PAVEMENT MANAGEMENT PROGRAM

FOR

GENERAL AVIATION AIRPORTS

PREPARED BY:

THE AVIATION DIVISION
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Dear Airport Sponsor:

The attached Pavement Management Program has been prepared for your airport. It contains four chapters, which include the following information:

Chapter 1	INTRODUCTION, which gives background information on pavement management programs, their cost benefits, and their basic components,
Chapter 2	F.A.A. REQUIRED ELEMENTS, which describes the minimum components of a pavement management program which meets FAA requirements for federally funded airport improvement projects,
Chapter 3	ROUTINE AIRPORT MAINTENANCE PROGRAM, which describes the Aviation Division's RAMP program designed to assist airport owners and operators in performing routine pavement maintenance.
Chapter 4	MONTHLY INSPECTION RECORDS, which includes an airport pavement layout sketch, the pavement inspection sections, and the record keeping forms for each section, to be filled out and dated by the designated pavement manager for your airport. These records must be retained in your permanent files for a minimum of five years, and copies must be available on request by the FAA and TxDOT,
Appendix 1	PAVEMENT MAINTENANCE METHODS, which provides an overview of common pavement distresses, identification of distress types and causes, and recommended maintenance activities,
Appendix 2	PAVEMENT MANAGEMENT SYSTEMS, which includes a reprint of the FAA Advisory Circular Number 150/5380-7 titled "A Pavement Management System".

If you have any questions about the Pavement Management Program, please call the Aviation Division of the Texas Department of Transportation at 1 (800) 68-PILOT, or write us at 125 E. 11th Street, Austin, Texas 78701-2483.

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FAA PAVEMENT MAINTENANCE / MANAGEMENT REQUIREMENTS

As part of the Federal Aviation Administration's (FAA) Airport Improvement Program (AIP) funds, Congress has mandated that facilities receiving federal monies for replacement or reconstruction of paved surfaces must create a pavement maintenance / management program.

Historically, the FAA and TxDOT have assisted sponsors in improving runways, taxiways, and aprons by contributing 90% of the project cost. Appropriate and timely maintenance will prolong pavement life, maintain a high level of ride quality, and reduce the lifetime cost of the pavement. Unfortunately, in the past, the pavement often did not receive any preventive or remedial maintenance after it was constructed.

Since January 1, 1995 airport sponsors that accept AIP funds for pavement replacement or reconstruction are required to commit to a grant assurance which stipulates that an effective pavement maintenance / management program will remain in effect throughout the useful life of the constructed pavement. Such a program will have four basic components:

- a pavement inventory which shows the dimensions, locations, and maintenance history of all paved surfaces,

- a prescribed inspection schedule, which will minimally involve detailed annual assessments, and monthly drive-by observations,

- record keeping which documents inspection dates, findings, locations of distress, and remedial actions scheduled and performed,

- a method of data retrieval which would permit a comprehensive presentation to the FAA if they request one.

A thoughtfully conceived pavement maintenance/management program creates a win-win situation. Your airport will have a logical and structured method of addressing maintenance requirements in a timely fashion. This will minimize your costs. And repairing and rehabilitating pavements, rather than reconstructing pavements, will allow TxDOT to maximize state and federal dollars for system improvements.

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Chapter 107 (E) of the Federal Aviation Act of 1994 requires that after January 1, 1995, a grant for the construction, reconstruction, or replacement of an airport pavement may be approved only if the sponsor has provided assurances or certifications that they have implemented an effective pavement maintenance/management program.

The sponsor must establish and maintain a pavement management program that details the procedures that will be taken to assure that proper maintenance is performed. The program should be simple and straightforward.

As a minimum, the program must include the following:

1. Pavement Inventory:

    a. Show the location, dimensions, and pavement type of all runways, taxiways, and aprons.

    b. The year of construction and most recent major rehabilitation.

2. Inspection Schedule:

    a. Detailed inspections must be conducted at least once annually.

    b. Drive-by inspections must be conducted at least once monthly.

3. Record Keeping (Documentation):

Complete information on all inspections and maintenance performed must be recorded and kept on file for a minimum of five years. The types of pavement distresses, their location, and remedial action scheduled or performed, must be documented.

For drive-by inspections, the date of inspection and any maintenance performed must be recorded.

The minimum information to be recorded is listed below,

a. Inspection Date
b. Location
c. Distress Type
d. Maintenance Scheduled of Performed.

4. Information Retrieval:

An airport sponsor may use any form of record keeping it deems appropriate, as long as the information and records may be retrieved to provide a report to the FAA as may be required.

Records of materials and equipment used to perform maintenance should be kept on file for future reference. These records may be used to identify materials and remedial measures which may reduce maintenance costs and improve pavement serviceability. Unless adequate records are kept, there will be no benefit to the future use of this information to possibly reduce your maintenance costs.

Remember, if inspections and remedial actions are not documented, then they did not occur. Documentation is vital.

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ROUTINE AIRPORT MAINTENANCE PROGRAM

In addition to the requirement that airports have a pavement management program in order to be eligible for federal funding, airports are also required to participate in the Texas Department of Transportation, Aviation Division program known as RAMP, the Routine Airport Maintenance Program, or have an equivalent program of their own, in order to be eligible for state funds.

The RAMP program will use TxDOT resources, and existing maintenance contracts or new contracts, to assist local governments in providing needed airport maintenance. Work performed under RAMP may be funded on a 50% state, and 50% local basis (i.e. $30,000 state funds, and $30,000 local funds), up to a total of $60,000 per year. There is no minimum on the amount of work eligible.

The RAMP program is designed to promote a well managed maintenance program that will enhance the safety, serviceability, and useful life of the airport pavements in Texas. The data collected during the pavement inspections can be used to develop the scope of RAMP work to be performed.

In other words, the Pavement Management Program can identify work to be done, and the RAMP program can execute that work, at a significantly reduced cost.

Work eligible for RAMP funding includes, but is not limited to, the following:

- base repairs, point repairs, and HMAC repairs
- fog seal, slurry seal, and crack seal
- milling
- sweeping and vacuuming
- chemical vegetation control
- pavement markings (painting, reflective beads, reflectors)
- blading, and erosion control.

The pavement distress notes from the monthly inspections can be used to develop the scope of work to be performed under RAMP. General guidelines for maintenance cycles of typical work items can be used to predict future scheduling

Work Item	TypicalScheduling	Average Unit Cost (1999 prices)
Fog seal	2 years	$0.10 to $0.20 / square yard
Slurry seal	3-5 years	$1.00 to $2.00 / square yard
Crack seal	annually	$0.30 to $1.00 / linear foot
Pavement markings	3-5 years	$0.30 to $0.60 / square foot
Chemical vegetation control	1-3 times / year	variable depending on quantity

Other maintenance items such as base repairs, point repairs, HMAC repairs, milling, sweeping, blading, and erosion control are typically performed on an as needed basis.

Using current maintenance costs and quantities it is very easy to estimate the cost for future maintenance work, and schedule and budget accordingly. Contact your local TxDOT representative to coordinate RAMP work at your airport, or contact the Aviation Division at 1(800)68-PILOT for more information.

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MONTHLY FIELD INSPECTIONS

As discussed in previous chapters, the airport pavement areas must be inspected, a minimum of once per month.

The airport should be divided into discreet pavement sections, as shown on the Pavement Section Drawing. Each section should have a separate sheet for recording the monthly observed pavement condition and distresses. A sample sheet has been included for reference. A blank form is included. Make multiple copies and use as needed.

Refer to Appendix 1 and Appendix 2 for additional information regarding distresses and maintenance.

HOW TO PERFORM THE INSPECTION:

To complete the monthly inspection:

1) Walk or slowly drive the airport pavements, looking for any irregularities, damage, or deficiencies.

2) Make written notes describing the date, the pavement section, the location, the type, and the extent of the problems. Forms are attached for this purpose.

3) Note the corrective action taken, or to be taken, including the date of action.

It is very helpful to inspect the pavements either early or late in the day, when the sun is low to the horizon, or just after a rain. At these times, shadows or moisture highlight deformities in the pavement surface.

On runways, it is helpful to reference locations to runway lights. They should have numbered tags attached to each fixture.

Remember, to paraphrase Yogi Berra, “ It’s amazing what you can see, just by looking around.”

AIRPORT: ____

LOCATION: _____________ **SECTION**: ________ **DIMENSIONS**: _________________

CONSTRUCTION HISTORY:

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MONTHLY INSPECTION NOTES:

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MONTHLY INSPECTION NOTES:

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PAVEMENT MAINTENANCE

In operating and maintaining an airport, managers and maintenance personnel are continually faced with problems involving pavement distress and deterioration. Age, weather, and ordinary use are some of the causes of pavement damage. This chapter will provide information on types of pavement distress, and recommend corrective actions.

PAVEMENT TYPES

Airport pavements are designed, constructed, and maintained to support the critical loads imposed on the pavement and to produce a smooth and safe riding surface. The pavement must be of such quality and thickness that it will not fail under the loads of aircraft and be durable enough to withstand the abrasive action of traffic, adverse weather conditions, and other deteriorating influences. Pavements are divided into three classes: rigid, flexible, and overlays.

RIGID PAVEMENTS (PCC)

Rigid pavements normally involve the use of Portland cement concrete (PCC) as the prime structural element. Depending upon conditions, the pavement slab may be designed with plain, lightly reinforced, continuously reinforced, prestressed, or fibrous concrete. The concrete slab is usually placed on a compacted granular subbase which, in turn, is supported by a compacted subgrade. A typical rigid pavement structure possesses a high degree of rigidity. This rigidity and resulting beam action enables rigid pavements to distribute loads over large areas of the subgrade. For better pavement performance, it is important that support for the entire concrete slab is uniform. Rigid pavement construction strength is most economically built into the slab itself with optimum use of low-cost materials under the slab. Rigid pavement consists of the following layers:

Concrete Slab (Surface Layer) - Provides a skid-resistant surface, prevents the infiltration of surface water, and provides structural support to the aircraft.

Subbase - Provides uniform, stable support for the pavement slab. A minimum subbase thickness of 4 inches is generally required under rigid pavements. Other functions of the subbase are to control frost action, provide subsurface drainage, control swell of subgrade soils, and prevent mud pumping of fine grained soils.

Stabilized Subbase - Required for all new rigid pavements designed to accommodate aircraft weighing 100,000 pounds or more.

Frost Protection Layer - Rare in Texas, but provides a barrier against frost action and frost penetration into the lower frost-susceptible layers.

Subgrade - Compacted soil layer which forms the foundation for the pavement system. Subgrade soils are subjected to lower stresses than the surface and subbase courses. These stresses decrease with depth, and the controlling subgrade stress is usually at the top of the subgrade unless unusual conditions exist. Soil conditions are related to the ground water level, density, moisture content, and frost penetration. Since the subgrade soil supports the pavement and the loads imposed on the pavement surface, it is critical to investigate soil conditions to determine their effect on grading and paving operations and the necessity for underdrains.

FLEXIBLE PAVEMENTS (HMAC)

Flexible pavements support loads through bearing rather than flexural action; that is, they transmit their strength through several layers. Thus, they are composed of several layers of carefully selected materials designed to gradually distribute loads from the pavement surface to the layers underneath. The design is such that the load transmitted to each successive layer does not exceed the layer's load bearing capacity. The distribution of the load, from the surface on down through the lower layers of the pavement structure, covers a larger and larger area as the load penetrates the pavement toward the subgrade. The various layers of a flexible pavement and their functions are as follows:

Bituminous Surface or Wearing Course - Bituminous (petroleum product found in tar or coal [asphalt]) surface, or wearing course, comprised of a mixture of various selected aggregates bound together with asphalt cement, heavy grades of tars, or other bituminous binders. Its function is to prevent the penetration of water to the base course; provide a smooth, well-bonded surface free from loose particles (which might endanger aircraft or persons); resist the stresses developed as a result of aircraft loads; and furnish a skid-resistant surface without causing undue wear on tires.

Base Course - Principal structural component of the flexible pavement. It distributes the imposed wheel load to the pavement foundation, the subbase and/or the subgrade. The base course must be of a quality and thickness to prevent failure in the subgrade and/or the subbase, withstand the stresses produced in the base itself, resist vertical pressures that tend to produce consolidation and a result in distortion of the surface course, and resist volume changes caused by fluctuations in its moisture content. The materials that compromise the base course are select, hard and durable aggregates which generally fall into two main classes: stabilized and granular. The stabilized bases normally consist of crushed and uncrushed aggregate that has been bound with a stabilizer such as cement or bitumen. The quality of the base course is a function of its composition, physical properties, and compaction of the material.

Subbase - Layer used in areas where frost action is severe or in locations where the subgrade soil is extremely weak. The function of the subbase course is similar to the base course. The material requirements for the subbase are not as strict as those for the base course since the subbase is subjected to lower load stresses. The subbase consists of stabilized or granulated materials properly compacted.

Frost Protection Layer - Once again, rare in Texas. The frost protection layer functions as mentioned in Paragraph 4 under rigid pavements.

Subgrade - Compacted soil layer which forms the foundation for the pavement system. Subgrade soils are subjected to lower stresses than the surface, base, and subbase courses. Since load stresses decrease with depth, the controlling subgrade stress is usually at the top of the subgrade. The combined thickness of subbase, base, and wearing surface must be great enough to reduce the stresses occurring in the subgrade soil layer. Factors affecting subgrade behavior are discussed in Paragraph 5 under rigid pavements.

OVERLAYS

Pavement overlays are usually undertaken to correct deteriorating pavement surfaces, to improve ride quality or surface drainage, to maintain the structural integrity, or to increase pavement strength. For instance, a pavement may have been damaged by overloading; it may require strengthening to serve heavier aircraft; uneven settling may have caused severe puddling; or the original pavement simply may have served it useful life and be worn out.

PAVEMENT DISTRESS

The deterioration of a pavement, be it runway or highway, manifests itself by various external signs or indicators which can be associated with the probable causes of the failure or imperfection. Discussions of problems relating to pavement distress are generally based on pavement type, either concrete or bituminous. However, while each possesses its own particular characteristics, the various pavement distress manifestations for bituminous and concrete pavements generally fall into one of the following broad categories: cracking, distortion, disintegration, or skid resistance. The indicated repair procedures are advisory in nature. In no way should they be taken over the advice of an experienced engineer, who should be consulted before undertaking any large repair project.

CONCRETE PAVEMENTS

Portland Cement Concrete (PCC) pavements are subject to the following distresses:

Blowups	Faulting
Contaminants	Joint Seal Damage
Cracking, Longitudinal	Polished Aggregate
Cracking, Transverse	Pumping
Cracking, Diagonal	Roughness
Cracking, Corner	Shattered Slab
Cracking, "D"	Spalling, Joint
Cracking, Shallow	Spalling, Corner
Distortion	Skid Resistance

BLOWUPS (PCC)

Blowups usually occur at a transverse crack or joint. They generally occur in hot weather, usually at a transverse crack in the joint that is not wide enough to permit expansion of the concrete slabs. 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 normally occur only in thin pavement sections.

Repair Procedure:

-Make a vertical cut with a concrete saw approximately 6 inches outside of each end of the broken area.

-Break out the concrete with pneumatic tools and remove concrete down to the subbase/subgrade material.

-Add subbase material, if necessary, and compact

-In reinforced pavement construction, joint techniques should be used to tie the new concrete to the old reinforced material. Any replacement joints should be doweled and built to joint specifications. For simplicity of construction, all tiebars, dowels, and reinforcement may be omitted from small interior pavement patches on well-compacted subgrades.

-Dampen the subgrade and the edges of the old concrete.

-Place the concrete.

-Use ready-mix concrete if it is satisfactory and can be obtained economically. It may be desirable to use a mixture providing high early strength in order to permit the earliest possible use.

-Finish the concrete so that the surface texture approximates that of the existing pavement.

-Immediately after completing the finishing operations, the surface should be properly cured. Either a moist cure or curing compound may be used.

CONTAMINANTS (PCC)

Contaminants such as rubber deposits building up over a period of time will reduce the surface friction characteristics of a pavement.

Repair Procedure:

Rubber deposits may be removed by use of high-pressure water or biodegradable chemicals.

CRACKING (PCC)

Cracking often results from stresses caused by contraction or warping of the pavement. Overloading, loss of subgrade support, insufficient and/or improperly cut joints acting singularly or in combination is also possible causes. The following are types of cracks in concrete pavement:

CRACKS; LONGITUDINAL, TRANSVERSE, AND DIAGONAL (PCC)

Longitudinal, transverse, and diagonal cracks are usually caused by a combination of repeated loads and shrinkage stresses and are characterized by cracks which divide the slab into two or more pieces.

Repair Procedure:

-Route out a groove about 3/8 inch wide and 3/4 inch deep around the crack.

-Clean out with compressed air. The crack must be free of dirt, dust, and other material that might prevent bonding of the sealant. Fill the crack with sealant materials.

CRACKS; CORNER (PCC)

Corner cracks are caused by load repetition combined with loss of support and curling stresses. This type of break is characterized by a crack that intersects the joints at a distance less than one-half of the slab length on both sides, measured from the corner slabs. A corner crack 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.

Repair Procedure:

The following procedure is used to repair corner cracks accompanied by loss of subgrade support. For low severity cracks, the procedure for crack sealant should be used.

-Make a vertical cut with a concrete saw and remove the broken corner.
-Add subbase material, if necessary, and compact.
-Clean the vertical faces of the remainder of the slab with a high-pressure water jet or compressed air.
-Coat the faces of the adjacent slab with a bond-breaking compound to prevent bonding of the new concrete.
-Maintain the existing joint by using temporary inserts or by sawing the required kerf.
-Coat the clean surface with sand-cement epoxy grout.
-Place the Portland cement concrete in the patch area while the grout is still tacky.
-After the concrete has cured, remove the joint inserts or saw a kerf.
-Seal joints.

CRACKING; “D” (PCC)

“D” cracking usually appears as a pattern of cracks running in the vicinity of and parallel to a joint or linear crack. It is caused by the concrete’s inability to withstand environmental factors such as freeze-thaw cycles. “D” cracking is unusual in Texas.

Repair Procedure:

The Repair Procedure: of this type of distress usually requires the complete slab be repaired, since normally “D” cracking will reoccur adjacent to the repaired area.

CRACKING; SHALLOW (PCC)

Scaling, map cracking, and crazing refers to a network of shallow hairline cracks that extend only through the upper surface of the concrete. Crazing usually results from improper curing and/or finishing of the concrete and may lead to scaling of the surface. Scaling is the disintegration caused by improper curing or finishing, freeze-thaw cycles, and unsuitable aggregate.

Repair Procedure:

-Make a vertical cut with a concrete saw about 1 to 2 inches deep at the perimeter of the scaled area.

-Break out the broken concrete with pneumatic tools until sound concrete is exposed.

-Clean the area with compressed air or high-pressure water jet.

-Dampen the surface with water. Coat the surface with a sand-cement grout.

-Place the PCC patch material while the grout is still wet.

-If the patch crosses or abuts a working joint, the joint must be continued through the patch.

DISTORTION (PCC)

Distortion is a change in the pavement surface from its original position and results from foundation settlement, expansive soils, frost susceptible soils, or loss of fine grain soils through improperly designed subdrains of the drainage system. If not too extensive, some forms of distortion such as from settlement can be remedied by raising the slab to the original grade. The following are types of distress due to distortion:

FAULTING OR SETTLEMENT (PCC)

Settlement or faulting is a difference in elevation at a joint or crack caused by upheaval or differential consolidation. This condition may result from loss of fine grain soils from frost heave or from swelling.

Repair Procedure:

Slabjacking procedures may be used to correct this type of distress. In slabjacking, a grout is pumped under pressure through holes bored in the pavement into the void under the pavement. This creates an upward pressure on the bottom of the slab in the areas around the void. The upward pressure lessens as the distance from the grout hole increases. Thus, it is possible to raise one corner of a slab without raising the entire slab. Because of the special equipment and experience required, slabjacking is usually best done by specialty contractors.

JOINT SEAL DAMAGE (PCC)

Joint seal damage is any condition, which enables soil or rocks to accumulate in the joints or allows infiltration of water. Accumulation of materials prevents the slabs from expanding and may result in buckling, shattering, or spalling. Typical types of joint seal damage include stripping, extrusion, hardening of the joint sealant, loss of bond with the slab edges, and the absence of sealant in the joint. Joint sealant damage is caused by improper joint width, use of the wrong type of sealant, incorrect application, and/or not cleaning the joint properly before sealing.

Repair Procedure:

-Use joint router to remove the joint sealing material to a depth of at least 1-inch.

-Reface the sides of the joint to expose sound concrete that is free of old sealer. This may be accomplished with a power saw.

-Use a power wire brush to remove debris.

-Blow out the joints with compressed air.

-Seal joints with hot or cold compounds. Hot poured sealant should be injected into the joint through nozzles shaped to penetrate into the joint and fill the gap from the bottom. On small jobs, hand-pouring pots may be used.

-Disintegration is the breaking up of a pavement into small, loose particles and is caused by improper curing and finishing of the concrete, unsuitable aggregates, and improper mixing of the concrete. It also includes dislodging of aggregate particles. The following are types of disintegration.

POLISHED AGGREGATES (PCC)

An aggregate, which has a low coefficient of friction, i.e. slippery when, wet. Aggregates become polished quickly under traffic. Others are naturally polished and will be a skid hazard if used in the pavement without crushing.

Repair Procedure:

Since polished aggregate distress normally occurs over an extensive area, grooving or milling of the entire pavement surface should be considered. Concrete or bituminous resurfacing may also be used to correct this condition.

PUMPING (PCC)

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

Repair procedure for pumping is the same as for faulting or settlement.

ROUGHNESS (PCC)

An inequality in the pavement surface which adversely effects the ride quality, or smoothness of the ride.

SHATTERED SLAB (PCC)

Shattered Slab is defined as a slab where intersecting cracks break up the slab into four or more pieces. This is caused by overloading and/or inadequate foundation support.

Repair Procedure:
Follow the same procedures for blowup repairs except that unstable subgrade materials should be removed to a minimum depth of 12 inches and replaced with select material. Poor drainage conditions should be corrected by the installation of drains to remove excess water.

SPALLING, JOINT SPALLING (PCC)

Joint spalling often results from excessive stresses at the joint or crack caused by infiltration of incompressible materials. Weak concrete at the joint (caused by overworking at the time of construction) combined with traffic loads is another cause of spalling. Joint spalling is the breakdown of the slab edges within 2 feet 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, CORNER SPALLING (PCC)

Corner spalling is the raveling or breakdown of the slab within approximately 2 feet of the corner. It differs from a corner break in that the spall usually angles downward to intersect the joint while a break extend vertically through the slab.

The repair procedure for joint and corner spalling is the same.

Repair Procedure:

- -Make a vertical cut with a concrete saw 1-inch in depth and approximately 2 inches behind the spalled area.
- -Break out the unsound concrete with air hammers or pneumatic drills and blow out the area with compressed air.
- -Pressure rinse the area to be replaced.
- -Treat the surface with a grout mixture to insure a good bond between the existing pavement and the new concrete. Apply the grout immediately before placing the patch mixture and spread with a stiff broom or brush to a depth of 1/16 inch.
- -Place a thin strip of wood or metal coated with bond-breaking material in the joint groove and tamp the new mixture into the old surface. The mix should be air-entrained and designed to produce a concrete without a slump, which will require tamping to place the patch.
- -After edging of the patch has been completed, it should be finished to a texture matching the adjacent area.
- -After curing for a minimum of 3 days, the open joint should be filled with joint material prior to opening to traffic.

SKID RESISTANCE (PCC)

Skid resistance refers to the ability of a pavement to provide a surface with good friction characteristics under all weather conditions and is a function of the surface texture or the buildup of contaminants. The idea is to have enough surface friction to prevent skidding. The following are distresses leading to a loss in skid resistance: Treatment includes resurfacing, grooving, milling, and surface cleaning.

BITUMNOUS REPAIRS FOR CONCRETE PAVEMENT

Broken concrete (PCC) areas can be patched with bituminous concrete (HMAC) as an interim measure. Repair for corner cracks, diagonal cracks, blowups, and spalls can be made using the following procedure:

-Make a vertical cut with a concrete saw completely through the slab.
-Break out the concrete with pneumatic tools and remove the broken concrete down to the subbase/subgrade material.
-Add subbase/subgrade material if required and compact.
-Apply prime coat to subbase material.
-Apply tack coat to sides of slab.
-Place bituminous concrete in layers not exceeding 3 inches.
-Compact each layer with a vibratory-plate compactor, roller, or mechanical rammers.
Normal traffic may be permitted on bituminous patches immediately after completion of the patch.

BITUMINOUS PAVEMENTS

Bituminous pavements, also known as hot mix asphalt concrete (HMAC), or just hot mix, are used on most small airports in Texas. They are subject to the following distresses:

BLEEDING	DEPRESSIONS
CONTAMINANTS	DISTORTION
CORRUGATION	FUEL SPILLAGE
CRACKING, ALLIGATOR	OXIDIZED PAVEMENT
CRACKING, BLOCK	POLISHED AGGREGATE
CRACKING, LONGITUDINAL	POT HOLES
CRACKING, TRANSVERSE	RAVELING
CRACKING, REFLECTION	RUTTING
CRACKING, SHRINKAGE	SKID RESISTANCE
CRACKING, SLIPPAGE	SWELLING

BLEEDING (HMAC)

A film of bituminous material on the pavement surface, which resembles a shiny, glass-like reflecting surface that usually becomes quite sticky, characterizes bleeding. It is caused by excessive amounts of asphalt cement or tars in the mix and/or low air-void content and occur when asphalt fills the pavement. Since the bleeding process is not reversible during cold weather, asphalt or tar will accumulate on the surface. Extensive bleeding may cause a severe reduction in skid resistance.

Repair procedures using hot sand or aggregate are as follows:

-Apply slag screenings, sand, or rock screenings to the affected area. The aggregate should be heated to at least 300 F and spread at the rate of 10 to 15 pounds per square yard.

-Immediately after spreading, roll with a rubber-tired roller.

-When the aggregate has cooled, sweep off loose particles.

-Repeat the process, if necessary.

-A pavement planing machine, such as a heater-planer, may be used to remove the excess asphalt; specifically:

- Remove the asphalt film with a heater-planer,
- Leave the surface as planed, or
- Apply either a plant-mixed surface treatment or seal coat.

CONTAMINANTS (HMAC)

Contaminants, such as rubber, over a period of time will reduce the skid resistance of a pavement.

Repair Procedure:

Rubber deposits may be removed by using high-pressure water or biodegradable chemicals.

CORRUGATION (HMAC)

Corrugation results from a form of plastic surface movement typified by ripples, not more than 2 feet apart, across the surface. Shoving is a form of plastic movement resulting in localized bulging of the pavement surface. Corrugation and shoving can be caused by lack of stability in the mix and poor bond between material layers.

Repair Procedure:

The repair procedure for this type of distress is the same as for patch repair of alligator cracking.

CRACKING (HMAC)

Cracking in bituminous pavements is caused by deflection of the surface over an unstable foundation, shrinkage of the surface, poorly constructed land joints, or reflective cracking. The following are types of cracking found in bituminous pavements and typical repair procedures:

General Repair Procedure:

Cracking takes many forms. In some cases, simple crack filling may be the proper corrective action. In others, complete removal of the cracked area and the installation of drainage may be necessary.

CRACKS, ALLIGATOR (HMAC)

Alligator Cracks are interconnected cracks that form a series of small blocks resembling an alligator skin. They may be caused by fatigue failure of the bituminous surface under repeated loading or by excessive deflection of the surface over an unstable foundation. The unstable support is usually the result of water saturation of the bases or subgrade.

Repair Procedure:

Permanent repairs by patching may be carried out as follows:

- -Remove the surface and base as deep as necessary to reach a firm foundation. In some cases, a portion of the subgrade may also have to be removed. A power saw should be used to make a vertical cut through the pavement. The cut should be square or rectangular.
- -Replace base material with material equal to that removed.
- -Apply prime coat to the base material and vertical faces of existing pavement.
- -Place bituminous concrete and compact.
- -Applying a seal coat to the affected area can make temporary repairs.

CRACKS, BLOCK (HMAC)

Block cracking is caused by shrinkage of the asphalt concrete and daily temperature cycles, which result in daily stress/strain. These are interconnected cracks that divide the pavement into approximately rectangular pieces. The occurrence of this type of distress usually indicates that the asphalt has hardened significantly. Block cracking generally occurs over a large portion of the pavement area and may sometimes occur only in nontraffic areas.

Repair Procedure:
-If the block cracking is serious, the slab should be replaced.

CRACKS, LONGITUDINAL AND TRANSVERSE (HMAC)

Longitudinal and transverse cracks are caused by shrinkage of the bituminous concrete surface. Poorly constructed lane joints also cause longitudinal cracks.

Repair Procedure:
Narrow cracks (less than 1/8 inch) are too small to seal effectively. In areas where narrow cracks are present, a seal coat, slurry seal, or fog coat may be applied. Wide cracks (greater than 1/8 inch) should be sealed using the following procedures:

-Clean out crack with compressed air to remove all loose particles.
-Fill cracks with a prepared joint sealer.

CRACKS, REFLECTION (HMAC)

Reflection cracks are caused by vertical or horizontal movements in the pavement beneath an overlay brought on by expansion and contraction with temperature and moisture changes. These cracks in asphalt overlays reflect the crack pattern in the underlying pavement. They occur most frequently in asphalt overlays on Portland cement concrete pavements. However, they may also occur on overlays of asphalt pavements wherever cracks in the old pavement have not been properly repaired.

Insufficient compaction of the surface, insufficient asphalt in the mix, or overheating of the mix causes disintegration in a bituminous pavement. If not stopped in its early stages, disintegration can progress until the pavement needs complete rebuilding. The following are types of disintegration found in bituminous pavements:

CRACKS, SHRINKAGE (HMAC)

Interconnected cracks forming a series of large polygons, usually with sharp corners or angles. Caused by fluctuating moisture content in the base and subgrade.

CRACKS, SLIPPAGE (HMAC)

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

Repair Procedure:

One repair method commonly used for slippage cracks involves removing the affected area and patching with plant-mixed asphalt material. The specific steps are as follows:

-Remove the slipping area and at least 1-foot into the surrounding pavement. Make the cut faces straight and vertical. A power pavement saw makes a fast and neat cut.

-Clean the surface of the exposed underlying layer with a broom and compressed air.

-Apply a light tack coat.

-Place enough hot plant-mixed asphalt material in the cutout area to make the compacted surface the same grade as that of the surrounding pavement.

DEPRESSIONS (HMAC)

Depressions are localized low areas of limited size. In many instances, light depressions are not noticeable until after a rain, when ponding creates birdbath areas. Depressions can be caused by traffic heavier than that for which the pavement was designed, by localized settlement of the underlying layers, or by poor construction methods.

Repair Procedure:

-Determine the limits of the depression with a straightedge or string line. Outline it on the pavement surface with a marking crayon.

-If grinding equipment is available, grind down the area to provide a vertical face around the edge. If this equipment is not available, this step may be omitted.

-Thoroughly clean the entire area to at least 1-foot beyond the marked limits.

-Apply a light tack coat of asphalt emulsion diluted with equal parts of water to the area.

-Allow the tack coat to cure.
-Spread enough bituminous concrete in the depression to bring it to the original grade when compacted. The correct way to repair a deep depression is to begin in the deepest part of the depression and place a thin layer, the surface of which when compacted, will be parallel to the original pavement surface. Successive layers are placed in the same manner.
-If the pavement was not ground down, the edges of the patch should be feather-edged by careful raking and manipulation of the material. However, in raking, care should be taken to avoid segregation of the coarse and fine particles of the mixture.
-Thoroughly compact the patch with a vibrator-plate compactor, roller, or hand tamps.

DISTORTION (HMAC)

Distortion in bituminous pavements is caused by foundation settlement, insufficient compaction of the pavement courses, lack of stability in the bituminous mix, poor bond between the surface and the underlying layer of the pavement structure, or swelling soils or frost action in the subgrade. Repair techniques range from leveling the surface by filling with new material to complete removal of the affected area and replacing with new material. The following are types of distortion found in bituminous pavements:

FUEL SPILLAGE (HMAC)

Fuel spillage on bituminous surfaces over time will soften the asphalt. Areas subject to only minor fuel spillage will usually heal without repair, and only minor damage will result.

Repair Procedure:
Permanent repairs for areas subjected to continuous fuel spillage consist of removal of the damaged pavement and replacement with Portland cement concrete or an overlay with a tar emulsion seal coat.

OXIDIZED PAVEMENT (HMAC)

Hot mix pavement with dry, brittle asphalt. Usually requires a fog seal, slurry seal, or overlay to correct.

POLISHED AGGREGATE (HMAC)

Polished aggregate is caused by repeated traffic applications. It occurs when the aggregate extending above the asphalt is either very small, of poor quality, or contains no rough or angular particles to provide good skid resistance.

Repair Procedure:
One means of correcting this condition is to cover the surface with an aggregate seal coat. Grooving or milling the pavement surface may also be used.

POT HOLE (HMAC)

Bowl shaped holes of varying size caused by localized disintegration of the pavement.

Maintenance is similar to that for alligator cracking.

RAVELING (HMAC)

Raveling is the wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder. As the raveling continues, larger pieces break free, and the pavement takes on a rough and jagged appearance.

Repair Procedure:
Further deterioration from raveling may be prevented by the following:
-Sweep the surface free of all dirt and loose aggregate material.
-Apply a fog seal diluted with equal parts of water.
-Close area to traffic until the seal has cured.
-Apply a surface treatment such as an aggregate seal coat.
-A pavement-planing machine, such as a heater-plane, may be used to soften the surface of the pavement; then, apply a seal coat or bituminous overlay.

RUTTING (HMAC)

Rutting is characterized as a surface depression in the wheel path. In many instances, ruts are noticeable only after a rainfall when the wheel paths are filled with water. This type of distress is caused by a permanent deformation in any of the pavement layers or the subgrade and is caused by consolidation of the materials due to traffic loads.

Repair Procedure:

-Determine the severity of the rutting with a straightedge or string line. Outline the areas to be filled.
-Apply a light tack coat of asphalt emulsion diluted with equal parts of water.
-Spread dense-graded asphalt concrete with paver and compact. Be sure that the material is feathered at the edges.
-Place a thin overlay of bituminous concrete over the entire area.

SKID RESISTANCE (HMAC)

Factors which decrease the skid resistance of a pavement surface leading to hydroplaning include too much asphalt in the bituminous mix, too heavy a prime coat, poor aggregate subject to wear, and buildup of contaminants. Treatment includes removal of excess asphalt, resurfacing, grooving to improve surface drainage, and removal of rubber deposits.

SWELLING (HMAC)

An upward bulge in the pavement surface characterizes swelling. It may occur sharply over a small area or as a longer gradual wave. Both types of a swell may be accompanied by surface cracking. A swell is usually caused by frost action in the subgrade or by swelling soil.

Repair Procedure:
The repair procedure is the same as for patch repair of alligator cracking.

DRAINAGE

A proper drainage system is a fundamental consideration of preventive maintenance. Pavement failures should always be investigated for deficient drainage. Probably no other factor plays such an important role in determining the ability of a pavement to withstand the effects of weather and traffic. The purpose of airport drainage is to dispose of the water, which may hinder activity necessary to the safe and efficient operation of the airport. The drainage system collects and removes surface water runoff, removes excess underground water, lowers the water table, and protects all slopes from erosion. An inadequate drainage system can cause saturation of the subgrade and subbase, damage to slopes by erosion, and loss of the load-bearing capacity of the paved surfaces.

Water damage to pavement is related to the amount of water in the boundaries between the structural layers of the pavement. When water fills the voids and spaces at the boundaries between the layers, heavy wheel loads applied to the surface of the pavement produce impacts on the water that are comparable to a water-hammer type action. The resulting water pressure causes erosion of the pavement structure and ejection of material out of the pavement. Drainage is discussed in detail in Advisory Circular AC 150/5320-5 "Airport Drainage".

There are two classes of drainage systems, surface and subsurface. Classification depends on whether the water is on or below the surface of the ground at the point where it is first intercepted or collected for disposal. Where both types of drainage are required, it is generally better for each system to function independently.

The purpose of surface drainage is to control and collect water from rainstorms and melting snow and ice. Surface drainage of pavements is achieved by constructing the pavement surface to allow for adequate runoff. Surface water may be collected at the edges of the paved surface in ditches, gutters, and catch basins. Surface drainage includes the disposal of all water present on the surface of the pavement and nearby ground.

Surface water should not be allowed to enter a subdrainage system because it often contains soil particles in suspension. These particles tend to deposit as the water percolates through the granular material of the subdrain causing it to silt up. Inevitably, some water will enter the pavement structure through cracks, open joints, and other surface openings, but this may be kept to a minimum by proper surface maintenance procedures.

Subsurface drainage is provided for the pavement by a highly permeable layer of sand-aggregate mixture placed under the full width of the travel way. Longitudinal pipes for collecting the water and an outlet removes excess water from the subsurface drainage system. Drainage removes excess water from pavement foundations to prevent weakening of the base and subgrade and to reduce damage from frost action.

PAVEMENT INSPECTION

A high priority should be given to the upkeep and repair of all pavement surfaces on the airport to insure continued safe operations. While deterioration of pavement due to usage and exposure cannot be completely prevented, a timely and effective maintenance program can reduce this deterioration to a minimum level. Lack of adequate and timely maintenance is the greatest single cause of pavement deterioration. Many cases are known where failures of airport pavements and drainage structures were directly attributed to inadequate maintenance characterized by the absence of a vigorously followed inspection program. It should be noted that maintenance, no matter how effectively carried out, cannot overcome or compensate for a major design or construction inadequacy. It can, however, prevent the total and possibly disastrous failure, which may result from such deficiencies. The maintenance inspection can reveal at an early stage where a problem exists and, thus, provide the warning and time to permit a corrective repair project.

INSPECTION PROCEDURES

Maintenance is a continuous function and is the responsibility of airport personnel. A series of scheduled, periodic inspections, conducted by an experienced engineer or trained maintenance personnel, must be carried out in a effective maintenance program. These surveys must be controlled to insure that each element or feature being inspected is thoroughly checked, that potential problem areas are identified, and that proper corrective measures are recommended. The maintenance program must provide for adequate follow-up to ascertain that the corrective work is expeditiously accomplished and recorded. Although the organization and scope of maintenance activities will vary in complexity and degree from airport to airport, the general types of maintenance are relatively the same regardless of airport size or extent of development. The Texas Department of Transportation has engineers and airport inspectors available to assist with pavement evaluation. They can also assist is setting up a pavement management program.

MATERIALS AND EQUIPMENT

Normal day-to-day pavement maintenance requires only hand tools, but certain specialized equipment may sometimes be needed. Several shovels, a hand tamper, and several buckets of cold mix asphalt should always be kept in case of an emergency such as a lightning strike hole in a runway.

REFERENCES

Advisory Circular AC 150/5380-6 “Guidelines and Procedures for Maintenance of Airport Pavements”

Advisory Circular AC 150/5380-7 “Pavement Management System”

Advisory Circular AC 150/5320-5 “Airport Drainage”

“Maintenance of Joints and Cracks in Concrete Pavements”, Portland Cement Association

“Patching Concrete Pavements”. Portland Cement Association

“Cement Grout Subsealing and Slab-Jacking of Concrete Pavements”, Portland Cement Association

PAVEMENT MANAGEMENT PROGRAM

APPENDIX 2: PAVEMENT MANAGEMENT SYSTEMS

FEDERAL AVIATION ADMINISTRATION
ADVISORY CIRCULAR 150/5380-7

9/28/88

Initiated by: AAS-200

1. PURPOSE.

This advisory circular (AC) presents the concepts of a Pavement Management System, discusses the essential components of such a system, and outlines how it can be used in making cost-effective decisions regarding pavement maintenance and rehabilitation.

2. APPLICATION.

The guidelines contained herein are recommended by the Federal Aviation Administration for use when considering implementation of a pavement management system.

3. BACKGROUND.

a. Historically, most agencies have made decisions regarding maintenance and rehabilitation based on experience rather than using documented data. This approach did not allow the agency to evaluate the cost-effectiveness of alternative maintenance and repair strategies and led to an inefficient use of funds.

b. Every agency must decide how to allocate its available funds most effectively. Many agencies use the "ad hoc" approach, whereby the staff applies the maintenance and repair procedure that their experience indicates is the best solution. This approach usually results in the repeated application of a select few alternatives and does not necessarily select the best or most economical option. The "existing condition" approach is also used. Here, the pavement network is first evaluated by means of various condition indicators. Based on an analysis of these indicators, maintenance and repair alternatives are selected. However, life cycles cost comparisons of the alternatives are not considered. This approach selects the maintenance and repair procedures that relate to the deficiencies in the pavement, but the choice may not be the most cost-effective method based on life-cycle costing.

c. Since these approaches worked well, they became part of the standard operating procedure in some agencies. Today, however, with limited money to spend on maintenance and rehabilitation and new technology providing more options for repair, these established procedures do not answer some basic questions. For example, what if funds are available to do only half the overlays that the procedure indicates is necessary in particular year? Should some pavements be overlaid to the proper thickness while the remainder receives no overlay? Should the thickness be reduced and a thin overlay be placed on all pavements? It is evident that decisions made today will have an effect on the pavements condition in future years. The question then becomes which course of action to take and the immediate and future consequences of such action.

4. NEW DECISION-MAKING PROCESS.

a. The question can best be answered on the basis of the predicted effects of each action. For example, if a thin overlay is placed on all pavements there will be an immediate improvement to all the pavements. However, due to rapid deterioration there will probably be a need for further rehabilitation in a short period of time. If some of these same pavements need work again next year, in addition to other pavement in need of work, the overall condition of the pavement network will deteriorate. Alternatively, if the full thickness overlay is placed only on selected pavements, they will not need rehabilitation for many years. During each of these years it may be possible to overlay some of the remaining pavements so that ultimately the number of pavements needing rehabilitation may decrease. However, those pavements that have not been overlaid will continue to deteriorate under this strategy, and the overall pavement condition will probably be worse during the first few years than under the first strategy.

In order to determine which of these actions is preferable, we must be able to predict the future consequences of the various scenarios. For example, we must know the life span of a thick overlay, say 4 inches, versus a thin 2-inch overlay. We should also have a knowledge of the rate of deterioration of pavements, with and without maintenance, and a good understanding of the causes of current pavement deterioration.

b. These predictions may be made using "engineering judgment" in the decision making process. However, if the consequences are predicted using a predetermined methodology, it will be possible to analyze previous predictions and to improve on the prediction procedure over a period of time.

c. One such methodology is a Pavement Management System (PMS). The idea of a pavement management system is to improve on the decision making process, expand its scope, allow for feedback based on decisions made, and to ensure that consistent decisions are made throughout an organization.

5. PAVEMENT MANAGEMENT SYSTEM (PMS).

A pavement management system provides a consistent objective and systematic procedure for setting priorities and schedules, allocating resources, and budgeting for pavement maintenance and rehabilitation. It can also quantify information and provide specific recommendations for actions required to maintain a pavement network at an acceptable level of service while minimizing the cost of maintenance and rehabilitation.

A PMS is not a "black box" solution but is a tool for helping the engineer, budget director, and management to do a better job in making cost-effective decisions regarding pavement maintenance and rehabilitation.

a. Concepts of a Pavement Management System.

A PMS not only evaluates the present condition of a pavement but also predicts its future condition through the use of a pavement condition indicator. By projecting the rate of deterioration, a life cycle cost analysis can be performed for various alternatives, and the optimal time of application of the best alternative is determined.

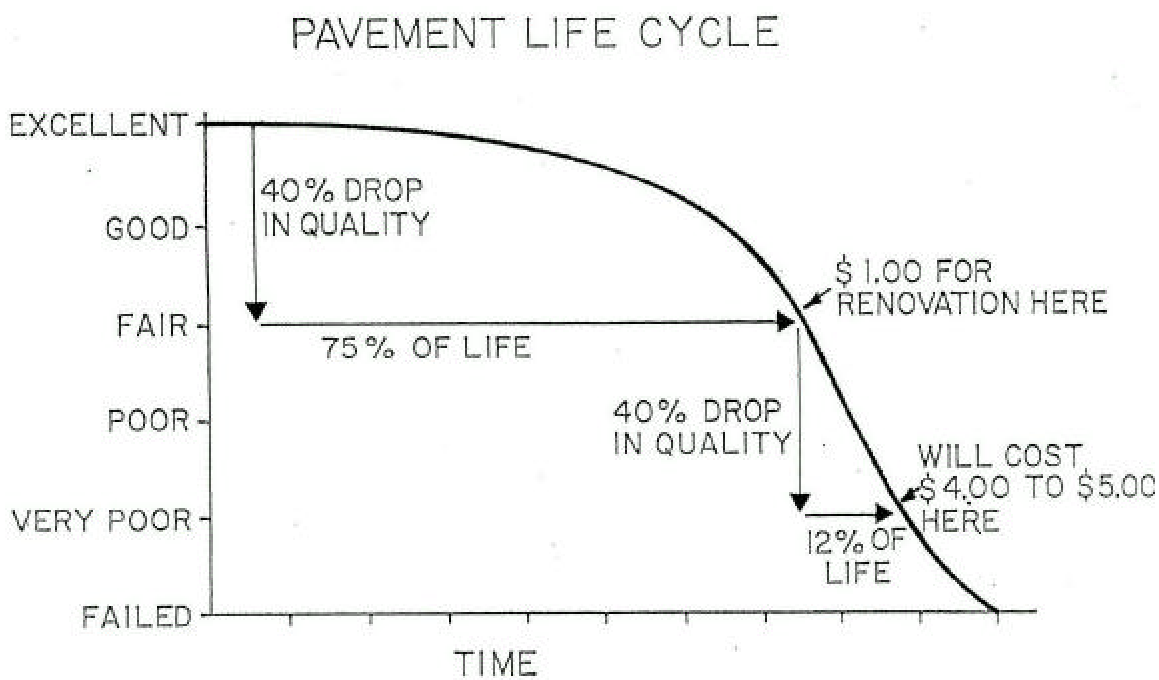
Such a decision is critical in order to avoid higher maintenance and repair (M & R) costs at a later date. Figure 1 illustrates how a pavement generally deteriorates and the relative cost of rehabilitation at various times throughout its life. Note that during the first 75 percent of a pavements' life, it performs relatively well, After that, however, it begins to deteriorate rapidly. The number of years a pavement stays in "good" condition depends on how well it is maintained. Numerous studies have shown that the ratio of total annual costs between maintaining a good pavement and periodically rehabilitating a poor pavement is in the order of 1 to 4 or 5.

Figure 1 also shows that the optimum time for major rehabilitation is just as a pavement's rate of deterioration begins to increase. Maintenance and rehabilitation solutions would be more easily managed if pavements exhibited a clear sign at this point, but this is not the case. The shape of the deterioration curve, and therefore the optimal maintenance and repair points, vary considerably within a pavement network. A pavement experiencing a sudden increase in operations or aircraft loading will have a tendency to deteriorate more rapidly than a pavement deteriorating from environmental causes. In addition, there are no obvious visual signs at this time. A pavement deteriorating from environmental damage may have a number of cracks that need filling but still be structurally sound. Conversely, this same pavement may be in the early stages of load damage deterioration, which can only be detected with proper testing.

Since there is no "positive signal" as to when a pavement reaches the 75 percent deterioration point, we depend on a PMS to help us target our resources to this optimum rehabilitation point. This can be accomplished through the use of a pavement condition rating system, which will predict future conditions and indicate whether the distress is load, or environmentally related.

b. cost-effective Solutions.

Information on pavement deterioration, by itself, is not sufficient to answer questions involved in selecting cost-effective maintenance and repair strategies. For example, should a pavement be seal coated, recycled, or resurfaced? This type of decision requires information on the cost of various maintenance and repair procedures and their effectiveness. Effectiveness in this case means:



The proposed solution is targeted toward the source of the deficiency and will improve the pavement's condition rating.

The pavement will stay in this improved condition for several years to optimally recover the cost of the solution.

A pavement management system will enable a user to store information in a database and use the system's programs to determine the most cost-effective solution to these questions.

TYPICAL PAVEMENT CONDITION LIFE-CYCLE (Reprinted from APWA Reporter, November 1983)

6. COMPONENTS OF A PAVEMENT MANAGEMENT SYSTEM.

In order to take full advantage of a pavement management system, information must be collected and periodically updated. Decision criteria must be established, alternative strategies must be identified, predictions of the performance and costs of alternative strategies must be made, and optimization procedures that consider the entire pavement life cycle must be developed.

A system for accomplishing these objectives must generally include:

- A systematic means for collecting and storing information,
- An objective and repeatable system for evaluating pavement condition.
- Procedures for identifying alternative strategies.
- Procedures for predicting the performance and costs of alternative strategies.
- Procedures for identifying the optimum alternative.

A discussion of the essential components of a PMS follows.

a. Data Base. There are several elements critical to making good pavement maintenance and repair decisions pavement structure, maintenance history, including costs, traffic data, and information on the condition of a pavement. This data can be stored in a system's database.

(1) Pavement Structure. A key to analyzing problems and designing solutions is a knowledge of when the pavement was originally built, the structural compositions (material and thickness), and subsequent overlays, rehabilitation, etc, "As built" records should provide this information. If they are not available or if records are suspect, it will be necessary to take test cores in the existing pavement.

(2) Maintenance History. A history of maintenance performed and its associated costs provide valuable information on the effectiveness of various maintenance procedures on flexible and rigid pavements. The cost of each maintenance procedure is necessary when performing a life cycle cost analysis.

(3) Traffic Data. The number of operations and type of aircraft using the pavement are necessary when analyzing probable causes of deterioration and when considering rehabilitation procedures,

(4) Pavement Condition. A basic component of any pavement management system is the ability to track a pavement's deterioration and determine the cause of the deterioration. This requires an evaluation process that is objective, systematic, and repeatable. A pavement condition rating system that is based on the quantity, severity, and type of distress is a rating of the surface condition of a pavement performance with implications of structural performance. Condition rating data collected periodically will track the performance of a pavement.

b. Alternative Strategies. In order to compare alternative solutions to a particular problem, the system must contain a list of feasible actions related to the pavement condition. These alternative strategies should take into consideration such factors as pavement condition, rate of deterioration, causes of distress, previous maintenance, and current and future traffic.

c. Performance and Costs of Alternatives. Based on the results of identifying alternative strategies, the system must be able to predict the future performance of a pavement for the various alternatives and perform an economic analysis to compare the costs of all alternatives (life cycle costing).

d. Optimization. In order to select the alternative that satisfies cost and performance constraints, a procedure that evaluates several alternative solutions to a specific set of conditions is needed.

7. MICRO-PAVER.

a. Background. A pavement management system that has been used on airport pavement networks at the state and local level is Micro-PAVER. The U.S. Army Construction Engineering Research Laboratory under contract to the Federal Aviation Administration developed this system, which operates on a microcomputer.

The program allows for storage of pavement condition history, nondestructive testing data, and construction and maintenance history, including cost data. This database provides many capabilities including evaluation of current conditions, prediction of future conditions, identification of maintenance and rehabilitation needs, inspection scheduling, economic analysis, and budget planning. Micro-PAVER not only evaluates the present condition of the pavement using the pavement condition index (PCI) described in Appendix A of AC 150/5380-6, Guidelines and Procedures for Maintenance of Airport Pavements but can also predict its future condition. The PCI is a numerical indicator that reflects the structural integrity and surface operational condition of a pavement. It is based on an objective measurement of distress type, severity, and quantity. By projecting the rate of deterioration, a life cycle cost analysis can be performed for various maintenance and rehabilitation alternatives. Not only is the best alternative selected but the optimal time of application is also determined.

b. Management Levels. Once a database has been established, Micro-PAVER can be used to assist in making pavement management decisions. Managing a pavement system effectively requires decision making at two levels:

(1) Network level. At the network level in which decisions are made regarding the management of an entire pavement network. For example, at the local level, all the pavements on an airport, and at the state level, all the pavements on each of the airports in the state system.

(2) Project level. At the project level, decisions are made regarding the selection of the most cost-effective maintenance and rehabilitation alternative for a pavement identified as a candidate for work at the network level.

8. NETWORK LEVEL.

a. In network level management, questions are answered concerning short and long range budget needs, the overall condition of the network, both currently and in the future, and identification of pavements for consideration at the project level.

b. In addition to providing an automated inventory of pavements being managed, Micro-PAVER provides a series of programs, which access the database and produce customized reports. These reports help the user make decisions regarding inspection scheduling, identification of pavements for rehabilitation, budget forecasting, identification of routine maintenance projects, evaluation of current condition, and prediction of future condition.

c. Condition prediction is used as the basis for developing inspection schedules and identifying pavements requiring maintenance or rehabilitation. Once pavements requiring future work have been identified, a budget for the current year and for several years into the future can be developed. By using an agency's prioritization scheme, maintenance policy, and maintenance and rehabilitation costs and comparing the budget to the actual funds available for the current year, a list of potential projects is produced. This list becomes the link with project level management.

9. PROJECT LEVEL.

In project level management, decisions are made regarding the most cost-effective maintenance and rehabilitation alternative for the pavements identified in the network analysis. At this level each of these pavements should have a detailed condition survey. In addition, nondestructive and/or destructive tests should be made to determine the pavements load carrying capacity.

Roughness and friction measurements may be useful for project development. Roughness measurements may be useful when there is evidence of roughness, usually in the form of frequent pilot complaints. Roughness measurement is of more value when the pavement is in very good condition with little or no distress.

If reconstruction is imminent, roughness measurements of the existing pavement may not be of any value. Friction measurements, on the other hand, should be made on a periodic basis to measure the textural properties of the pavement and determine the amount of deterioration that has occurred. Nondestructive test data, friction measurements, roughness measurements, and drainage information, may all be entered into the database. This information is used to identify feasible alternatives that can correct existing deficiencies. The various alternatives identified including no action, are then compared on a life cycle cost basis. The results, combined with budget and management constraints, produce the current year's maintenance and repair (M & R) program.

10. REPORT GENERATION AND USAGE.

Micro-PAVER can assist in the decision making process through the use of several standard reports. Each report can be customized to include only the pavements and/or conditions of interest and can be generated to represent various budget/condition scenarios. The use of each report is briefly outlined below.

a. Inventory Report. This report is a listing of all pavements in a network and contains information such as surface type, location, area, and pavement function, that is, runway, taxiway, apron.

b. Inspection Scheduling Report. This report allows the user to schedule inspections for the next 5 years based on a pavements minimum acceptable PCI condition level and rate of deterioration.

c. PCI Frequency Report. This report provides the user with an indication of overall network condition, based on the PCI scale, for the current or future years. The projected condition can be used to assist in planning future maintenance and repair needs and to inform management of present and future conditions. Since the PCI extrapolation used presumes no major repairs have occurred between the last inspection and prediction dates, the user can see the impact on the overall network condition of performing no major repairs.

d. Budget Planning Report. This report allows the user to produce 5 year projected budgets required to maintain the pavement network above a user specified condition level. The user is required to input three forms of data; (1) minimum PCI values for each pavement type (2) average unit repair costs based on surface type and PCI ranges, (3) the inflation rate during the analysis period. The report predicts for each pavement selected the year in which the minimum PCI will be reached and calculates the cost of repair.

e. Network Maintenance Report. This report uses the agency's maintenance policy, which is stored in the database and applies it to the distresses identified in the latest PCI survey. This report can be used to estimate both the type and cost of routine maintenance for the development of an annual work plan.

f. Economic Analysis Report. This report can be used to help select the most cost-effective alternative for a pavement repair. For each feasible alternative, the user must input initial costs, periodic maintenance costs, one time future maintenance costs, interest rates, and discount rates. The program performs a life cycle cost analysis and provides the user with an equivalent uniform annual cost per square yard. The program allows the user to vary interest rates, repair costs, and timing so that their effect on alternatives can be analyzed.

11. MICRO-PAVER SOFTWARE.

The Micro-PAVER Program can be operated on an IBM compatible personal computer having a hard disk with 20 megabytes storage capacity and 640K random access memory (RAM). Version 2.0, or greater, of MS-DOS is the operating system required.

The Micro-PAVER software package, together with a user's guide, may be obtained from a distribution center. Currently, there are three distribution centers, with each center responsible for establishing individual fees for distribution and providing updates and corrections as they become available. The fees vary according to the service provided to the user (training, implementation assistance, user's group membership, etc.), but range between $300 and $500 per year. Users should contact each center and determine which one will best suit their needs. The location of the centers is contained in AC 150/5000-6, Micro-PAVER, Pavement Management System.

Additional information concerning Micro-PAVER is contained in report number DOT/FAA/PM-87/8, Micro-PAVER, Concept and Development Airport Pavement Management System, dated July 1987.

12. OTHER PAVEMENT MANAGEMENT SYSTEMS.

Pavement management systems other than consulting engineer firms that uses Micro-PAVER provide pavement evaluation and management services. The software programs used by these firms are not in the public domain and therefore cannot be purchased for use by an individual or an agency.

13. BENEFITS OF A PAVEMENT MANAGEMENT SYSTEM.

Some of the benefits to be gained from implementation of a PMS include:

a. provides an objective and consistent evaluation of the condition of a network of pavements.
b. provides a systematic and documentable engineering basis for determining maintenance and rehabilitation needs.
c. identifies budget requirements necessary to maintain pavements at various levels of serviceability.
d. provides documentation on the present and future condition or the pavements in a network.
e. determines life-cycle costs for various M & R alternatives.
f. identifies the impact on the pavement network as a result of performing no major repairs.

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