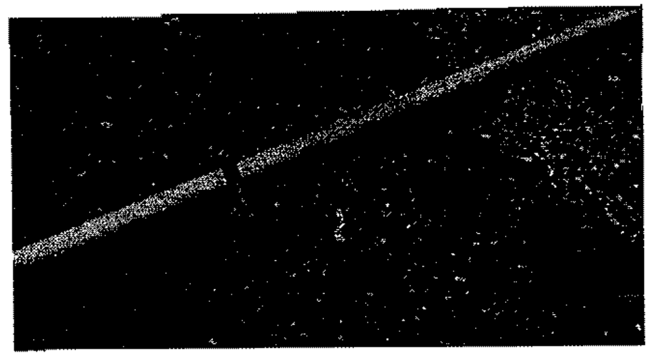
4. The only severity criterion for this distress type is maximum depth. Depth is measured under a ten foot straightedge. Severity of a depression is a function of the maximum such measurement in the area of distress.

5. Always measure for depth of depression under the straightedge. Do not estimate. Shadows can be very deceiving.

6. Be alert to distinguish swells from depressions. Envision the surface as it was originally constructed. Depressions and swells may exist in the same area. When in doubt, record depressions.

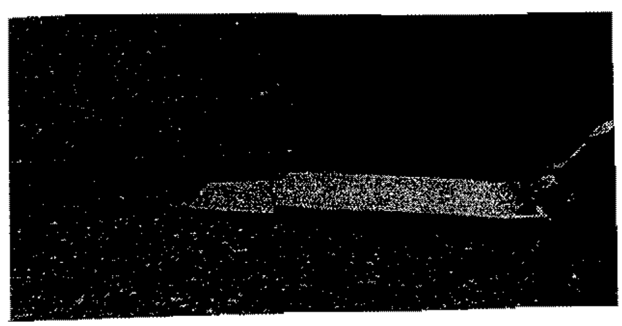
7. The size of a depression may be measured with a ten foot straightedge if points of contact (representing the distress boundary) are inboard from the

ends of the straightedge. Larger areas may be defined by sliding a straightedge out from center until the leading end breaks contact with the surface as in Figure 5-57. Then measure inboard from point of contact until minimum measurable clearance is located as in Figure 5-58. Mark this point with paint or crayon as the depression boundary.



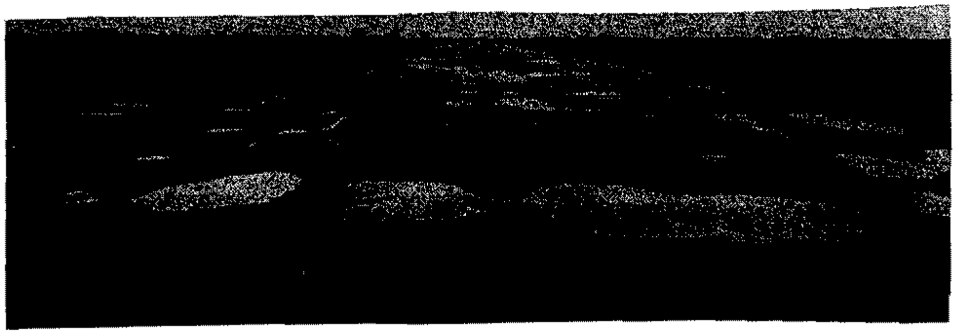
LOCATING BOUNDARY OF LARGE DEPRESSIONS

Figure 5-57 Figure 5-58



LOCATING AND MEASURING DEPRESSIONS ON RUNWAYS

Figure 5-59 Figure 5-60



DEPRESSIONS (?) AFTER RAIN
Figure 5-61

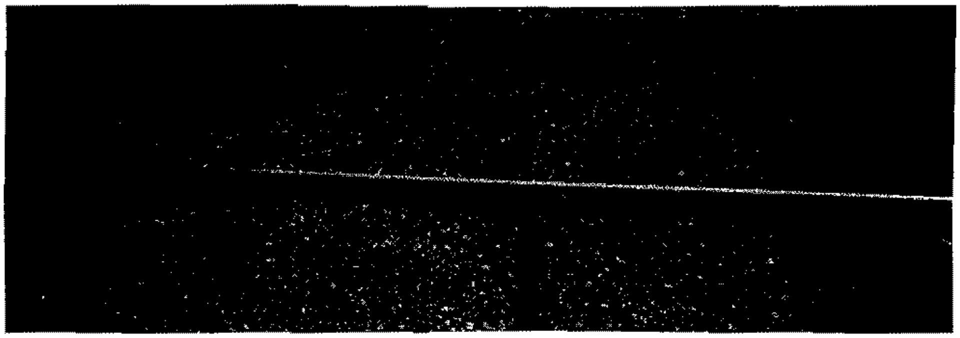
The only thing water on pavement indicates is a "bird bath". Presence of a depression can only be determined by measuring under a 10 foot straightedge. Size of a depression, if present, can only be determined by meaurement.

MEASURING FOR DEPRESSION AT FACILITY BOUNDARY

Incorrect
Figure 5-62

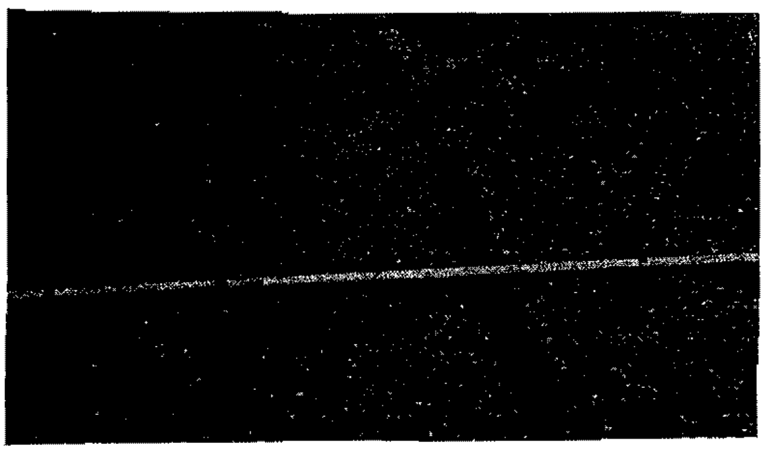
Correct
Figure 5-63

These figures show a "bird bath" at intersection of a runway with a taxiway. Grade change at the intersection is by design. Therefore, placement of the straightedge should not be across the grade change.



DEPRESSION AT TRANSVERSE CRACK
Figure 5-64

Subsidence at this L & T crack is further than 6 inches from the crack. Pavement pieces are larger than two feet. This condition is recorded as a Depression plus one medium severity L & T, and two low severity L & T cracks.



DEPRESSION CAUSED BY POOR CONSTRUCTION
Figure 5-65

The elevation differential shown at Figure 5-65 is caused by a poorly matched paving lane joint. However, the condition can cause water to pond, leaving a hydroplaning potential on the pavement. Placement of the straightedge is important in obtaining accurate measurement. Place the end of the straightedge at the high side of the construction joint. Measure for depression on the low side under the full 10 foot straightedge.

JET BLAST EROSION - DISTRESS NO. 6.

Standard Text.

Description.

Jet blast erosion causes darkened areas on the pavement surface where bituminous binder has been burned or carbonized. Localized burned areas may vary in depth up to approximately 1/2 inch.

Severity Levels.

No degrees of severity are defined. It is sufficient to indicate that jet blast erosion exists.

Measuring Criteria.

Jet blast erosion is measured in square feet of surface area.

Additional Criteria

1. Jet blast erosion damage is caused almost exclusively by ram jet engines of military fighter aircraft. Turbofan engines of the civilian fleet and military cargo aircraft disperse jet blast so that pavement damage rarely results.

2. Look for this distress type at airports with a history of significant military operations. Jet blast erosion is most commonly found at the ends of runways where aircraft "spool up" before releasing brakes for takeoff.

JET BLAST EROSION

Figure 5-66 Figure 5-67

JOINT REFLECTION CRACKING FROM PCC (LONGITUDINAL AND TRANSVERSE) - DISTRESS NO. 7.

Standard Text.

Description.

This distress occurs only on pavements having an asphalt or tar surface over a portland cement concrete (PCC) slab. This category does not include reflection cracking from any other type of base (i.e., cement stabilized, lime stabilized). Such cracks are listed as longitudinal and transverse cracks. Joint reflection cracking is caused mainly by movement of the PCC slab beneath the asphaltic concrete (AC) surface because of thermal and moisture changes. It is not load-related. However, traffic loading may cause a breakdown of the AC near the crack, resulting in spalling. 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 cracks.

Severity levels.

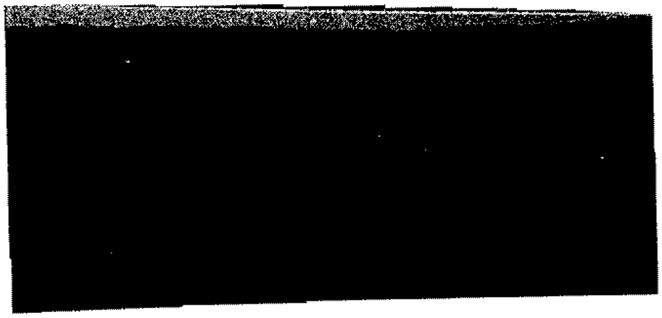
(Severity levels are described above in General Comments, item 9, page 5-5).

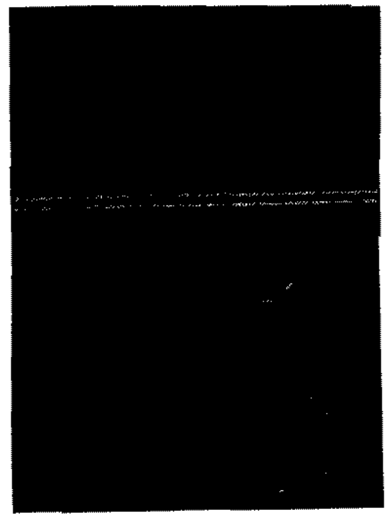
Measuring Procedure.

Joint reflection cracking is measured in linear feet. The length and severity level of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion should be recorded separately. For example, a crack that is 50 ft long may have 10 ft of a high severity crack, 20 ft of a medium severity, and 20 ft of a light severity. These would all be recorded separately.

Additional Criteria

1. Joint reflection cracking is pattern cracking. Look for the underlying PCC pavement joint pattern to be evidenced on the surface. The pattern may be difficult to distinguish in early stages of reflection. It will be most noticeable when looking out over a large expanse of pavement. Cracks may be intermittent in early stages, but the pattern will cover the entire surface. Joint reflection cracks follow very straight lines.

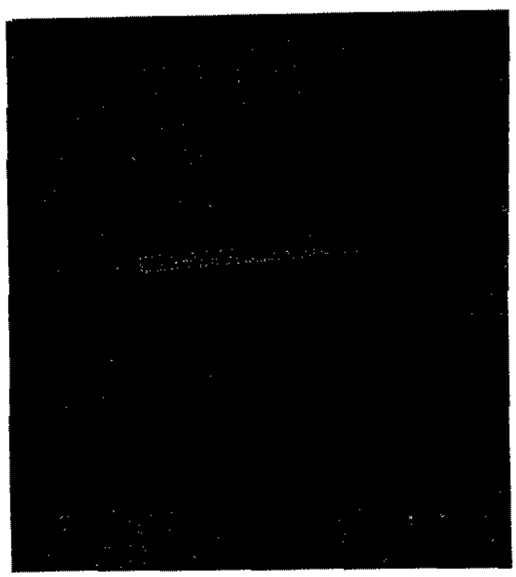




JOINT REFLECTION CRACKS

Figure 5-66 Figure 5-67

2. Joint reflection cracks may "meander" back and forth across the PCC joint, but the cause of the crack, and its relationship to the underlying joint will be obvious.



JOINT REFLECTION CRACK w/L & T CRACK
Figure 5-68

One of the cracks shown in Figure 5-68 is a Joint Reflection crack. The other may be from shrinkage in the surface or a reflection of a crack in the underlying PCC pavement. Only one can be recorded as Joint Reflection Crack. The other must be a L & T crack. (A secondary crack within 6 inches of the primary is used to rate severity of the primary crack).

LONGITUDINAL AND TRANSVERSE CRACKING (NON-PCC JOINT REFLECTIVE) - DISTRESS NO. 8.

Standard Text.

Description.

Longitudinal cracks are parallel to the pavement's center line or laydown direction. they may be caused by (a) a poorly constructed paving lane joint, (b) shrinkage of the AC surface due to low temperatures or hardening of the asphalt, or (c) a reflective crack caused by cracks beneath the surface course, including cracks in PCC slabs (but not at PCC joints). Transverse cracks extend across the pavement at approximately right angles to the pavement's center line or direction of laydown. They may be caused by items b or c above. These types of cracks are not usually load-associated. If the pavement is fragmented along cracks, the crack is said to be spalled.

Severity Levels.

(Severity levels are described above in General Comments, item 9, page 5-5).

Measuring Procedure.

Longitudinal and transverse cracks are measured in linear feet. The length and severity of each crack should be identified and recorded. 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. For an example see joint reflection cracking.

Additional Criteria

1. Diagonal cracks are recorded as longitudinal/transverse unless clearly associated with alligator or slippage cracking.

OIL SPILLAGE - DISTRESS NO. 9.

Standard Text.

Description.

Oil spillage is the deterioration or softening of the pavement surface caused by the spilling of oil, fuel, or other solvents.

Severity Levels.

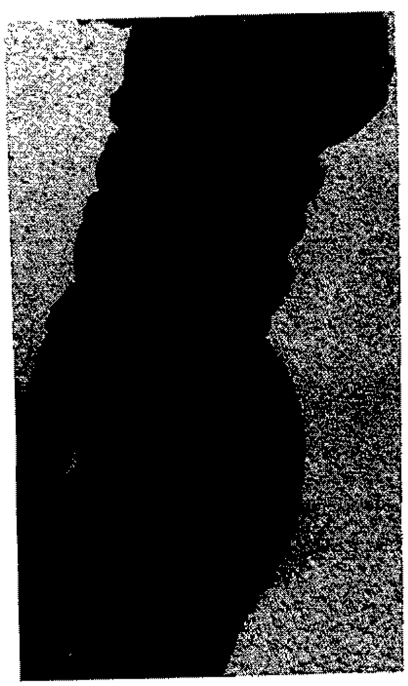
No degrees of severity are defined. It is sufficient to indicate that oil spillage exists.

Measuring Procedure.

Oil spillage is measured in square feet of surface area.

Additional Criteria

1. A stain is not a distress unless material has been lost or binder has been softened. Use a knife blade to check for stability of binder in the stained area. If hardness is approximately the same as on surrounding pavement, and if no material has been lost, do not record as a distress.



Checking For
Surface Damage
Figure 5-69

2. Do not record oil spillage when less than 25 square feet of area in a sample unit is damaged.

OIL SPILLAGE

Figure 5-70 Figure 5-71

Oil spills are typically found around fuel pumps and in parking areas.

PATCHING AND UTILITY CUT PATCH - DISTRESS NO. 10.

Standard Text.

Description.

A patch is considered a defect, no matter how well it is performing.

Severity Levels.

a. Low severity level (L). Patch is in good condition and is performing satisfactorily.

b. Medium severity level (M). Patch is somewhat deteriorated and affects riding quality to some extent.

c. High severity level (H). Patch is badly deteriorated and affects ride quality significantly. Patch soon needs replacement.

Measuring Procedure.

Patching is measured in square feet of surface area. However, if a single patch has areas of differing severity levels, these areas should be measured and recorded separately. For example, a 25 sq-ft patch may have 10 sq ft of medium severity and 15 sq ft of light severity. These areas should be recorded separately.

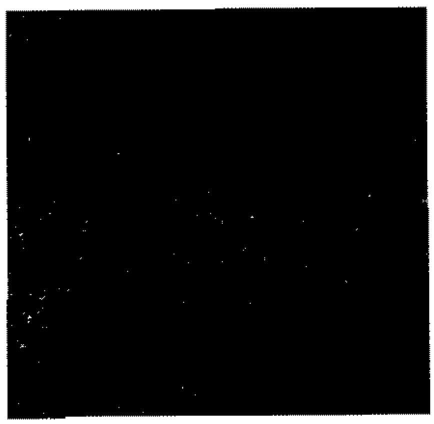
Additional Criteria

1. It is sometimes difficult to distinguish a patch from a leveling course, or "skin patch". To be recorded as a distress, a patch must replace original pavement. Therefore, do not record maintenance overlay, placed to level a surface, as a patch.

Pavement Skin Patch
No Distress
Figure 5-72

2. A clean sawed edge is the best indicator of a patch. This clearly represents a replacement of material. A feathered edge requires additional investigation. Usually, a feathered edge indicates additional material on an original surface. Do not record feathered edge pavement as a patch unless it is possible to determine that original pavement has been removed and replaced. A reflective crack paralleling the feathered edge is an indicator of pavement replacement.

3. The edges of a patch are rated as longitudinal/transverse cracks. Crack density is linear feet of crack divided by area of patch. (Note: On small patches it is possible for calculated density to exceed 100%. In such cases, use the 50+ column from Table 5-2.)



PATCH
Figure 5-73

Edges of the patch are considered L & T cracks and are used to rate patch severity.

4. A very large patch, or feathered edge pavement, may qualify as a separate Feature. If the total area is more than 2500 square feet, establish a separate Feature.

5. Patch severity is determined by summing deduct points of distress types from Table 5-2.

TABLE 5-2

		Density (%) Distress		
	Severity	<20	20 - 50	50+
Alligator	(1) L	4	5	7
	M	6	7	8
	H	7	11	15
Bleeding	(2) -	4	6	7
Corrugation	(4) L	3	5	7
	M	5	7	9
	H	6	8	11
Depression	(5) L	3	4	6
	M	4	5	8
	H	5	7	10
Long/Trans	(8) L	2	4	5
	M	3	5	7
	H	5	8	10
Ravel/Weather	(12) L	1	2	3
	M	2	3	5
	H	5	7	8
Rutting	(13) L	3	4	5
	M	4	6	8
	H	6	9	11
Slippage	(15) -	5	7	8
Swell	(16) L	2	3	4
	M	3	5	7
	H	6	7	11

Rate patch as follows:

Low severity - < 8 points
Medium severity - 8 to 15 points.
High severity - > 15 points.

POLISHED AGGREGATE - DISTRESS NO. 11.

Standard Text.

Description.

Aggregate polishing is caused by repeated traffic applications. Polished aggregate is present when close examination of a pavement reveals that the portion of aggregate extending above the asphalt is either very small, or there are no rough or angular aggregate particles to provide good skid resistance.

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.

Measuring Procedure.

Polished aggregate is measured in square feet of surface area.

Additional Criteria

1. Polished aggregate is very rare on airport pavement. The necessary criterion is that aggregate be smooth and polished. Even uncrushed stones usually have creases and pits in the surface which are visible to close examination. These imperfections give friction properties necessary to safe aircraft movements. If such irregularities exist on aggregate visible at pavement surface, the aggregate is not polished.

2. Traffic is not essential to the presence of polished aggregate. River stone may have been polished by nature before being incorporated into the pavement.

3. Snow plows may shear stones at a pavement surface. These exposed aggregate are not polished.

4. When in doubt, do not record this distress. Polished aggregate should exist over at least 25 percent of the sample unit surface before being recorded.

RAVELING AND WEATHERING - DISTRESS NO. 12.

Standard Text.

Description.

Raveling and weathering are the wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt or tar binder. They may indicate that the asphalt binder has hardened significantly.

Severity Levels.

a. Low severity level (L). Aggregate or binder has started to wear away with few, if any, loose particles.

b. Medium severity level (M). Aggregate and/or binder has worn away with some loose and missing particles. The surface texture is moderately rough and pitted.

c. High severity level (H). Aggregate and/or binder has worn away with a large amount of loose and missing particles. The surface texture is severely rough and pitted.

Measuring Procedure.

Raveling and weathering are measured in square feet of surface area.

Additional Criteria

1. This is a materials related distress type often uniformly evident over large areas of pavement surface. If caused by construction, it may be found in lanes as from a bad truckload of mix, or in strips paralleling paving lanes as from a cold spot on a screed or poor compaction on one side of a longitudinal construction joint.

2. The deduct curves for this distress type dictate that a significant amount of material loss be evident. Discoloration or bleached appearance of the pavement surface, or large amount of exposed stone does not justify recording as a distress.

3. Low severity is recorded when coarse aggregate at the surface of the pavement is exposed to a depth of half the diameter of individual stones. The surface may be pitted from aggregate loss, but

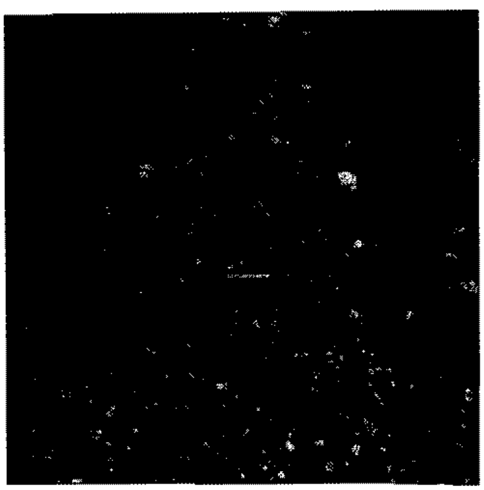
pits should not be larger than a wallet, and pitted surface should not comprise more than 10 percent of the area being measured at low severity. Areas of low severity distress smaller than 25 square feet are not recorded.

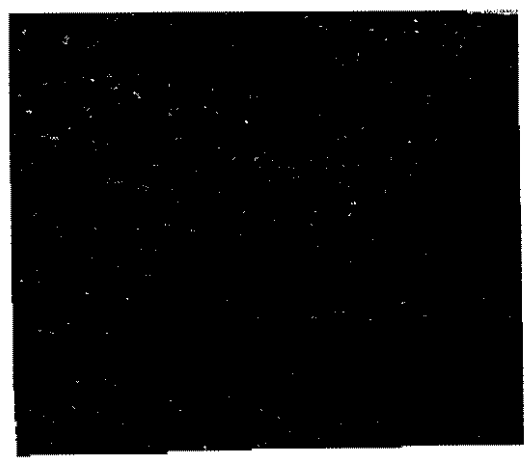
4. Medium severity is recorded in areas where more than 10 percent, but less than 50 percent of the top layer of coarse aggregate in the measured area has raveled away. Areas of medium severity distress smaller than 25 square feet, when in larger areas of low severity distress, are included at low severity.

5. High severity is recorded in areas where more than 50 percent of the top layer of coarse aggregate in the measured area has raveled away.

Any area larger than 5 square feet in which all of the top layer of coarse aggregate has raveled away is measured separately and recorded at high severity.

6. Pavement with chip seal surface treatment may appear to be raveled and weathered. Do not record this distress type on pavement which has received a surface treatment.





NO DISTRESS - RAVELING AND WEATHERING

Figure 5-74 Figure 5-75

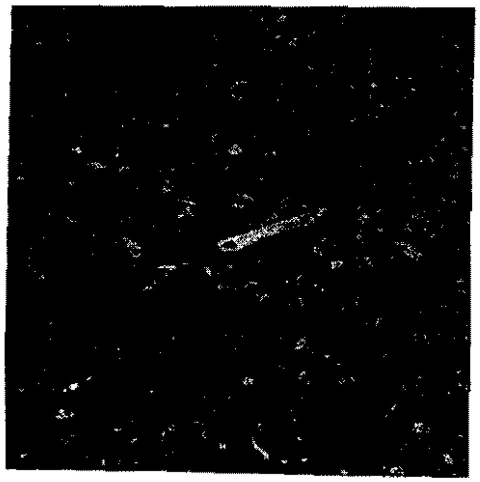
In Figure 5-74 surface aggregate is obviously exposed, and, in Figure 5-75 there is some pitting at the surface, but neither condition is serious enough to be recorded as pavement distress.

LOW SEVERITY RAVELING AND WEATHERING
Figure 5-76

In Figure 5-76, weathering has progressed to the point where binder and fines have eroded away from the course aggregate.

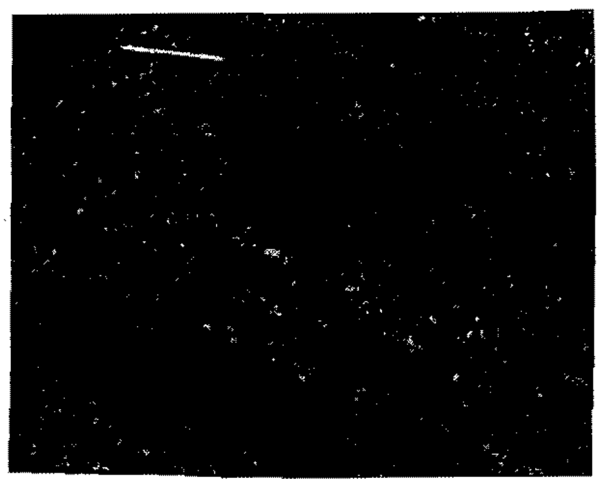
MEDIUM SEVERITY RAVELING AND WEATHERING
Figure 5-77

Figure 5-77 shows a raveled surface approaching high severity. Nearly 50 percent of surface aggregate has been eroded away.

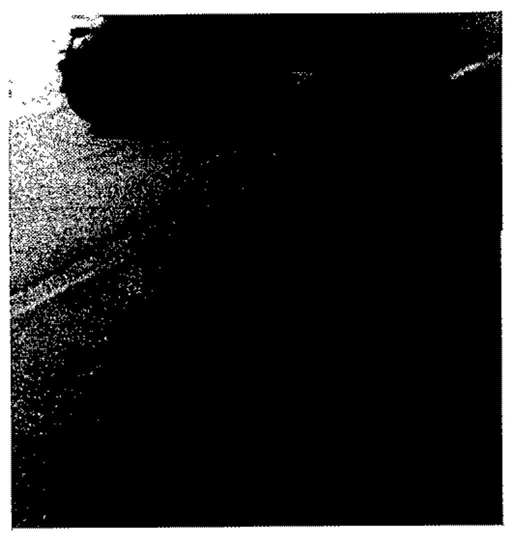


HIGH SEVERITY RAVELING AND WEATHERING
Figure 5-78

Figure 5-78 shows a condition where nearly all the surface aggregate has been eroded away.



NO DISTRESS
Figure 5-79



FUTURE DISTRESS
Figure 5-8Ø

Figure 5-79 shows an open graded surface course. The pavement is designed as a friction course with a high percentage of voids between aggregate particles. Figure 5-8Ø shows a contractor induced distress.

RUTTING - DISTRESS NO. 13.

Standard Text.

Description.

A rut is a surface depression in the wheel path. Pavement uplift may occur along the sides of the rut; however, in many instances ruts are noticeable only after a rainfall, when the wheel paths are filled with water. Rutting stems from a permanent deformation in any of the pavement layers or subgrade, usually caused by consolidation 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 Criteria

Severity	All Pavement Sections
L	1/4 - 1/2 in.
M	$\geq$ 1/2 - 1 in.
H	$\geq$ 1 in.

Measuring Procedure.

Rutting is measured in square feet of surface area, and its severity is determined by the mean depth of the rut. To determine the mean depth, a straightedge should be laid across the rut and the depth measured. The mean depth in inches should be computed from measurements taken along the length of the rut.

Additional Criteria

1. Rutting in a single wheel path is usually quite evident. However, rutting can occur over larger expanses of pavement on aprons and taxiways where traffic is not channelized.

2. Locate rutting by visual examination and with a straight edge, as with depressions.

3. Boundaries of the distressed area is measured in the same manner as are depressions. Measuring rut depth, however, is somewhat different. Minimum distress depth of a rut is 1/4 inch, irrespective

of whether it occurs on a runway, taxiway or apron. Rating is based on mean depth, not maximum depth as with depressions.

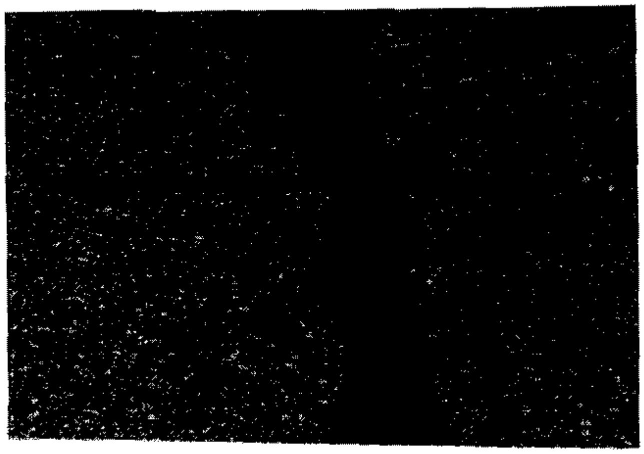
4. Wheel tracks left in pavement by rollers or other equipment while the mix was still hot during construction are not recorded as ruts. They are depressions.

5. Uplift associated with rutting is recorded as part of the rut distress; not as swell.

6. Rutting can often occur in areas not normally associated with aircraft traffic lanes, as near edges of taxiways and runways. These may have been caused by maintenance vehicles or snow plows. Rutting may also occur near fuel tanks, caused by bulk fuel tankers; or near fuel truck parking areas, or along the front of rows of tiedowns on an apron. Record all rutting caused by ground support vehicle traffic.

NO DISTRESS
Figure 5-81

Depth of rut is less than 1/4 inch.



MEDIUM SEVERITY RUTTING
Figure 5-82

Rutting shown at Figure 5-82 is caused by a L & T crack and is associated with alligator cracking. Mean depth exceeds 1/2 inch.

HIGH SEVERITY RUTTING
Figure 5-83

Ruts shown in Figure 5-83 are caused by parked aircraft on unstable pavement. Mean depth exceeds one inch. One typical "wheel basin" is measured and the area multiplied by the number of "basins".

SHOVING OF ASPHALT PAVEMENT BY PCC SLABS - DISTRESS NO. 14.

Standard Text.

Description.

PCC pavements occasionally increase in length at ends where they adjoin flexible pavements (commonly referred to as "pavement growth"). This "growth" shoves the asphalt- or tar-surfaced pavements, causing them to swell and crack. The PCC slab "growth" is caused by a gradual opening up of the joints as they are filled with incompressible materials that prevent them from reclosing.

Severity Level.

a. Low severity level (L). A slight amount of shoving has occurred with little effect on ride quality and no breakup of the asphalt pavement.

b. Medium severity level (M). A significant amount of shoving has occurred, causing moderate roughness and little or no breakup of the asphalt pavement.

c. High severity level (H). A large amount of shoving has occurred, causing severe roughness or breakup of the asphalt pavement.

Measuring Procedure.

Shoving is measured by determining the area in square feet of the swell caused by shoving.

Additional Criteria

1. This distress type only occurs at interface between flexible and rigid pavement. It is only recorded on the flexible pavement side of the interface.

2. Evidence of compression of the flexible pavement by rigid pavement is necessary. A ridge left by poor construction of an adjoining flexible pavement is not a shoving distress.

3. Rate shoving as follows:

   a. Measure vertical displacement as with swell.

b. Examine pavement surface condition for evidence of other distress, such as cracking.

c. Rate severity of swell and other distress conditions separately.

d. Record severity of the shoving distress at the highest of the distress severities measured.

4. Since areas of potential shoving are so limited in a pavement Facility, the presence of this distress might escape a sampling survey. Any time shoving is identified on a project, document the distress by designating sample units containing shoving as "additional" sample units. If the distress is not contained in any designated sample unit, inspect additional sample units to incorporate the distress into the survey.

SLIPPAGE CRACKING - DISTRESS NO. 15.

Standard Text.

Description.

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

Severity Levels.

No degrees of severity are defined. It is sufficient to indicate that a slippage crack exists.

Measuring Procedure.

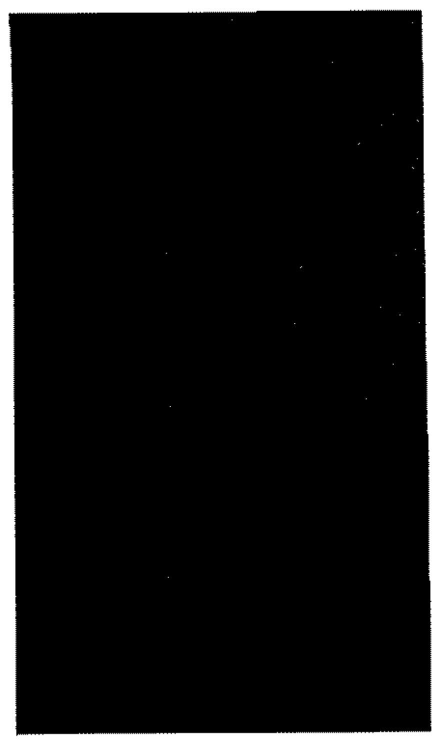
Slippage cracking is measured in square feet of surface area.

Additional Criteria

1. This is not a common distress type on airports. It might well be associated with corrugations as the two distress types have similar cause factors.

2. Slippage cracks may be distinguished from surface blemishes, such as roller marks left during construction in that they extend through the surface course of pavement to the underlying slippage layer.

3. Do not record circular surface blemishes left by turning and braking aircraft on tender pavement.



SLIPPAGE CRACKING
Figure 5-84

SWELL - DISTRESS NO. 16.

Standard Text.

Description.

Swell is characterized by an upward bulge in the pavement's surface. A swell may occur sharply over a small area or as a longer, gradual wave. Either type of swell can be accompanied by surface cracking. A swell is usually caused by frost action in the subgrade or by swelling soil, but a small swell can also occur on the surface of an asphalt overlay (over PCC) as a result of a blowup in the PCC slab.

Severity Levels.

a. Low severity level (L). Swell is barely visible and has a minor effect on the pavement's ride quality as determined at the normal aircraft speed for the pavement section under consideration. (Low severity swells may not always be observable, but their existence can be confirmed by driving a vehicle over the section at the normal aircraft speed. An upward acceleration will occur if the swell is present.

b. Medium severity level (M). Swell can be observed without difficulty and has a significant effect on the pavement's ride quality as determined at the normal aircraft speed for the pavement section under consideration.

c. High severity level (H). Swell can be readily observed and severely affects the pavement's ride quality at the normal aircraft speed for the pavement section under consideration.

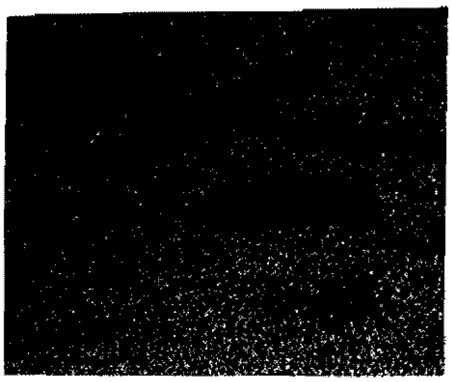
Measuring Procedure.

The surface area of the swell is measured in square feet. The severity rating should consider the type of pavement section (i.e., runway, taxiway, or apron). For example, a swell of sufficient magnitude to cause considerable roughness on a runway at high speeds would be rated as more severe than the same swell located on an apron or taxiway where the normal aircraft operating speeds are much lower. The following guidance is provided for runways:

Severity	Height Differential
L	≤ 3/4 in.
M	3/4 - 1-1/2 in.
H	≥ 1-1/2 in.

Additional Criteria

1. Man made structures, such as catch basins, tie-down anchors or in-pavement light fixtures, which move differentially from the surrounding flexible pavement, can cause this type of distress. Swell is quite a common result of such structures in an underlying pavement reflecting movement through a flexible overlay.



NO DISTRESS
Figure 5-85

The distress in Figure 5-85 is caused by an in-runway light in an underlying pavement layer. It is not recorded because the area is incidental.

2. Rate severity on high speed taxiways using measurement criteria provided above. Double the height differential criteria for other taxiways and aprons.

3. Measuring swells requires a slightly different technique than measuring ruts and depressions. Locate the highest point of the swell. Rest a ten foot straightedge on that point so that both ends are equal distance above pavement. Measure this distance to establish severity rating.

LOW SEVERITY SWELL
Figure 5-86

The distress shown at Figure 5-86 is caused by frost heave from a cable trench. It is on a taxiway and is less than 1-1/2 inch high.

HIGH SEVERITY SWELL
Figure 5-87

LOW SEVERITY SWELL
Figure 5-88

The distress shown at Figure 5-88 represents an attempt at crack sealing. The result is a bump in the runway causing reduction in rideability. This distress rates as a medium severity L & T crack (filler is not pliable) and a low severity swell. This is not a patch (does not replace original material).

Rigid Pavement

General Comments

1. Durability "D" cracking, in advanced stages, results in loss of material at a joint or corner which resembles loss due to spalling. If the tell tale pattern of fine line discolored cracks is evident around the area of lost material, record the distress as "D" cracking. If "D" crack evidence is absent, record spalling. It may be appropriate to record that both distresses exist in a slab.

2. "D" cracking along a longitudinal, transverse and diagonal (L/T/D) crack contributes to the severity rating of the L/T/D crack, and is not recorded as "D" cracking unless the "D" crack pattern extends to at least 3 inches from the opposite face of the crack or until cracks on opposing sides of the L/T/D crack are at least 3 inches apart.

3. Any loose or missing pieces at a slab joint or corner are not considered in identification of distress types unless the resulting void is at least 3 inches wide measured perpendicular from the opposite joint face to the point where the void is 1/4 inch deep. Such voids are repairable by joint sealer. This interpretation is based on an FAA standard of 3 inch maximum allowable width for open trench in an air traffic area.

4. Spalls are created by the same types of force which create blowups. Spalling results from localized compressive forces usually caused by incompressibles in a joint. The result is failure evidenced by a diagonal shear plane from the joint face to the surface.

   Blowups, on the other hand, result from compressive failure of either or both adjoining slabs through the full depth of pavement.

   A spall may present a buckled appearance immediately following failure. However, individual loose pieces will soon be dislodged by traffic, or may be lifted out by hand, to reveal the classic diagonal break characteristic of spalling. If the slab face appears to be otherwise undamaged, the distress is recorded as a spall.

5. Joints and cracks often collect debris which can obscure joint filler. This debris must be removed before filler can be evaluated. Do not read sand

or grass clippings as evidence of unsatisfactory joint/crack filler.

6. Try to determine degree of chipping under filler which has overflowed the surface. Chipping affects severity independently of filler.

7. A crack wider than three inches rates at high severity regardless of filler condition. However, be sure to measure crack width between vertical walls, not from edges of chips or spalls.

8. 1/8 inch is the smallest measurable dimension in rating severity of Blowup and Settlement/Faulting.

9. Distress conditions in structural pavement (i.e. pavement designed to isolate a structure from the catch basin) are not recorded.

10. A PCI survey provides a record of the condition of pavement at an instant in time. Record what you see, not what you believe, or think will be.

11. Pavement in excellent condition can be fairly represented with a reduced sampling rate. When authorized by the Owner, pavement with PCI above 90 may be inspected at a 10 percent sampling rate. This requires that all inspected sample units have PCI above 90. Inspectors must visually confirm that inspected sample units are, in fact, representative of the pavement.

Cracking Distress

Several distress types are rated for severity on the basis of associated crack patterns and severity. Since determination of crack severity is the same for all distress types, cracking distress is described below.

Standard Text.

Crack Severity Levels.

a. Low severity level (L). Crack has little or no spalling with no loose particles. If nonfilled, it has a mean width less than approximately 1/8 in. A filled crack can be of any width but the filler material must be in satisfactory condition.

b. Medium severity joint (M). One of the following following conditions exists:

(1) Filled or nonfilled crack is moderately spalled with some loose particles.

(2) A nonfilled crack has a mean width between 1/8 and 1 in.

(3) A filled crack is not spalled or only lightly spalled, but the filler is in unsatisfactory condition.

c. High severity level (H). One of the following conditions exists:

(1) Filled or nonfilled crack is severely spalled with loose and missing particles.

(2) A nonfilled crack has a mean width greater than approximately 1 in., creating a tire damage potential.

Additional Criteria

1. By our interpretation of inspection criteria, a spall must be at least 3 inches wide from opposite crack or joint face. As used in the standard discription of crack severity developed by the Corps of Engineers, the word "spall" is also used to define smaller pieces of loose or missing material.

To distinguish between the term, as used in defining crack severity, and the term, as used in describing spalled concrete, we have introduced the term "chip". A chip is a small piece of loose or missing concrete at a crack or joint which is less than 3 inches wide, measured perpendicular from the opposite face of the crack or joint.

Chip
Figure 5-89

2. A lightly frayed crack edge, as by sandpapering, is not a spall/chip. Spalling/chipping is evidenced by secondary cracks along the primary crack. Little or no spalling or lightly spalled means chipping defined by secondary cracks which are less than six inches long and occur over less than ten percent of the length of crack. No loose particles means

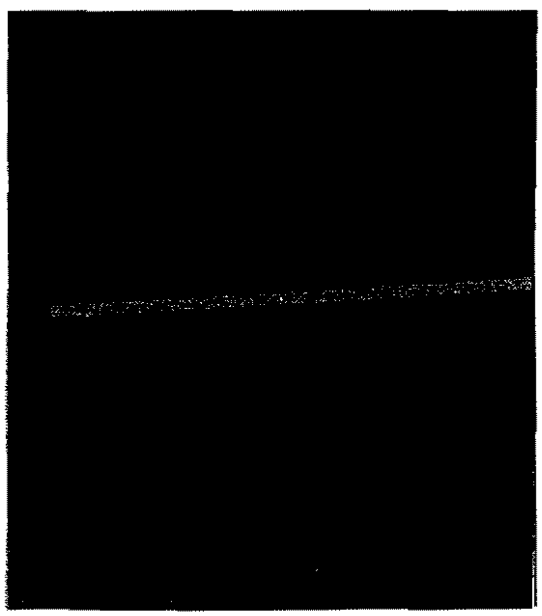
loose or missing pieces are smaller than one square inch.

3. Moderate spalling/chipping means secondary cracks can be of any length but both ends must intersect the primary crack. Individual pieces wider than 3 inches are not cracked and broken. Some loose particles means loose pieces can be of any length but must be less than three inches wide (chips). Missing pieces wider than 3 inches must effect less than ten percent of the crack length.

4. Do not measure across chips in determining mean crack width.

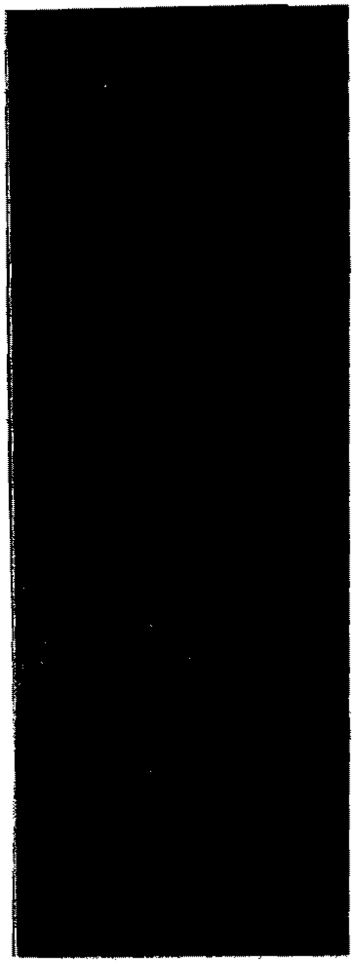
5. Filler in satisfactory condition prevents entry of water into the crack, is less than 1/2 inch below the surface and has some elasticity. If cracks have vegetation growing in them, filler is not satisfactory. Absence of satisfactory conditions over less than ten percent of the crack does not make the condition unsatisfactory.

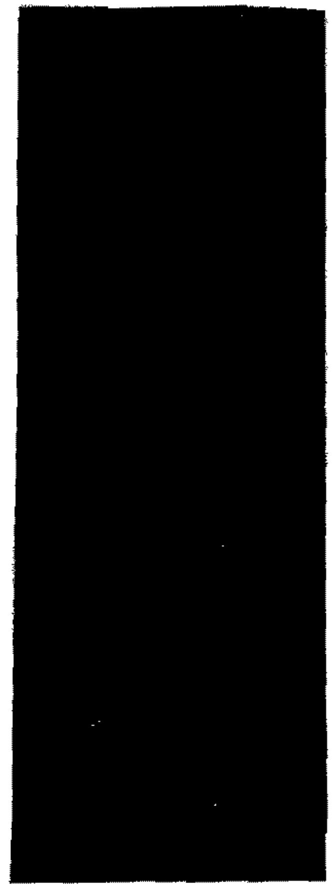
6. Filled cracks with unsatisfactory filler are subject to width criteria. Pavement condition is not reduced by Owner maintenance.



LOW SEVERITY CRACK
Figure 5-90

The crack at Figure 5-90 is less than 1/8 inch wide and is not chipped or spalled. If the crack does not intersect a joint at both ends, it is recorded as a shrinkage crack.

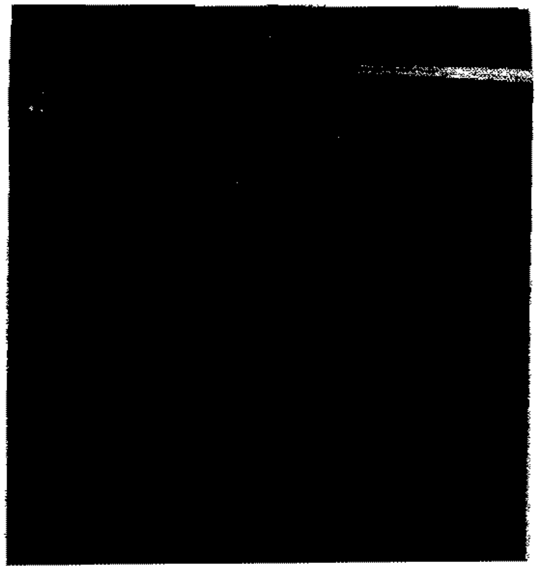


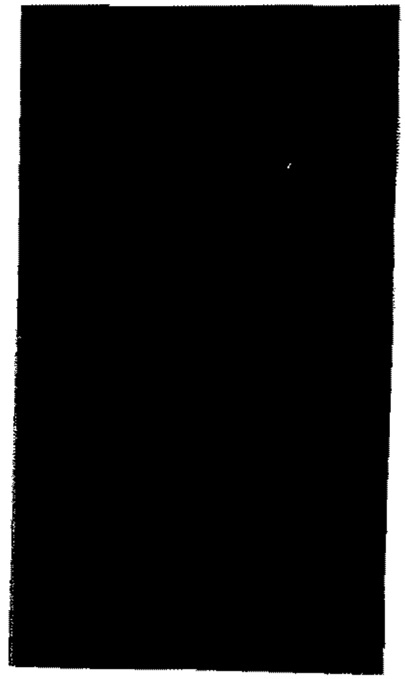


LOW SEVERITY CRACKS

Figure 5-91 Figure 5-92

Crack at Figure 5-91 is approaching medium severity, but chipping is over less than 10 percent of length and missing pieces are less than one square inch. Crack at Figure 5-92 is at low severity if sealer is in satisfactory condition. Chips meet low severity criteria. If sealer is in unsatisfactory condition, crack is at low severity if width can be established to be less than 1/8 inch. Note that this crack has been routed for sealing. Width at surface is not representative of crack width.

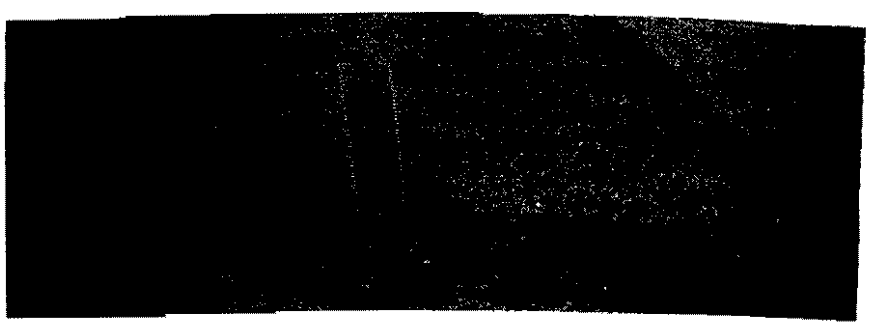




MEDIUM SEVERITY CRACKS

Figure 5-93 Figure 5-94

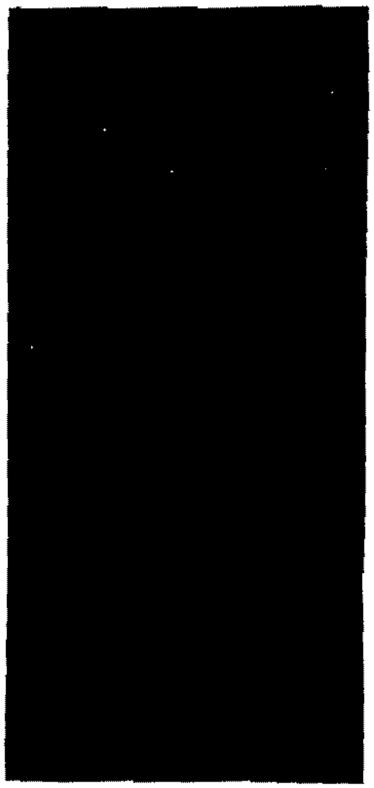
Crack at Figure 5-93 is wider than 1/8 inch. Crack at Figure 5-94 has unsatisfactory sealer and meets other medium severity criteria.

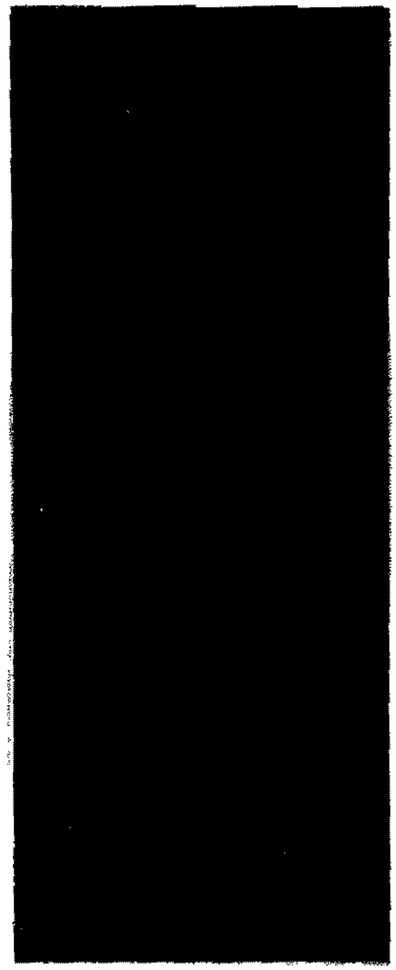


HIGH SEVERITY CRACK

Figure 5-95

Crack at Figure 5-95 is unfilled and more than one inch wide.





MEDIUM SEVERITY CRACK
Figure 5-96

HIGH SEVERITY CRACK
Figure 5-97

Crack at Figure 5-96 is chipped over more than 10 percent of its length. Crack at Figure 5-97 is severely spalled.

BLOWUP - DISTRESS NO. 1

Standard Text.

Description.

Blowups occur in hot weather, usually at a transverse crack or joint that is not wide enough to permit expansion of the concrete slabs. 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. Blowups can also occur at utility cuts and drainage inlets. This type of distress is almost always repaired immediately because of severe damage potential to aircraft. the main reason blowups are included here is for reference when closed sections are being evaluated for reopening.

Severity Levels.

a. Low severity level (L). Buckling or shattering has not rendered the pavement inoperative, and only a slight amount of roughness exists.

b. Medium severity level (M). Buckling or shattering has not rendered the pavement inoperative, but a significant amount of roughness exists.

c. High severity level (H). Buckling or shattering has rendered the pavement inoperative.

For the pavement to be considered operational, all foreign material caused by the blowup must have been removed.

Counting Procedure.

A blowup usually occurs at a transverse crack or joint. At a crack, it is counted as being in one slab, but at a joint two slabs are affected and the distress should be recorded as occurring in two slabs.

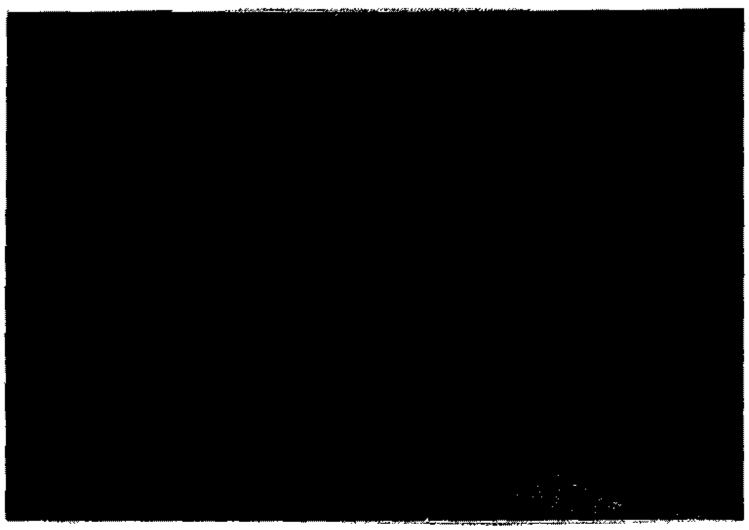
Additional Criteria

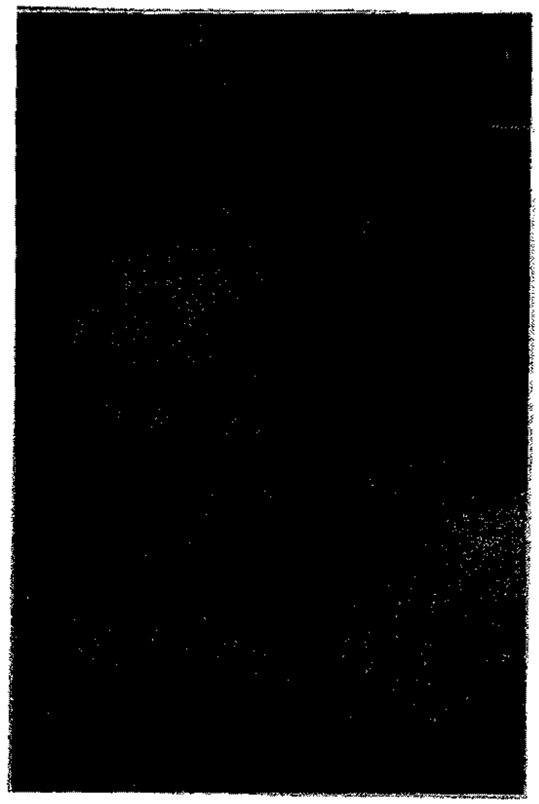
1. To designate severity, use twice the elevation differential prescribed for Settlement/Faulting. This measurement may be from upheaval or due to missing materials, or a combination.

2. Record blowup on a slab only if the distress is evident on that slab. Severity may be different on adjacent slabs.

3. Vertical displacement or material loss must be evident over at least ten percent of the joint width to establish the level of severity.

4. If blowup has been repaired by patching, establish severity by differential elevation per foot of patch (ramp).





BLOWUP

Figure 5-98
Low Severity

Figure 5-99
High Severity

Blowup at Figure 5 -98 has been repaired by ramping, and differential elevation on the taxiway is less than one inch per foot of ramp. Blowup at Figure 5-99 is at high severity because differential elevation at several points is greater than 2 inches. Note that an earlier Blowup at this same joint was patched and ramped to restore serviceability.

CORNER BREAK - DISTRESS NO. 2.

Standard Text.

Description.

A corner break is a crack that intersects the joints at a distance less than or equal to one-half of the slab length on both sides, measured from the corner of the slab. For example, a slab with dimensions of 25 by 25 ft that has a crack intersecting the joint 5 ft from the corner on one side and 17 ft on the other side is not considered a corner break; it is a diagonal crack. However, a crack that intersects 7 ft on one side and 1Ø ft 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 cause corner breaks.

Severity Levels.

a. Low severity level (L). (Use crack severity definitions presented above under Cracking Distress, page 5-64, plus the following).

The area between the corner break and the joints is not cracked.

b. Medium severity joint (M). (Use crack severity definitions presented above under Cracking Distress page 5-64, plus the following).

The area between the corner break and the joints is lightly cracked.

c. High severity level (H). (Use crack severity definitions presented above under Cracking Distress page 5-64, plus the following).

The area between the corner break and the joints is severely cracked.

Counting Procedure.

A distress slab is recorded as one slab if it (a) contains a single corner break, (b) contains more than one break of a particular severity, or (c) 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 light and medium severity corner breaks should be counted as one slab with a medium corner break.

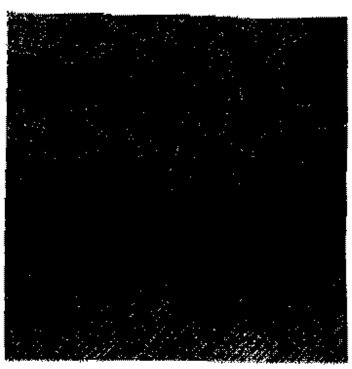
Additional Criteria

1. Lightly cracked means one low severity crack dividing the corner into two pieces.

2. If the corner is faulted 1/8 inch or more, increase severity to next higher level. If the corner is faulted more than 1/2 inch, rate Corner Break at high severity. (If faulting in corner is incidental to faulting in the slab, rate faulting separately.)

2. The angle of crack into the slab is usually not evident at low severity. Unless crack angle can be determined, to differentiate between corner break and corner spall, use the following criteria.

If the crack intersects both joints more than two feet from the corner, it is a corner break. If either intersect point is closer to the corner than two feet, the crack is a corner spall or joint spall.



LOW SEVERITY CORNER BREAKS

Figure 5-100 Figure 5-101

Corner Break at Figure 5-100 is defined by a low severity crack with frayed edges. Sealer is unsatisfactory. Corner Break at Figure 5-101 is defined by a low severity crack with satisfactory sealer. Appearance of the sealer suggests the corner has settled. If measured settlement is 1/8 inch or more, Corner Break is at medium severity.

MEDIUM SEVERITY CORNER BREAK
Figure 5-102

Corner Break at Figure 5-102 is defined by a medium severity crack due to spalling wider than 3 inches with missing pieces.

HIGH SEVERITY CORNER BREAKS
Figure 5-103 Figure 5-104

These corner breaks are severely cracked. Break at Figure 5-104 has also settled.

LONGITUDINAL, TRANSVERSE, AND DIAGONAL CRACKS - DISTRESS NO. 3.

Standard Text.

Description.

These cracks, which divide the slab into two or three pieces, are usually caused by a combination of load repetition, curling stresses, and shrinkage stresses. (For slabs divided into six or more pieces, see shattered/intersecting cracks.) Low severity cracks are usually warping- or friction-related and are not considered major structural distresses. Medium or high severity cracks are usually working cracks and are considered major structural distresses. (Note: Hairline cracks that are only a few feet long and do not extend across the entire slab are rated as shrinkage cracks.)

Severity Levels.

Low severity level (L). (Use crack severity definitions presented above under Cracking Distress page 5-64).

Medium severity level (M). (Use crack severity definitions presented above under Cracking Distress page 5-64, plus the following).

The slab is digtlal tehr hsnaa utaoaf cy low severity cracks.

c. High severity level (H). (Use crack severity definitions presented above under Cracking Distress page 5-64, plus the following).

The slab is divided into three pieces by two or more cracks, one of which is at least of medium severity.

Counting Procedure.

Once the severity has been identified, the distress is recorded as one slab.

Additional Criteria

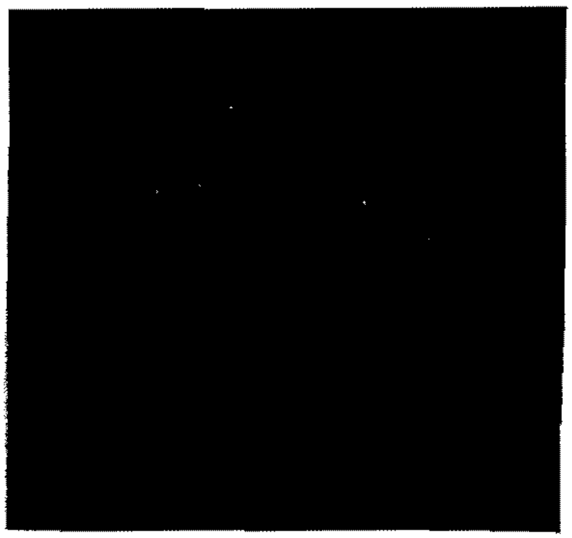
1. Longitudinal, transverse, and diagonal cracking will hereafter be abbreviated as "L/T/D cracking".

2. If the slab is divided into four or more pieces

by L/T/D cracks, refer to "Shattered Slab/Intersecting Cracks" distress type, below.

3. Cracks used to define and rate corner breaks, "D" cracks, patches, shrinkage cracks and spalls are not recorded as L/T/D cracks.

4. Minor spalling (chipping) means the same as little, or lightly. See descriptions under Cracking Distress, page 5-64.



HIGH SEVERITY L/T/D CRACKING
Figure 5-105

Cracks at Figure 5-105 divide the slab into three pieces, and one crack is at medium severity (wider than 1/8 inch). Note that this is <u>not</u> a corner break since the piece in the corner is defined by two distinct cracks. Note, also, that both cracks, and the joint at bottom of picture, are pumping.

DURABILITY ("D") CRACKING - DISTRESS NO. 4.

Standard Text.

Description.

Durability cracking is caused by the concrete's inability to withstand environmental factors such as freeze-thaw cycles. It usually appears as a pattern of cracks running parallel to a joint or linear crack. A dark coloring can usually be seen around the fine durability cracks. This type of cracking may eventually lead to disintegration of the concrete within 1 to 2 ft of the joint or crack.

Severity Levels.

a. Low severity level (L). Pieces are defined by light cracks and cannot be removed.

b. Medium severity level (M). "D" cracks are well defined. Small pieces have been displaced.

c. High severity level (H). "D" cracking has developed over a considerable amount of slab area (greater than approximately one-quarter of the slab area), and the pieces are well defined and can be removed easily.

Counting Procedure.

When the distress is located and rated at one severity, it is counted as one slab. If more than one severity level is found, the slab is counted as having the higher severity distress. For example, if light and medium durability cracking are located on one slab, the slab is counted as having medium only.

Additional Criteria

1. "D" cracking can be outlined by white coloring if leaching is taking place.

2. Except in its very early stages, "D" cracking is easily distinguishable from corner or joint spalling by the multiplicity and pattern of cracks. When in doubt, rate as a spall. At low severity, the deduct values are nearly identical.

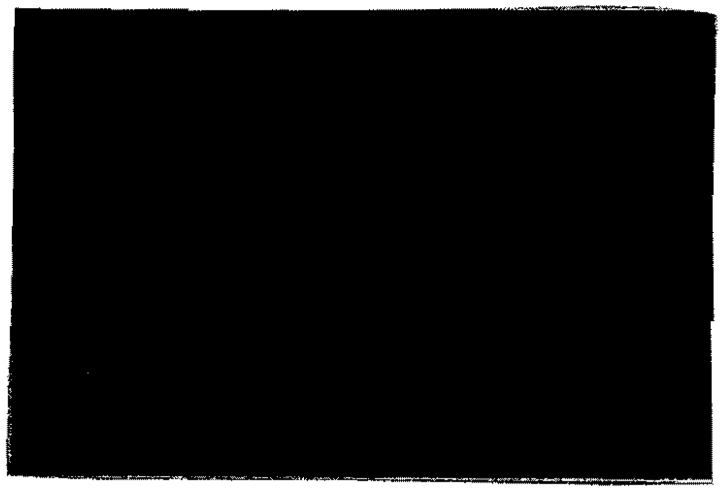
3. The key to a rating of low severity is to recognize the pattern. If pieces are loose or

missing, rate the slab at medium severity except disregard loose and missing pieces within three inches of the corner.

If the identifiable pattern covers 25 percent or more of the slab area and if there are loose or missing pieces, rate the slab at high severity.

If more than five percent of the slab surface is loose or missing, regardless of pattern coverage, rate the slab at high severity.

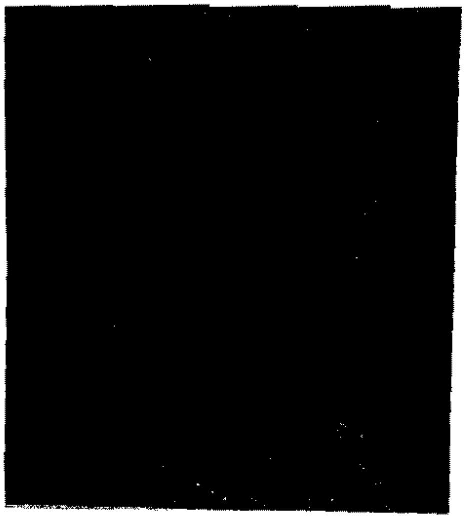
4. "D" cracking is a function of materials deterioration and is, therefore, usually evident for considerable distances in paving lanes or along longitudinal joints where water has ponded through the years.

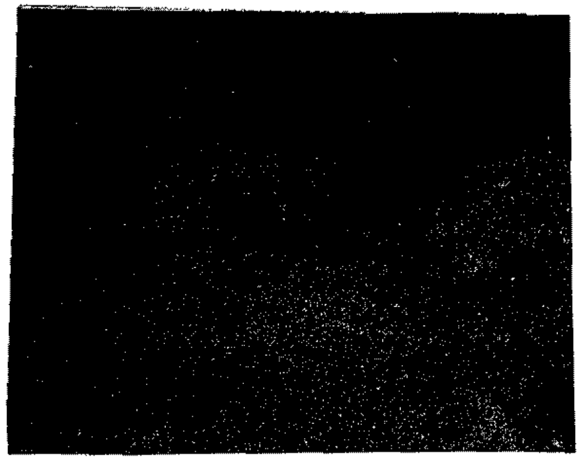


LOW SEVERITY "D" CRACKING

Figure 5-106 Figure 5-107

Figure 5-106 shows earliest stages of "D" cracking. "D" cracking at Figure 5-107 is a well defined pattern at low severity since pieces have not begun to separate from the slab.





LOW SEVERITY "D" CRACKING

Figure 5-1Ø8 Figure 5-1Ø9

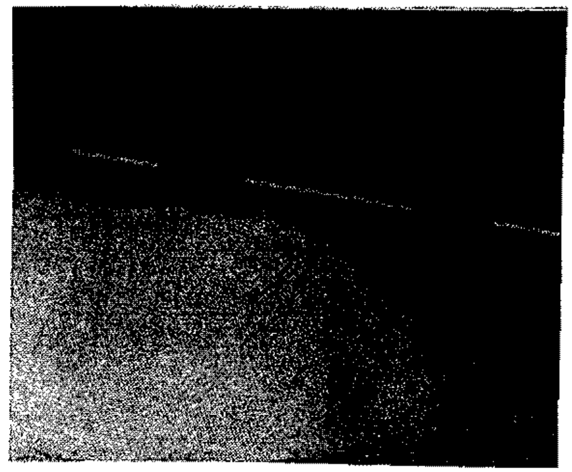
"D" cracking in Figure 5-1Ø8 is at low severity with missing pieces within 3 inches of the joint. Figure 5-1Ø9 shows "D" cracking on wet pavement. (There is a tendency to rate distresses on wet pavement at higher severity.) If closer examination discloses loose or missing pieces, this rating will be at medium severity.

MEDIUM SEVERITY "D" CRACKING

Figure 5-11Ø Figure 5-111

Figure 5-11Ø shows "D" cracking at medium severity in the near slab, and at low severity in the other slabs.

Each slab must be rated independently. Note that size of pattern does not affect rating until pattern covers 25 percent of the slab surface, or until 5 percent of the surface is loose or missing. At Figure 5-111, coverage exceeds 25 percent.



HIGH SEVERITY "D" CRACKING

Figure 5-112 Figure 113

Pattern at Figure 5-112 will cover 25 percent of slab surface if all corners are similar to those shown. Figure 5-113 rates at high severity "D" cracking due to missing pieces. Rate "D" cracking rather than Patch since "D" cracking is the more severe distress.

JOINT SEAL DAMAGE - DISTRESS NO. 5.

Standard Text.

Description.

a. Joint seal damage is any condition which enables soil or rocks to accumulate in the joints or allows significant infiltration of water. 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 accumulation of materials and also prevents water from seeping down and softening the foundation supporting the slab.

b. Typical types of joint seal damage are: stripping of joint sealant, extrusion of joint sealant, weed growth, hardening of the filler (oxidation), loss of bond to the slab edges, and lack or absence of sealant in the joint.

Severity Levels.

a. Low severity level (L). Joint sealer is in generally good condition throughout the section. Sealant is performing well with only a minor amount of any of the above types of damage present.

b. Medium severity level (M). Joint sealer is in generally fair condition over the entire surveyed section with one or more of the above types of damage occurring to a moderate degree. Sealant needs replacement within 2 years.

c. High severity level (H). Joint sealer is in generally poor condition over the entire surveyed section with one or more of the above types of damage occurring to a severe degree. Sealant needs immediate replacement.

Counting Procedure.

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

Additional Criteria

1. Joint sealer is in satisfactory condition if it prevents entry of water into the joint, if it is less than 1/2 inch below the joint edge, it has

some elasticity, and if there is no vegetation growing between the sealer and joint face.

2. Joint seal damage is at low severity if ten percent or more of the sealer has debonded from, but is still in contact with, the joint edge. This condition exists if a knife blade can be inserted between sealer and joint face without resistance.

3. Joint seal damage is at medium severity if ten percent or more of the joint has any of the following conditions.

(a) Joint sealer is in place, but water access is possible through visible openings no more than 1/8 inch wide. Do not rely on appearance in evaluating this condition. If a knife blade cannot be inserted easily between sealer and joint face, this condition does not exist.

(b) Joint sealer is more than 1/2 inch below joint edge but less than one inch.

(c) Pumping stains are evident at the joint.

(d) Joint sealer is oxidized and "lifeless" but pliable (like a rope), and generally fills the joint opening.

(e) Vegetation in the joint is obvious, but does not obscure the joint opening.

4. Joint seal damage is at high severity if ten percent or more of the joint sealer exceeds limiting criteria listed above, or if ten percent or more of sealer is missing.

5. Premolded joint sealer is a compressed rubber or synthetic rectangular strip pressed into the joint by mechanical means. During installation a lubricant is applied to facilitate placement. Premolded sealer adheres to the joint walls by friction. It is not "glued" in place. Premolded sealer is rated using the same criteria as above except as follows.

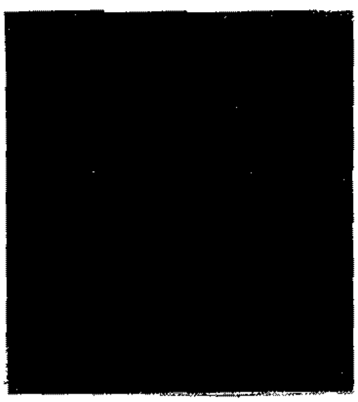
(a) Premolded sealer must be elastic and must be firmly pressed against the joint walls.

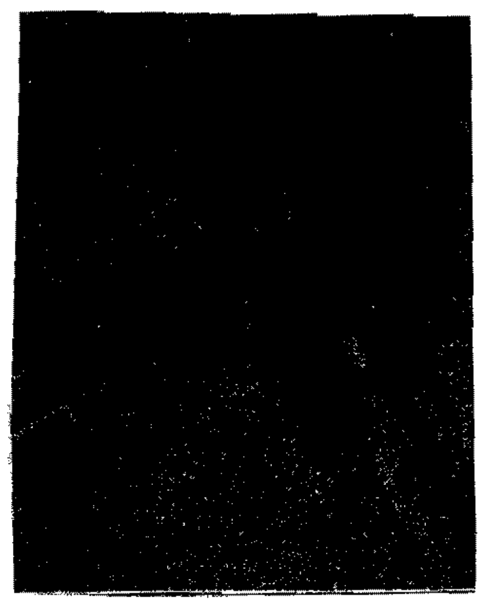
(b) Premolded sealer must be below the joint edge. If it extends above the surface, it can be caught by moving equipment such as snow plows or brooms and be pulled out of the joint. Premolded sealer is recorded at low severity if any part is visible above joint edge. It is at medium severity if ten percent or more of the length is above joint edge or if any part is more than 1/2 inch above joint edge. It is at high severity if 20 percent or more is above joint edge or if any part is more than one inch above joint edge, or if ten percent or more is missing.

6. Rate joint sealer by joint segment. Sample unit rating is the same as the most severe rating held by at least 20 percent of segments rated.

7. Do not rate downstation and right side joints along a sample unit boundary. They belong to adjacent slabs. Rate only the left and upstation joints along Sample Unit boundaries.

8. In rating oxidation, do not rate on appearance. Rate on resilience. Some joint sealer will have a very dull surface, and may even show surface cracks in the oxidized layer. This can be misleading. If the sealer is performing satisfactorily and has good characteristics beneath the surface, it is satisfactory. A pocket knife is essential to joint seal damage evaluation.

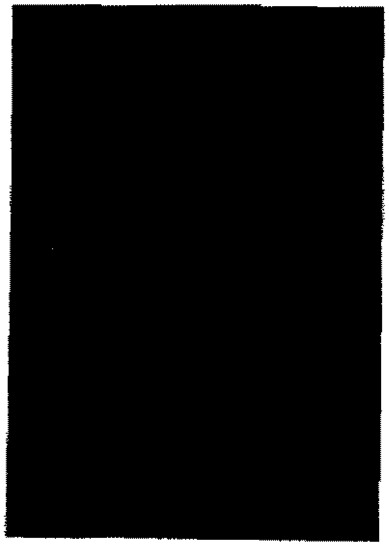


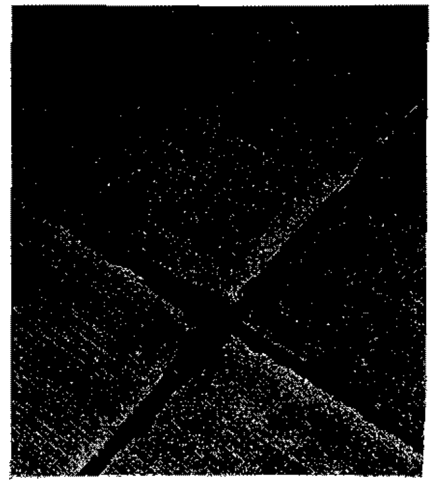


NO DISTRESS

Figure 5-114 Figure 5-115

Joints are not straight and smooth, but sealer is good.

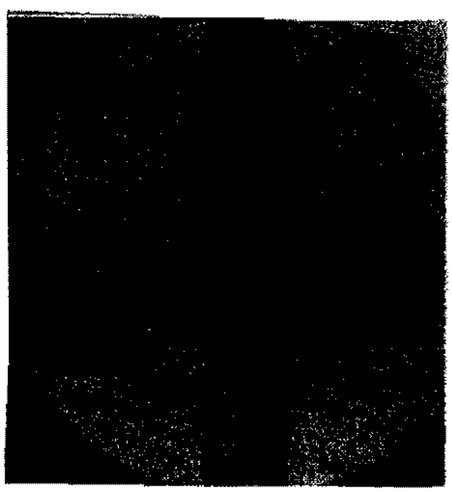


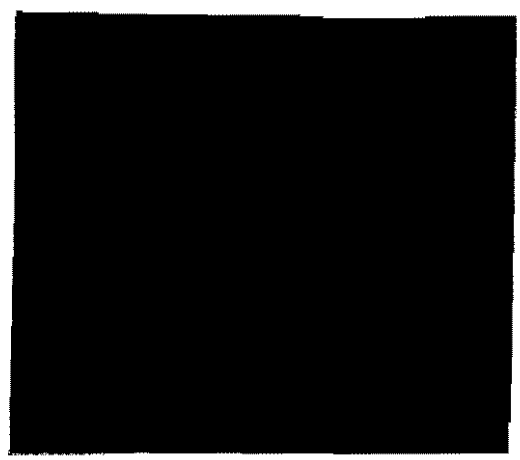


NO DISTRESS

Figure 5-116 Figure 5-117

Sometimes sand and debris must be removed from a joint before sealer can be rated (Figure 5-116). Do not rate debris. In Figure 5-117, sealer looks weathered and cracked, but closer examination with a knife blade reveals excellent material.

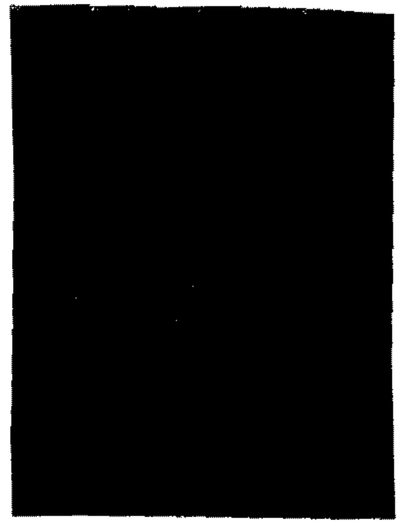




LOW SEVERITY JOINT SEAL DAMAGE

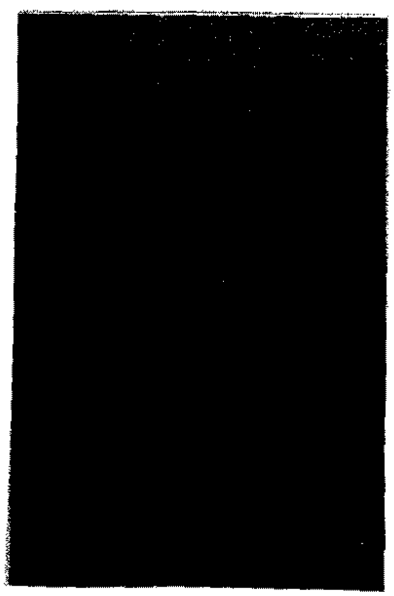
Figure 5-118 Figure 5-119

This sequence illustrates joint sealer at low severity. There is no bond between sealer and joint wall. This condition can only be determined with a knife blade.



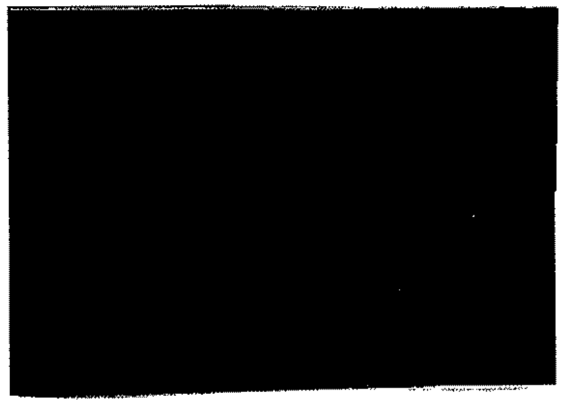
MEDIUM SEVERITY JOINT SEAL DAMAGE
Figure 5-120 Figure 5-121

Joint sealer at Figure 5-120 is visibly separated from the joint wall by less than 1/8 inch. This must be confirmed with a knife blade. Often, sealer will be separated at the top, but bonded to the joint wall beneath. Vegetation at Figure 5-121 causes severity to be medium.



MEDIUM SEVERITY JOINT SEAL DAMAGE
Figure 5-122 Figure 5-123

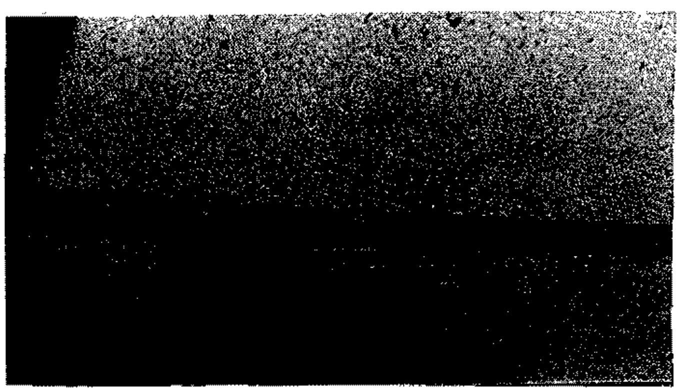
Sealer at Figure 5-122 is bonded to chips, but chips are separated. This condition can be corrected by resealing, but present condition is at medium severity. Figure 5-123 shows old sealer which has lost elasticity and bond. Note that grass clippings do not contribute to the rating.

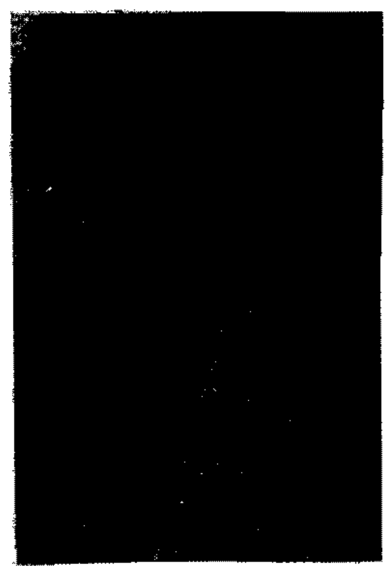


MEDIUM SEVERITY JOINT SEAL DAMAGE

Figure 5-124 Figure 5-125

These figures show expansion joints which have been extruded from the joints by slab expansion. They are tightly sealed as shown, but damage will be evident when joints open during cold weather.

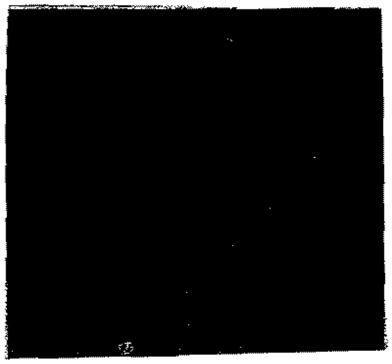




HIGH SEVERITY JOINT SEAL DAMAGE

Figure 5-126 Figure 5-127

In Figure 5-126, sealer is badly deteriorated, and in Figure 5-127, sealer is missing altogether.



HIGH SEVERITY JOINT SEAL DAMAGE
Figure 5-128

The distress at this joint is more complex than sealer. Chipping has destroyed bond at the joint wall. Still, the condition can be corrected by sealing the joint. Therefore, if the condition affects more than 10 percent of the joint segment, it is rated as high severity Joint Seal Damage.

PATCHING, SMALL (LESS THAN 5 SQ FT)- DISTRESS NO. 6

Standard Text.

Description.

A patch is an area where the original pavement has been removed and replaced by a filler material. For condition evaluation, patching is divided into two types: small (less than 5 sq ft) and large (over 5 sq ft). Large patches are described in the next section.

Severity Levels.

a. Low severity level (L). Patch is functioning well with little or no deterioration.

b. Medium severity level (M). Patch has deteriorated and/or moderate spalling can be seen around the edges. Patch material can be dislodged with considerable effort.

c. High severity level (H). Patch has deteriorated, either by spalling around the patch or cracking within the patch, to a state which warrants replacement.

Counting Procedure.

If one or more small patches having the same severity level are located in a slab, it is counted as one slab containing that distress. If more than one severity level occurs, it is counted as one slab with the higher severity level being recorded.

Additional Criteria

1. A patch is actually a separate piece of pavement. Therefore, it is appropriate to rate patch severity using distress types present in the patch pavement. Use Table 5-3 below, to establish a rating for rigid patches.

2. Edges of a patch are rated as L/T/D cracks, whether cracks are visible or not.

3. Patches smaller than ten inches on a side or in diameter are not counted (measure diagonal of corner patch). If a patch smaller than ten inches is in failed condition, record the distress that was corrected by the patch.

4. Patches less than ten inches wide along joints are not recorded.

TABLE 5-3.

Distress Type		Severity	Points
Corner Break	(2)	L	4
		M	7
		H	9
L/T/D Crack	(3)	L	2
		M	6
		H	8
"D" Crack	(4)	L	2
		M	3
		H	6
Scaling, etc.	(1Ø)	L	2
		M	5
		H	9
Settlement	(11)	L	4
		M	6
		H	9
Shattered Slab	(12)	L	6
		M	9
		H	12
Spalling, Joint	(14)	L	1
		M	4
		H	5
Spalling, Corner	(15)	L	2
		M	3
		H	5

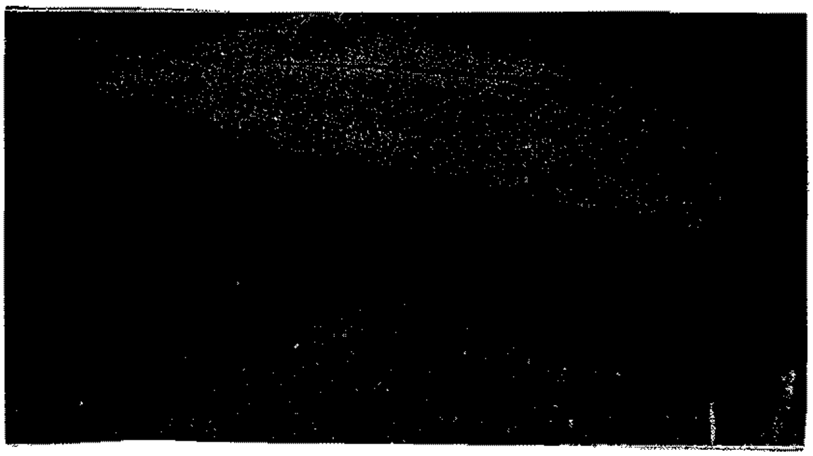
The following comments pertain to rating of patches.

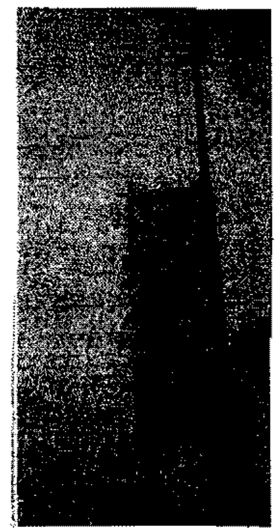
a. Rate patch at low severity if the sum of distress points from Table 5-3 is less than 4; medium severity if the total points are between 4 and 8, inclusive; and high severity if the total points are more than 8.

b. Rate corner break and spalling only at joints. Otherwise, rate as L/T/D cracking and scaling, respectively.

c. Distresses used to rate patches are not used again in rating the slab.

d. Rate each occurrence of a distress in a patch separately and add the points.





NO PATCH

Figure 5-129 Figure 5-130

Patch must replace original material. Figure 5-129 shows a "ramp", or leveling course placed to return a Blowup to serviceable condition. This is not rated as a patch, but should be investigated and rated as a Blowup. Figure 5-130 shows a joint repair less than 10 inches wide. The distress shown is rated as a Joint Spall if, at its widest point, it is more than 3 inches wide.

PATCHING, LARGE (OVER 5 SQ FT) AND UTILITY CUT - DISTRESS NO. 7.

Standard Text.

Description.

Patching is the same as defined in the previous section. A utility cut is a patch that has replaced the original pavement because of placement of underground utilities. The severity levels of a utility cut are the same as those for regular patching.

Severity Levels.

a. Low severity level (L). Patch is functioning well with very little or no deterioration.

b. Medium severity level (M). Patch is deteriorated and/or moderate spalling can be seen around the edges. Patch material can be dislodged with considerable effort.

c. High severity level (H). Patch has deteriorated to a state which causes considerable roughness with loose or easily dislodged material. the extent of the deterioration warrants replacement of the patch.

Counting Procedure.

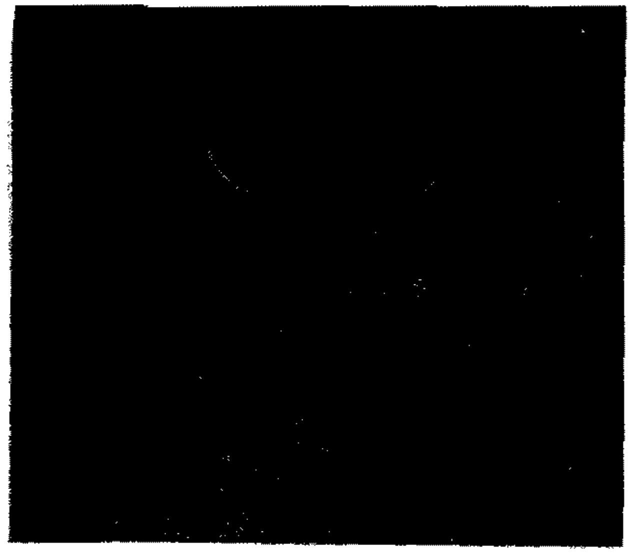
The criteria are the same as for small patches.

Additional Criteria

1. Use criteria prescribed above, and Table 5-3, as for small patches, but use the following rating procedure.

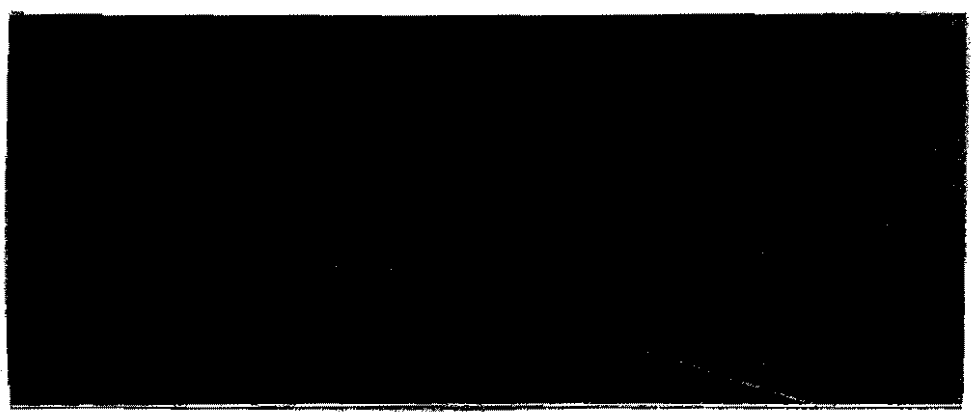
2. Rate patch at low severity if total points accumulated from Table 5-3 are fewer than 7; medium severity if total points are between 7 and 15, inclusive, and high severity if total points are more than 15.

LARGE PATCH
Figure 5-131



NO PATCH
Figure 5-132

Patch at Figure 5-131 is larger than 5 square feet. Since the patch is of asphalt, it must be rated using rating criteria for a flexible patch (Table 5-2). The patches at Figure 5-132 (both rigid and flexible patches are shown) are in a slab with high severity scaling. Since the condition of surrounding pavement is more severe than the patches, rate the surface condition and ignore the patches.



NO DISTRESS
Figure 5-133

Slab replacement is not a patch.

POPOUTS - DISTRESS NO. 8.

Standard Text.

Description.

A popout is a small piece of pavement that breaks loose from the surface due to freeze-thaw action in combination with expansive aggregates. Popouts usually range from approximately 1 to 4 in. in diameter and from 1/2 to 2 in. deep.

Severity Levels.

No degrees of severity are defined for popouts. However, popouts must be extensive before they are counted as a distress; i.e., average popout density must exceed approximately three popouts per square yard over the entire slab area.

Counting Procedure.

The density of the distress must be measured. If there is any doubt about the average being greater than three popouts per square yard, at least three random 1-sq-yd areas should be checked. When the average is greater than this density, the slab is counted.

Additional Criteria

1. Stains from iron-rich aggregate do not identify popouts unless the stones are missing from the surface.

2. Minimum dimensions of a popout, 1 inch diameter and 1/2 inch deep, eliminate most surface voids left by stone loss. This distress type is not common, although voids from stone loss are quite common. Be sure a significant number of voids meeting minimum dimension requirements are present before recording this distress type.

POPOUTS

Figure 5-134

Figure 5-135

Figure 5-134 shows a minimum size void to be called a Popout. Figure 5-135 shows a slab with Popouts.

PUMPING - DISTRESS NO. 9.

Standard Text.

Description.

Pumping is the ejection of material by water through joints or cracks caused by deflection of the slab under passing loads. As water is ejected, it carries particles of gravel, sand, clay, or silt resulting in a progressive loss of pavement support. Surface staining and base or subgrade material on the pavement close to joints or cracks are evidence of pumping. Pumping near joints indicates poor joint sealer and loss of support, which will lead to cracking under repeated loads.

Severity Levels.

No degrees of severity are defined. It is sufficient to indicate that pumping exists.

Counting Procedure.

Slabs are counted as follows: one pumping joint between two slabs is counted as two slabs. However, if the remaining joints around the slab are also pumping, one slab is added per additional pumping joint.

Additional Criteria

1. Do not be fooled by stains caused by ponding water on the low side of a longitudinal joint. Pumping stains will be intermittent along the joint and will usually fade gradually in direction of flow downslope from the joint.

2. Fines and subgrade materials pumped out of the joint are excellent evidence of pumping, but be alert to distinguish these from wind blown debris. Furthermore, subgrade materials may be washed or blown away from the joint. Identify pumping by the tell tale stain. Do not rely on loose material at the joint.

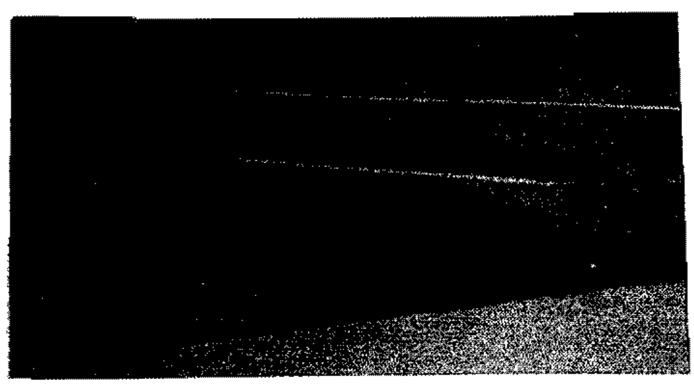
3. A pumping stain may be any color from very dark, caused by subgrade, to brown from base course materials or subgrade, to near white from bleaching of pavement. Dark stain may also be from joint sealant residue. This may be a result of surface water running in a joint and exiting at point of stain. Such a stain is not evidence of pumping.

4. If in doubt rate as a pumping joint.

5. Pumping can occur at cracks as well as joints.

NO DISTRESS
Figure 5-136

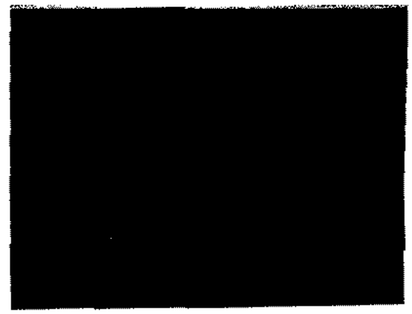
At first glance, stains at Figure 5-136 seem to be classic Pumping stains. On closer examination, however, it is clear that stains are from ponding water on slabs that have warped, or curled, at joints. Gradient of pavement is down toward top of picture.



PUMPING

Figure 5-137 Figure 5-138

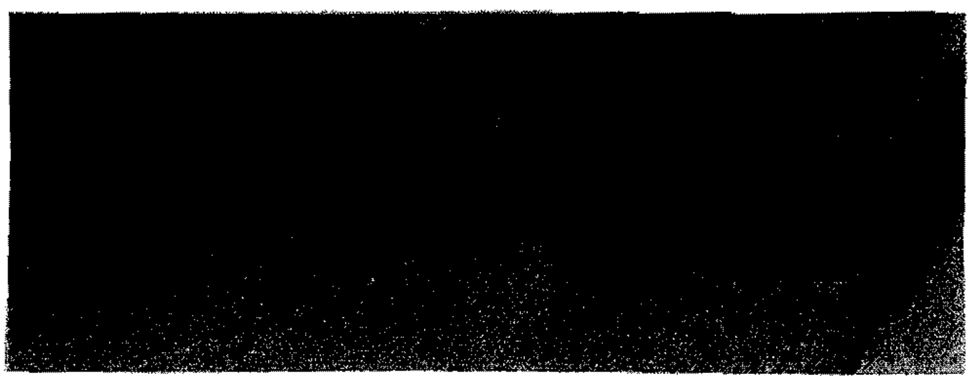
Both figures show classic flow patterns diminishing away from the joints.



PUMPING

Figure 5-139 Figure 5-140

Stain at Figure 5-139 could be from ponding water except that gradient is clearly to shoulder. Figure 5-140 shows a classic Pumping stain.



PUMPING
Figure 5-141

Stain in Figure 5-141 is from joint sealer. Gradient is critical here. If this is the low point of a vertical curve, stains may be from water running in the joint and being forced out at the bottom of the curve. Otherwise, this is Pumping.

SCALING, MAP CRACKING, AND CRAZING -DISTRESS NO. 10

Standard Text.

Description.

Map cracking or crazing refers to a network of shallow, fine, or hairline cracks that 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 over finishing the concrete and may lead to scaling of the surface, which is the breakdown of the slab surface to a depth of approximately 1/4 to 1/2 in. Scaling may also be caused by deicing salts, improper construction, freeze-thaw cycles, and poor aggregate. Another recognized source of distress is the reaction between the alkalies ($Na2O$ and $K2O$) in some cements and certain minerals in some aggregates. Products formed by the reaction between the alkalies and aggregate result in expansions that cause a breakdown in the concrete. This generally occurs throughout the slab and not just at joints where "D" cracking normally occurs.

Severity Levels.

a. Low severity level (L). Crazing or map cracking exists over most of the slab area. the surface is in good condition with no scaling. Note: The low severity level is an indicator that scaling may develop in the future.

b. Medium severity level (M). Slab is scaled over approximately 5 percent or less of the surface with some loose or missing material.

c. High severity level (H). Slab is severely scaled with a large amount of loose or missing material. Usually, more than 5 percent of the surface is affected.

Counting Procedure.

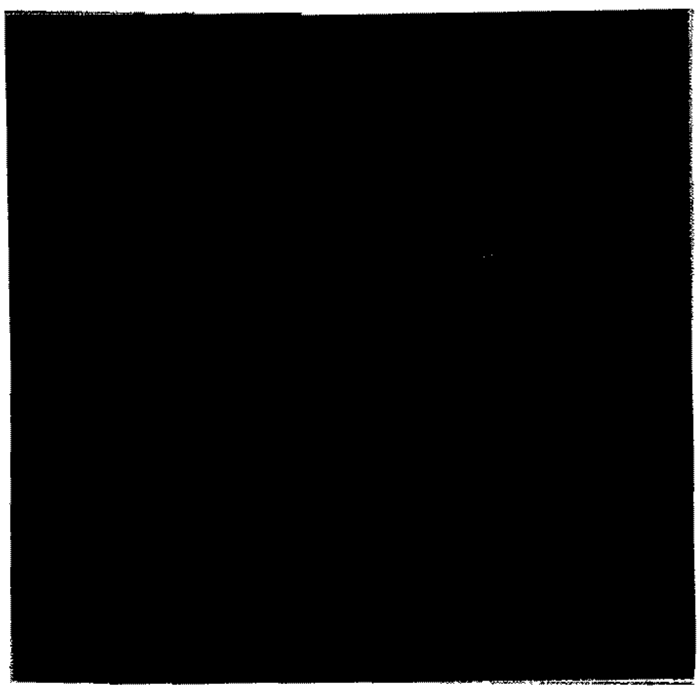
If two or more levels of severity exist on a slab, the slab is counted as one slab having the maximum level of severity. For example, if both low severity crazing and medium scaling exist on one slab, the slab is counted as one slab containing medium scaling.

Additional Criteria

1. Low severity is defined by map cracking/crazing. The crack pattern must be well defined and easily recognized. Individual cracks should show some evidence of wear. Very early stages are ignored. The crack pattern must be evident over more than 50 percent of slab surface.

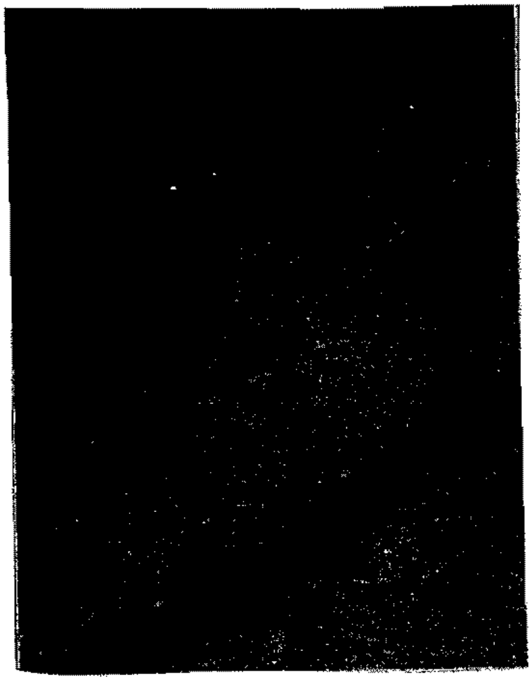
2. Medium and high severity are rated by scaling. Medium severity means surface disintegration (scaling) is evident over five percent or less of the slab. A rating of high severity requires that more than five percent of the slab surface be loose or missing.

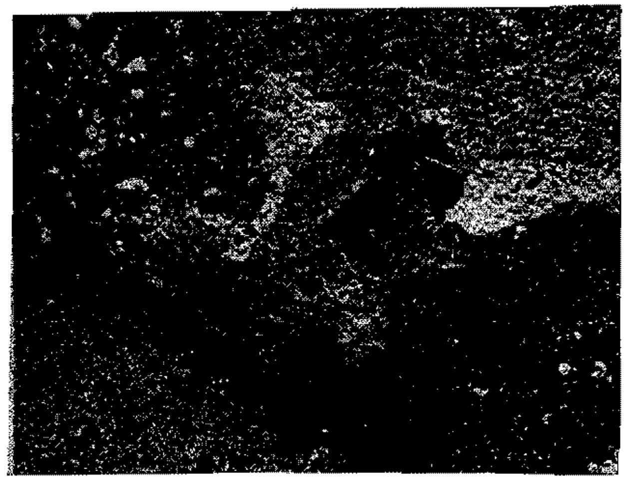
3. Sun angle and moisture can change the appearance of map cracks significantly. Use caution when recording map cracking on wet pavement surfaces.



MAP CRACKING
Figure 5-142

Cracks are well defined. No scaling has occurred. This is recorded as low severity distress.

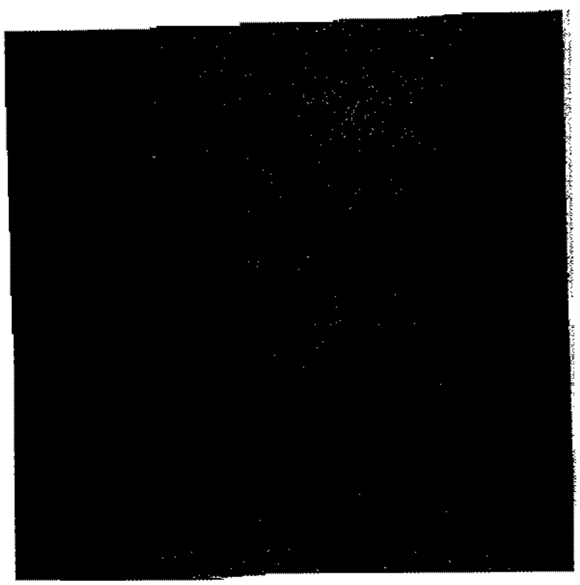




SCALING

Figure 5-143 Figure 5-144

Loss of surface material represented by Scaling.



HIGH SEVERITY SCALING

Figure 5-145 Figure 5-146

In Figure 5-146, map cracking is visible in the background with scaling at the near corner. Scaling and "D" cracking can have similar appearance. Look for a pattern at lower severity elsewhere in the pavement.

SETTLEMENT OR FAULTING - DISTRESS NO. 11.

Standard Text.

Description.

Settlement or faulting is a difference of elevation at a joint or crack caused by upheaval or consolidation.

Severity Levels.

Severity levels are defined by the difference in elevation across the fault and the associated decrease in ride quality and safety as severity increases.

Difference in Elevation

	Runways/Taxiways	Aprons
L	< 1/4 in.	1/8 < 1/2 in.
M	1/4 - 1/2 in.	1/2 - 1 in.
H	> 1/2 in.	> 1 in.

Counting Procedure.

In counting settlement, a fault between two slabs is counted as one slab. A straightedge or level should be used to aid in measuring the difference in elevation between the two slabs.

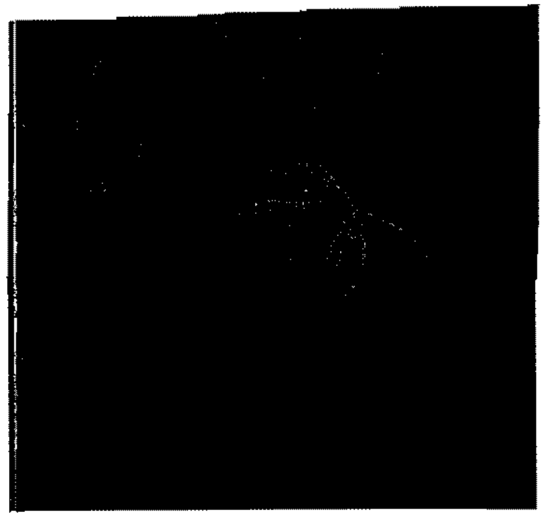
Additional Criteria

1. Construction induced elevation differential is not rated in PCI procedures.

2. Construction differential can only occur at a construction joint. Where construction differential exists, it can often be identified by the way the high side of the joint was rolled down by finishers (usually within 6 inches of the joint) to meet the low slab elevation. Construction differential is quite common at longitudinal joints between paving lanes.

3. If the slab which moved (up or down) can be identified by relative position of surrounding

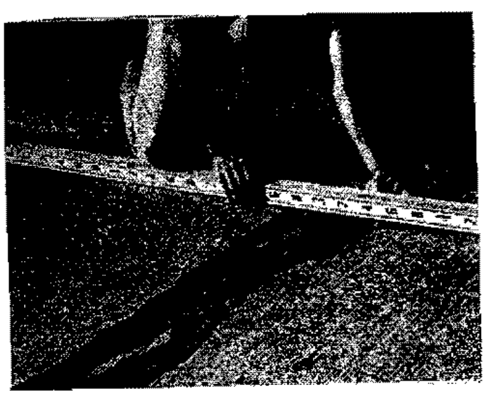
slabs, rate the slab that moved. If positive determination cannot be made, rate the low slab.



NO DISTRESS

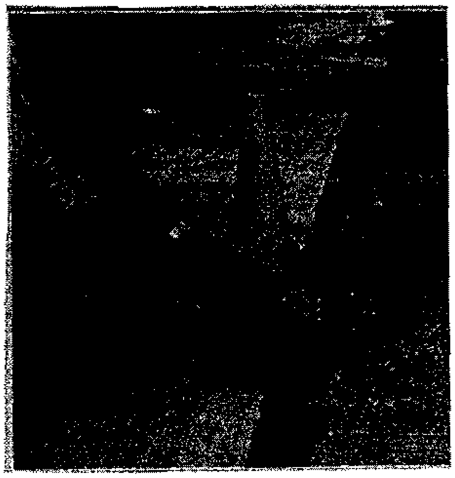
Figure 5-147 Figure 5-148

Construction induced differential elevations do not represent vertical slab movement.



SETTLEMENT OR FAULTING

Figure 5-149 Figure 5-150



SETTLEMENT OR FAULTING

Figure 5-151 Figure 5-152

Measurement may be made with a clipboard straightedge. Settlement or Faulting are often emphasized by sealer or asphalt "skin patch" on the low side. Measurement must be from surface of one slab to surface of the other.

SHATTERED SLAB/INTERSECTING CRACKS- DISTRESS NO. 12

Standard Text.

Description.

Intersecting cracks are cracks that break the slab into four or more pieces due to overloading and/or inadequate support. The high severity level of this distress type, as defined below, is referred to as shattered slab. If all pieces or cracks are contained within a corner break, the distress is categorized as a severe corner break.

Severity Levels.

a. Low severity level (L). Slab is broken into four or five pieces with some or all cracks of low severity.

b. Medium severity level (M).

(1) Slab is broken into four or five pieces with some or all cracks of medium severity.
(2) Slab is broken into six or more pieces with all cracks of low severity.

c. High severity level (H). At this level of severity, the slab is called shattered.

(1) Slab is broken into four or five pieces with some or all cracks of high severity.

(2) Slab is broken into six or more pieces with some or all cracks of medium or high severity.

Counting Procedure.

If a slab is rated as medium or high severity level shattered slab, then no other distress type should be counted in the slab. The deduct values for shattered slab distress are high since this condition is essentially failure; therefore, the counting of other distress types in the slab would tend to underrate the PCI of the sample unit.

Additional Criteria

1. The title of this distress type tends to create confusion. We use the term "segmented slab" to

define slabs rated at low and medium severity. A segmented slab is not a shattered slab.

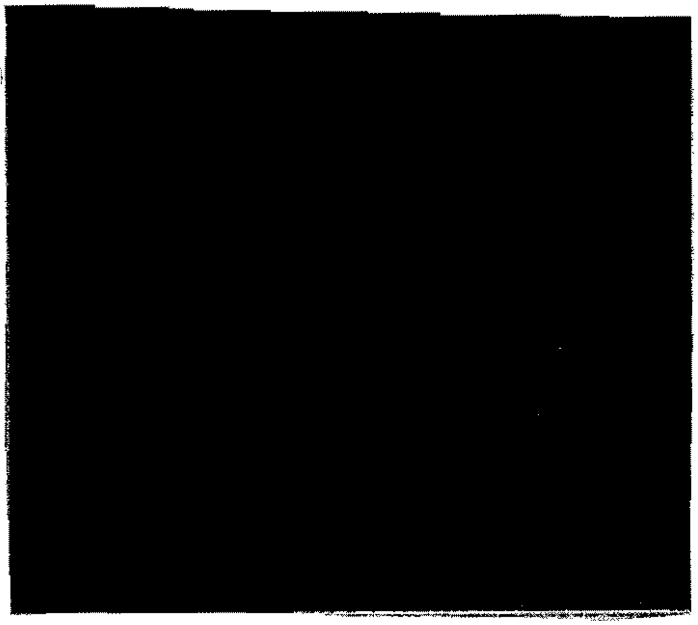
2. To be rated at low severity, all defining cracks must be at low severity.

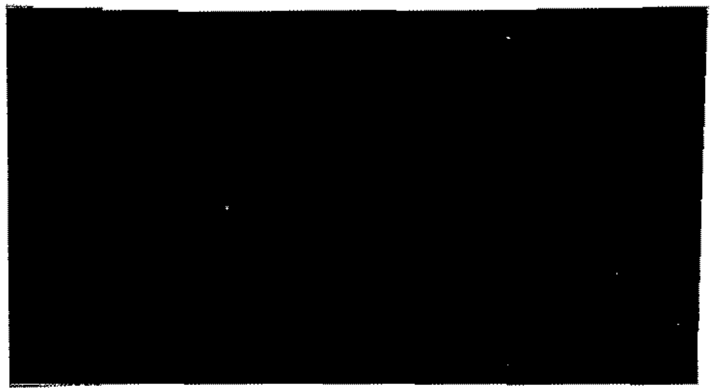
3. Cracks must separate the pavement into segments. Count only L/T/D cracks. Corner breaks do not identify a segment for evaluating this distress type.

5. If a segmented slab is rated at medium severity, no other distress types on that slab are recorded.

LOW SEVERITY SEGMENTED SLAB
Figure 5-153

Slab is divided into 5 pieces by low severity cracks. (Pieces smaller than one foot wide are not counted.)

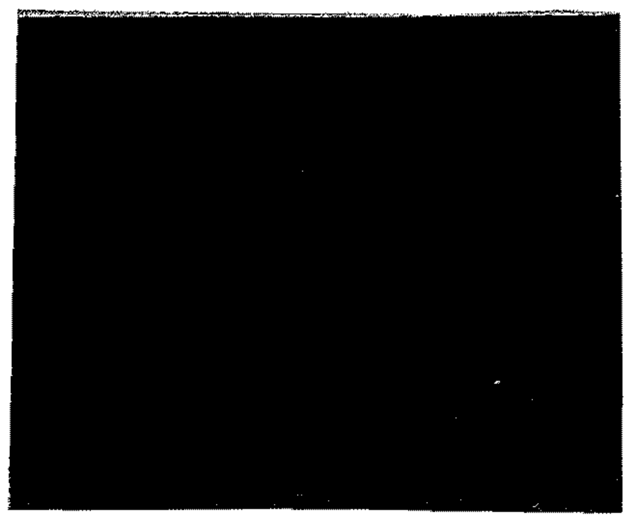




MEDIUM SEVERITY SEGMENTED SLAB

Figure 5-154 Figure 5-155

Slab at Figure 5-154 is divided into 4 pieces (one crack has been graphically enhanced), but one crack is at medium severity (wider than 1/8 inch.) Figure 5-155 shows defining cracks at medium severity.



SHATTERED SLAB

Figure 5-156 Figure 5-157

Slab in Figure 5-156 has more than 6 pieces. Slab in Figure 5-157 is divided by high severity cracks.

SHRINKAGE CRACKS - DISTRESS NO. 13.

Standard Text.

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 sufficient to indicate that shrinkage cracks exist.

Counting Procedure.

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

Additional Criteria

1. The single criterion for identification of a shrinkage crack is that it does not extend full width of a slab. A crack that intersects two joints of a slab is a corner break, L/T/D crack or spall.

2. Shrinkage cracks are formed at time of construction and will therefore be weathered and covered by any debris or stains on the surface. Shrinkage cracks do not have internal movement and, therefore, will not "cut" through a stain or rubber mark from a tire. Fresh new cracks and working cracks are not shrinkage cracks.

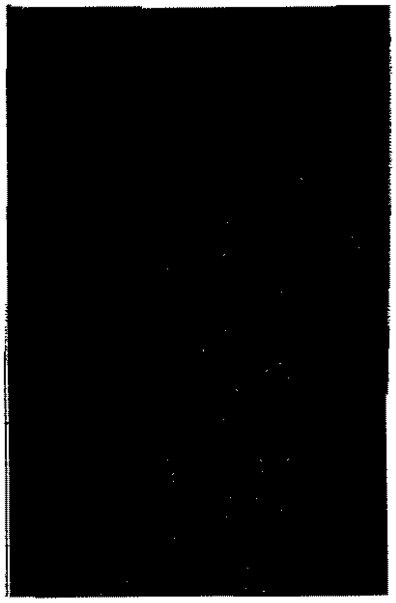


Figure 5-158

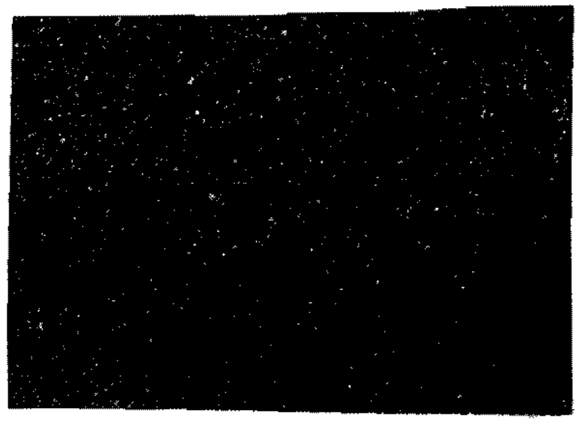


Figure 5-159

Figure 5-160
SHRINKAGE CRACKS

The above figures present typical examples of Shrinkage Cracks.

SPALLING (TRANSVERSE AND LONGITUDINAL JOINT) - DISTRESS NO. 14.

Standard Text.

Description.

Joint spalling is the breakdown of the slab edges within 2 ft of the side of the joint. A joint spall usually does not extend vertically through the slab but intersects the joint at an angle. Spalling results from excessive stresses at the joint or crack caused by infiltration of incompressible materials or traffic load. Weak concrete at the joint (caused by overworking) combined with traffic loads is another cause of spalling.

Severity Levels.

a. Low severity level (L).

(1) Spall over 2 ft long:

(a) Spall is broken into no more than three pieces defined by low or medium severity cracks.

(b) Joint is lightly frayed either with little, if any, loose or missing material.

(2) Spall less than 2 ft long is broken into pieces or fragmented with little loose or missing material or tire damage potential.

b. Medium severity level (M).

(1) Spall over 2 ft long:

(a) Spall is broken into more than three pieces defined by light or medium cracks.

(b) Spall is broken into no more than three pieces with one or more of the cracks being severe with some loose or missing material.

(c) Joint is moderately frayed with some loose or missing material.

(2) Spall less than 2 ft long is broken into pieces or fragmented with some of the pieces

loose or absent with some tire damage potential.

c. High severity level (H).

Spall over 2 ft long:

(1) Spall is broken into more than three pieces defined by one or more high severity cracks with high possibility of the pieces becoming dislodged.

(2) Joint is severely frayed with a large amount of loose or missing particles.

Note: If less than 2 ft of the joint is lightly frayed, the spall should not be counted.

Counting Procedure.

If the joint spall is located along the edge of one slab, it is counted as one slab with joint spalling. If spalling is located 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.

Additional Criteria

1. AC 150/5380-6 presents conflicting information related to low severity joint spalls. The definitions and photographs associated with the description at page B-85 and B-86 of AC 150/5380-6 seem clear, but specific action for this condition given at Table B-1, page B-3, suggests otherwise. We have given precedence to Table B-1.

Minor fraying or spalling of a joint edge does not reduce serviceability of pavement any more than a filled core hole, single popout or surface texture blemish. The examples given in photographs Figure B-129 and B-130 on page B-86 show joint spalling and joint fraying that can be filled during a joint seal repair and should not be recorded.

2. Any frayed edge or chip within three inches of a joint, measured from the opposite joint edge, should not be recorded.

3. Lightly frayed refers to a process where individual stones and particles are dislodged and worn

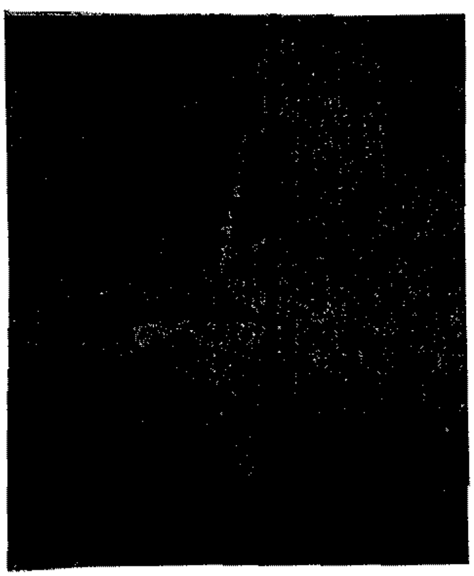
away by traffic as opposed to a chunk of pavement being broken away. Lightly frayed joints are less than 3 inches wide measuring from opposite joint edge as described above. A moderately frayed joint exceeds three inches from opposite joint edge. A severely frayed joint edge exceeds six inches from opposite joint edge. Moderate and severe frayed edges normally result from spalls from which all material is missing.

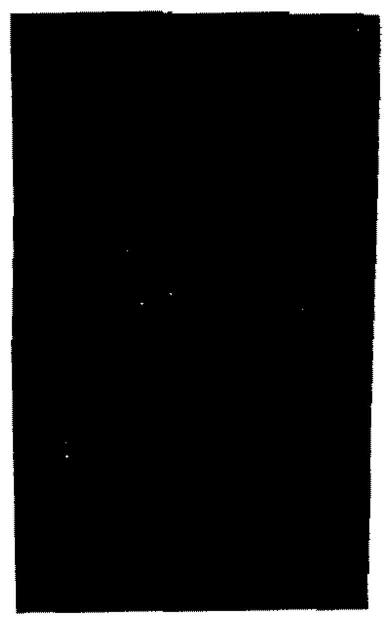
4. Normally, both ends of the boundary crack of a joint spall will intersect the same joint. However it is possible for a joint spall to terminate at a slab corner. The following criteria are used to identify joint spalls terminating at slab corners. All three conditions are necessary.

a. The spall length is at least five times greater than the spall width.

b. The spall width is less than one foot.

c. The spall length is greater than two feet.



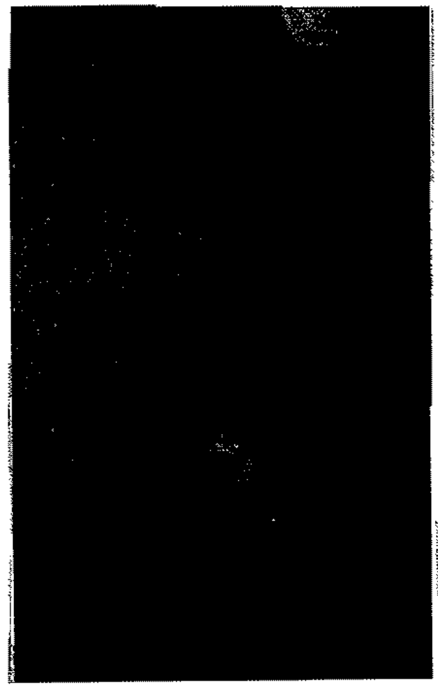


NO DISTRESS

Figure 5-161

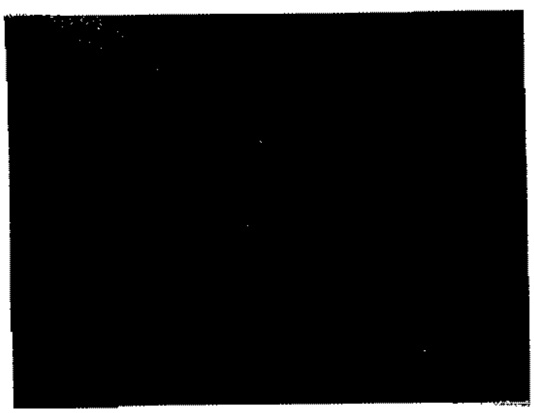
Figure 5-162

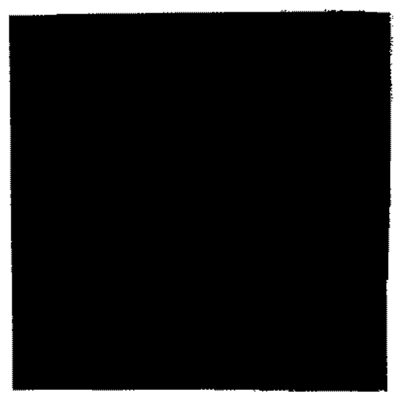
Spalls presented in Figures 5-161 and 5-162 are less than 3 inches wide.



LOW SEVERITY JOINT SPALLS

Figure 5-163 Figure 5-164



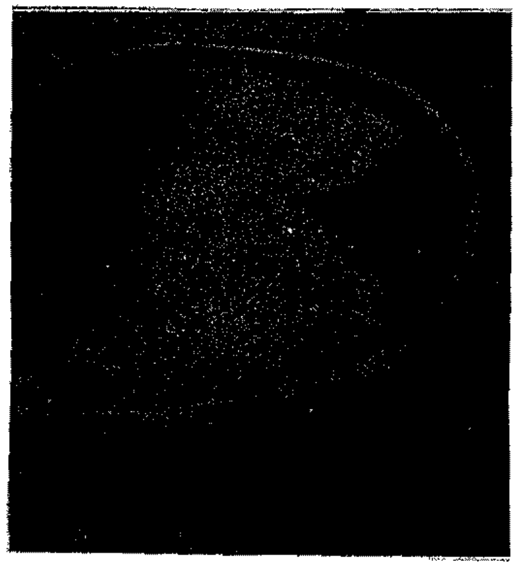


LOW SEVERITY JOINT SPALLS

Figure 5-165 Figure 5-166

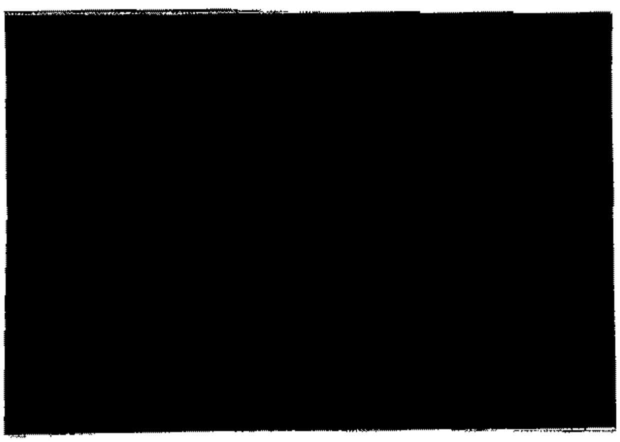
The crack defining the spall at Figure 5-165 has not yet connected to the joint, but tapping on the area between the crack and the joint gives a hollow sound indicative of failure. Spall at Figure 5-166 is less than 2 feet long and presents no tire damage potential.

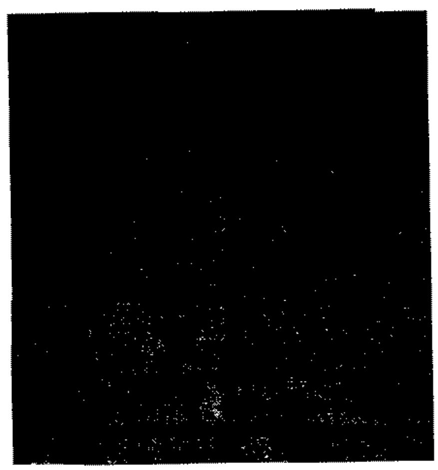
MEDIUM SEVERITY
JOINT SPALL
Figure 5-167



HIGH SEVERITY
JOINT SPALL
Figure 5-168

Spall at Figure 5-167 is longer than 2 feet, defined by a high severity crack. Although the crack has not connected to the joint, the space between has failed.





JOINT SPALLS AT SLAB CORNER
Figure 5-169 Figure 5-170

These spalls meet special criteria at page 5-112 for joint spalls which intersect slab corners.

SPALLING (CORNER) - DISTRESS NO. 15.

Standard Text.

Description.

Corner spalling is the raveling or breakdown of the slab within approximately 2 ft 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.

Severity Levels.

a. Low severity level (L). One of the following conditions exists:

(1) Spall is broken into one or two pieces defined by low severity cracks. Pieces are not easily dislodged.

(2) Spall is defined by one medium severity crack with the material secured in place.

b. Medium severity level (M). One of the following conditions exists:

(1) Spall is broken into two or more pieces defined by medium severity crack(s), and a few small fragments may be absent or loose.

(2) Spall is defined by one severe, fragmented crack that may be accompanied by a few hairline cracks.

(3) Spall has deteriorated to the point where loose material exists.

c. High severity level (H). One of the following conditions exists:

(1) Spall is broken into two or more pieces defined by high severity fragmented crack(s) with loose or absent fragments.

(2) Pieces of the spall have been displaced to the extent that a tire damage hazard exists.

Counting Procedure.

If one or more corner spalls having the same severity level are located 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 having the higher severity level.

Additional Criteria

1. A corner spall smaller than three inches wide, measured from the opposite joint edge, is not recorded. Otherwise, the size of a spall is not a factor in rating severity.

2. The ends of the boundary crack of a corner spall must intersect at perpendicular joints which form a corner of the slab.

3. Loose and missing materials within three inches of a joint, measured from the opposite joint edge, are ignored when rating a spall.

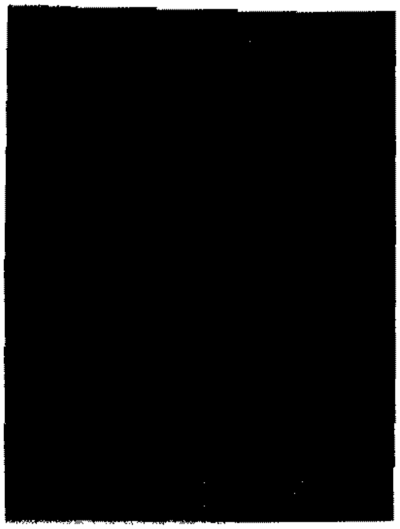
4. In rating, there is no distinction between loose and missing material in a spall. Pieces which cannot be easily dislodged are not loose pieces.

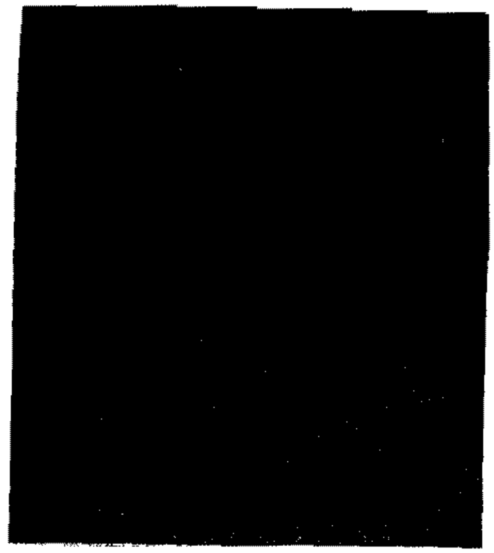
5. A fragmented crack is actually two or more cracks in close proximity which meet below the surface forming a single channel to subbase. The multiple cracks are interconnected to form small fragments, or pieces, of pavement.

6. If more than ten percent of the spalled surface is loose or missing, excluding loose areas within three inches of a joint measured from the opposite joint face, the spall is rated at high severity.

NO DISTRESS
Figure 5-171

Distress is less than 3 inches wide.

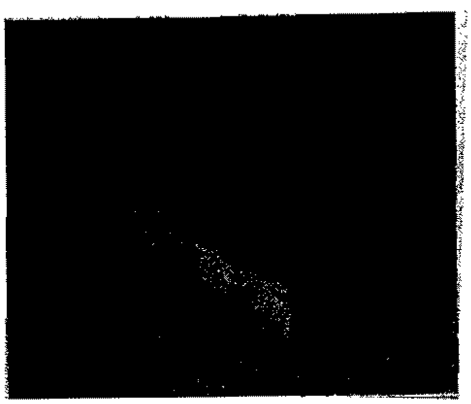




LOW SEVERITY CORNER SPALLS

Figure 5-172 Figure 5-173

Loose pieces in the spall at Figure 5-173 are all contained within 3 inches of the corner.



MEDIUM SEVERITY CORNER SPALLS

Figure 5-174 Figure 5-175

CHAPTER 6

DRAINAGE CONDITION INDEX PROCEDURES

CONCEPT

Drainage Condition Index (DCI) is an indicator of the impact uncontrolled moisture has on pavement condition. Parameters are chosen to indicate drainage conditions according to their impact on pavement serviceability. Each parameter is defined, and measuring procedures are described, so that consistent results are possible during field inspection.

The DCI technology described here has been developed to closely parallel Pavement Condition Index (PCI) technology. Selected pavement sample units are examined, and pavement features are rated, using identical layout procedures prescribed for PCI. Drainage condition indicies range from 100 to 0, and are calculated by deducting points from 100 for drainage condition indicators according to impact and severity.

Drainage Condition Indicators are easily identified, and can be readily measured and rated. Deduct values are calculated for each indicator by severity and according to impact on pavement condition.

Since DCI will be implemented in conjunction with (PCI), the DCI technology was developed so that data may be collected simultaneously during a PCI survey. PCI distress conditions caused, or aggravated, by poor drainage are used as DCI condition indicators. Several additional parameters are defined to assure comprehensive representation of drainage conditions, but expensive and time consuming techniques, such as coring, laboratory testing and elaborate analytical computer models are not used in the data collection and rating process.

INDICATORS

DRAINAGE PARAMETERS

The following drainage parameters are measured and rated to establish a Drainage Condition Index for airport pavement systems.

SLOPE TO SHOULDER (INLET). - DISTRESS NO. D1.

Description.

Gradient on pavement to expedite runoff is largely a matter of safety and appearance. The affect of standing water on pavement serviceability is minimal. However, the amount of water that can infiltrate to subgrade from cracks in the surface is increased as rate of runoff decreases.

Transverse slope on a runway or taxiway, and slope to edge or drainage structure on an apron, establish the rate at which water can run off the pavement surface. A good rate of runoff is desirable to minimize the time of exposure of the pavement structure to infiltration.

Severity Levels.

a. Low Severity Level (L). Slope is less than one percent but more than one half percent.

b. Medium Severity Level (M). Slope is one half percent or less but more than flat.

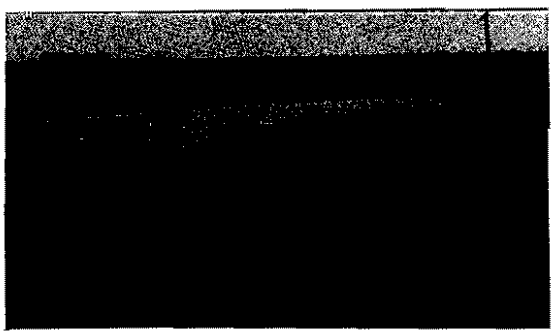
c. High severity Level (H). Slope is flat or negative (ponding is evident).

Measuring Procedure.

One measurement is made for each 2000 square feet of sample unit area. Measurements are made along a ten foot horizontal distance. Points of measurement are selected within a sample unit to represent typical, or average, slope conditions. On taxiways and runways, at least one measurement is made each side of centerline. On aprons, at least one measurement is made in each quadrant approaching a drainage structure and one measurement is made toward each pavement edge. The average of measurements in a sample unit is used to establish severity level. Measurements are made to the nearest 0.1 percent.

Slope Measurement on Pavement
Figure 6-1

Slope measurements are used to establish severity unless ponding water, or ponding stains, are evident to the inspector. Evidence of ponding water on less than one quarter of the surface results in a minimum rating of medium severity (slope measurements are recorded). Evidence of ponding water over one quarter or more of the surface results in a rating of high severity (slope measurements need not be made).



Ponding Water
Figure 6-2

SHOULDER SLOPE. - DISTRESS NO. D2.

<u>Description.</u>

Shoulder slope away from pavement edge is important to assure that surface runoff water is transported away from the pavement substructure. If shoulders are flat, or if reverse slope exists, water will soak into and saturate shoulder soil, limiting potential for subsurface moisture to drain away from the structure, ultimately softening subgrade and reducing load capacity of the pavement.

Severity Levels.

a. Low Severity Level (L). Slope is less than three percent but more than one and one half percent.

b. Medium Severity Level (M). Slope is one and one half percent or less but more than flat.

c. High Severity Level (H). Slope is flat or negative.

Measuring Procedure.

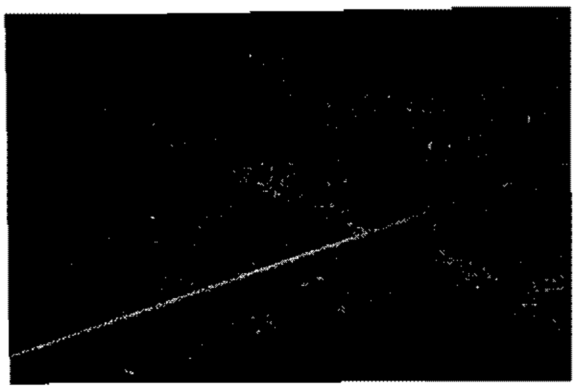
Slope is measured from ground level at pavement edge to a point ten feet from pavement edge. Measurements are made along a ten foot horizontal distance. Where the shoulder is uneven on the line of measurement, the mean slope in the ten foot distance is recorded. Care must be used to establish ground level at pavement edge. Buildups of dead grass or loose sand should be cleared away before measurements are taken. These parameters, and washouts adjacent to pavement, are accounted for in the following distress, "Shoulder Condition". Measurements are made to the nearest Ø.5 percent.

Measuring Shoulder Slope
Figure 6-3

SHOULDER CONDITION. - DISTRESS NO. D3.

Description.

Shoulder condition at edge of pavement is an important drainage parameter. Turf and incompressibles washed from the surface may build up over time to create an effective "dam" against runoff. On the other hand, if runoff water has eroded the shoulder at pavement edge, a trench may be formed which catches and funnels water into the subgrade. In either case, water will be trapped and will gradually infiltrate into the subgrade and reduce bearing capacity of the pavement.



Shoulder Condition

Built up Edge
Figure 6-4

Damaged Shoulder
Figure 6-5

Severity Levels.

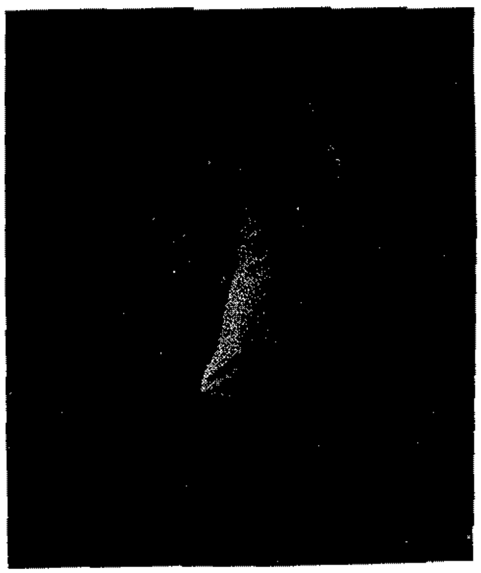
a. Low Severity Level (L). Shoulder within one foot of pavement edge generally permits unrestricted runoff with exception of dam or trench capable of holding ponded water along no more than ten percent of its length.

b. Medium Severity Level (M). Shoulder within one foot of pavement edge is dammed or trenched sufficiently to hold ponded water over more than ten percent but less than 50 percent of its length.

c. High Severity Level (H). Shoulder within one foot of pavement edge is dammed or trenched sufficiently to hold ponded water over more than 50 per cent of its length.

Measuring Procedure.

Grass stems and loose sand at pavement edge do not restrict runoff unless they become mixed with soil (mud) or other impervious materials to form a dam. A trench is evidenced by flat or negative slope within one foot of pavement edge. Unrepaired tire ruts in shoulder within one foot of pavement edge are measured to establish severity. Tightly woven turf (grass root mass at pavement edge) will hold ponded water and is measured to establish severity. An effective technique for determining degree of shoulder "damming" is to walk along the pavement edge. Damming is indicated if ankles tend to rotate toward the pavement side.



Shoulder Condition Measuring Technique
Figure 6-6

INLET CONDITION

Description.

Inlets and catch basins are normally found in large expanses of pavement as at aprons. They are designed to remove surface water from the paved surface more expeditiously than runoff to shoulders will allow. Any condition which prevents an inlet from accepting runoff from the pavement is a distress. Distress can range from joint seal damage around the inlet, to lifting or settlement of the structure relative to surrounding pavement, to debris in grates and catch basins, to sludge in catch basins, to physical deterioration of inlet grates, structure or associated storm drains. Severity of inlet distress is related to degree of flow restriction (Flow Rate - Distress No. D4) and condition of structure (Structural - Distress No. D5).

Measuring Procedure.

Only inlets constructed in, or within ten feet of, rated pavement are rated. Rate all inlets in rated pavement. Include trench-type as well as box inlets.

Flow Rate - DISTRESS NO. D4.

Severity Levels.

Low Severity Level (L). Distress is limited to condition(s) correctable by staff maintenance, such as debris in grates or catch basins. Low and medium severity joint seal damage at perimeter of structure constitutes low severity inlet flow distress. Structural faulting or settlement of one quarter inch or less is a low severity distress.

Medium Severity Level (M). High severity perimeter joint seal damage constitutes medium severity distress. Structural faulting or settlement greater than one quarter inch but less than one inch is rated at medium severity. Sludge at bottom of catch basin less than one forth the depth of the smallest diameter connecting storm drain constitutes medium severity distress. (Mud or sludge at or below flow line of the lowest outlet is not considered in rating inlets).

High Severity Level (H). Examples of high severity distress include: (1) Sludge in bottom of catch basin (not debris induced) deeper than one quarter of the depth of the smallest diameter connecting storm drain. (2) Structural faulting or settlement of one inch or greater.

Structural - DISTRESS NO. D5.

Severity Levels.

Low Severity Level (L). Inlet and structure are generally serviceable. Distress is limited to condition(s) correctable by staff maintenance, such as tuck pointing masonry and grouting small cracks in structure walls. Cracks in catch basin walls or floor one eighth inch wide or less with no faulting at cracks constitutes low severity distress. Mortar damage in block walls is a low severity distress if blocks are securely in place.

Medium Severity Level (M). Distress is correctable without major structural rehabilitation, such as a broken inlet grate or cracked and faulted structure slabs. Cracked catch basin walls or floor less than one half inch wide with faulting less than one half inch constitutes medium severity distress. Mortar damage in masonry walls resulting in voids between blocks, with some blocks loose but not broken or displaced is a medium severity distress. Any movement of inlet casting under body weight of the inspector constitutels medium severity distress.

High Severity Level (H). Correction of distress requires major structural rehabilitation. Examples of high severity distress include: (1) Shattered structure slab with missing pieces and faulting of one inch or more; (2) Shattered walls or floor of catch basins with multiple cracks of one half inch or more and faulting at cracks of one half inch or more; (3) Missing pieces from walls or floor exposing reinforcing steel and mesh; (4) Broken or displaced masonry blocks in the structure.

PCI DISTRESS PARAMETERS

Several distress types used for rating PCI contribute to uncontrolled moisture conditions in the pavement structure. These distress types become drainage condition indicators for establishing DCI. They include:

Flexible Pavement

Depressions
Rutting
Alligator Cracking
Block Cracking
Reflective Cracking
Longitudinal, Transverse Cracking

Rigid Pavement

Longitudinal, Transverse, Diagonal Cracking
Settlement or Faulting
Pumping
Joint Seal Damage
Shattered Slab

PAVEMENT STRUCTURE PARAMETERS

Pavement components and subgrade are very important parameters in rating drainage impact. Underdrains installed under, or adjacent to, a runway, taxiway or apron also contribute substantially to control of moisture which, in turn, reduces the impact on pavement condition. Drainage condition indicators related to materials in the pavement and subgrade, and underdrain systems include:

Base Course Type
Subbase Type
Subgrade Type
Underdrain System

DATA COLLECTION PROCEDURES

Records research of pavement history yields information on underdrains, and base course, subbase and subgrade types, in addition to traditional historical information. PCI distress conditions used for calculation of DCI are retrieved from PCI file data.

Pavement slope and shoulder slope of inspected sample units are measured. Measurements may be made with a ten foot straightedge and a carpenters level. The straightedge is placed on pavement or shoulder at desired point of measurement. The low end is raised until the pipe is level (demonstrated by a level bubble). The distance from surface is measured in tenths of feet and recorded. This measurement directly translates to percent slope.

Shoulder condition and inlet condition are rated based on descriptions given. Surveyors inspect shoulder condition of sample units inspected, and all inlets in rated pavement.

CALCULATION OF DCI

Deduct points are calculated for each measured drainage parameter based on severity of distress. If a parameter meets the established standard, there is no deduct.

If underdrains are installed at pavement edges, deduct values are reduced. The reason is that, for most of the year, edge drains help to control moisture in shoulder soil. However, at critical periods in the spring, the drains may be below frost line and ineffective. When this condition occurs, elements above frost line perform as if without underdrains.

Shoulder condition is a critical condition in that water trapped adjacent to edge of runway invariably filters back under pavement to subgrade. The condition is much less serious if underdrains are installed along pavement edges.

Inlet deterioration reduces capacity of an underground storm drain system and often allows direct access of surface water into subgrade. Separate deducts are calculated for flow restrictions, and for structural deterioration.

Drainage deducts for rated PCI distress types are calculated as a function of total PCI deduct. Deduct factors reflect the relationship of drainage to each rated PCI distress type.

Pavement and subgrade materials are acted on by uncontrolled moisture. They are the reason drainage is important. Consequently, base course, subbase course and subgrade are factored into DCI calculations in a different manner than other condition indicators.

As quality of material in each of these components improves, the impact of uncontrolled moisture is reduced. Therefore, the Total Deduct Value (TDV), the sum of deducts from parameters described above, is reduced by a factor related to the quality of pavement components and subgrade.

Underdrains are a primary means of controlling moisture in a pavement structure, and in subgrade. They allow continuous drainage of water from base and subbase courses in pavement, and they effectively lower the water table in subgrade, helping to stabilize and strengthen the foundation material.

Correction factors for a broad range of types and classes of base course, subbase course and subgrade, with and without underdrains, are calculated.

COMPUTER EVALUATION

Eckrose/Green AIRPAV programs are outlined in Chapter 2. Drainage conditions are fully integrated into the AIRPAV software. DCI minimum service levels are assigned, costs for maintenance and rehabilitation actions are estimated, and corrective actions are incorporated into AIRPMS Master File and AIRCIP modules.

Pavement rehabilitation actions presented in the Master File correct drainage conditions to varying degrees. For instance, a "Reconstruction" alternative in flexible or rigid pavement corrects all drainage deficiencies and restores DCI to 100. Other alternatives improve DCI to a lesser degree by correcting specific rated deficiencies. "Structural Overlay" in flexible pavement, and "Reseating/Overlay" in rigid pavement, correct pavement slope deducts. Structural Overlay, Reseating/Overlay, and "Resurfacing", also correct all PCI distress and inlet flow deducts, but do not effect inlet structural, shoulder, pavement materials, or subgrade deducts. A corrected DCI value, based on any of the above rehabilitation options, is presented in the Master File to show degree of improvement.

In addition to pavement actions, six drainage actions are evaluated in the Management Program and presented in the Master File. They are:

Shoulder Grading (slope)
Shoulder Grading (condition)
Underdrains
Inlet (flow)
Inlet (structure repair)
No Action

Each of these actions may be performed independently from pavement actions to improve drainage conditions. These actions are presented in the Master File with cost estimates and corrected DCI values. They are also presented in the AIRCIP Capital Improvements module, and may be integrated into capital improvement and maintenance programs for an airport.

DRAINAGE CONDITION INDEX PROCEDURES

ADDITIONAL CRITERIA

Underlined text is reproduced as it appears in Chapter 6 of the manual "Airport Inspection by PCI". Additional criteria are added following each distress description and measuring procedure.

SLOPE TO SHOULDER (INLET). - DISTRESS NO. D1.

Description.

Gradient on pavement to expedite runoff is largely a matter of safety and appearance. The affect of standing water on pavement serviceability is minimal. However, the amount of water that can infiltrate to subgrade from cracks in the surface is increased as rate of runoff decreases.

Transverse slope on a runway or taxiway, and slope to edge or drainage structure on an apron, establish the rate at which water can run off the pavement surface. A good rate of runoff is desirable to minimize the time of exposure of the pavement structure to infiltration.

Severity Levels.

a. Low Severity Level (L). Slope is less than one percent but more than one half percent.

b. Medium Severity Level (M). Slope is one half percent or less but more than flat.

c. High severity Level (H). Slope is flat or negative (ponding is evident).

Measuring Procedure.

One measurement is made for each 2000 square feet of sample unit area. Measurements are made along a ten foot horizontal distance. Points of measurement are selected within a sample unit to represent typical, or average, slope conditions. On taxiways and runways, at least one measurement is made each side of centerline. On aprons, at least one measurement is made in each quadrant approaching a drainage structure and one measurement is made toward each pavement edge. The average of measurements in a sample unit is used to establish severity level. Measurements are made to the nearest 0.1 percent.

Slope measurements are used to establish severity unless ponding water, or ponding stains, are evident to the inspector. Evidence of ponding water on less than one quarter of the surface results in a minimum rating of medium severity (slope measurements are recorded). Evidence of ponding water over one quarter or more of the surface results in a rating of high severity (slope measurements need not be made).

Additional Criteria.

1. Slope measurements are recorded, on taxiways and runways, according to location left or right of centerline. Measurements on aprons are not recorded by location.

2. Slope measurements are recorded as positive in direction of designed flow. A superelevated pavement, for instance, has positive slopes, even though runoff is across centerline.

3. Slope on apron pavement is measured in the direction of maximum slope (to establish the direction of flow of surface water). On some aprons, this direction will be obvious. Where direction of flow is in question, the inspector should make several slope measurements in a representative area. The maximum slope in a representative area is recorded.

The term "maximum slope" refers only to measurements in a representative area of the sample unit. The inspector is responsible to establish a representative slope(s) for the sample unit. If pavement contour is variable, several areas should be measured to assure accurate representation. Record the maximum slope in each area.

4. "Ponding" is a difficult distress to quantify. When water or stains are present, ponding is evident, but the area must be determined. Ponding may also be evidenced by depressions, but can exist where depressions are not recorded. Ponding potential may be identified by reverse slopes in a sample unit. Once the dominant direction of slope has been established, a negative slope indicates ponding potential.

Time consuming and precise measurements are not required. It is only necessary to establish that ponding may exist (requires medium severity rating), then whether it exists over more than 25 percent of the sample unit area (requires high severity rating). Record medium severity ponding with a 0.05 slope. Record high severity ponding with a -10 slope. These values will be indicators, on data sheets, of ponding.

5. Disregard depressions and ponding areas smaller than 250 square feet.

SHOULDER SLOPE. - DISTRESS NO. D2.

Description.

Shoulder slope away from pavement edge is important to assure that surface runoff water is transported away from the pavement substructure. If shoulders are flat, or if reverse slope exists, water will soak into and saturate shoulder soil, limiting potential for subsurface moisture to drain away from the structure, ultimately softening subgrade and reducing load capacity of the pavement.

Severity Levels.

a. Low Severity Level (L). Slope is less than three percent but more than one and one half percent.

b. Medium Severity Level (M). Slope is one and one half percent or less but more than flat.

c. High Severity Level (H). Slope is flat or negative.

Measuring Procedure.

Slope is measured from ground level at pavement edge to a point ten feet from pavement edge. Measurements are made along a ten foot horizontal distance. Where the shoulder is uneven on the line of measurement, the mean slope in the ten foot distance is recorded. Care must be used to establish ground level at pavement edge. Buildups of dead grass or loose sand should be cleared away before measurements are taken. These parameters, and washouts adjacent to pavement, are accounted for in the following distress, "Shoulder Condition". Measurements are made to the nearest 0.5 percent.

Additional Criteria.

1. Shoulders affect pavement condition within a relatively short distance from pavement edge (perhaps five feet). On taxiways and runways, this is a significant percentage of the total pavement area. Aprons, on the other hand, are normally more rectangular in shape, and the pavement edges are relatively insignificant. Consequently, shoulder slopes adjacent to aprons are not rated.

2. Shoulders in confined areas, as at hangar taxiways, and near buildings, are often designed sloping toward pavement. The inspector should recognize such landscaped shoulders as having an "architectural" rather than a "drainage" function. Such shoulders should be recorded as N/R (not rated).

SHOULDER CONDITION. - DISTRESS NO. D3.

Description.

Shoulder condition at edge of pavement is an important drainage parameter. Turf and incompressibles washed from the surface may build up over time to create an effective "dam" against runoff. On the other hand, if runoff water has eroded the shoulder at pavement edge, a trench may be formed which catches and funnels water into the subgrade. In either case, water will be trapped and will gradually infiltrate into the subgrade and reduce bearing capacity of the pavement.

Severity Levels.

a. Low Severity Level (L). Shoulder within one foot of pavement edge generally permits unrestricted runoff with exception of dam or trench capable of holding ponded water along no more than ten percent of its length.

b. Medium Severity Level (M). Shoulder within one foot of pavement edge is dammed or trenched sufficiently to hold ponded water over more than ten percent but less than 50 percent of its length.

c. High Severity Level (H). Shoulder within one foot of pavement edge is dammed or trenched sufficiently to hold ponded water over more than 50 per cent of its length.

Measuring Procedure.

Grass stems and loose sand at pavement edge do not restrict runoff unless they become mixed with soil (mud) or other impervious materials to form a dam. A trench is evidenced by flat or negative slope within one foot of pavement edge. Unrepaired tire ruts in shoulder within one foot of pavement edge are measured to establish severity. Tightly woven turf (grass root mass at pavement edge) will hold ponded water and is measured to establish severity. An effective technique for determining degree of shoulder "damming" is to walk along the pavement edge. Damming is indicated if ankles tend to rotate toward the pavement side.

Additional Conditions. (See additional criteria for Distress No. 2, above.)

INLET CONDITION

Description.

Inlets and catch basins are normally found in large expanses of pavement as at aprons. They are designed to remove surface water from the paved surface more expeditiously than runoff to shoulders will allow. Any condition which prevents an inlet from accepting runoff from the pavement is a distress. Distress can range from joint seal damage around the inlet, to lifting or settlement of the structure relative to surrounding pavement, to debris in grates and catch basins, to sludge in catch basins, to physical deterioration of inlet grates, structure or associated storm drains. Severity of inlet distress is related to degree of flow restriction (Flow Rate - Distress No. D4) and condition of structure (Structural - Distress No. D5).

Additional Criteria.

1. Only surface distress at inlets is rated. This is a modification of rating procedures, and will be incorporated into the text at next revision. The change is effective April 1, 1989, but will only be implemented on contracts in effect on that date with prior concurrence of the Client.

Ratings of interior conditions have not proved to be quantifiable. Once runoff water enters an inlet, it is no longer a threat to pavement components and subgrade. Therefore, flow and structural ratings of inlets will, henceforth, be limited to those parameters visible and quantifiable at the surface.

Measuring Procedure.

Only inlets constructed in, or within ten feet of, rated pavement are rated. Rate all inlets in rated pavement. Include trench-type as well as box inlets.

Flow Rate - DISTRESS NO. D4.

Severity Levels.

Low Severity Level (L). Distress is limited to condition(s) correctable by staff maintenance, such as debris in grates or catch basins. Low and medium severity joint seal damage at perimeter of structure constitutes low severity inlet flow distress. Structural faulting or settlement of one quarter inch or less is a low severity distress.

Medium Severity Level (M). High severity perimeter joint seal damage constitutes medium severity distress. Structural faulting or settlement greater than one quarter inch but less than one inch is rated at medium severity. Sludge at bottom of catch basin less than one forth the depth of the smallest diameter connecting storm drain constitutes medium severity distress. (Mud or sludge at or below flow line of the lowest outlet is not considered in rating inlets).

High Severity Level (H). Examples of high severity distress include: (1) Sludge in bottom of catch basin (not debris induced) deeper than one quarter of the depth of the smallest diameter connecting storm drain. (2) Structural faulting or settlement of one inch or greater.

Structural - DISTRESS NO. D5.

Severity Levels.

Low Severity Level (L). Inlet and structure are generally serviceable. Distress is limited to condition(s) correctable by staff maintenance, such as tuck pointing masonry and grouting small cracks in structure walls. Cracks in catch basin walls or floor one eighth inch wide or less with no faulting at cracks constitutes low severity distress. Mortar damage in block walls is a low severity distress if blocks are securely in place.

Medium Severity Level (M). Distress is correctable without major structural rehabilitation, such as a broken inlet grate or cracked and faulted structure slabs. Cracked catch basin walls or floor less than one half inch wide with faulting less than one half inch constitutes medium severity distress. Mortar damage in masonry walls resulting in voids between blocks, with some blocks loose but not broken or displaced is a medium severity distress. Any movement of inlet casting under body weight of the inspector constitutes medium severity distress.

High Severity Level (H). Correction of distress requires major structural rehabilitation. Examples of high severity distress include: (1) Shattered structure slab with missing pieces and faulting of one inch or more; (2) Shattered walls or floor of catch basins with multiple cracks of one half inch or more and faulting at cracks of one half inch or more; (3) Missing pieces from walls or floor exposing reinforcing steel and mesh; (4) Broken or displaced masonry blocks in the structure.

Errata

1. Page 2-16

   Fourth Paragraph - First Sentence:

   Micro PAVER is now capable of generating curves to represent pavement deterioration.

2. Page 5-16

   c. Area boundaries of Block Cracking are defined by the outermost crack in the pattern.

3. Page 5-19

   6. Cracks which define blocks larger than 2 feet on a side are not alligator cracks. Measure and record appropriately.

4. Page 5-20

   Second Paragraph:

   (a) blocks which are approximately equally sided, and usually smaller than 6 inches on a side,

   (b) individual cracks usually rate at medium or high severity,

5. Page 5-47

   Second Paragraph - First Sentence:

   The edges of a patch are considered as longitudinal/transverse cracks only while using Table 5-2 to determine patch severity; these cracks are part of the patch and are not recorded separately as L & T cracks.

   Caption Beneath Figure 5-73:

   Edges of the patch are considered L & T cracks only while using Table 5-2 to determine patch severity; these cracks are part of the patch and are not recorded separately as L & T cracks.

6. Page 5-63

The distress shown at Figure 5-88 represents an attempt at crack sealing. The distress is rated as an L & T crack. This is not a patch (does not replace original material).

7. Page 5-64

Third Paragraph - First Sentence:

Any loose or missing pieces at a slab joint or corner are not considered in identification of distress types unless the resulting void is at least 3 inches wide measured horizontally from the edge of the slab to the point where the void is 1/4 inch deep.

Fifth Paragraph:

Blowups, on the other hand, result from compressive failure of either or both adjoining slabs through the full depth of pavement, or shattering (immediate displacement of pavement caused by explosive force) at the surface affecting more than 50 percent of the joint length.

8. Page 5-66

Additional Criteria

First Paragraph - First Sentence:

By our interpretation of inspection criteria, a spall must be at least 3 inches wide from the opposite face of the crack or from the edge of the slab.

Second Paragraph - Second Sentence:

A chip is a small piece of loose or missing concrete at crack or joint which is less than 3 inches wide, measured horizontally from the opposite face of the crack or from the edge of the slab.

Last Paragraph - Third Sentence:

Little or no spalling or lightly spalled means chipping defined by secondary cracks occurring over less than ten percent of the length of crack.

9. Page 5-76

Fourth Paragraph:

The slab is divided into three pieces by low severity cracks.

10. Page 5-89

Additional Criteria

Second Paragraph:

Edges of the patch, are considered L/T/D cracks only while using Table 5-3 to determine patch severity. These cracks are part of the patch and are not recorded separately as L/T/D cracks.

APPENDIX A

FEATURE DATA SUMMARY

Instructions for use:

Facility Description:

Record the name most commonly used on the airport. (i.e. "Runway 12L-30R" or "Taxiway B" or "East Terminal Apron").

Feature Location:

Record pavement location within the Facility. (i.e. "From Taxiway C to end of runway" or "northeast 1/3 of taxiway" or "west side of GA apron").

MSL:

This is the Minimum Service Level for the Feature as designated by the Owner. (MSL is usually assigned by Facility, but may vary within a Facility if a significant functional change occurs).

Construction History:

State year of construction and brief description (i.e."1982 2-1/2" flexible overlay" or,"8 in PCC on 12" cem trtd base on 6" soil cement subbase"). Present up to four most recent construction projects in reverse chronological order. Do not record projects where the associated pavement has been replaced during more recent construction.

Maintenance History:

Present types of maintenance performed, month and year of most recent application, and whether this was an initial application or part of a continuing program. Present brief description of material/application (i.e. "rubberized bituminous" or "Sand/Epoxy" or "Chip Seal"). List materials used and brief description of specifications under "Additional Comments", if information is available.

Additional Comments:

This section is for general use by researcher and inspector. Present any information which may be of value during inspection or evaluation. Use reverse side of form, as necessary.

FEATURE DATA SUMMARY

AIRPORT: ______________________________ FEATURE NO. ________

SURVEY YEAR: ____________

FACILITY DESCRIPTION: ____________________________________

FEATURE LOCATION: ____

FEATURE AREA: _________ SQ. FT. MSL ______________

CONSTRUCTION HISTORY: (Maximum 100 characters per project).

A. ____

____

B. ____

____

C. ____

____

D. ____

____

BASE COURSE: ________________ SUBBASE COURSE ______________

UNDERDRAINS: ____

SUBGRADE CLASS: _________________

MAINTENANCE HISTORY:	Latest (month/yr)	Previous (year)	Type
Crack/Joint Repair	________	________	____________
Patching	________	________	____________
Surface Treatment	________	________	____________

ADDITIONAL COMMENTS: _____________________________________

____

____

APPENDIX B

Sample Unit Data Sheets

FLEXIBLE PAVEMENT

Instructions for use:

Heading information is self explanatory.

Record number of measured feet, or square feet, of distress, by severity. Multiple entries may be made for each in cases where complex measurements are required.

Use care to make entries in the proper line. Transposed entries are sometimes difficult to detect during quality review.

Units will be totaled during quality review and at data entry. Make entries carefully and legibly.

RIGID PAVEMENT

Instructions for use:

Heading information is self explanatory.

Sketch the slab configuration of the Sample Unit by connecting the appropriate dots on the form.

Record each distress type and severity, by number/letter (i.e. "3L" for low severity L/T/D crack, or "9" for pumping since there are not degrees of severity for pumping) in the space representing the slab in which the distress is located. Record joint seal damage in the "NOTES" area.

DRAINAGE ENTRIES

Record Pavement slopes to the nearest Ø.1 percent.

Record Shoulder slopes to the nearest Ø.5 percent.

Record Shoulder Condition and Inlet ratings by severity.

GENERAL COMMENTS

Use a separate data sheet for each Sample Unit.

Summarize distresses on each sheet at least daily.

FLEXIBLE PAVEMENT
AIRPORT PAVEMENT CONDITION SURVEY SHEET

AIRPORT			FEATURE ID
SAMPLE UNIT NUMBER	NUMBER OF SQUARE FEET	DATE	SURVEYED BY

DISTRESS TYPES	SEVERITY		
	LOW	MEDIUM	HIGH
* 1 ALLIGATOR CRACKING			
2 BLEEDING			
* 3 BLOCK CRACKING			
4 CORRUGATION			
* 5 DEPRESSION			
6 JET BLAST			
7 JT REFLECTION (PCC)			
8 LONG & TRANS CRACKING			
9 OIL SPILLAGE			
10 PATCHING			
11 POLISHED AGGREGATE			
12 RAVELING/WEATHERING			
* 13 RUTTING			
14 SHOVING FROM PCC			
15 SLIPPAGE CRACKING			
16 SWELL			

NOTE: Measure * Distresses Separately When Found In Combination With Other * Distress. Circle Combinations And Connect w/ Line.

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PAVEMENT SLOPE		SHOULDER SLOPE		SHOULDER CONDITION		INLET CONDITION	
LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	SLOPE	RATING
							FLOW
							STRUCT

JOINTED RIGID PAVEMENT
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

AIRPORT		DATE
FACILITY	FEATURE	SAMPLE UNIT
SURVEYED BY		SLAB SIZE

DISTRESS TYPES

1 BLOW-UP
2 CORNER BREAK
3 LONGITUDINAL/ TRANSVERSE/ DIAGONAL CRACK
4 "D" CRACK
5 JOINT SEAL DAMAGE
6 PATCHING, <5 FT^3
7 PATCHING/ UTILITY CUT
8 POPOUTS
9 PUMPING
10 SCALING/MAP CRACK/CRAZING
11 SETTLEMENT/ FAULT
12 SHATTERED SLAB
13 SHRINKAGE CRACK
14 SPALLING — JOINTS
15 SPALLING — CORNER

PAVEMENT SLOPE		SHOULDER SLOPE		SHOULDER CONDITION		INLET CONDITION	
LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	SLOPE	RATING
							FLOW
							STRUCT

DIST. TYPE	SEV.	NO. SLABS

SKETCH

10
9
8
7
6
5
4
3
2
1

1 2 3 4 5 6

NOTES

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BIOGRAPHY

William H. Green, P.E.
Chief Engineer
Eckrose/Green Associates, Inc.
Madison, Wisconsin

Bill Green is a professional engineer who has specialized in airport planning and development for the past 16 years. He served as Airport Construction Engineer with the Wisconsin Division of Aeronautics. He was Chief Airport Development Engineer in the Iowa Aeronautics Division. He served on the staff of the Des Moines Municipal Airport as Assistant Director. Before forming Eckrose/Green Associates with Roy Eckrose, he was Chief Airport Engineer with a major engineering firm in the Midwest.

Since 1982, Bill has been developing and improving pavement testing and evaluation techniques for airports. He has been Project Manager of comprehensive pavement studies at the Des Moines International Airport, El Paso International Airport, Tulsa International Airport, Fort Wayne Baer Field, and Hulman Field at Terre Haute, Indiana. He directed inspection activities in a PCI runway inspection conducted at night, by artificial lighting, at O'Hare Field, Chicago. He has organized and directed statewide airport system pavement studies in Wisconsin and Indiana.

He and Mr. Eckrose have developed an extensive library of computer software for evaluating and programming airport improvements. Projects currently in progress include statewide airport system pavement studies in Michigan and Minnesota.

Mr. Green is an instrument rated commercial pilot with over 4000 hours in 25 years of experience flying airplanes and helicopters.

BIOGRAPHY

Roy Eckrose, P.E.
President
Eckrose/Green Associates, Inc.
Madison, Wisconsin

Roy Eckrose is a professional engineer who has nearly 30 years of experience in design, evaluation, rehabilitation and recycling of pavements, including ten years as a consulting engineer preceded by more than 18 years in the Department of Public Works of a major Wisconsin city.

Mr. Eckrose has directed inspection, testing and evaluation of pavement systems at the Des Moines International Airport, the El Paso International Airport, and the Fort Wayne and Terre Haute airports in Indiana. He has directed special investigations of pavement at Tulsa International Airport and O'Hare Field, Chicago. He has managed pavement evaluation of statewide airport system projects for States of Indiana and Wisconsin. He is presently managing pavement evaluation of statewide airport system projects for Michigan and Minnesota.

Mr. Eckrose is a respected public speaker on topics ranging from pavement to economics. He has published numerous articles on these and other subjects and has made presentations to various organizations across the country. These include the American Concrete Institute, American Public Works Association, Federal Highway Administration, Wisconsin Aviation Conference and the National Asphalt Pavement Association. He has taught and lectured widely at Universities of Ilinois, Missouri, and Wisconsin, and at Marquette and Iowa State Universities.

Mr. Eckrose has written a comprehensive library of micro-computer programs for pavement evaluation and management which is gaining national attention among airport owners and administrators as the most effective software available for managing airport pavement systems.