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MANUAL ON MAINTENANCE OF AERODROME PAVEMENTS

FOREWORD

This Manual provides detailed information to aerodrome operators on procedures to be used in the maintenance of pavements at an aerodrome. While this manual addresses pavement maintenance of aerodrome components regardless of the aerodrome size or role, the description of tasks has been restricted to the maintenance of those pavements which are critical to aircraft operations.

This manual consolidates in one document a review of the pavement maintenance practices required at an aerodrome to ensure the safety, efficiency and regularity of aircraft operations. It is only concerned with the aspects of pavement maintenance which are normally the responsibility of the aerodrome operator. This manual does not provide guidance on maintenance of such facilities as radio navigational aids, electrical systems, visual aids, buildings and meteorological equipment.

Proper maintenance of aerodrome pavements is important both for the safe operation of aircraft and extending the service life of the paved surfaces. It is hoped that this manual will establish the proper position of pavement maintenance in the overall aerodrome maintenance programme.

The responsibility for amendments of the Manual lies with the Director General, Civil Aviation Authority. Future editions will be improved on the basis of experience gained, comments and suggestions received from the users of this manual. Readers are invited to give their views, comments and suggestions on this edition. All the comments or queries to be sent to:

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ABBREVIATIONS AND SYMBOLS

Abbreviations

APMS	Aerodrome Pavement Management System
ASR	Alkali Silica Reactivity
FOD	Foreign Object Debris
FWD	Falling Weight Deflectometer
GPR	Ground Penetrating Radar
HMA	Hot Mix Asphalt
PCC	Portland Cement Concrete
PCI	Pavement Condition Index

CHAPTER 1: INTRODUCTION TO AERODROME PAVEMENT MAINTENANCE

1.1 INTRODUCTION

The paved surfaces at an aerodrome should be maintained in a condition that precludes harmful irregularities or breaking off of pieces that would be a hazard to aircraft operation. The Manual of Aerodrome Standards requires continuous monitoring of pavement condition, and repair when necessary. Repair of pavements is costly and often imposes restrictions on the aerodrome traffic even when damaged areas are small. Preventive maintenance is therefore of high importance to aerodrome pavement management.

1.2 BACKGROUND

1.2.1 The aviation community has a large investment in aerodrome pavements. The major objective in the design and construction of these pavements is to provide adequate load-carrying capacity and good ride quality necessary for the safe operation of aircraft under all weather conditions. Immediately after completion, aerodrome pavements begin a gradual deterioration that is attributable to several factors. Traffic loads in excess of those forecast during pavement design can shorten pavement life considerably. Normal distresses in the pavement structure result from surface weathering, fatigue effects, and differential movement in the underlying sub-base over a period of years. In addition, faulty construction techniques, substandard materials, or poor workmanship can accelerate the pavement deterioration process.

1.2.2 Many pavements were not designed for servicing today's aircraft, which impose loads much greater than those initially considered. Also, the frequency of takeoffs and landings at many aerodromes has increased considerably. Both factors result in accelerated deterioration of the pavement structure. To assure safe operations, aerodromes must make special efforts to upgrade and maintain pavement serviceability. Consequently, aerodrome pavements require continual routine maintenance, rehabilitation, and upgrading.

1.2.3 The most effective means of preserving aerodrome runways, taxiways, and apron pavement areas is to implement a comprehensive maintenance program. To be effective, such a program must take a coordinated, budgeted, and systematic approach to both preventive and remedial

maintenance. The comprehensive maintenance program should be updated annually and feature a schedule of inspections and a listing of required equipment and products. The aerodrome operator should systematically make repairs and take preventive measures, when necessary, on an annual basis at a minimum. The systematic approach assures continual vigilance and permits the stockpiling of maintenance materials, which assures their availability for routine and emergency maintenance.

1.2.4 The Civil Aviation (Aerodromes Designs and Operations) Regulations 2024 require aerodrome operators to develop and maintain an effective aerodrome maintenance program. The Manual of Aerodrome Standards recommends aerodromes that are not specifically required to develop maintenance programs to do so as a means of preserving their facilities.

1.2.5 Two major elements contribute to pavement deterioration; the effects of weathering and the action of aircraft traffic. Early detection and repair of pavement defects is the most important preventive maintenance procedure. Failure to perform routine maintenance during the early stages of deterioration may eventually result in serious pavement distresses that require extensive repairs that will be costly. In all cases of pavement distress manifestations, the causes of the problem should first be determined. If the causes are known, an aerodrome operator can select a repair method that will not only correct the present damage, but also prevent its progression.

1.2.6 The selection of a specific rehabilitation method involves considering both economic and engineering impacts. Aerodrome operators should prioritize long-term effects rather than focusing on immediate short-term remedies. They should compare the cost of rehabilitation alternatives over some finite period of time (life cycle) and consider the future economic consequences of a repair method as well as the initial maintenance costs.

1.2.7 The present or immediate costs of a pavement rehabilitation/maintenance project include actual costs of the repairs and the estimated costs that aerodrome users will incur because of the project. Aerodrome user costs include those experienced by airlines, fixed base operators, concession operators, and others due to traffic delays, re-routings, etc. Future costs include those incurred later in the life cycle (depending on the life expectancy of the repair) plus the routine maintenance costs expected over the same period. A comparative analysis of these costs for the various alternatives will suggest the most economical rehabilitation scheme.

CHAPTER 2: AERODROME PAVEMENTS - COMPOSITION AND FUNCTION.

2.1 INTRODUCTION TO AERODROME PAVEMENTS

Aerodrome pavements are designed, constructed, and maintained to support the critical loads imposed on them and to produce a smooth, skid-resistant, and safe-riding surface. The pavement must be of such quality and thickness to ensure it will not fail under the loads imposed and be durable enough to withstand the abrasive action of traffic, adverse weather conditions, and other deteriorating influences. To ensure the necessary strength of the pavement and to prevent unmanageable distresses from developing, the aerodrome operator should consider various design, construction, and material-related parameters. This chapter helps aerodromes operators to assess these parameters by providing information on the composition of pavement sections and the functional aspects of flexible and rigid pavement components.

2.2 CLASSIFICATION OF AERODROME PAVEMENTS

Generally, pavements fall into two classes: rigid and flexible pavements. Combinations of different pavement types and stabilized layers form complex pavements that can be classified as variations of the normal rigid and flexible types. Overlay pavements—existing pavement structures that are overlaid by either of the pavement types—are also common.

2.3 RIGID PAVEMENT COMPOSITION AND STRUCTURE

2.3.1 Rigid pavements normally use Portland cement concrete (PCC) as the prime structural element. Depending on conditions, the PCC pavement slab may be designed with plain, lightly and continuously reinforced, pre-stressed, or fibrous concrete and usually lies on a compacted granular or treated sub-base, which is supported by a compacted sub-grade. The sub-base provides uniform stable support and may provide subsurface drainage.

2.3.2 The PCC pavement slab has considerable flexural strength and spreads the applied loads over a large area. Figure 2-1 illustrates a typical rigid pavement structure. Rigid pavements have a high degree of rigidity.

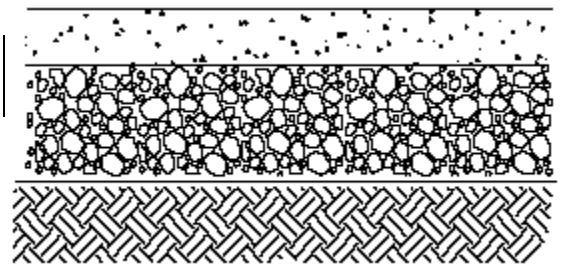

Figure 2 – 1: Typical Rigid Pavement Structure

Figure 2-2 shows how this inflexibility and the resulting beam action enable rigid pavements to distribute loads over large areas of the sub-grade. Better rigid pavement performance requires that support for the PCC pavement slab be uniform. Rigid pavement strength is most economically built into the PCC pavement slab itself with optimum use of low-cost materials under the slab.

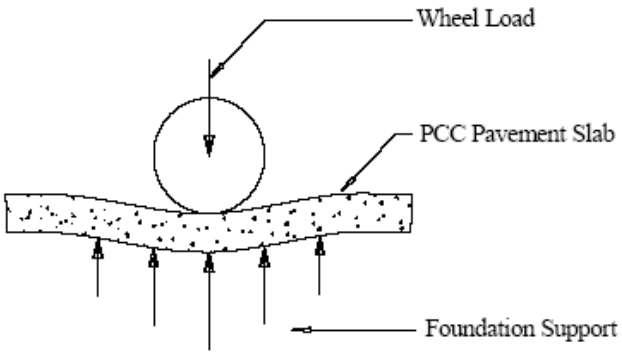

Figure 2 – 2: Transfer of Wheel Load to Foundation in Rigid Pavement Structure

2.3.3 PCC Pavement Slab (Surface Layer).

The PCC pavement slab provides structural support to the aircraft, provides a skid-resistant surface, and prevents the infiltration of surface water into the sub-base.

2.3.4 Sub-base.

The sub-base provides uniform stable support for the pavement slab. The sub-base also provides subsurface drainage, control swelling of sub-grade soils, provide a stable construction platform for

rigid pavement construction, and prevent mud pumping of fine-grained soils. Rigid pavements generally require a minimum sub-base thickness of 100 mm.

2.3.5 Stabilized Sub-base.

All new rigid pavements designed to accommodate aircraft weighing 45,000 kg or more must have a stabilized sub-base. The structural benefit imparted to a pavement section by a stabilized sub-base is reflected in the modulus of sub-grade reaction assigned to the foundation.

2.3.6 Sub-grade.

2.3.6.1 The sub-grade is the compacted soil layer that forms the foundation of the pavement system. Sub-grade soils are subjected to lower stresses than the surface and sub-base courses. These stresses decrease with depth, and the controlling sub-grade stress is usually at the top of the sub-grade unless unusual conditions exist such as a layered sub-grade or sharply varying water content or densities, may change the locations of the controlling stress. The soils investigation should check for these conditions. The pavement above the sub-grade must be capable of reducing stresses imposed on the sub-grade to values that are low enough to prevent excessive distortion or displacement of the sub-grade soil layer.

2.3.6.2 Since sub-grade soils vary considerably, the interrelationship of texture, density, moisture content, and strength of sub-grade material is complex. The ability of a particular soil to resist shear and deformation will vary with its density and moisture content. In this regard, the soil profile of the sub-grade requires careful examination. The soil profile is the vertical arrangement of layers of soils, each of which may possess different properties and conditions. Soil conditions are related to the ground water level, presence of water-bearing strata, and the properties of the soil, including soil density, particle size and moisture content. Since the sub-grade soil supports the pavement and the loads imposed on the pavement surface, it is critical to examine soil conditions to determine their effect on grading and paving operations and the need for under-drains.

2.4 FLEXIBLE PAVEMENT COMPOSITION AND STRUCTURE

2.4.1 Flexible pavements support loads through bearing rather than flexural action. They comprise several layers of selected materials designed to gradually distribute loads from the pavement surface to the layers underneath. The design ensures the load transmitted to each successive layer does not exceed the layer's load-bearing capacity. A typical flexible pavement section is shown in Figure 2-3.

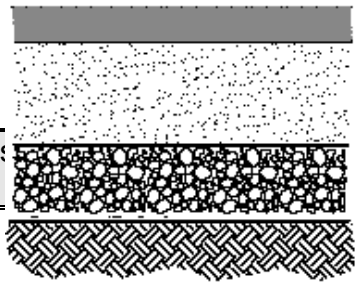

Figure 2-3. Typical Flexible Pavement Structure

Figure 2-4 depicts the distribution of the imposed load to the sub-grade. The various layers composing a flexible pavement and the functions they perform are described below:

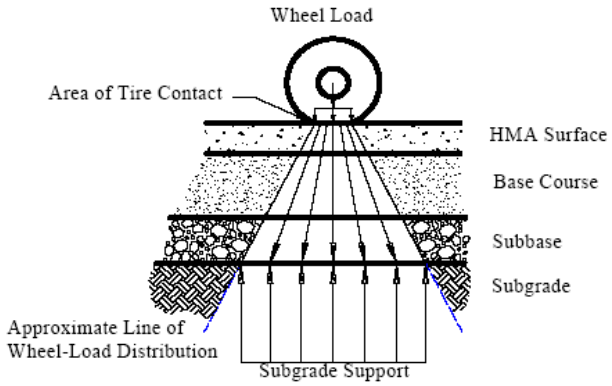

Figure 2 - 4. Distribution of Wheel Load in Flexible Pavement

2.4.2 Bituminous Surface (Wearing Course).

The bituminous surface, or wearing course, is made up of a mixture of various selected aggregates bound together with asphalt cement or other bituminous binders. The material used in the surface course is commonly referred to as Hot-Mix Asphalt (HMA). This surface prevents the penetration of surface water to the base course; provides a smooth, well-bonded surface free from loose particles, which might endanger aircraft or people; resists the stresses caused by aircraft loads; and provides a skid-resistant surface without causing undue wear on tires.

2.4.3 Base Course.

2.4.3.1 The base course serves as the principal structural component of the flexible pavement. It distributes the imposed wheel load to the pavement foundation, the sub-base, and/or the sub-

grade. The base course must have sufficient quality and thickness to prevent failure in the sub-grade and/or sub-base, withstand the stresses produced in the base itself, resist vertical pressures that tend to produce consolidation and result in distortion of the surface course, and resist volume changes caused by fluctuations in its moisture content.

2.4.3.2 The materials composing the base course are selected hard and durable aggregates, which generally fall into two main classes: stabilized and granular. The stabilized bases normally consist of crushed or uncrushed aggregate bound with a stabilizer, such as Portland cement or bitumen.

2.4.4 Sub-base.

This layer is used in areas where sub-grade soil is extremely weak. The sub-base course functions like the base course. The material requirements for the sub-base are not as strict as those for the base course since the sub-base is subjected to lower stresses. The sub-base consists of stabilized or properly compacted granular material.

2.4.5 Sub-grade.

The sub-grade is the compacted soil layer that forms the foundation of the pavement system. Sub-grade soils are subjected to lower stresses than the surface, base, and sub-base courses. Since load stresses decrease with depth, the controlling sub-grade stress usually lies at the top of the sub-grade. The combined thickness of sub-base, base, and wearing surface must be great enough to reduce the stress in soil layer.

2.5 AERODROME PAVEMENT OVERLAYS

Aerodrome pavement overlays may correct deteriorating pavement surfaces, improve ride quality or surface drainage, maintain structural integrity, or increase pavement strength. Overlays are used when a pavement is damaged by overloading, requires strengthening to serve heavier aircraft, shows severe ponding because of uneven settling, or has simply served its design life and is worn out. Aerodrome pavement overlays generally consist of either PCC or HMA pavements or the resulting pavement system may be classified as either rigid or flexible for load-support purposes.

CHAPTER 3: PAVEMENT DISTRESSES

3.1 GENERAL

Various external signs or indicators make the deterioration of a pavement apparent, and often reveal the probable causes of the failure. This chapter provides a detailed discussion and description of the types of pavement distress and relates them to likely causal factors.

3.2 TYPES OF PAVEMENT DISTRESSES.

The discussions of problems related to pavement distress are generally based on whether the pavement has a rigid or flexible surface type. However, while different distresses possess their own particular characteristics, the various types generally fall into one of the following broad categories:

a. Cracking

b. Joint Seal Damage

c. Disintegration

d. Distortion

e. Loss of skid resistance

3.3 RIGID PAVEMENT DISTRESSES.

3.3.1 Cracking.

Cracks in rigid pavements often result from stresses caused by expansion and contraction or warping of the pavement. Overloading, loss of subgrade support and insufficient and/or improperly cut joints acting singly or in combination are also possible causes. Several different types of cracking can occur:

a) Longitudinal, Transverse, and Diagonal Cracks.

A combination of repeated loads and shrinkage stresses usually causes this type of distress. It is characterized by cracks that divide the slab into two or three pieces. These types of cracks can indicate poor construction techniques, underlying pavement layers that are structurally inadequate for the applied load, or pavement overloads.

b) Corner Breaks.

Load repetition, combined with loss of support and curling stresses, usually causes cracks at the slab corner. The lack of support may be caused by pumping or loss of load transfer at the joint. This type of break is characterized by 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. A corner crack differs from a corner spall in that the crack extends vertically through the entire slab thickness; a corner spall intersects the joint at an angle.

c) Durability "D" Cracking.

"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 because of variable expansive aggregates. This type of cracking may eventually lead to disintegration of the concrete within 1 to 2 feet (30 to 60 cm) of the joint or crack.

d) Shrinkage Cracking.

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. Typically, shrinkage cracks do not extend greater than 6.4 mm from the slab surface and may be primarily in the finished surface.

3.3.2 Joint Seal Damage.

Joint seal damage is any condition that enables soil or rocks to accumulate in the joints or that allows infiltration of water. Accumulation of materials prevents the slabs from expanding and may result in buckling, shattering, or spalling. Water infiltration through joint seal damage can cause pumping or deterioration of the sub-base. Typical types of joint seal damage include stripping of joint sealant, extrusion of joint sealant, hardening of the filler (oxidation), loss of bond to the slab edges, and absence of sealant in the joint. Joint seal damage is caused by improper joint width, use of the wrong type of sealant, incorrect application, and/or not properly cleaning the joint before sealing.

3.3.3 Disintegration.

Disintegration is the breaking up of a pavement into small, loose particles and includes the dislodging of aggregate particles. Improper curing and finishing of the concrete, unsuitable aggregates and improper mixing of the concrete can cause this distress. Disintegration falls into several categories:

a) Scaling, Map Cracking, and Crazing.

Scaling is the disintegration and loss of the wearing surface. A surface weakened by improper curing or finishing can lead to scaling. Map cracking or 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. Alkali-Silica Reactivity (ASR) is another source of distress associated with map cracking. ASR is caused by an expansive reaction between aggregates containing silica and alkaline pore solutions of the cement paste.

b) Joint Spalling.

Joint spalling is the breakdown of the slab edges within 2 feet (60 cm) of the side of the joint. A joint spall usually does not extend vertically through the slab but intersects the joint at an angle. Joint spalling often results from excessive stresses at the joint or crack caused by infiltration of incompressible materials or weak concrete at the joint (caused by overworking) combined with traffic loads. Joint spalling also results when dowels, which can prevent slab movement, become misaligned either through improper placement or improper slippage preparation.

c) Corner Spalling.

Corner spalling is the raveling or breakdown of the slab within approximately 2 feet (60 cm) of the corner. It differs from a corner break in that the spall usually angles downward to intersect the joint, while a break extends vertically through the slab. The same mechanisms that cause joint spalling often cause corner spalling, but this type of distress may appear sooner because of increased exposure.

d) Shattered Slab/Intersecting Cracks.

A shattered slab is defined as a slab where intersecting cracks break up the slab into four or more pieces. This is primarily caused by overloading due to traffic and/or inadequate foundation support.

e) Blowups.

Blowups usually occur at a transverse crack or joint that is not wide enough to permit expansion of the concrete slabs. Insufficient width may result from infiltration of incompressible materials into the joint space or by gradual closure of the joint caused by expansion of the concrete due to ASR. When expansive pressure cannot be relieved, 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, although blowups can also appear at drainage structures (manholes, inlets, etc.). The frequency and severity of blowups may increase with an asphalt overlay due to the additional heat absorbed by the dark asphalt surface. They generally occur during hot weather because of the additional thermal expansion of the concrete.

f) Patching.

A patch is defined as an area where the original pavement has been removed and replaced by a filler material. Patching is usually divided into two types:

i) **Small.** A small patch is defined as an area less than 0.5 m^2.

ii) **Large and Utility Cuts.** A large patch is defined as an area greater than 0.5 m^2. A utility cut is defined as a patch that has replaced the original pavement due to placement of underground utilities.

3.3.4 Distortion.

Distortion refers to a change in the pavement surface's original position, and it results from foundation settlement, expansive soils or loss of fines through improperly designed sub-drains or drainage systems. Two types of distortion generally occur:

a) Pumping.

The deflection of the slab when loaded may cause pumping, which is characterized by the ejection of water and underlying material through the joints or cracks in a pavement. As the water is ejected, it carries particles of gravel, sand, clay, or silt with it, resulting in a progressive loss of pavement support that can lead to cracking. Evidence of pumping includes surface staining and base or sub-grade material on the pavement close to joints or cracks. Pumping near joints indicates poor joint-load transfer, a poor joint seal, and/or the presence of ground water.

b) Settlement or Faulting.

Settlement or faulting is a difference in elevation at a joint or crack caused by upheaval or non-uniform consolidation of the underlying pavement layer(s) material. This condition may result from loss of fines, loss of load transfer device (key, dowel, etc.), or swelling soils.

3.3.5 Loss of Skid Resistance.

Skid resistance refers to the ability of a pavement to provide a surface with the desired friction characteristics under all weather conditions. It is a function of the surface texture. Loss of skid resistance is caused by the wearing down of the textured surface through normal wear and tear or the buildup of contaminants.

3.3.6 Polished Aggregates.

Some aggregates become polished quickly under traffic. Naturally polished aggregates create skid hazards if used in the pavement without crushing. Crushing the naturally polished aggregates creates rough angular faces that provide good skid resistance.

3.3.7 Contaminants.

Rubber deposits building up over a period of time will reduce the surface friction characteristics of a pavement. Oil spills and other contaminants will also reduce the surface friction characteristics.

3.4 FLEXIBLE PAVEMENT DISTRESSES

3.4.1 Cracking.

Cracks in flexible pavements are caused by deflection of the surface over an unstable foundation, shrinkage of the surface, thermal expansion and contraction of the surface, poorly constructed lane joints, or reflection cracking. Five types of cracks commonly occur in these types of pavements:

a) Longitudinal and Transverse Cracks.

Longitudinal and transverse cracks often result from shrinkage or contraction of the HMA surface. Shrinkage of the surface material is caused by oxidation and age hardening of the asphalt material. Contraction is caused by thermal fluctuations. Poorly constructed paving lane joints may accelerate the development of longitudinal joints cracks.

b) Block Cracking.

Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 1 by 1 foot (0.3m by 0.3m) to 10 by 10 feet (3m by 3m). Block cracking is caused mainly by contraction of the asphalt and cyclic daily temperature. 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 non-traffic 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 (that is, wheel paths).

c) Reflection Cracking.

Vertical or horizontal movements in the pavement beneath an overlay cause this type of distress. These movements may be due to expansion and contraction caused by temperature and moisture changes or traffic loads. The cracks in HMA overlays reflect the crack pattern or joint pattern in the underlying pavement. They occur most frequently in HMA overlays on PCC pavements. However, they may also occur on overlays of HMA pavements wherever cracks or joints in the old pavement have not been properly repaired.

d) Alligator or Fatigue Cracking.

Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the HMA surface under repeated traffic loading. The cracking initiates at the bottom of the HMA 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 or by excessive deflection of the HMA surface over a weakened or under-designed foundation, the cracks connect, forming many sided sharp angled pieces that develop a pattern resembling chicken wire or alligator skin. The pieces are less than 2 feet (0.6M) on the longest side.

e) Slippage Cracks.

Slippage cracks appear 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 the next layer of the pavement structure. These cracks are crescent or half-moon-shaped with the two ends pointing away from the direction of traffic.

3.4.2 Disintegration.

Disintegration in a flexible pavement is caused by insufficient compaction of the surface, insufficient asphalt binder in the mix, loss of adhesion between the asphalt coating and aggregate particles, or severe overheating of the mix.

a) Raveling and Weathering.

The most common type of disintegration in HMA pavements is raveling/weathering. Raveling/weathering is the wearing away of the pavement surface caused by the dislodging of aggregate particles and the loss of asphalt binder. This distress may indicate that the asphalt binder has aged and hardened significantly. As the raveling/weathering continues, larger pieces are broken free, and the pavement takes on a rough and jagged appearance and can produce a significant source for Foreign Object Debris/Damage (FOD).

b) Potholes.

A pothole is defined as a disruption in the pavement surface where a portion of the pavement material has broken away, leaving a hole. Most potholes are caused by fatigue of the pavement surface. As fatigue cracks develop, they interlock forming alligator cracking. When the sections of cracked pavement are worked loose, they may eventually be picked out of the surface by continued wheel loads, thus forming a pothole.

c) Asphalt Stripping.

Asphalt stripping is caused by moisture infiltration into the HMA pavement structure leading to “stripping” of the bituminous binder from the aggregate particles. Asphalt stripping of HMA

pavements may also be caused by cyclic water-vapor pressures within the mixture scrubbing the binder from the aggregates.

3.4.3 Jet Blast Erosion.

Jet blast erosion is defined as a darkened area of pavement surface where the bituminous binder has been burned or carbonized. Localized burned areas may vary in depth up to approximately 13 mm.

3.4.4 Patching and Utility Cut Patch.

A patch is defined as an area where the original pavement has been removed and replaced by a filler material. A patch is considered a defect in the pavement, regardless of how well it is performing. Deterioration of patch areas affects the riding quality and has FOD potential.

3.4.5 Distortion.

Distortion in HMA 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, and swelling soils in the sub-grade. Four types of distortion commonly occur:

a) Rutting.

A rut is characterized by a surface depression in the wheel path. In many instances, ruts become noticeable only after a rainfall when the wheel paths fill with water. This type of distress is caused by a permanent deformation in any one of the pavement layers or sub-grade, resulting from the consolidation or displacement of the materials due to traffic loads.

b) Corrugation.

Corrugation results from a form of plastic surface movement typified by ripples across the surface. Corrugation can be caused by a lack of stability in the mix and a poor bond between material layers.

c) Shoving.

Shoving is the localized bulging of a pavement surface. It can be caused by lack of stability in the mix or lateral stresses produced by adjacent PCC pavement during expansion.

d) Depression.

Depressions are localized low areas of limited size. In many instances, light depressions become noticeable only after a rain, when ponding creates "birdbath" areas. Depressions may result from traffic heavier than that for which the pavement was designed, localized settlement of the underlying pavement layers, or poor construction methods.

e) Swelling.

An upward bulge in the pavement's surface characterizes swelling. It may occur sharply over a small area or as a longer gradual wave. Both types of swell may be accompanied by surface cracking. A swell is usually caused by excessive moisture variations in excessively expansive or weak soils.

3.4.6 Loss of Skid Resistance.

Factors that decrease the skid resistance of a pavement surface and can lead to hydroplaning include too much asphalt in the bituminous mix, too heavy a tack coat, poor aggregate subject to wear, and buildup of contaminants. In bituminous pavements, a loss of skid resistance may result from the following:

a) Polished Aggregate.

Aggregate polishing is caused by repeated traffic applications. Polished aggregate is present when the potion of aggregate extending above the asphalt is either very small, of poor quality, or there are no rough or angular particles to provide good skid resistance.

b) Contaminants.

Accumulation of rubber particles, oils, or other external materials on the pavement surface will reduce the skid resistance of a pavement. Buildup of rubber deposits in pavement grooves will reduce the effectiveness of the grooves and increase the likelihood of hydroplaning.

c) Bleeding.

Bleeding is characterized by a film of bituminous material on the pavement surface that resembles a shiny, glass-like, reflecting surface that usually becomes quite sticky. It is caused by excessive amounts of asphalt binder in the mix and/or low air-void content and occurs when asphalt binder fills the voids in the mix during hot weather and then expands out onto the surface of the pavement. Bleeding may also result when an excessive tack coat is applied prior to placement of the HMA surface. Since the bleeding process is not reversible during cold weather, asphalt binder will accumulate on the surface. Extensive bleeding may cause a severe reduction in skid resistance.

d) Fuel/Oil Spillage.

Continuous fuel/oil spillage on a HMA surface will soften the asphalt. Areas subject to only minor fuel/oil spillage will usually heal without repair, and only minor damage will result.

3.5 DRAINAGE OF AERODROME PAVEMENTS

3.5.1 A proper drainage system is essential to preventive maintenance. 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 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 sub-grade and sub-base, damage to slopes by erosion, and loss of the load-bearing capacity of the paved surfaces. Whenever pavement failure occurs, the aerodrome should investigate the possibility of deficient drainage.

3.5.2 The damage mechanism of free water in the pavement system is related to the amount of free water in the boundaries between the structural layers of the pavement system. When water fills the voids and spaces at the boundaries between layers, heavy wheel loads applied to the surface of the pavement produce impacts on the water comparable to a water-hammer type of action. The resulting water pressure causes erosion of the pavement structure and ejection of the material out of the pavement.

3.5.3 There are two general 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 good practice for each system to function independently.

a) Surface Drainage.

Surface drainage controls, collects, and disposes of water from rainstorms that accumulate on the surface of the pavement and nearby ground. Surface drainage of pavements is achieved by constructing the pavement surface and adjacent ground in a way that allows for adequate runoff. The water may be collected at the edges of the paved surface in ditches, gutters, and catch basins. Surface water should not be allowed to enter a sub-drainage system as it often contains soil particles in suspension. As the water percolates through the granular material of the sub-drain, these particles cause it to silt up. Inevitably, some water will enter the pavement structure through cracks, open joints, and other surface openings, but this penetration may be kept to a minimum by proper surface maintenance procedures.

b) Subsurface Drainage.

Subsurface drainage is provided for the pavement by a permeable layer of aggregate or permeable stabilized layers—such as cement-treated or asphalt-treated layers under the full width of the traveled way—with longitudinal pipes for collecting the water and outlet pipes for rapid removal of

the water from the subsurface drainage system. Subsurface drains may also consist of perforated collection pipes or conduits in permeable sand or gravel trench encased in geo-textiles with outlet pipes. These systems remove excess water from pavement foundations to prevent weakening of the base and sub-grade and to reduce damage from movements. Subsurface drainage trenches placed at the pavement edge also prevent surface runoff moisture from entering the pavement structure from the pavement perimeter.

CHAPTER 4 PROCEDURES FOR INSPECTION OF PAVEMENTS

4.1 INTRODUCTION TO PAVEMENT INSPECTION

4.1.1 This chapter describes procedures for inspection of aerodrome pavements. Aerodrome operators should prioritize the upkeep and repair of all pavement surfaces in the aircraft operating areas of the aerodrome to ensure continued safe aircraft operations. While deterioration of the pavements from usage and exposure to the environment cannot be completely prevented, a timely and effective maintenance program can minimize this deterioration. Many cases exist where inadequate maintenance characterized by the absence of a vigorously followed inspection program directly attributed to failures of aerodrome pavements and drainage features. It should be noted that maintenance, no matter how effectively carried out, cannot overcome or compensate for a major design or construction inadequacy. However, it can prevent the total and possibly disastrous failure that can result from such deficiencies. The maintenance inspection can reveal at an early stage where a problem exists and thus provide enough warning and time to permit corrective action. Postponement of minor maintenance can develop into a major pavement repairs.

4.1.2 Although there are numerous distress types associated with aerodrome pavements, a particular concern on aerodrome pavements is the possibility that pavement distress will generate loose material that may strike aircraft propellers or be ingested into jet engines. This loose material

and the resulting damage are commonly labeled as foreign object debris/damage (FOD). More important, FOD can cause undetected damage to an aircraft, making it unsafe to operate. In addition to the pavement inspection procedures, pavement inspections should also address the issue of FOD to minimize its potential hazard.

4.2 INSPECTION PROCEDURES.

4.2.1 Maintenance is an ongoing process and a critical responsibility of the aerodrome operator. Effective maintenance programs require a series of scheduled, periodic inspections or surveys, conducted by experienced engineers, technicians, or maintenance personnel. These surveys must be controlled to ensure that each element or feature being inspected is thoroughly checked, potential problem areas are identified, and proper corrective measures are recommended. The maintenance program must provide for adequate follow-up of the inspection to ensure that the corrective work is expeditiously accomplished and recorded. Although the organization and scope of maintenance activities will vary in complexity and degree from aerodrome to aerodrome, the general types of maintenance required are similar, regardless of aerodrome size or extent of development.

4.2.2 Inspection Schedules.

The aerodrome is responsible for establishing a schedule for pavement inspections. Inspection schedules should ensure that all areas, particularly those that are not observed daily, are thoroughly checked. All paved areas should be inspected at least twice a year. Severe storms or other conditions that may adversely affect the pavement may necessitate additional thorough inspections. Aerodrome personnel should also solicit reports from aerodrome users and conduct daily drive-by-type inspections.

4.2.3 Record keeping.

The aerodrome should prepare and maintain complete records of all inspections and maintenance performed. These records should document the severity level of existing distress types, their locations, their probable causes, remedial actions, and results of follow up inspections and maintenance. In addition, the files should contain information on potential problem areas and preventive or corrective measures identified. Records of materials and equipment used to perform all maintenance and repair work should also be kept on file for future reference. Such records may be used later to identify materials and remedial measures that may reduce maintenance costs and improve pavement serviceability.

4.3 FRICTION SURVEYS

Aerodromes should maintain runway pavements that provide surfaces with good friction characteristics under all weather conditions. Parameters that affect the skid resistance of wet pavement surfaces include the following:

a) Texture depth

b) Rubber deposits

c) Paint marking

d) Pavement abnormalities, such as rutting, raveling, and depression

Visual observations made during a pavement inspection are an inadequate predictor of skid resistance.

4.4 NON-DESTRUCTIVE TESTING.

In addition to collecting information from visual inspections of the pavement area, aerodromes operators should consider collecting data from non-destructive testing. Nondestructive testing involves a large number of readings, and a statistical average is used. Such data are used to evaluate the pavement load-carrying capacity. Loads are applied to the pavement through loading plates or wheels, and the pavement deflection response is recorded. Equipment for such tests includes the Falling Weight Deflectometer (FWD), Benkelman Beam or Deflectographs etc. The stiffness or strength of the aerodrome pavement can be related to the magnitude of these deflections. Principle set up and operation of the FWD is as outlined in **Appendix C**.

4.5 DRAINAGE SURVEYS

The maintenance program should take into account the importance of adequate drainage of surface and ground water because water is directly or partly responsible for many pavement failures and deterioration. Sufficient drainage for collection and disposal of surface runoff and excess ground water is vital to the stability and serviceability of pavement foundations. Trained personnel should conduct periodic and complete inspections of drainage systems and record and correct defective conditions of surface and subsurface drainage systems. Runway and taxiway edge drains and catch basins should be inspected at intervals (i.e., spring, summer, fall, and winter) and monitored following unusually heavy rainfall. The personnel making the inspection should look for distress signals that may indicate impending problems. These distress signals include the following:

a) Ponding of water

b) Soil buildup at pavement edge preventing runoff

c) Eroded ditches and spill basins

d) Broken or displaced inlet grates or manhole covers

e) Clogged or silted inlet grates and manhole covers

f) Blocked subsurface drainage outlets

g) Broken or deformed pipes

h) Backfill settlement over pipes

i) Erosion around inlets

j) Generally poor shoulder shaping and random erosion

k) Discoloration of pavement at joints or crack

4.6 PAVEMENT MANAGEMENT SYSTEMS

4.6.1 Aerodrome pavement management system (APMS) provides a method of establishing an effective maintenance and repair system. An APMS is a systematic and consistent technique for scheduling maintenance and rehabilitation with a view to maximizing benefits and minimizing costs. An APMS not only evaluates the present condition of a pavement, but also can be used to forecast its future condition. By projecting the rate of deterioration, an APMS can facilitate a life-cycle cost analysis for various alternatives and help determine when to apply the best alternative.

4.6.2 The primary component of any APMS is the ability to track a pavement's deterioration and determine the cause of the deterioration. This requires an evaluation procedure that is objective, systematic, and repeatable such as Pavement Condition Index (PCI) determination. The PCI is a rating of the surface condition of a pavement which indicates functional and structural performance. Periodic PCI determinations on the same pavement will show the change in performance level over time. In addition, apart from the PMS can be implemented by using field instrumentation such as FWD. Principle set up and operation of the FWD is as outlined in **Appendix C**.

4.7 PAVEMENT EVALUATION

Where necessary and after the pavement has served excessive aircraft loading, the aerodrome operator may plan, initiate and conduct a pavement evaluation project. The pavement evaluation is intended to assess the existing structural capacity and remaining life available for the pavement to enable consideration for strengthening purposes. In case, no remaining life is left, the aerodrome operator will be required to plan for strengthening measures. The pavement evaluation is a “project level” exercise which is instrument base where FWD, GPR, Deflectographs etc measurements are used to evaluate the structural capacity

CHAPTER 5: MATERIALS AND EQUIPMENT

5.1 GENERAL

Normal day-to-day pavement maintenance requires only hand tools, but some maintenance necessitates specialized equipment. For example, cleaning out joints in PCC pavements is best accomplished with hand-operated, motor-driven machines especially designed for the task. Specialized sawing equipment may be required to establish the proper joint sealant shape dimension when sealing cracks in HMA pavement. Equipment to apply nontoxic herbicides may be necessary to prevent weeds from growing until sealant materials can be applied. Expedient plow-type devices also aid in removing old joint material. Joint sealing can be accomplished by hand pouring from kettles with narrow spouts, but some sealing materials require pressure application with specialized equipment. Most normal maintenance projects, however, require the following:

a. Mechanical Hammers.

Mechanical hammers can be used to break PCC pavement slabs for easy removal. These hammers can also drill slabs. When using mechanical hammers, maintenance staff should take precautions to avoid damaging adjacent slabs.

b. Trailer-Type Asphalt Kettles.

The use of trailer-type asphalt kettles can expedite patching and spot sealing. Kettles equipped with a powered hand-spray bar are valuable maintenance and repair items.

c. Compaction Equipment.

Compaction of HMA patches and sub-base repairs can be accomplished with hand tampers, but small vibrating compactors produce better and more-uniform results. These vibrating compactors are easy to operate, are transportable in small vehicles, work well in confined areas, and do an excellent job.

d. Distributors.

A large-scale project such as seal coating an extensive area requires specialized equipment, including pressure distributors for bitumen, aggregate spreaders, and rollers. Generally, contractors or others organized for such large-scale activities should perform this type of work.

e. Work Crew.

Two to six people, trained in the various techniques of repairing and familiar with the tools available to them, can perform the routine maintenance required by pavement surfaces. If the work requires more staff, it will probably be a major repair and require methods, materials, and equipment beyond those used for normal maintenance.

5.2 COMMON MATERIALS FOR MAINTENANCE AND REPAIR

The materials listed below are commonly used for maintenance and repair of pavements.

5.2.1 Hot-Mix Asphalt.

HMA is a blend of asphalt binder and well-graded, high-quality aggregates. The materials are mixed in a plant and placed and compacted while hot. HMA is used for construction of new aerodrome pavement and patching and overlay of aerodrome pavements.

5.2.2 Tack Coat.

A tack coat, usually a light application of emulsified asphalt, is applied to an existing pavement to provide a bond with an overlying course, such as a HMA overlay. A tack coat is also used on the sides of an existing pavement that has been cut vertically before patching. Asphalt emulsions are manufactured in several grades and are selected by the desired setting time.

5.2.3 Prime Coat.

A prime coat of emulsified or cutback asphalt is applied to an aggregate base course for the following purposes:

To waterproof the surface of the base
To plug capillary voids
To promote adhesion between the base and the surface course

5.2.4 Fog Seal.

A fog seal is a light application of emulsified asphalt used to rejuvenate the surface of a HMA pavement.

5.2.5 Aggregate Seal.

This process is used to seal the surface of weathered pavements. Aggregate seals consist of sprayed asphalts that are immediately covered with aggregate and rolled to seat the aggregate in the asphalt coating. **The aggregate seals or surface dressing are not recommended for aerodrome pavements because of the potential for propeller and engine damage caused by loose aggregates.**

5.2.6 Slurry Seal.

A slurry seal is a mixture of asphalt emulsion, fine aggregate, mineral filler, and water. The mixture is prepared in slurry form and applied in a film approximately 1/8 inch (3 mm) thick. Slurry seals are used to seal small cracks, correct surface conditions, and improve the skid resistance of pavement surfaces.

5.2.7 Crack and Joint Sealing Material for Flexible Pavement.

Material for sealing cracks should meet designated and approved standards for the type of pavement and service for which the pavement is intended. Some aerodromes have used silicone sealants to seal cracks and joints in bituminous pavements. Proper use of silicone sealants requires that the material modulus be matched to the application.

5.2.8 Crack and Joint Sealing Material for Rigid Pavement

Material for sealing joints in Portland cement concrete pavement may be hot- or cold-applied compounds, as long as they meet the following prescribed standards:

5.2.9 Crack Filler Material for Flexible or Rigid Pavement.

Material for filling cracks in rigid or flexible pavement should meet the prescribed standards as appropriate.

5.2.10 Concrete

Concrete is a blend of Portland cement, fine and coarse aggregate, and water, with or without additives. Concrete is used to repair a distressed Portland cement concrete pavement so it may be used at its original designed capacity.

5.2.11 Epoxy Grouts and Concretes

There are many types of epoxy resins; the type to be used depends on the intended application. Under normal conditions, mixed resins may be workable up to 1 hour after mixing. Repairs with epoxy materials are costly, so their use should be limited to small areas and their application left to experienced personnel.

5.3 EQUIPMENT USED FOR PAVEMENT MAINTENANCE.

There are many different types and models of equipment aerodromes can use for pavement maintenance. Maintenance crews commonly use the equipment listed below for the following types of projects:

5.3.1 Pavement Removal.

a) Power Saws. A pavement power saw is usually a one-person-operated, dolly-mounted unit with an abrasive circular blade. This type of saw can cut a straight line through flexible or rigid pavements and leave vertical sides.

b) Cutting Disks. A cutting disk is a circular, heavy-duty steel plate with a sharpened edge. The disk is usually attached to a motor grader or other piece of equipment capable of pushing the disk through a bituminous pavement. It is limited to approximately 3 inches (8 cm) in cutting depth. Since the cutting disk is much faster than a saw, its use should be considered when larger areas must be removed.

c) Jackhammers. Jackhammers with a chisel head are commonly used for cutting pavement surfaces.

d) Pavement Grinders. A pavement grinder may be a one-person-operated, dolly-mounted unit with an abrasive cylindrical head 4 inches (10 cm) or more wide, or it may be variable-width diamond grinding equipment. Diamond grinding is a common rehabilitation technique used for tasks as varied as paint removal and pavement texturing.

e) Cold Milling Machines. Cold milling machines use an adjustable rotating mandrel with cutting bits to remove various depths of pavement material. Bits can be added or removed to vary the cutting width and roughness. Advantages of cold milling include speed of removal, precision of removal, and grade control.

f) Hand Tools. Hand tools can be used to make vertical cuts through pavements and to break up deteriorated pavement. Chisels, sledgehammers, shovels, pry bars, and picks fall into this category of equipment.

g) Front-end Loaders and Skid-steer Loaders. Front-end loaders are useful when loading trucks with removed pavement. Skid-steer loaders are small versatile loaders that can be equipped with numerous attachments. Their small size and maneuverability make them ideal for maintenance activities.

h) Dump Trucks. Dump trucks are used to haul removed pavement and repair materials.

5.3.2 Maintenance Equipment.

5.3.2.1 Asphalt Kettle.

Asphalt kettles are usually small-tractor-mounted units that have the capacity to heat and store 40 to 500 gallons (150 – 2000 liters) of bituminous material. A pump forces the liquid material through spray nozzles located on a hand-held hose. These units are used for priming and tacking on small jobs and for crack or surface sealing of HMA surfaces.

5.3.2.2 Aggregate Spreaders.

Aggregate spreaders can be either truck-mounted or separate units. They are used to evenly place a controlled amount of sand or aggregate on an area.

5.3.2.3 Hand Tools.

Rakes, lutes, and other such hand tools are used to move and level material placed in a patch area.

5.3.3 Compaction Equipment.

Vibratory Plate Compactors.

Vibratory plate compactors are hand-operated units used to compact granular base or HMA plant-mix materials.

Vibratory and Non Vibratory Steel-Wheel Rollers.

Steel-wheel rollers are used to compact material, including HMA in patchwork areas. Smaller rollers can be hand operated, while large rollers are self-powered.

Rubber-Tired Rollers. Rubber-tired rollers are self-powered and used to compact HMA pavement.

5.3.4 Crack and Joint Sealing Equipment.

a) **Joint Plow.** A joint plow is used to remove old sealer from joints. This is usually a specially made tool attached to a skid-steer loader.

b) **Joint Router.** A joint router is used to clear existing cracks or joints to be resealed. A router is usually a self-powered machine operating a rotary cutter or revolving cutting tool. A rotary routing tool with a V-shaped end can be used for cleaning out random cracks. Rotary cutting tools for PCC pavements are not recommended due to excessive fracturing of aggregates. The use of a random crack saw is preferred.

c) **Random Crack Saw.** A random crack saw is designed to follow irregular crack patterns in concrete and asphalt surfaces. The crack saw utilizes small diameter, dry-cut diamond blades in standard widths to create smooth sided cuts to prepare surfaces for proper crack filling. Maximum straight line cutting depth is 38 mm. A center mounted blade configuration allows that crack saws to pivot about its own axis to more exactly follow random crack patterns easily.

d) **Power Brush.** A power-driven wire brush may be used to clean joints after all of the old joint sealer has been removed.

e) **Air Compressor and Sand Blasting.** Sand blasting may be used for final removal of old joint sealant, and the it is recommended as the final cleaning method for PCC surfaces prior to application of new sealant. Joints and cracks should be blown out with clean compressed air immediately before applying new

sealer. Air compressors should be equipped with oil and moisture traps to prevent contaminating the cleaned surface.

f) **Pavement Sweeper.** A pavement sweeper can be used for cleaning the pavement surface and removing excess aggregate. Cleaning operations are necessary in preparation for seal coating and crack filling.

g) **Heating Kettle.** A heating kettle is a mobile, indirect-fired double boiler used to melt hot-applied joint sealing material. It is equipped with a means to agitate and circulate the sealer to ensure uniform heating and melting of the entire charge in the kettle. Sealants may be applied to joints with a pressure base attached directly to a pump unit on the kettle.

h) **Pouring Pot.** A pouring pot is hand carried or mounted on a hand-pushed pot dolly and used to pour hot sealing materials into a previously prepared crack or joint.

i) **High-pressure Water Sprayer.** A water sprayer can be used to clean out joints prior to resealing and to clean vertical faces of pavement to be patched.

j) **Hot Air Lance.** A hot air lance enhances adhesion by drying and heating cracks in existing bituminous material while removing debris prior to crack sealing.

5.3.5 Removal of Pavement Markings.

a) **High Pressure Water Jet.** A high-pressure water jet, with proper selection of spray nozzle and pressure, can be highly effective in removal of pavement markings.

b) **Abrasive Blasting.** Pavement markings can be removed by the impact of edged particles accelerated by pressurized air, although care must be exercised to avoid damage to the pavement surface.

Solvent Cleaning. Chemical agents can be employed to remove markings from pavement, but proper attention must be paid to environmental concerns and cleanup.

CHAPTER 6: METHODS OF REPAIR

6.1 GENERAL

This chapter describes various methods aerodromes can use to correct aerodrome pavement distress. While these repair methods apply to specific types of distress and pavements, they should all take into account the possibility of FOD to aircraft. Untidy repair activities may leave potential FOD at or near the repair sites. Improperly constructed repairs may disintegrate and cause a FOD potential. All maintenance activities must include quality control monitoring to assure that repairs are conducted properly and clean-up activities undertaken to remove this potential.

a. Visible evidence of excessive stress levels or environmental distress in pavement systems may include cracks, holes, depressions, and other types of pavement distresses. The formation of distresses in aerodrome pavements may severely affect the structural integrity, ride quality, and safety of aerodrome pavements. To alleviate the effects of distresses and to improve the aerodrome pavement serviceability, aerodromes should adopt an effective and timely maintenance program and adequate repair procedures.

b. In all cases of pavement distress, the first step in rehabilitating a pavement is to determine the causes of distress. Then, the proper procedures for repair - which will not only correct the damage, but also prevent or retard its further occurrence - may be applied. Pavement repairs should be made as quickly as possible after the need for them arises to ensure continued and safe aircraft operations. Aerodromes should perform repairs at early stages of distress, even when the distresses are considered minor. A delay in repairing pavements may allow minor distresses to progress into major failures. While deterioration of pavements due to traffic and adverse weather conditions cannot be completely prevented, maintenance and repair programs can significantly reduce the rate of deterioration and minimize the damage.

c. Weather conditions may limit repair measures undertaken to prevent further pavement damage. For example, rehabilitation by crack filling is more effective in cool and dry weather conditions, whereas pothole patches, seal coats, and other surface treatments require warm, dry weather for best results. This does not mean that resurfacing work cannot be performed under cold and damp conditions or that crack filling cannot be done in warm weather. Rather, these repairs just require much greater care when made during such periods.

d. The minimum depth of repair for Portland cement concrete should be 5 cm. Repairs made thinner than 5 cm usually deteriorate quickly on an aerodrome pavement. (Most distresses needing repair will extend at least 5 cm into the pavement.) Rigid pavement repairs that are thinner than 5 cm may benefit from the use of epoxy materials

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6.2 REPAIR METHODS FOR RIGID AND FLEXIBLE PAVEMENTS

Repair methods for the different types of pavements and distresses are dependent on the degree of severity and mechanism of failure of such pavements. These methods are as indicated from

Table 6-1 to 6-10 and further procedural techniques are described in a step by step approach in Appendix B of this Manual. It can be appreciated that the repair procedures only provide means but not necessarily the only means for rehabilitating and maintaining aerodrome pavements.

Table 6 – 1: QUICK GUIDE FOR MAINTENANCE AND REPAIR OF COMMON PAVEMENT SURFACE PROBLEMS

PROBLEM	PROBABLE CAUSE	REPAIR
Crack and joint sealer missing or not bonded to slabs	-Faces of joints (cracks) not clean when filled -Incorrect application temperature of sealer -Wrong kind of seal material -Improper joint width	-Remove old material sealer if extensive areas affected; clean (preferably by sandblasting) joints and cracks; reseal properly
Random cracking	-Uncontrolled shrinkage (improper joint spacing) -Overstressed -Slab support lost -Sub-grade settlement -Bitumen too hard or overheated in mix	-Clean and seal newly formed cracks; replace sub-base to establish support; -If pavement being overloaded, probably will require overlay.
Or breakup	**Rigid Pavement** -Overworked finishing operation -Inadequate curing **Flexible Pavement** -Overheated binder -Poor aggregate gradation -Insufficient binder -Incorrect binder or aggregate -Fuel spillage -Stripping	**Rigid Pavement** -Remove and replace panel -Resurface with thin bonded concrete -Resurface area with a bituminous concrete **Flexible Pavement** -Apply seal coat -Overlay
Joint (1) faulting or (2) spalling	**Faulting (1)** -Variable support for un-bonded slabs -Loss of load-transfer capability **Spalling (2)** -Incompressible matter in joint spaces -Excessive joint finishing	**Faulting** -Remove problem slab; replace slab (dowel to existing pavement). **Spalling (2)** -Clean joint; refill with bituminous-sand mix; reseal.
Pumping	-Saturated pavement	-Prevent entrance of water

PROBLEM	PROBABLE CAUSE	REPAIR
	foundation -Lack of sub-base	(correct the drainage problem) -Pump slurry under slabs to reseal -Replace slabs and slab foundation -Install drainage
Surface irregularities (rutting, washboarding, birdbaths, undulations)	**Rigid Pavement** -Poor placing control -Broken slabs -Poor finishing **Flexible Pavement** -Non-uniform settlement from inadequate compaction of pavement or fill -Unstable mix (poor aggregate gradation, too rich, etc) -Poor laying control	**Rigid Pavement** -Patch local areas -Overlay if widespread **Flexible Pavement** -Patch local areas -Applying leveling course -Roto-mill
Bleeding of bituminous binder	- Too much binder in mix (overly rich mix)	- Scrape off excess material; blot with sand. NOTE: Bleeding is usually an indication that other surface deformities (rutting, washboarding, etc.) will occur.
Potholes	- Water entering pavement structures - Segregation in base course material	- Remove and replace base (and sub-base if required); replace surface and seal.
Bleeding of bituminous binder	- Too much binder in mix (overly rich mix)	- Scrape off excess material; blot with sand. NOTE: Bleeding is usually an indication that other surface deformities (rutting, washboarding, etc.) will occur.
Potholes	- Water entering pavement structures - Segregation in base course material	- Remove and replace base (and sub-base if required); replace surface and seal.

PROBLEM	PROBABLE CAUSE	REPAIR
Oxidation of bituminous binder	- Lack of timely seal coat - Binder overheated in mixing - Wrong grade of asphalt for climate	- Apply seal coat - Heater planer - Resurface.
Map cracking, crazing, alligator cracking	**Rigid Pavement** - Excessive surface finishing - Alkali-Aggregate Reactivity **Flexible Pavement** - Overload - Oxidized binder - Under-designed surface course (too thin)	**Rigid Pavement** - If surface deforms or breaks, resurface, grind. **Flexible Pavement** - Overlay - Apply seal coat.
Pop-outs at joints	- Dowel misaligned	- Fill pop-out hole with bituminous concrete or bituminous sand mix (if recurring, may require replacement of slabs).
Slab blowup	- Incompressible material in joints preventing slab from expanding - Alkali-Aggregate Reactivity	- Replace slab in blowup area; clean and reseal joints.
Slipperiness	**Rigid Pavement** - Improper finish (too smooth) - Improper type of curing membrane - Excessive curing membrane - Polished aggregate - Rubber deposits **Flexible Pavement** - Overly rich mix - Poorly designed mix - Polished aggregate - Improperly applied seal coat - Wrong kind of seal coat - Rubber deposits	**Rigid Pavement** - If finish too smooth, resurfacing required to provide texture - Wire broom to remove curing membrane – Grooving - Remove rubber. **Flexible Pavement** - Apply textured seal coat - Grooving - Remove rubber.

Table 6 – 2: MAINTENANCE AND REPAIR OF RIGID PAVEMENT SURFACES – CRACKING

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./REPAIR TYPE	SUGGESTED MAINT./REPAIR METHOD	MATERIAL DESCRIPTION

Longitudinal, Transverse, or Diagonal Cracking	L surface crack	R/P	No action	none
	M < 3.2 mm wide	R/P	No action	none
	H ≥ 3.2 mm wide	R/P	Rotary-random saw and seal	hot-applied sealant
				cold-applied sealant
Corner Breaks	N pavement ≤ 0.3M thick	R/P	Full-depth repair w/ #4 rebar	Conventional mix
				pre-packaged mix w/ aggregate
				rapid setting, early strength
	N pavement > 0.3M thick	R/P	Full-depth repair w/ #5 rebar	conventional mix
				rapid setting, early strength
	N joints parallel or oblique to direction of traffic	R/P	Full-depth repair w/ load transfer bars	conventional mix
				rapid setting, early strength
Durability "D" Cracking	N	R/P	Remove and replace entire slab	conventional mix
		T/E	Same repair as Corner Breaks	
			Same repair as Scaling, Map Cracking, or Crazing	
			Partial depth repair, mill 5-7.6 cm	High quality HMA
Shrinkage Cracking	N	R	No action	none
		Other	Fill voids w/ cement paste	epoxy cement

LEGEND

N = No degree of severity R = Recommended

L = Low
M = Medium
H = High
P = Permanent
T = Temporary
E = Emergency

Table 6 – 3: MAINTENANCE AND REPAIR OF RIGID PAVEMENT SURFACES – JOINT SEAL DAMAGE

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./ REPAIR TYPE	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL DESCRIPTION
Joint Seal Damage	N Conventional joint seal	R/P	Remove old and reseal joint	hot-applied sealant
				cold-applied sealant
	N Preformed compression joint seal	R/P	Remove old and reseal joint	hot-applied sealant
				cold-applied sealant
				Performed sealant

LEGEND:

N = No degree of severity
L = Low
M = Medium
H = High
R = Recommended
P = Permanent
T = Temporary
E = Emergency

Table 6 – 4: MAINTENANCE AND REPAIR OF RIGID PAVEMENT SURFACES – DISINTEGRATION

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./ REPAIR TYPE	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL DESCRIPTION
Scaling, Map Cracking, or Crazing	L	R/P	Seal	Penetrating concrete sealer
			No action	none
	M	T/E	Micro-mill and seal	surface asphalt emulsion
	H	R/P	Micro-mill to grade install thin bonded overlay	high performance concrete
		R/P	Remove and replace if extensive area	conventional mix
				rapid setting, early strength
Joint Spalling	N	R/P	Saw cut, remove unsound concrete and patch	pre-packaged mix w/ aggregate
				pre-packaged mix w/o aggregate
				rapid setting, early strength
		T/E	Remove unsound concrete, patch	HMA pavement overlay
Corner Spalling	N	R/P	Saw cut, remove unsound concrete and patch	pre-packaged mix w/ aggregate
				pre-packaged mix w/o aggregate
				rapid setting, early strength
		T/E	Remove unsound concrete, patch	HMA pavement overlay

PAVEMENT DISTRESS	PAVEMENT DISTRESS	MAINT./ REPAIR	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL

	SEVERITY	TYPE		DESCRIPTION
Shattered Slab/ Intersecting Cracks	N	R/P	Remove and replace entire slab	conventional mix
Blowups	N	R/P	Remove and replace concrete full-depth	conventional mix
Pop-outs	L ≤ 5 cm diameter	R/P	Seal	hot-applied sealant
				hot-applied sealant
				elastomeric compound
	M -H > 5 cm) diameter	R/P	Patch w/ elastomeric compound w/ aggregate	Elastomeric compound w/ aggregate
Patching, Small	L	R	No action	None
	M	R/P	Remove and replace the patch	pre-packaged mix w/ aggregate
				pre-packaged mix w/o aggregate
				rapid setting, early strength
		T/E	Seal cracks within patch	hot-applied sealant
				cold-applied sealant
	H	R/P	Remove and replace the patch	pre-packaged mix w/ aggregate
				pre-packaged mix w/o aggregate
				rapid setting, early strength

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./ REPAIR TYPE	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL DESCRIPTION
Patching, Large and Utility Cut	L	R/P	No action	none
	M	T/E	Seal cracks within patch	hot-applied sealant
				cold-applied sealant
		R/P	Repair distressed area only	Same as Patching, Small
		R/P	Remove and replace the patch	conventional mix
		T/E	Remove and replace the patch	rapid setting, early strength
	H	R/P	Remove and replace the patch/slab	conventional mix
		T/E	Remove and replace the patch	rapid setting, early strength

LEGEND:

N	=	No degree of severity	R	=	Recommended
L	=	Low	P	=	Permanent
M	=	Medium	T	=	Temporary
H	=	High	E	=	Emergency

Table 6 – 5: MAINTENANCE AND REPAIR OF RIGID PAVEMENT SURFACES – DISTORTION

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./ REPAIR TYPE	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL DESCRIPTION
Pumping	L -M Minimal movement	R/P	Base stabilization, slab leveling, and saw cut	expandable foam injection
				cementitious grout pump under pressure through holes cored in pavement into void
	H movement ≥ 2.5 cm	R/P	Base stabilization, slab-leveling, saw cut, and install load transfer devices	Expandable foam injection
				cementitious grout pump under pressure through holes cored in pavement into void
Settlement or Faulting	L no movement	R/P	Micro-mill surface to true and level	none
	M -H movement	R/P	Slab jacking	cementitious grout pump under pressure through holes cored in pavement into void
				cementitious grout pump under pressure through holes cored in pavement into void

LEGEND:

N = No degree of severity
L =Low
M =Medium
H =High

R =Recommended
P =Permanent
T =Temporary
E =Emergency

Table 6 – 6: MAINTENANCE AND REPAIR OF RIGID PAVEMENT SURFACES – LOSS OF SKID RESISTANCE

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./ REPAIR TYPE	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL DESCRIPTION
Polished Aggregate	N	R/P	Micro-mill entire surface	none
			Diamond grind entire surface	none
			Grooving	none
			Resurfacing	HMA pavement overlay
				thin bonded PCC overlay
Contaminants	N	R	Surface Cleaning	high-pressure water
				Biodegradable chemicals

LEGEND:

N	=	No degree of severity	R	=	Recommended
L	=	Low	P	=	Permanent
M	=	Medium	T	=	Temporary
H	=	High	E	=	E

Table 6 - 7. MAINTENANCE AND REPAIR OF FLEXIBLE PAVEMENT SURFACES – CRACKING

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./ REPAIR TYPE	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL DESCRIPTION
Longitudinal, Transverse, Block, or Reflection Cracking	L < 1/8"(3.2 mm) wide	R/P	No action	none
		T/E	Seal coat	coal-tar pitch emulsion
			Slurry seal	emulsified asphalt
			Fog coat	emulsified asphalt
	≥ 1/8" (3.2 mm) M wide & < 1/4" (6.4 mm) wide	R/P	Rout, clean and seal	hot-applied sealant
				cold-applied sealant
	≥ 1/4" (6.4 mm) M wide & 3/4" (19 mm) wide	R/P	Rout, clean and seal	hot-applied sealant
				cold-applied sealant
	≥ 3/4" (19 mm) H wide & 1-1/4" (32 mm) wide	R/P	Pavement < 4" (102 mm) thick, remove and replace (i.e., saw/mill, remove existing pavement, repave and seal saw cuts)	Modified surface mix *
			Pavement ≥ 4" (102 mm) thick, remove and	Modified surface mix *

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./ REPAIR TYPE	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL DESCRIPTION
			replace (i.e., mill, remove existing pavement, repave and seal saw cuts)	
		T/E	Rout edges only, clean, and seal	hot-applied sealant
				cold-applied sealant
	H ≥ 32 mm wide & 57 mm wide	R/P	Pavement < 4" (102 mm) thick, remove and replace	Modified surface mix *
			Pavement ≥ 4" (102 mm) thick, remove and replace	Modified surface mix *
		T/E	Rout edges only, clean, install backer rod, and seal	hot-applied sealant
				cold-applied sealant
	H ≥ 57 mm wide	R/P	Pavement < 102 mm thick, remove and replace	Modified surface mix *
			Pavement ≥ 102 mm thick, remove and replace	
Alligator or Fatigue Cracking	N	R/P	Saw cut area, remove and replace	Modified surface mix *
		T/E	Slurry seal	emulsified asphalt
			Seal coat	coal-tar pitch

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./ REPAIR TYPE	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL DESCRIPTION
				emulsion
Slippage	N	R/P	Remove and replace	
		T/E	Crack seal	hot-applied
				cold-applied
			Slurry seal	emulsified asphalt

LEGEND:

N = No degree of severity
L = Low
T = Temporary
H = High
R = Recommended
P = Permanent
M = Medium
E = Emergency

* - “Modified surface mix” refers to a modified standard mix with a minimum of 5% retained on the 12.7 mm sieve and 0% passing the 19 mm sieve.

Table 6 – 8 MAINTENANCE AND REPAIR OF FLEXIBLE PAVEMENT SURFACES - DISINTEGRATION

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./ REPAIR TYPE	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL DESCRIPTION
Potholes	N	R/P	Saw cut area, remove and replace	Modified surface mix *
		T/E	Prepare existing pothole, remove loose material, fill and compact	hot-applied, polymer modified asphalt binder w/ aggregate
				cold-applied, emulsified asphalt w/ aggregate
		R/P	Remove and replace	Modified surface mix *
			Seal coat	coal-tar pitch emulsion

Raveling and Weathering	N Small Area	T/E		
			Slurry seal	emulsified asphalt
			Apply rejuvenator	sealer-rejuvenator
	N Large Area	R/P	Overlay	Modified surface mix *
		T/E	Seal coat	coal-tar pitch emulsion
			Slurry seal	emulsified asphalt
			Apply rejuvenator	sealer-rejuvenator
Asphalt Stripping	N	R/P	Remove to sound pavement & replace	Modified surface mix *
Jet Blast Erosion	N	R	No action	none
		R/P	Partial-depth patch	Modified surface mix *
		T/E	Apply rejuvenator	sealer-rejuvenator

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./ REPAIR TYPE	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL DESCRIPTION
Patching and	L	R/P	No action	none
	M	T/E	Seal cracks	hot-applied sealant
				cold-applied sealant
			Repair distressed area (small) only	Modified surface mix *

Utility Cut Patch		R/P	Remove and replace the patch	Modified surface mix *
	H	R/P	Remove and replace the patch	Modified surface mix *

LEGEND:

N = No degree of severity

L = Low

M = Medium

H = High

R = Recommended

P = Permanent

T = Temporary

E = Emergency

* - "Modified surface mix" refers to a modified standard mix with a minimum of 5% retained on the 13 mm sieve and 100% passing the 19 mm sieve.

Table 6 - 9. MAINTENANCE AND REPAIR OF FLEXIBLE PAVEMENT SURFACES – DISTORTION

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./ REPAIR TYPE	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL DESCRIPTION
Rutting	N	R/P	Remove and replace	Modified surface mix *
		T/E	Patch w/ elastomeric compound w/ aggregate	elastomeric compound w/ aggregate
		R/P	Saw cut area, remove and replace	Modified surface mix *

Corrugation and Shoving	N	T/E	Slurry seal	emulsified asphalt
			Seal coat	coal-tar pitch emulsion
Depression	N	R/P	Remove and replace	Modified surface mix *
Swelling	N	R/P	Saw cut area, remove and replace	Modified surface mix *
		T/E	Slurry seal	emulsified asphalt
			Seal coat	coal-tar pitch emulsion

LEGEND:

N = No degree of severity
L = Low
M = Medium
H = High
R = Recommended
P = Permanent
T = Temporary
E = Emergency

* - “Modified surface mix” refers to a modified standard mix with a minimum of 5% retained on the 13 mm sieve and 100% passing the 19 mm sieve.

Table 6 - 10. MAINTENANCE AND REPAIR OF FLEXIBLE PAVEMENT SURFACES – LOSS OF SKID RESISTANCE

PAVEMENT DISTRESS	PAVEMENT DISTRESS SEVERITY	MAINT./ REPAIR TYPE	SUGGESTED MAINT./ REPAIR METHOD	MATERIAL DESCRIPTION
Polished Aggregate	N	R/P	Slurry seal	emulsified asphalt
		P	Micro-milling or diamond grinding	none
			Grooving	none
			Overlay	Modified surface mix
Contaminants	L	R/P	Clean surface	high-pressure water
				Biodegradable chemicals
	M	R/P	Clean surface and apply coal-tar emulsion seal coat	coal-tar pitch emulsion
	H	R/P	Remove and replace	Modified surface mix *
Bleeding	N	R/P	Scrap surface and blotter-sand-roll	blotter sand
			Mill and repave	Modified surface mix *
Fuel/Oil Spillage	L – M Isolated Areas	R/P	Clean w/ application of biodegradable chemicals	Biodegradable chemicals
		R/P	Clean and application of coal-tar emulsion seal coat	coal-tar pitch emulsion
	H Areas of continuous spillage	R/P	Remove and replace	Modified surface mix *
				conventional PCC

				mix

LEGEND:

N = No degree of severity
L = Low
M = Medium
H = High
R = Recommended
P = Permanent
T = Temporary
E = Emergency

* - “Modified surface mix” refers to a modified standard mix with a minimum of 5% retained on the 13 mm sieve and 100% passing the 19 mm sieve.

APPENDIX A. PAVEMENT MAINTENANCE MANAGEMENT PROGRAM

An effective pavement maintenance management program specifies the procedures to be followed to assure that proper preventative and remedial pavement maintenance is performed. An aerodrome sponsor may use any format it deems appropriate, but the program must, as a minimum, include the following:

A-1. Pavement Inventory: The following must be depicted in an appropriate form and level of detail:

a. Location of all runways, taxiways, and aprons
b. Dimensions
c. type of pavement
d. Year of construction or most recent major rehabilitation
e. Whether Federal financial assistance was used to construct, reconstruct, or repair the pavement.

A-2. Inspection Schedule

a. Detailed Inspection. Trained personnel must perform a detailed inspection of aerodrome pavements at least once a year.

b. Drive-By Inspection: A drive-by inspection must occur a minimum of once per month to detect unexpected changes in the pavement condition.

A-3. Record Keeping. The aerodrome must record and keep on file for a minimum of 5 years complete information about all detailed inspections and maintenance performed. The types of distress, their locations, and remedial action, scheduled or performed, must be documented. The minimum information to be recorded is listed below:

a. Inspection date
b. Location
c. Distress types
d. Maintenance scheduled or performed

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

A-4. Information Retrieval. An aerodrome operator may use any form of record keeping it deems appropriate, so long as the information and records produced by the pavement survey can be retrieved as necessary for any reports required by the Civil Aviation Authority.

A-5. Program Funding. The program should identify funding and other resources available to provide remedial and preventive maintenance activities.

APPENDIX B: REPAIR METHODS OF PAVEMENT DISTRESSES

1. REPAIR METHODS FOR RIGID PAVEMENTS

B-1 CRACK REPAIR AND SEALING

Sealing cracks prevents surface moisture from entering the pavement structure. This type of repair first requires establishing a properly shaped sealant reservoir, which should be done with a saw rather than with router equipment because routers use a mechanical impact to remove material and can cause micro-cracks in the concrete.

Longitudinal, Transverse, and Diagonal Cracks. The procedures for repairing these types of cracks are as follows:

i) Saw a groove to the width and depth recommended by the sealant manufacturer. The width needs to be sufficient to allow the material to stretch and contract with movement in the pavement. Common hot-pour materials typically require a width equal to the depth. Silicone materials typically require a width twice the dimension of the depth.
ii) Sand blast both sides of the sealant reservoir, and clean it out with compressed air. The groove must be dry and free of dirt, dust, and other material that might prevent bonding of the sealant.
iii) Place a bond breaker at the proper depth to establish the joint sealant reservoir. Bond breakers are necessary to prevent bonding of the sealant material to the bottom of the crack.

iv) Fill the joint reservoir with sealant, recessing the sealant approximately ¼ inches (6 mm) below the pavement surface. Excess sealant on the pavement surface does not assist in sealing the crack and is prone to tracking and damage from wheels and snow removal equipment.

Corner Cracks. Structural distress requires full-depth repairs. Corner cracks (cracking of the panel between two adjacent joints), cracks more than ¾-inches (19 mm) wide with spalling, cracks more than 1-1/2-inches (38 mm) wide, and/or cracks associated with loss of subgrade support typically signify the presence of structural distress. The procedures for repairing these types of cracks are as follows:

i) Make full-depth saw cuts at constructed joints. Make the saw cuts so the repair area is rectangular when the repair is for wide cracks that transect a panel. For corner cracks, cut the repair area square.
ii) Use a jackhammer or tractor mounted hammer to remove material within the limits of the saw cuts. During the repair, try to minimize any disturbance to the subgrade soils or base materials.
iii) Restore subgrade or subbase materials to the base elevation of the panel being repaired.
iv) Use tie-bars consisting of #4 deformed bars (#5 bars for pavements more than 12-inches (30 cm) thick) in the faces of the parent panel. Install by drilling into the face and using an epoxy bonding agent. Use equidistant spacing of the bars, but do not install them more than 24-inches (60 cm) apart.

Use dowel bars in the joint that parallels the direction of traffic. On aprons and areas where traffic may be oblique to joints, install dowels in both joint faces. Dowels are installed by drilling and spaced at least one bar spacing away from faces parallel to the dowel bar.

i) Install nonabsorbent board within the limits of the joint seal reservoirs along the adjacent concrete panels. When repairing multiple panels, restore the joint seal reservoirs with the nonabsorbent filler board.
ii) Backfill the repair area with concrete, being sure to consolidate the concrete along the limits of repair. Exercise caution when working adjacent to existing concrete faces during consolidation, and watch for segregation of the concrete.
iii) After the concrete cures, remove the filler board by sawing. Reinstall joint seal material.

D" Cracking. This type of distress usually requires repairing the complete slab since "D" cracking will normally reappear adjacent to the repaired areas.

Joint Seal Damage. The sequence of operations for preparing joints for resealing is as follows:

i) Use a joint plow or diamond saw blade to remove the joint sealing material to the full depth of the reservoir for contraction and construction joints. As a minimum, remove the joint sealant material to a depth sufficient to establish a proper shape factor for the new sealant material.
ii) When changing the material type of the joint seal, re-facing is recommended. Re-facing will result in a change to the reservoir shape factor (width to depth ratio). Remove any remaining debris by sand blasting each face of the joint reservoir.
iii) If the same material will be used to replace the existing joint seal, clean the reservoir with high-pressure water or sand blasting.
iv) Immediately prior to sealing, blow out the joint with clean, oil-free compressed air to remove sand, dirt, and dust.
v) Install new dry backer rod.
vi) Seal joints with hot or cold compounds.

B-2 DISINTEGRATION

If not impeded in its early stages, disintegration can progress rapidly until the pavement requires complete rebuilding.

a) Scaling, Map Cracking, and Crazing. This distress is often noticeable with little or no surface deterioration. Severe cases of scaling, map cracking, or crazing can produce considerable FOD, which can damage propellers and jet engines. If the distress is severe and produces FOD, the repair method is to remove the immediate surface and provide a thin bonded overlay. The procedures for repairing these types of distress are as follows:

i) Make a vertical cut with a concrete saw 2 inches (5 cm) in depth and approximately 2 inches (5cm) back of the affected area.
ii) Remove all unsound concrete until sound, intact material has been reached.
iii) Remove the unsound concrete with air hammers, pneumatic drills, shot blasters, or grinding equipment, and blow out the area with compressed air.
iv) Clean the area to be repaired with high-pressure water. Allow the patch area to dry completely if required by the patch material specification.
v) Treat the surface with a grout mixture to ensure 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 (2 mm).

vi) If the repair crosses or abuts a working joint, 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.

vii) After edging the patch, finish it to a texture matching the adjacent area.

viii) After a proper cure period, fill any open joints with joint sealant prior to opening to traffic.

b) Joint Spalling and Corner Spalling. The procedure for the repair of spalls is as follows:

i) Make a vertical cut with a concrete saw 2 inches (5 cm) in depth and approximately 2 inches (5 cm) back of the spalled area.

ii) Remove all unsound concrete until sound, intact material has been reached. Break out the unsound concrete with air hammers or pneumatic drills and blow out the area with compressed air.

iii) Clean the area to be repaired with high-pressure water. Allow patch area to dry completely if required by the patch material specification.

iv) Treat the surface with a grout mixture to ensure 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 (2 mm).

v) 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 no slump concrete, which will require tamping to place in the patch.

vi) After edging the patch, finish it to a texture matching the adjacent area.

vii) After a proper cure period, fill the open joint with joint sealant prior to opening to traffic.

c) Blowups. Blowups may be repaired using the following procedures:

i) Make a full-depth vertical cut with a concrete saw approximately 6 inches (15 cm) outside of each end of the broken area.

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

iii) Add subbase material, if necessary, and compact.

iv) In reinforced pavement construction, use joint techniques to tie the new concrete to the old reinforced material. Dowel any replacement joints, and build them to joint specifications.
v) Dampen the subgrade and the edges of the old grout.
vi) Place concrete on the area to be patched. Ready-mixed concrete may be used if it is satisfactory and can be obtained economically. Consider using a mixture providing high early strength in order to permit the earliest possible use.
vii) Finish the concrete so the surface texture approximates that of the existing pavement.
viii) Immediately after completing finishing operations, properly cure the surface with either a moist cure or a curing compound.

d) Shattered Slab. A shattered slab requires replacing the full slab. Follow the same procedures used for blowup repairs except remove unstable subgrade materials and replace with select material. Correct poor drainage conditions by installing drains for removal of excess water.

B-3 DISTORTION

If not too extensive, some forms of distortion, such as that caused by settlement, can be remedied by raising the slab to the original grade. Slabjacking procedures may be used to correct this type of distress. In slabjacking, a grout is pumped under pressure through holes cored in the pavement into the void under the pavement. This creates an upward pressure on the bottom of the slab in the area 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 performed by specialty contractors.

B-4 LOSS OF SKID RESISTANCE

Rehabilitation treatment includes resurfacing, milling, diamond grinding, shot peening, and surface cleaning. Grooving may be considered when a loss of skid resistance is observed. Grooving does not impact the surface texture but does provide a channel for water that becomes trapped between a pavement and the tire to escape. Grooving thus minimizes the potential for hydroplaning during wet conditions.

a) Polished Aggregate. Since polished aggregate distress normally occurs over an extensive area, consider milling or diamond grinding the entire

pavement surface. Concrete or bituminous resurfacing may also be used to correct this condition.

b) Contaminants. Remove rubber deposits with high-pressure water or biodegradable chemicals.

2. REPAIR METHODS FOR BITUMINOUS PAVEMENTS

B-5 CRACK SEALING

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

a) Longitudinal, Transverse, Reflection, and Block Cracking. In areas where narrow cracks are present, a seal coat, slurry seal, or fog coat may be applied. Narrow cracks can also be widened by sawing or routing. Wide cracks, greater than 1/4 inch (6mm), should be sealed using the following procedure:

i) Clean out the crack with compressed air to remove all loose particles. If necessary, rout to widen the crack prior to utilizing compressed air. Also, address any required weed prevention.
ii) Fill cracks with a prepared crack sealer.

b) Alligator Cracking. Permanent repairs by patching may be carried out as follows:

i) 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. Use a power saw to make vertical square or rectangular cuts through the pavement.
ii) Replace base material with material equal to that removed, but if the base material has proved problematic, replace it with a more appropriate material. Compact each layer placed.
iii) Apply a tack coat to the vertical faces of the existing pavement.
iv) Place bituminous concrete and compact
v) If necessary, saw and seal the joints around the perimeter of the patch area
.

c) **Slippage Cracks.** One repair method commonly used for slippage cracks involves removing the affected area and patching with plant-mixed asphalt material. Specific steps are given below:

i) Remove the affected area and at least 1 foot (30 cm) into the surrounding pavement. Make the cut faces straight and vertical. A power pavement saw makes a fast and neat cut.

ii) Clean the surface of the exposed underlying layer with brooms and compressed air.

iii) Apply a light tack coat.

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

v) Compact the asphalt mixture with steel-wheel or rubber-tire rollers until the surface is the same elevation as the surrounding pavement.

B-6 DISINTEGRATION

If not impeded in its early stages, disintegration can progress rapidly until the pavement requires complete rebuilding. Sealer-rejuvenator products can be applied to retard disintegration. The products help reverse the aging process of the surface asphalt. Deterioration from raveling may also be impeded by applying a light fog seal or a slurry seal. The basic procedures for either surface treatment are as follows:

i) Sweep the surface free of all dirt and loose aggregate material

ii) Apply the surface treatment

iii) Close to traffic until the seal has cured

B-7 DISTORTION

Repair techniques for distortion range from leveling the surface by filling with new material to completely removing of the affected area and replacing with new material. Cold milling can be employed prior to overlaying for many of these distresses.

a) **Rutting.** The repair procedures are as follows:

i) Determine the severity of the rutting with a straightedge or stringline. Outline the areas to be corrected on the pavement surface

ii) Mill or grind down the identified area to provide a vertical face around the edge.

iii) Thoroughly clean the entire area.
iv) Apply a light tack coat of asphalt emulsion to the area to receive asphalt material, including the vertical face of the patch area.
v) Spread enough dense-graded asphalt concrete in the prepared area to bring it to the original grade when compacted. Deeper patches may require multiply lifts to allow proper compaction of each lift.
vi) Thoroughly compact the asphalt patch material with a roller or vibratory plate compactor.

b) Corrugation and Shoving. The repair procedure for this type of distress is the same as for patch repair of alligator cracking.

c) Depressions. The repair procedures are as follows:
i) Determine the limits of the depression with a straightedge or stringline. Outline the depression on the pavement surface.
ii) Mill or grind down the area to provide a vertical face around the edge.
iii) Thoroughly clean the entire area to be repaired.
iv) Apply a light tack coat of asphalt emulsion to the area to receive asphalt material, including the vertical face of the patch area.
v) Spread enough bituminous concrete in the depression to bring it to the original grade when compacted. Deeper patches may require multiply lifts to allow proper compaction of each lift.
vi) If the pavement was not ground down, feather the edges of the patch by careful raking and manipulation of the material. However, in raking, take care to avoid segregation of the coarse and fine particles of the mixture. With additional effort, a more suitable and longer-lasting patch can result by vertically grinding the edges down or sawing and using a light jackhammer to create a vertical edge with no feathering and little raking required.
vii) Thoroughly compact the patch with a roller or vibratory-plate compactor.

B-8 SWELLING

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

B-9 LOSS OF SKID RESISTANCE

Treatment for loss of skid resistance includes removal of excess asphalt, resurfacing, grooving to improve surface drainage, and removing of rubber deposits.

a) **Bleeding.** A pavement milling or grinding machine may be used to remove the excess asphalt by milling off 1/8 inch to 1/4 inch (3 to 6 mm) of pavement. Repair procedures using hot sand or aggregate are as follows:

i) Apply slag screenings, sand, or rock screenings to the affected area. Heat the aggregate to at least 300º F (150º C) and spread at the rate of 10 to 15 pounds per square yard (4 to 9 kg per m2).

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

iii) When the aggregate has cooled, broom off loose particles.

iv) Repeat the process if necessary.

b) **Polished Aggregate.** One means of correcting this condition is to cover the surface with an aggregate seal coat. Grooving, milling, or diamond grindings the pavement surface are also useful techniques.

c) **Fuel Spillage.** Permanent repairs for areas subjected to continuous fuel spillage consist of removal of the damaged pavement and replacement with Portland cement concrete or bituminous asphalt, and application of a coal-tar emulsion seal coat or other fuel-resistant coating.

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

APPENDIX C - FALLING WEIGHT DEFLECTOMETER (FWD)

The falling weight deflectometer (FWD) is a trailer mounted device that places an 11.8 in. (300 mm) diameter load plate in contact with the pavement at each test location. The testing interval is set at 0.1 mi. (maximum) or 30 locations per project. A load column above the load plate carries a stack of weights that are dropped to impart a load to the pavement similar to that imparted by a passing dual truck tire set. A series of seven geophones spaced away from the load plate at 12 in. increments measure the surface deflection, generating a “deflection bowl.” Measurements are generally acquired in the right wheel path of the outside lane.

Figure C-1. Falling Weight Deflectometer (FWD).

Figure C-2. Falling Weight Deflectometer, detail view.

Some care in the placement of the load plate and sensors is required by the survey crew, especially where the pavement surface is rutted or cracked. The load plate should lay on a flat surface; the load plate and all geophones should lie on the same side of any visible cracks. A human spotter should be used to ensure placement in these case.

Temperature data collected at the time of testing is necessary for all flexible pavements since the modulus of bituminous materials is temperature-dependent. The FWD has a built-in thermocouple to measure ambient air temperature and records this temperature at each drop location. In addition, for pavements with bituminous surfaces at least 3.0 in. thick, in-pavement temperature measurements should be made at the beginning and end of each survey, at a minimum. Longer surveys or surveys made on days where rapid temperature changes occur will require temperature checks at additional intermediate locations. A portable drill with masonry bit is provided to accomplish this; holes are drilled to mid-depth or 3.0 in. maximum. Alternatively, surface temperatures measured by infrared devices can be made with correlations available for mid-depth temperature estimation.