Airfield Pavement Maintenance Manual

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Beca

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Contents

List of Abbreviations

ADF	Australian Defence Force
ADFP	Australian Defence Force Publication
AFHQ	Air Force Headquarters
AGL	Aeronautical Ground Lighting
AIS	Aerodrome Information Service
APCT	Airfield Pavement Concession Tool
APCRS	Airfield Pavement Condition Rating System
APMM	Airfield Pavement Maintenance Manual
APMS	Airfield Pavement Management System
APSEM	Airfield Pavement Strength Evaluation Manual
AVGAS	Aviation Gasoline
AVTUR	Aviation Turbine Fuel (also known as Jet A-1)
BAEO	Base Airfield Engineering Officer
BASO	Base Airfield Safety Officer
BSM	Base Services Manager
CASA	Civil Aviation Safety Authority
CES	Civil Engineering Section
CFI	Capital Facilities and Infrastructure Branch
CTB	Cement Treated Basecourse
CTR	Coal Tar Rejuvenator
DADM	Defence Airfield Design Manual
DEEP	Directorate of Estate Engineering Policy
DGA	Dense Graded Asphalt
DNAP	Directorate National Airfields Projects
DRMS	Document Records Management System
DSG	Defence Support Group
ERSA	EnRoute Supplement Australia
FAA	Federal Aviation Administration
FCR	Fine Crushed Rock
FOD	Foreign Object Damage
FRM	Fuel Resistant Membrane
GSE	Ground Support Equipment
ICAO	International Civil Aviation Organisation

ICBP	Interlocking Concrete Block Paving
IDA	Infrastructure Development Agency
IM	Infrastructure Management
IRI	International Ride Index
IVO	In the vicinity of
MoS	Manual of Standards
NAASRA	National Association of Australian State Road Authorities
NAP	National Airfields Project
NAMP	National Airfields Maintenance Program
NCW	National Capital Works
NMW	National Maintenance Works
OH&S	Occupational Health and Safety
OLA	Ordnance Loading Apron
ORP	Operational Readiness Platform
PCC	Portland Cement Concrete
PCN	Pavement Classification Number
PFC	Porous Friction Course
PIR	Pavement Inspection Report
PMB	Polymer Modified Binder
PMCA	Project Manager/Contract Administrator
PME	Polymer Modified Emulsion
PMS	Pavement Management System
PSV	Polished Stone Value
PVC	Poly Vinyl Chloride
RAAF	Royal Australian Air Force
RBB	Rubberised Bitumen Bandage
REO	Regional Environmental Officer
RESA	Runway End Safety Area
SAMI	Stress Alleviating Membrane Interlayer
SATCO	Senior Air Traffic Control Officer
SBS	Styrene-Butadiene-Styrene (an elastomeric polymer)
SEST	Surface Enrichment Sprayed Treatment
SPAs	Special Purpose Aprons
SRE(S)	Semi-Rigid Epoxy (with Sand)
TDZ	Touch Down Zone

UK	United Kingdom

Glossary of Terms

Age Cracking. Cracking of asphalt surface caused by the degradation (ageing) of the bituminous binder rather than by traffic loads. Bitumen shrinks and embrittles over time due to the gradual loss of volatiles and the action of air, water and ultraviolet light.

Aggregate. Mineral particles, such as sand, crushed rock or river gravel.

Alkali-Aggregate Reaction (Alkali-silica reaction). A reaction between a form of silica present in some concrete aggregates, and alkalis present in some cements. The reaction produces internal volume expansions that cause a pattern of cracks (map cracking) that typically extends throughout a concrete slab. Alkali-aggregate reaction is distinct from sulphate attack in that it involves large expansion without the softening that occurs with sulphate attack.

Apron (Ramp): An area on airports intended to accommodate aircraft for purposes of loading or unloading passengers and cargo, refuelling, parking, or maintenance.

Asphalt (Bituminous concrete, 'Hotmix'). Asphalt is a mixture of crushed stones and sand, glued/bound together with a bituminous binder. Concrete comprises a similar mixture of crushed stones and sand, but is glued/bound together with a paste of Portland cement (or blended cement) and water.

In concrete, when the cement paste sets it becomes rigid and brittle. In asphalt the bituminous binder harden paste. Because the bitumen can stretch it can accommodate shrinkage and temperature induced movements to a higher degree. Therefore, unlike concrete pavements, asphalt requires no joints.

Asphalt is normally provided as a waterproof surface that provides a smooth running surface on flexible pavements. However, it may also be used as a thicker structural layer (as in a deep stretch pavement) or as the only structural layer (as in a full depth asphalt pavement).

Base course. The pavement layer or layers of selected material placed on a sub-base or subgrade to support a surface course.

Bedding. Bedding is a layer of material specifically used as a base on which another material is placed. In pavements, bedding is normally a sand on which ICBP is installed.

Binder Application. An application of bituminous binder on a pavement by spraying or squeegeeing.

Birdbath. Localised pavement depression causing water to pond after rainfall.

Bitumen. A black viscous material obtained from the refinery processing of crude oil. It is solid at normal temperatures but softens when heated. It has excellent waterproofing properties and is a strong, inexpensive adhesive

Bitumen Emulsion. A liquid consisting of a suspension of extremely fine droplets of bitumen in water.

Bituminous Binder. A bituminous liquid or material which liquefies on heating and which is used to hold aggregate particles either together or to a surface. Generally bituminous binders will be in the form of cutback bitumen, bitumen emulsion or polymer modified rubberised bitumen.

Bituminous Concrete. See Asphalt

Bituminous Instant Repair Material. Proprietary pavement patching material (examples are Pavefix, Perma Patch and Repairite/Repairoad), EzyStreet. A fine graded cold asphalt which hardens on exposure to air and can be used in wet conditions. Immediately after being compacted the materials have substantial strength so that repairs can be opened to traffic. They differ from traditional cold mix which is made using bitumen temporarily softened with a fluxing oil and which therefore relies on evaporation to harden.

Bituminous Sprayed Seal. This is the pavement surfacing method common on many country roads and suburban streets. Bitumen is heated to soften it to a sprayable consistency then sprayed from a tanker onto the road surface. While the thin bitumen layer is still warm and soft, a one stone thick layer of single sized crushed stones is spread and pressed into the bitumen by rolling. This is termed a one coat hot bitumen sprayed seal .

A second spray of bitumen and a second layer of smaller crushed stones can then be added to produce a two coat hot bitumen sprayed seal. The second stones wedge in between the larger stones of the first layer and stop them from being rolled over and dislodged by vehicle tyres.

Sometimes a third application of bitumen and aggregate is employed. This is known as a triple coat hot bitumen sprayed seal.

Bleeding (flushing). Bitumen expands during hot weather.

In asphalt, bitumen sometimes expands and overfills the available space (voids) between the aggregates and flows on to the surface of the pavement.

In sprayed seals, an excessive application of binder in the original construction, or the loss of aggregate from the surface may result in free bitumen at the surface. The binder may be worked to the surface under the action of traffic, and is therefore commonly more prevalent in wheel track areas. The binder on the surface causes a loss of surface texture and reduces friction, and can be particularly slippery when wet.

Blistering (Bubbling). A circular bulge of a bituminous surface (usually a sprayed seal but can also occur in asphalt) caused by the development of water vapour or air pressure beneath the seal.

Block Cracking. Block cracks are inter-connected cracks that divide the pavement into approximately rectangular pieces. Blocks may range in size from 0.3m by 0.3m to 3m by 3m. Block cracking is not load-associated.

Boney Surface. An asphalt or unbound pavement surface deficient in fine matrix material, due usually to segregation , erosion or lack of compaction. The term is also used to describe concrete containing voids between coarse aggregates.

Breaking of emulsion. The separation of a bitumen emulsion into free bitumen and water. This process is accompanied by a colour change from brown to black.

Buckling (Tenting). Localised upward movement of a slab, usually occurring at a transverse crack or joint.

California Bearing Ratio (CBR). A commonly used measure of the stiffness and strength of a subgrade or unbound pavement construction material. It expresses the material's stiffness relative to a standard, well compacted, quality crushed rock base course material.

Cement. Portland or blended cement complying with AS 3972.

Coal Tar: Coal-tar or coal-tar oils are blended with maltenous type asphalt pavement rejuvenating agents and are designed to penetrate and to chemically improve the asphalt pavements.

Coal tar has been reported as being carcinogenic in some circumstances. OH&S procedures should be strictly observed for these products

Coarse Aggregate. Coarse crushed rock manufactured from hard durable stone free of clay lumps, organic matter and objectionable quantities of deleterious substances.

Cold Poured Joint Filler. One component cold poured joint filler.

Cold mix. Similar to asphalt but the bitumen glue binding the stone and sand particles together is a bitumen temporarily softened by mixing with a cutter, usually kerosene, or a fluxing oil, usually diesel. Thus the aggregate/bitumen mixture is workable at normal temperatures and is still useable after storage in stockpiles for long periods. It hardens gradually by the evaporation of cutter and fluxing oil. Cold mix is used for pothole patching and larger emergency patching but should only be placed in thin layers (approx. 20 mm) otherwise the cutters and flux cannot evaporate and the cold mix stays soft.

Concrete. A mixture of cement, aggregates, and water, with or without the addition of chemical admixtures.

Concrete Pavement (Rigid Pavement). Concrete is a mixture of crushed stones and sand, bound together with a paste of Portland cement (or blended cement) and water. Asphalt comprises a similar mixture of crushed stones and sand, but is bound together with a bituminous binder.

In asphalt, the bituminous binder hardens by cooling and forms a flexible ‘glue’ that can stretch. In concrete, when the cement paste sets it becomes rigid and brittle, and cannot accommodate shrinkage or temperature induced movements. To control cracking at the surface it must be provided with joints and/or reinforcement.

Concrete pavements distribute tyre loads to the underlying soil subgrade by using the high bending strength of the concrete. Accordingly, it is unnecessary to provide any significant thicknesses of base or sub-base courses because they do not contribute to the structural capacity. A base course is normally provided under a concrete slab as a working platform and as a layer to provide uniform support that will not pump.

Corner Break. Corner crack.

Corner Crack. A diagonal crack intersecting two edges or joints of a concrete slab to form a triangular shaped spall in the corner of the slab.

Course. Any one of the different layers of which a pavement may be constructed.

Cover Aggregate. Aggregate spread over the surface of a pavement after the application of a bituminous binder.

Crack. A crack visibly open for any part of its length. Cracks may be further sub-divided into the following categories.

Fine Crack. A fine crack is generally less than 1mm wide.

Medium Crack. A medium crack is generally between 1mm to 5mm wide.

Wide Crack. A wide crack is generally greater than 5mm wide.

Crack Filling. The process of inserting a filler into a crack and preventing the ingress of foreign matter and subsequent spalling.

Crazing (also called map cracking). A fine pattern of hairline cracks in concrete pavements that extend only to shallow depth below the surface of a concrete slab. They are usually caused by over finishing and sometimes lead to scaling.

Crocodile or Alligator Cracking. A series of close spaced inter-connecting cracks caused by fatigue failure of the bituminous surface layer under repeated traffic loading. The rate at which such cracking develops is increased if the pavement suffers high deflections under traffic.

Curling. See Warping.

Cutback Bitumen. Bitumen that has been blended with a volatile oil to reduce its viscosity, however when the volatiles evaporate the bitumen will eventually revert to its original viscosity. In general, bitumen can be softened by heating but also by mixing with a solvent such as kerosene which then evaporates leaving the bitumen solid again. Cutback bitumen is often used to prime a crushed rock pavement before applying a bituminous sprayed seal or an asphalt surfacing. Unlike bituminous emulsion, bitumen is in a dissolved form in cutback and will penetrate fine cracks where the bitumen globules of an emulsion will not. Also the solvent tends to rejuvenate hardened pavement binder by softening it.

Cutter. A volatile material such as kerosene (or turpentine) used to temporarily reduce the viscosity of bitumen.

D-Cracking (Durability cracking). A form of concrete distress uncommon in Australia where freeze-thaw conditions are rare. Typically consists of multiple fine cracks, often as sets of parallel cracks adjacent to joints and larger cracks.

Delamination. Loss of discrete areas of the wearing course layer to the full depth of the layer. There is usually a clear delineation of the wearing course asphalt and the layer below.

Dense Graded. This term is applied to asphalt and to crushed rocks that contain a range of stone sizes where the amount of each size is just sufficient to fill the gaps between the next largest size stones. Thus a dense graded material can be compacted to a very strong, dense mass containing few air voids.

Depression. Localised area within a pavement with elevation lower than the surrounding area. May not be confined to wheel paths and could extend across several wheel paths. Depressions normally hold water after rainfall.

Diagonal Crack. A crack or break approximately diagonal to the pavement centreline.

Disintegration. Deterioration into small fragments or particles.

Dragging. An open textured asphalt surface that has resulted from the layer of asphalt being placed to thin. The general rule of thumb is for the thickness of asphalt placed to be at least 2.5 times the nominal maximum aggregate size. If this does not occur, there is potential for the screed to 'drag' across the asphalt layer that is being placed.

Edge Break. Edge of the surface is fretted, broken or irregular.

Edge Drop Off. The vertical distance from the surface of the pavement at its edge to the surface just beyond the pavement edge.

Emulsion (Bituminous emulsion). When it is inconvenient to soften bitumen to a sprayable consistency by heating, bitumen emulsion is sometimes used for sealing work. The bitumen is applied in the form of minute globules suspended in water. The water evaporates and some might pass downwards into the pavement. The bitumen globules then join together to form a continuous layer. This process is called 'breaking' of the emulsion. An emulsion usually consists of approximately 50% bitumen, 50% water plus 1% of emulsifying agent. If weather conditions are such that evaporation of the water does not occur, a hard bitumen layer will not form (ie the bitumen emulsion will not "break"). Quick-breaking emulsion is used to provide a tack coat to a surface prior to placement of asphalt. It is not generally as effective as cutback bitumen in treating fine cracks because the bitumen globules are too large to enter the cracks and only form a skin over the cracks. Also, because it contains no bitumen solvent, an emulsion will not soften the aged bitumen in the pavement in the way that a cutback bitumen does.

Epoxide Resin Paint. Two pack epoxide resin paint supplied with base component and catalyst in separate containers for new line marking on surfaces of concrete pavements.

Erosion. Gradual loss of fine stone particles from the surface of an asphalt, unbound or concrete pavement. If not attended to, (eg by application of a SEST in the case of asphalt) larger stones will be eventually released that could damage aircraft.

Expansion Joint. A joint which is made in or between portions of a pavement for the specific purpose of permitting unrestrained expansion of the pavement on either side of the joint.

Expansive Soils - Expansive soils are soils that expand when water is added and shrink when they dry out.

Faulting. Differential vertical displacement of abutting slabs at joints or at cracks creating a step in the pavement surface. Faulting indicates that the keying (load transfer) across the joint or crack has been lost. Consequently the stresses caused by traffic are significantly increased.

Filler. A finely divided material mostly passing a 0.075mm (75 micron) AS sieve. It is used to partially fill the voids in an aggregate mixture.

Fine Aggregate. Fine crushed rock manufactured from hard durable stone free of clay lumps, organic matter and objectionable quantities of deleterious substances. The maximum size aggregate shall not exceed 4.75mm and be retained on a 0.075mm (75 micron) sieve.

Flexible Pavement. A pavement structure that distributes tyre loads to the underlying soil subgrade by the action of the aggregate interlock, particle friction and, to a lesser extent, soil cohesion of the pavement materials (sometimes called an 'unbound' pavement). The pavement is flexible relative to concrete, and is typically surfaced with a sprayed seal or asphalt. The pavement strength is very dependent upon the degree of compaction achieved during construction. Also, if the pavement materials are clayey, and therefore lose strength with increased moisture content, the pavement relies on the waterproofing provided by the bituminous surface.

Flushing. See bleeding.

Fluxed Bitumen. Bitumen that has had its viscosity reduced, generally through the addition of a non volatile oil.

FOD. Foreign Object Damage is damage sustained by an aircraft as a result of foreign debris or objects such as stones and pavement fragments striking the aircraft or being ingested into jet engines. FOD is also used to designate Foreign Object Debris which is any foreign substance or debris may potentially cause damage to an aircraft.

Formwork. Fixed boards of a suitable material used to contain materials (primarily concrete) during construction.

Foundation. The soil, subsoil or rock, whether built up or natural, upon which the pavement is supported.

Fretting. The progressive loss of aggregate particles from the edges of cracks in bituminous surfaces.

Fuel Resistant Surfacing. Fuel and oil resistant surfacing used for sealing bituminous surfaced pavement areas where fuel and oil spillages are a problem (generally aprons).

Grading. The particle size distribution of a mixture of aggregates.

Granular pavement. See 'unbound pavement'.

Hairline Crack. A hairline crack is a crack which is tight over its full length. (Barely or not visible from a standing position).

Hot Mix. A mixture of bitumen and pre-heated fine and coarse aggregate with or without a filler, spread and compacted while hot.

Hungry. Description applied to bituminous surfaces that are deficient in bitumen, sometimes in conjunction with an open or eroded surface texture.

Hydrophilic Aggregate. Aggregate which exhibits a marked affinity for water (meaning water loving) and is generally not acceptable for use in a pavement structure.

Interlocking Concrete Block Pavers (ICBP). Interlocking concrete block pavers are shaped concrete masonry blocks that are used as an alternative to asphalt, generally on apron areas and taxiways. Normally bedded on a thin layer of sand above a sound base course layer. ICBPs have been used successfully as a surfacing course on flexible pavements for aircraft.

Joint Filler Failure – Adhesion. Loss of joint filler adhesion to the concrete surface.

Joint Filler Failure – Chemical. Loss of joint filler properties or loss of filler from the joint by chemical degradation.

Joint Filler Failure – Cohesion. Internal rupture of the joint filler.

Joint Filler Failure – Extrusion. Joint filler protruding above the joint edges

Joint Filler Failure – Intrusion. Incorporation of aggregate particles or similar foreign material into joint filler.

Joint Filler Failure – Spalling. Disintegration of concrete adjacent to joint edge due to bond of joint filler.

Laitance. A thin layer of fine aggregate, cement and water brought to the surface of a concrete pavement during or soon after placing, usually due to overworking. The hardened product is weak and has poor durability.

Lightning Strikes. A steep sided or bowl-shaped cavity extending into the pavement surfacing resulting from a lightening strike.

Longitudinal Cracks. Crack running longitudinally along the pavement (parallel with the centreline or main axis of the pavement). This can happen in isolation or as a series of almost parallel cracks. Some limited branching may occur.

Macrotexture. Surface roughness of the pavement provided by the shape, size and spacing of coarse aggregate particles and the amount that they protrude from the surface.

Major Crack (concrete). A major crack in concrete pavements is defined as:

(a) a longitudinal crack greater than 7.5 m long but less than 30m long through two (2) successive transverse joints;

(b) a longitudinal hairline crack greater than 30m in length;

(c) a random, transverse or diagonal crack which is

- (i) continuous across a longitudinal joint; or
- (ii) across the full width of a slab and more than 600 mm away from a planned contraction joint where it meets the longitudinal joints;
- (iii) a random, transverse or diagonal hairline crack which is continuous across two (2) successive longitudinal joints.
- (iv) a crack which has an immediate or short term potential to create FOD.

Major Crack (flexible). A major crack in flexible pavements is defined as:

(a) a longitudinal crack greater than 7.5 m long;

(b) a longitudinal hairline crack greater than 30m in length;

(c) a crack which has an immediate or short term potential to create FOD.

Map Cracking. See crazing

Minor Crack. A minor crack in concrete pavement is defined as a short longitudinal, random, transverse or shrinkage crack confined to one slab.

A minor crack in a flexible pavement is defined as any crack that is less than 1m in length

Multigrade Bitumen. A specially refined bitumen that, like polymer-modified bitumen, softens less than normal bitumen at high temperatures and hardens and embrittles less than normal bitumen at low temperatures.

Multiple Cracking. A series of cracks at relatively close spacing that may lead to potential spalling.

Open Graded Friction Course (OGFC). A porous asphalt surfacing layer 20 to 30mm thick that contains 20% air voids. It has a high surface texture and the voids allow water to drain from beneath vehicle tyres during rain, thereby reducing the risk of aquaplaning. Also called 'porous asphalt' and 'popcorn mix'.

Open Graded Mix. A plant mix made with graded aggregates containing only small amounts of fine material and no added mineral filler. This mix depends largely upon mechanical interlock for stability and presents an open textured surface when compacted.

Oxidation. Hardening of the bituminous binder causing it to loose its elasticity.

Patch Failure. Failure of a repaired pavement area.

Patches. Patches are repaired sections of pavement which may or may not be associated with either a loss of serviceability (apart from a loss of appearance) or structural capacity. The extent and frequency of patching can be a useful indicator of the structural adequacy of the pavement.

Pavement. That portion of a runway, taxiway or apron placed above the subgrade which supports and forms a running surface for aircraft.

Pavement Growth. Pavement 'growth' involves progressive widening of joints in concrete pavements due to the slabs jacking themselves apart as thermal expansion and contraction occurs. This can happen if the wider gaps that exist between slabs at low temperatures are filled with sand and other incompressible debris. High temperatures then cause the slabs to expand, push against the incompressible fill and the pavement may 'grow' in length and width. However, in Australia, where extremes of temperature and frost do not occur, pavement growth is rarely of significant in practice for airfield pavements that are kept relatively clean. A similar phenomenon can occur when slabs migrate down a slope.

Paving. The process of constructing a pavement.

Pitting. General displacement of small individual particles of aggregates from the pavement surface without major displacement of the cement matrix

Plant Mix. A carefully proportioned mixture of aggregate and bituminous binder produced in a mixing plant.

Plastic Cracking. Short isolated cracks in the surface of fresh concrete soon after placing.

Pock Mark. Refers to the appearance of a concrete or asphalt surface that has numerous small cavities formed by the weathering out of weak particles.

Polymer Modified Bitumen (PMB). See Rubberised bitumen.

Polymer Modified Emulsion (PME). Typically a proprietary liquid surface treatment material consisting of fillers, sand, bitumen, water and other additives (ink, bentonite etc.) (products such as Liquid Road, Carbonyte, Jet Black etc.)

Popout. A cavity formed when a small piece of concrete, typically 25 to 100mm wide, breaks loose from the surface of a concrete pavement due to the expansion of unsound aggregates or foreign material within the concrete.

Porous asphalt friction course. See Open Graded Friction Course.

Potholes. Potholes are bowl-shaped depressions in the pavement surface resulting from the loss of wearing course and base course material. They are produced when traffic abrades small pieces of the pavement surface (cracking, delamination, etc) allowing the entry of water. Potholes will occur in pavements which are inadequately maintained.

Poured Joint Filler. Joint filler poured in a liquid state to form an elastic membrane

Precoating. The coating of an aggregate with an oil, water or bituminous based material, with or without an adhesion agent, to kill the dust and improve the subsequent adhesion of bituminous based material, with or without an adhesion of bituminous material.

Preformed Joint Filler. Joint filler formed into a fixed shape prior to insertion into a joint - normally able to be compressed for insertion into the joint and intended to expand insitu to completely fill the joint.

Pre-mix. A mixture of aggregate and bituminous binder prepared either by hand or in a mixing plant before its application to the pavement.

Primer. A bituminous material of low viscosity and low surface tension used in priming.

Primer binder. A material more viscous than a primer and required to act both as a primer and binder, and used in primer sealing.

Primerseal. An application of a primer binder with a fine cover aggregate to a prepared base to provide penetration of the surface and retain a light cover of aggregate. It is used as a preliminary treatment to a more permanent bituminous surfacing. It is intended to carry traffic for a longer period than a prime.

Priming is the spraying of a low viscosity (i.e. very fluid) bituminous material, often cutback bitumen, onto a prepared pavement to ensure that the subsequent sprayed seal or asphalt layer will adhere properly. The prime should be “thin” enough to penetrate the pavement by 5-10mm, and bind the fine dusty fractions of the pavement together. It should not be so “thick”: that it sits like a skin on the surface but should not be so “thin” that it penetrates the pavement too far thereby failing to bind the surface fines together.

Pumping is the ejection of water from saturated base courses or subgrades through joints or cracks in concrete pavements due to traffic-induced slab deflection. The ejected water carries fines from the base course or subgrade that supports the slabs, thereby undermining them. The lack of edge support then typically causes cracking of the slabs when subjected to repeated traffic loads.

Random Crack. An isolated crack with no clearly evident cause.

Ravelling. The loosening of aggregate particles from the surface of a pavement.

Reinforcement. Steel bar, wire or fabric used to control the width of cracks in concrete pavements.

Resheet. To recondition by adding a new layer of material of appreciable thickness.

Reflection cracks. Surface cracks reflecting from pre-existing cracks in an underlying layer, or from joints in an underlying concrete pavement.

Rejuvenation. A light application of an emulsified, cutback or proprietary bituminous material to replace part of the lost maltene fraction in oxidised bitumen.

Reseal. A seal applied to an existing sealed surface.

Residual Bitumen. The bitumen left on the pavement after water or solvent has evaporated from sprayed bituminous emulsion or cutback bitumen respectively. For example, since bituminous emulsion usually consists of water and bitumen in equal parts, 0.8 litres per square metre would have to be sprayed to produce 0.4 litres per square metre of residual bitumen.

Rigid Pavement. Refer to Concrete Pavement.

Roller Cracks. A pattern of fine parallel cracks in the transverse direction caused during laying and rolling of the asphalt. May also be caused by rolling a mix when it is too hot, or rolling over a highly deflecting base course.

Rubber Removal Compound. A mix of specialised detergents, rubber swelling and fused rubber softening agents designed to remove fused rubber particles from a runway surface (including grooves).

Rubberised Bitumen (Polymer Modified Bitumen). Bitumen can be modified by dissolving a percentage of rubber (2 to 7%) in it. Asphalt can be made with rubberised bitumen, the cost being approximately 30% higher than non-rubberised asphalt. Rubberised bitumen softens less than bitumen with increasing temperature and hardens and brittles less than bitumen at colder temperatures. Consequently hot weather rutting and cold weather cracking are both reduced.

Rubberised Bitumen Bandage (RBB) -

Run-on Landing. An emergency touchdown technique for helicopters fitted with skid landing gears that involves controlled impact with a grass or pavement surface.

Runway: A defined rectangular area of pavement (or grassed surface) on an airport prepared for the take-off or landing of aircraft along its length.

Rut (rutting). A rut is a surface depression in wheel paths, usually caused by consolidation or lateral movement of materials due to traffic loads.

SAM (Strain Alleviating Membrane). A sprayed seal with the binder containing a relatively large concentration of rubber or polymer modifier. It is used to provide a membrane to absorb strains that occur in a pavement and thereby reduce reflection cracking.

SAMI (Stress Absorbing Membrane Interlayer). Similar to SAM, but provided as an interlayer before placing an asphalt overlay.

Sand Seal. A light application of bituminous binder and sand to an existing sealed pavement to increase the binder and aggregate content of the surface. May be used to lock-in layers of aggregate in an overlying seal to arrest the loss of aggregate or to provide a higher surface texture.

Sawn Contraction Joint. A joint formed in a concrete pavement by cutting a groove in the hardened concrete

Seal (Bituminous). A thin layer of bituminous binder into which aggregate is incorporated.

Semi Rigid Epoxy (SRE). A proprietary material used to repair concrete spalls consisting of a semi-rigid epoxy typically bulk out with sand.

SEST (Surface Enrichment Spray Treatment). A light bituminous spray treatment applied to an asphalt or sprayed seal surface to extend the life of the bituminous binder, to seal fine cracks and to assist in retaining surface stones. Also referred to as a 'fog spray'.

Severe Longitudinal Crack. A severe longitudinal crack is a continuous longitudinal finite crack greater than 30 m in length

Scaling s the loss of thin (usually less than 5mm) planar pieces of the surface of a concrete pavement.

Shattering. Localised shattering of a concrete slab, usually occurring at a transverse crack or joint.

Shoulder. An area adjacent to the edge of an airfield pavement which may be sealed or unsealed, constructed to provide a transition between airfield pavement and the adjacent surface.

Shoving. Lateral deformation of asphalt surfacing due to braking, turning or accelerating vehicles.

Shrinkage Cracks (in Flexible Pavements). Cracks caused by shrinkage of pavement component materials rather than by traffic loads.

Shrinkage Cracks (in Concrete Pavements). Usually refers to very fine cracks that form during the setting and curing of concrete and which do not extend through the depth of the slab nor extend for the full slab width. No maintenance action is warranted. Shrinkage can also cause full depth cracks when insufficient joints have been provided or when joints are not sawn in time.

Single Sized Aggregate. An aggregate in which the size of a major proportion of the particles lie between narrow limits.

Slippage cracking. Slippage cracks are crescent or half-moon shaped cracks produced when braking or turning wheels cause an asphalt pavement surface layer to slide over the underlying layer.

Slurry Surfacing. Slurry surfacing is the application of a carefully proportioned mixture of bitumen emulsion, water, fine graded aggregate, and a mineral filler in the form of a slurry to a bituminous pavement by means of a squeegee or spreading box.

Softening. A flexible pavement surface becomes soft and unstable due to surplus binder on the surface or fuel or solvent spillage. The condition usually leads to accelerated deterioration of the pavement.

Softening Due To Solvent Spillage. Bulging and softening of a flexible pavement surface, generally in a localised area.

Spall – Major. A spall generally greater than 50 mm in width from a pavement discontinuity.

Spall – Minor. A spall generally less than 25mm in width from a pavement discontinuity.

Spall – Moderate. A spall generally between 25mm to 50 mm in width from a pavement discontinuity

Spalling is the formation of cracks between the surface of a concrete slab and vertical discontinuities, such as joints and cracks, so that pieces of concrete become loose. Spalling differs from slab breaks in that the cracks forming the spalls do not extend through the full depth of the slabs. Spalling is caused by excessive stresses at the joints due to incompressible foreign materials in the joint, or by weaknesses due to poor joint construction practices, or by traffic load. Spalling also occurs along "working" cracks in concrete.

Spalling can also occur on flexible pavements at interfaces with other pavement types and may also be associated with medium to high severity cracks or surface defects.

Sprayed seal. A pavement surfacing constructed by spraying the surface with hot bitumen, then spreading a layer of stones and pressing them into the adhesive bitumen.

Stabilisation. This is a general term which means improving a pavement subgrade or layer by mixing an additional material with it. For example, 3% of cement may be mixed into a fine crushed rock, 2% of hydrated lime may be added to plastic gravel, or coarse stones may be added to a fine gravel to improve its grading. The stabilising material may be added in a central mixing plant then delivered to site, or it may be added and mixed insitu using an appropriate machine. Insitu stabilisation is usually economical only when the job is large enough to absorb the high cost of establishing expensive mixing plant on site.

Staining. Staining of the pavement surface adjacent to joints or cracks.

Step. Faulting

Stone Mastic Asphalt (SMA). A rut-resistant asphalt used as a thin (2 to 3 stones thick) surfacing layer. It contains a high proportion of course stones so as to achieve a stone-on-stone skeleton to resist deformation. The spaces between stones are filled with a stiff, impermeable mastic of polymer modified bitumen and filler to which fibres have been added. The surface has a good texture depth approaching that of open grade friction course (porous asphalt friction course).

Strength Grade. The numerical value of the characteristic compressive strength f´c of concrete at 28 days

Stripping of Asphalt. The breakdown of bitumen-to-aggregate adhesive bonds within an asphalt layer.

Stripping of Sprayed Seals. Stone loss from the surface due to its loss of adhesion to the sprayed bitumen.

Subgrade. The upper part of the soil, natural or imported, upon which the pavement is built.

Sub-Base Course. The pavement layer or layers of selected material placed on a subgrade to support a base course.

Surface Course (Wearing Course). The top course of a pavement structure.

Surface Texture The surface texture of a pavement may be measured by the Sand Patch Test, a simple test which takes only a few minutes. The test involves spreading a known volume of fine sand over a circular patch on the pavement surface approximately 150mm in diameter. The sand grains fall into the many small surface depressions that constitute the surface's texture. The known volume of sand is then divided by the actual area of the surface it covers to give the average Sand Patch texture depth in millimetres. The following table lists typical Sand Patch texture depths.

SURFACE TYPE	INDICATIVE TEXTURE DEPTH (mm)
Concrete roughened by brooming	0.6 to 0.8
Asphalt	0.4 to 0.8
Two-Coat sprayed seal	1 to 2
Basecoat smooth enough for sealing	3 (max)

Tack Coat. A light application of a bituminous material (normally bitumen emulsion) without cover aggregate, to a prepared base as a preliminary treatment to promote surface adhesion, without penetration of the pavement surface.

Taxiway: A specially designated and prepared surface on an airport for aircraft to taxi to and from runways, aprons, hangars, etc.

Tender Asphalt Mix. An internally unstable mix that tends to displace laterally and shove rather than compact under roller loads. The mix stability is a function of asphalt binder viscosity and aggregate grading and shape.

Tenting. See Buckling

Thermoplastic Paint. Emulsion base paint pigmented with titanium dioxide, or lead chromate to produce white or yellow tinted colour

Transverse Cracks. Crack running transversely across the pavement.

Unbound Pavement (Granular Pavement). An unbound pavement is composed of individual stone particles, or 'aggregates', that are not bound (ie not 'glued/bound') to each other. Loads are transmitted through the pavement structure via the normal and frictional forces developed at the point contacts between particles. Because no 'glue' is involved, tensile forces cannot be resisted and cannot develop. Therefore the concept of fatigue cracking is not relevant. Bound materials such as asphalt, concrete and cement-stabilised gravels lose strength and stiffness under repeated loading because their 'glued' connections are progressively broken.

Uniform Grading. A potentially confusing term, referring to a mixture of stones in which most are of similar size. When applied to gravel or crushed rock, for example, it would mean that they were not "well graded". A sealing aggregate should be uniformly graded. A base course gravel should be well graded in that it should contain a full range of aggregates from small to large.

Vibrator Crack. Cracks formed in a concrete pavement in the direction of the paving. Cracks are at similar spacings of the drawn vibrators used during construction (this is no longer permitted). This is a special form of longitudinal cracking.

Voids. Spaces within the bulk of a material not occupied by solid matter or cementing material.

Volatile. Rapidly evaporating constituent ingredient of an emulsion or cutback bitumen.

Warping. Warping, also known as curling, is slab bending due to temperature or moisture differentials. Warping of slabs is a dynamic phenomenon and is only considered as a pavement defect when its magnitude is such to appreciable effect the riding quality of the pavement, or to lead to another form of defect (e.g. transverse cracking).

Weathered Surface. A pavement surface that shows the effects of prolonged outdoor exposure. Typically there is a loss of matrix so that the coarse aggregate particles protrude. In the case of bituminous surfaces, 'weathered' also implies oxidation of the binder.

Working Cracks. A crack that changes width with changes in environmental conditions or with application of load. The changing of the crack width may result in fracturing or spalling at the crack edges.

1. Introduction

1.1 Background

The Department of Defence is the largest single owner of airfields in Australia. Defence operates an array of airfields from major Royal Australian Air Force (RAAF) Bases which are similar in nature to Australia's international and major domestic airfields, down to training area airfields, which are similar in nature to rural aerodromes.

Similarly, Defence operates a large range of aircraft types. The RAAF operates the majority of Defence's aircraft ranging from small, high performance jet fighters to large transport aircraft and commercial style aircraft for transport and freight purposes. In addition, the Army and Navy also operate aircraft (rotary wing) for Defence, primarily in transport and reconnaissance roles.

As a large organisation with a wide range of aircraft types supported by a large number of airfields it is important that Defence has a reliable and efficient Airfield Pavement Management System (APMS). The Defence Support Group (DSG), through the Directorate of Estate Engineering Policy (DEEP) is responsible for the management and implementation of Defence's APMS.

1.2 Defence's Airfield Pavement Management System

Defence's APMS comprises four (4) elements:

(a) Airfield pavement condition inspection program;

(b) Three (3) tiers of airfield pavement maintenance works;

(c) Pavement concession management; and

(d) Central technical depository system.

These are discussed further below.

1.2.1 Pavement Condition Inspection Program

Each airfield managed under the Defence APMS is inspected on a regular basis – in the case of major airfields on an annual basis and for minor airfields on a less frequent basis (typically every two (2) to three (3) years). The inspection is visual only and provides recommendations for airfield pavement maintenance for the coming ten-year period. Guidelines for pavement inspection and reporting are contained within this manual along with details of defects and standard maintenance treatments. This manual is available electronically on the DSG Infrastructure Management (IM) website (http://www.intranet.defence.gov.au/im or www.defence.gov.au/im).

1.2.2 Pavement Concession System

DEEP is responsible for the approval of airfield pavement concessions when overload or high tyre pressure operations are requested. In addition, DEEP is responsible for setting and reviewing the Pavement Classification Number (PCN) for each pavement at each airfield for promulgation by the RAAF Aerodrome Information Service (AIS). The pavement strength data and guidelines for the approval of pavement concessions are contained in the Airfield Pavement Strength Evaluation Manual (APSEM) and within the online Airfield Pavement Concession Tool (APCT), which are available on the DSG IM website (http://www.intranet.defence.gov.au/im or www.defence.gov.au/im).

1.3 Airfield Pavement Maintenance Manual

1.3.1 Overview

The maintenance of airfield pavements is an essential and continuing activity that ensures:

- Pavements are kept in a condition that minimises risk to aircraft operations; and
- Pavements are adequately preserved to maintain the operational capability of the airfield and maximise the serviceable life of the infrastructure.

It is a primary responsibility of those involved in the management of airfield pavements to accomplish this aim in the most practical and economical manner using the resources that are available.

Timely and appropriate maintenance of airfield pavements not only permits expensive aircraft to operate from them with a minimum of risk but also allows the longest possible functional design life of pavements to be achieved so that costly closures for resurfacing, or reconstruction, are deferred for as long as possible. Attention to maintenance during the life of a pavement may also reduce the extent of resurfacing or reconstruction work which eventually becomes necessary, giving savings in both cost and time.

Given the importance of maintaining airfield pavements and the necessity to strive to improve methods, materials and equipment to preserve these assets, it is essential to continually review the criteria and techniques currently utilised.

DEEP commissions specialist pavement maintenance inspections of Defence airfields, conducted by Consultants, on a routine basis and it is intended that this Manual should serve as a reference document for the implementation of recommendations which arise from such inspections. Inspections by these specialists does not preclude more frequent inspections being carried out by local staff in order to identify, monitor and remedy pavement defects as they occur.

The information included in this Manual addresses the following:

(a) Identification of and severity of defects;

(b) Possible causes of defects;

(c) Techniques to repair the defects; and

(d) Products to repair the defects.

In deciding to carry out a repair, the following needs to be taken into account:

(a) Location;

(a) Size and nature of the defect;

(b) Number of defects;

(c) Evaluation of alternatives (i.e. not carrying out repair);

(d) Safety and operational considerations;

(e) Time available to do the work; and

(f) Program and funds available.

This Manual draws on information and standards from a range of existing Australian Government documents relating to airfield pavement maintenance. This Manual has also drawn extensively on the knowledge of personnel who have been directly involved in the maintenance of airfield pavements over an extended period of time.

1.3.2 Guide to this Manual

The APMM has been written to provide assistance to Airfield Managers, DSG regional maintenance personnel, Base Airfield Engineering Officers (BAEO) and as a guide for the maintenance of airfield pavements by experienced contractors under the superintendence of professional engineers.

Major maintenance of airfield pavements, such as partial reconstruction, slab replacement, and asphalt resurfacing/overlays will generally be delivered by the Directorate of National Airfield Pavements (DNAP) and is outside the scope of this Manual.

The APMM provides a uniform approach to the identification and assessment of typical pavement defects occurring on airfield runways, taxiways and aprons and their effective repair using suitable techniques and materials. Although specific products are recommended for use in this Manual, each product needs to be assessed for its particular application and judged on its merits considering the product's characteristics and cost as well as the local site conditions. DEEP-Civil Engineering Section (CES) may be able to provide additional information upon request.

The APMM contains the following Sections:

Section	Step
Section 1 – Introduction	Step 1. Know Airfield Pavement Theory. Know the Defence Process
Section 2 – Airfield Pavement Characteristics	
Section 3 – Airfield Pavement Maintenance Management	
Section 4 – Flexible Pavement Defects	Step 2. Identify Defects. Identify Overall Condition. Identify Severity and Risks
Section 5 – Concrete Pavement Defects	
Section 6 – Interlocking Concrete Block Pavement Defects	
Section 7 – Miscellaneous Defects and Repairs (Review)	
Section 8 – Pavement Condition Rating System	
Section 9 – Airfield Pavement Inspection, Reporting and Maintenance Programming	Step 3: Report and Identify Maintenance Requirements
Section 10 – Flexible Pavement Repairs	Step 4: Perform Repairs and Maintenance
Section 11 – Concrete Pavement Repairs	
Section 12 – Interlocking Concrete Block Pavement Repairs	
Section 13 – Pavement Maintenance Products	

In each of the sections detailing pavement defects, photographs and descriptions of the defects are provided together with recommended repair methods detailed within the subsequent section.

1.4 Changes to the 2009 Aircraft Pavement Maintenance Manual

Changes to the 2009 version of APMM incorporated in this version of APMM are summarised below:

(a) New and additional photographs of pavement defects;

(b) Addition of sections on landscaping and edge drop rectification in Section 7;

(c) New section on the introduction of a simple Airfield Pavement Condition Rating System (APCRS) in Section 8 and;

(d) Update of Section 13 – Pavement Maintenance Products;

1.5 Further Developments

For this Manual to remain current, it is imperative that feedback of field performance and new construction techniques or materials be provided to enable amendments and subsequent improved practices to be disseminated. This Manual is not intended to formally specify maintenance procedures, nor to establish absolute criteria, but rather to serve as a guide. There may be instances where the repair technique described in this Manual may not be the most appropriate repair strategy due to the cause of distress being unclear or due to other site conditions. Where this situation occurs, contact should be made with the DEEP for further advice and investigation if required.

This Manual has been formatted to allow it to be progressively developed and updated. Suggestions for additions and changes to this Manual are welcomed, particularly literature on the latest products and technology which are appropriate for use in the field. These should be forwarded to DEEP in Canberra to the contacts noted below:

Senior Civil Engineer - 02 6266 8183
Civil Engineer - 02 6266 8207
Email – adf.ces@defence.gov.au
Fax – 02 6266 8211

2. Airfield Pavement Characteristics

2.1 Functional Requirements of Airfield Pavements

To serve the purpose for which it has been provided, an airfield pavement must perform certain functions to acceptable standards. Maintenance is intended to keep pavements in satisfactory condition for them to continue to meet the required standards. The functional requirements of airfield pavements are described below:

2.1.1 Protection of Subgrade against Overloading

The loads imposed upon a pavement and the weight of the pavement itself is ultimately supported by the subgrade beneath the pavement. A pavement structure is designed so that the loads imposed by the aircraft using it are distributed in such a manner so as to limit the pressure exerted on any point of the subgrade. The magnitude of the pressure that the subgrade can support differs according to the subgrade soil type, its relative density and its moisture content. In many cases the latter parameter is of crucial importance. This is the reason, for example, why a pavement designed to carry a particular aircraft will be thicker when constructed on a soft, wet clay soil than on compacted sand.

If the pavement does not distribute the wheel loads adequately, due to insufficient thickness, inferior pavement material quality, excessive moisture content, inadequate density or other reasons, the subgrade may fail. The particular nature of the subgrade failure depends on the soil type. Non-cohesive subgrades (e.g. clean sand) normally fail due to shear, whereas cohesive subgrade soils fail by permanent (plastic) deformation. Any failure (distress) in the subgrade will reflect at the pavement surface where it will manifest as one or more of the symptoms described in this Manual eventually resulting in an inability of the pavement to satisfy other functional requirements.

A pavement may not adequately protect its subgrade from overload if:

(a) It is of inadequate thickness for the applied load;

(b) The materials of which the pavement is composed are not as strong as assumed by the designer (i.e. inferior quality) because of deterioration in service or because of initial low quality materials;

(c) The relative density of any pavement layer is inadequate;

(d) The moisture content of any pavement layer is excessive; or

(e) Bound layers in the pavement have become unbound due to fragmentation (e.g. cracking), degradation (e.g. stripping) of the binding material or leaching out of lime or cement.

2.1.2 Protection of Subgrade against the Environment

Many soils are weaker (lower bearing capacity) when they are at a high moisture content. Conversely, when they are dry or relatively dry their strength may exceed the design strength by a significant amount (perhaps more than 100%). If a pavement has been designed on the assumption that the subgrade (and pavement layers) will remain relatively dry, the pavement must provide good waterproofing (particularly the surfacing) to underlying layers, including (and most importantly) the subgrade.

2.1.3 Freedom from Loose Surface Particles

Aircraft engines, surfaces and fittings are vulnerable to damage by loose particles (e.g. aggregate particles, concrete spall debris, asphalt fragments or other loose materials) that may emanate from the pavements and their margins. Foreign Object Damage (FOD) caused by such material striking fast-moving aircraft when disturbed (blown or sucked up from the pavement surface) or by being ingested into jet engines, is potentially dangerous and such damage can be very expensive to repair or cause serious accidents.

The tyres on many military fighter jet aircraft are inflated to very high pressures and are therefore vulnerable to cuts from sharp edges that may develop on pavement surfaces. Tyre bursts on aircraft with single wheel undercarriage assemblies when they are taking off or landing at high speed can be extremely hazardous.

Therefore, a high proportion of the airfield maintenance effort (and thus cost) is concerned with keeping the airfield pavements free of loose particles and sharp edges.

2.1.4 Ride Quality

Many military fighter jet aircraft have high tyre pressures and operate on runways at high speeds. Unevenness of the pavement surfaces may cause shock and vibration to these aircraft and their contents. This may reduce the fatigue life of airframes, disrupt sensitive instruments and other components, or be discomforting to passengers.

Failure to initially construct pavement surfaces to the specified tolerances is often a cause of poor ride quality, but the pavement surface shape may deteriorate in service due to settlement, post construction compaction, faulting of concrete slabs, extrusion of joint sealant, rutting, etc.

Consideration should be given to the measurement of ride quality by use of National Association of Australian State Road Authorities (NAASRA) testing to determine a NAASRA Index and/or International Ride Index (IRI).

2.1.5 Surface Water Drainage

The skidding resistance provided by a pavement surface diminishes when it is wet. When the pavement surface is covered by a continuous film of water (approximately 1mm deep) aircraft using the pavement may aquaplane and lose directional control. In freezing climates, hazardous ice patches may form, but this is uncommon in Australia. In addition, the spray caused by aircraft traversing ponded water on the pavement at speed can cause flame out in jet engines.

Airfield pavements must therefore have good surface water drainage characteristics. This is accomplished mainly by providing evenly graded surfaces to facilitate quick water runoff to the pavement edges or to an adequate number of correctly positioned drainage pits, grated or slotted drains or other points of entry to a piped drainage system. However, due to the operational requirements of aircraft the surface gradients are relatively flat (i.e. less than 2%) and therefore they are easily affected adversely by construction inaccuracies, rutting or settlement/subsidence. Resurfacing work, patching, partial reconstruction, slab replacement, etc on airfield pavements demands greater precision than similar work on roads and the compaction requirements are significantly higher to prevent post-construction rutting by aircraft or service vehicles.

2.1.6 Surface Texture and Skid Resistance

(a) General

The skid resistance provided by a pavement surface depends on its macro texture (surface texture depth) and the micro texture of the exposed aggregate surfaces in the surfacing material/treatment.

Micro texture is the fine texture provided by size and nature of the mineral grains of which the rock is composed and which can just be detected by rubbing the fingers over the exposed surface of aggregate particles.

Macro texture is the surface roughness provided by the shape, size and spacing of coarser aggregate particles in the surfacing material and the amount by which they protrude above the level of the binder. Macro texture also includes any enhancement to the surface roughness provided by such treatments as grooving of asphalt or the surface texturing of plastic concrete with a broom finish.

Runways require a macro texture depth of not less than 1mm when measured by the sand patch test (CASA MoS Part 139 Chapter 6.2.9.1). Since it is difficult to achieve this level of surface texture with an asphalt surface whilst retaining other desirable properties such as a dense surface for low permeability and minimisation of the potential for loose particles and FOD, asphalt surfaced runways used for jet aircraft are normally grooved as are the runways at most major ADF airfields. Consideration should be given to using the British Pendulum TRL Swing Test equipment (BS7976 and AS/NZS4663) to determine an indication of relative skid resistance where full friction testing by a trailer mounted friction testing unit is not practical. These can be used to determine the relative change of surface skid resistance values before and after an application of PME or SEST treatment or to assist to determine if rubber removal is required as a result of rubber build up in the Touch Down Zones (TDZs).

The aggregate used in the surfacing material on airfield pavements is not normally required to be polish resistant as the traffic volumes thereon are relatively low. The frictional requirements for runway surfaces are set out in the publication FAA Advisory Circular AC 150/5320 -12C and ICAO Airport Services Manual Part 2 - Pavement Surface Conditions with further guidance being provided in the ADF Friction Policy Document dated May 2011.

Taxiways and aprons do not have specific surface friction requirements, except Rapid Exit Taxiways which should comply with the frictional requirements for runways. The primary consideration for friction on aprons is that they should not be hazardous to pedestrians. It has been reported that some Fuel Resistant Membranes (FRMs) are slippery under foot when wet.

(b) Friction Deterioration

Over time, the skid resistance of runway pavement deteriorates due to a number of factors. The primary factors are mechanical wear and the polishing action from aircraft tyres rolling or braking on the pavement and the accumulation of contaminants, primarily rubber, on the pavement surface. The effect of these two factors is directly dependent upon the volume and type of aircraft traffic. Other influences on the rate of deterioration are local weather conditions, the type of pavement (asphalt or concrete), the materials used in original construction, any subsequent treatment and airfield maintenance practices.

Structural pavement failure such as rutting, ravelling, cracking, joint failure, settling, or other indicators of distressed pavement can also contribute to runway friction losses. Prompt repair of these problems should be undertaken as appropriate.

Contaminants, such as rubber deposits, dust particles, jet fuel, oil spillage, water, snow, ice, and slush, all cause friction loss on runway pavement surfaces. The most persistent contaminant problem is deposits of rubber from tyres of landing jet aircraft. Rubber deposits occur in the TDZ areas on runways and can be quite extensive. Heavy rubber deposits can completely cover the pavement surface texture causing loss of aircraft braking capability and directional control, particularly when runways are wet.

Further guidance is provided in the ADF Friction Policy Document dated May 2011.

2.1.7 Durability and Reliability of Airfield Pavements

Closure of an airfield pavement for maintenance is expensive, not just in terms of materials and the cost of the works, but also due to the unavailability of the pavement to the airfield operator. Pavement materials and their construction and maintenance treatments must therefore be durable and able to withstand wear and tear from aircraft operations, jet blast, fuel and oil spillage, regular (daily or weekly) sweeping, and exposure to all weather conditions.

2.1.8 Standards for Airfield Pavements

Various authorities have established the standards for aerodrome design criteria that are considered necessary for the safe operation of aircraft. These standards cover such topics as minimum geometric dimensions, limiting gradients and minimum clearances as well as obstruction criteria, visual aids and equipment and services which should be installed for normal working and emergency procedures. For Defence airfields, the following standards are relevant (in order of precedence):

(a) Department of Defence
Australian Defence Force Publication
Joint Services Works and Administration
ADFP 602 - Aerodrome Design Criteria
This document is due to be replaced by the Defence Airfield Design Manual (DADM) in 2012/2013.

(b) Department of Defence
ADF Friction Policy Manual
Version 1.2: May 2011

(c) Civil Aviation Safety Authority (CASA)
Manual of Standards Part 139 – Aerodromes
Version 1.10: May 2012

(d) International Civil Aviation Organisation (ICAO)
International Standards and Recommended Practices for Civil Aerodromes
Annex 14 to the Convention on International Civil Aviation (ICAO Annex 14)
Volume I – Aerodrome Design and Operations
Fifth Edition, July 2009

On joint user airfields, criteria should comply as far as possible with each user's requirements and any deviations should be subject to the dispensation process managed by DEEP.

2.2 Operational Requirements of Airfield Pavements

When deciding whether maintenance work is necessary on an airfield pavement or when determining the type of treatment that is appropriate, it is important to understand the operational requirements of the various pavement areas. The following paragraphs give guidance in this respect:

2.2.1 Runways and Taxiways

The operational requirements for runways and taxiways include:

(a) A relatively smooth ride quality, particularly in high-speed areas;

(b) Good friction characteristics, particularly in high-speed areas.

(c) Effective drainage of run-off water; and

(d) A surface free of loose or potentially loose particles.

2.2.2 Parking and Servicing Aprons

The following operational requirements are relevant for apron areas:

(a) No ponded water;

(b) No faulted slabs, stepped edges or potholes that could cause a trip hazard to personnel servicing aircraft;

(c) No loose particles;

(d) Bituminous surfacing must be protected against damage due to fuel spills using a Fuel Resistant Membrane or special asphalt mixes;

(e) Spilt fuel and oil must not be permitted to accumulate and should be cleaned off the pavement surface immediately;

(f) The type of pavement, based on the intended operations such as tight turns, extended period of static loading;

(g) The type of joint sealant (for rigid pavements); and

(h) Depressions in the aircraft wheel standing positions on flexible pavements should not be permitted to develop due to the significantly increased break-away thrust required to initiate movement.

2.2.3 Special Purpose Aprons

Special Purpose Aprons (SPAs) comprise operational readiness platforms (ORPs) and Ordnance Loading Aprons (OLAs). The requirements listed above for parking and servicing aprons also apply to these Special Purpose Aprons. ORPs are usually located in close proximity to the runway and particular emphasis on freedom from loose particles is required as aircraft may be positioned at these locations for extended periods of time with engines running.

2.2.4 Aircraft Wash Bays

These pavements are usually constructed as concrete pavements to facilitate static loading and complex geometry to enable drainage. It is necessary to ensure that the drainage provisions are adequate and that all surface water draining from the bay passes through oil/fuel interceptor traps and sumps to prevent polluted water entering natural water ways and/or the ground water.

If the subgrade can be degraded or weakened by moisture ingress, the wash bay pavement should be maintained in a waterproof condition (i.e. all slab joints and cracks sealed) and all wash water should be contained and removed by a drainage system and not allowed to flow naturally off the paved surface and onto a natural surface where it could soak in and undermine the pavement.

2.2.5 Compass Swinging Bays and Hardened Aircraft Shelter Floors

The requirements for aprons also apply to Compass Swing Bays and Hardened Aircraft Shelter Floors. An additional requirement for these is that all materials used in pavement construction or maintenance must have very low magnetic permeability. Iron fittings, such as drainage grates, must not be used and the aggregates should be checked for their magnetic properties before use.

2.2.6 Shoulder Pavements

Paved or surfaced shoulders are provided to minimise erosion and generation of FOD from aircraft jet blast. The design of the shoulder pavement should be such to provide adequate protection from jet blast and should also be capable of safely supporting the “occasional” operation of the design aircraft and emergency and maintenance vehicles. The shoulder pavement is intended to allow safe operation of the aircraft across the paved area without damage to the aircraft. The shoulder pavement may require inspection and/or repair after each operation.

Chapters 6.2 and 6.3 of CASA MoS 139 (May 2012) provide guidance on the dimensions, characteristics and surface requirements for runway and taxiway shoulders.

Chapter 6.2.12 e of CASA MoS 139 (May 2012) notes that a runway shoulder must "*be flush with the runway surface except during runway overlay works where a step down not exceeding 25 mm is permitted".*

Advice on the design of airfield pavement shoulders is given in Chapter 7 of US FAA AC150/5320-6E.

Asphalt Surfaced Taxiway Shoulder

2.3 Aircraft Characteristics Relevant to Pavements

2.3.1 Military Fighter Jet Aircraft

Military fighter jet aircraft impose the most demands on pavements from an operational perspective. This is due to their high take-off and landing speeds, generally small single wheels, high tyre pressures, and high engine efflux temperatures that may adversely affect the pavement surface at rotation.

2.3.2 Transport and Passenger Aircraft

These aircraft impose the heaviest loads on the pavements but this is generally balanced by their multiple wheel main gear assembles and lower tyre pressures.

2.3.3 Propeller-Driven Aircraft

These aircraft can vary from light single engine training aircraft to twin engine commuters and executive transport types. Aircraft masses are typically low as well as operating speeds and tyre pressures, and they are less demanding of the pavement surface.

FOD is equally a hazard to propeller driven aircraft as it is to jets because of the possibility of propeller and skin damage. Pavement surfaces for propeller driven aircraft must be maintained to minimise the generation of loose particles.

2.3.4 Rotary Wing Aircraft (Helicopters)

Rotor wash from helicopters may propel loose particles on the pavement surfaces against nearby aircraft, ground equipment, pedestrians or infrastructure. The pavement surfaces on which these aircraft operate must therefore be particularly clean.

It should be noted that the landing gear on some helicopters consist of skids which can cause pavement defects such as surface abrasion. Particular attention should be given to pavement maintenance materials and techniques in areas where helicopters with skids operate to ensure products such as rubberised bitumen bandage treatments are not used as they have the potential to become loose and constitute a FOD problem.

Helicopters are often serviced and refuelled on their parking areas/pads and the surfaces become contaminated with hydraulic oil and fuel spillages. Concrete pads are common and the joint sealant materials should not consist of rubberised/PMB bitumen. Asphalt and spray seals must be protected with a Fuel Resistant Membrane (FRM) that is maintained in an impervious condition. Special asphalt mixes can also be used.

2.4 Pavement Types

2.4.1 Pavement Definition

A pavement consists of the layers that make up the strengthening support. This includes the subgrade, sub-base, base and wearing (or surface) course.

- The subgrade is the insitu layer that forms the foundation for the pavement.
- The sub-base is generally select fill or crushed rock and due to the lower stresses imposed is generally of poorer quality than the base course material.
- The base course is generally high quality well graded fine crushed rock, though can be cement treated or bituminous bound.
- The wearing course or pavement surface is generally either a flexible or rigid pavement. Generally flexible pavements are of asphalt construction, but can vary in construction methodology from dirt unsealed, to spray sealed through to asphalt sealed, though Interlocking Concrete Block Paving (ICBP) has been used on a number of apron pavements. Rigid pavements are generally of concrete construction on an aggregate or cement treated aggregate base.

2.4.2 Flexible Pavements

In Australia, major new flexible airfield pavements typically consist, with few exceptions, of unbound granular layers of heavily compacted graded Fine Crushed Rock (FCR) with a relatively thin (50mm to 60mm) asphalt surfacing layer. Older pavements often consist of natural gravels originally having a sprayed seal surface which have subsequently been resurfaced with asphalt on a number of occasions such that the total asphalt thickness is now substantial.

A typical cross section of a flexible pavement construction is shown in Figure 2-1.

Flexible pavement thicknesses generally range between nominally 400mm and 2,000mm depending upon the strength of the underlying soil and the frequency and mass of the aircraft it is designed to carry. Bound pavement layers using cement or another binder have been used but are not common in Australia.

Dense Graded Asphalt (DGA) is commonly used as the pavement surfacing and typically with conventional Class 320 bitumen binder. Class 170 bitumen binder is unsuitable (too soft) for use in asphalt surfacing on airfield pavements. The use of Polymer Modified Binders (PMB) and Multigrade bitumen is increasing to cater for special needs, such as fuel resistance or rut resistance under high temperature conditions, etc. Some guidance on the relative merits of various types of bitumen can be found in Austroads AP-T41/06.

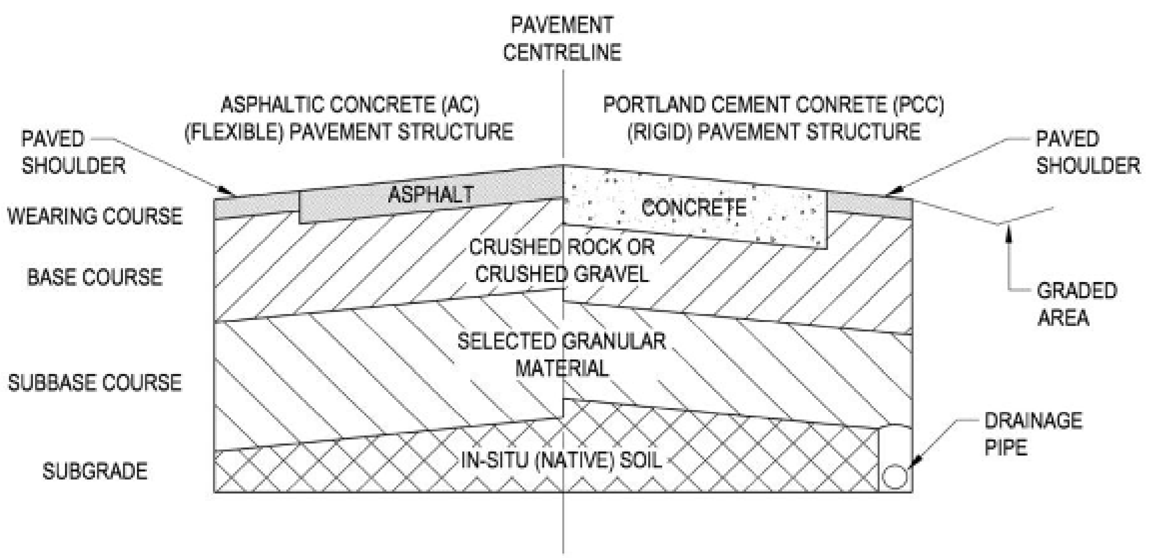
Hot sprayed bituminous seals are used on many airfield pavements, particularly those catering for lighter aircraft and non-jet aircraft. The main distinction between sealing of airfield pavements and road sealing practice is that there is much more concern about loose particles which are a potential FOD hazard. Higher bitumen spray rates are used to firmly secure the stones and also to provide a longer surface life.

Airfield pavements are infrequently trafficked by comparison with roads so the bitumen is likely to fail by aging and embrittlement rather than by load fatigue. Due to the low traffic volume on airfields relative to most road situations, the tendency of sealing aggregates to "polish" (ie lose their surface texture) under traffic is not usually of concern.

The surface of flexible pavements normally have a functional life in the order of 12 to 15 years between major maintenance treatments (noting that they are typically designed for a 20 year life), however the actual interval depends largely on the environmental conditions, with bituminous surfaced pavements ageing faster in hot climates. A mid-life surface treatment of a Polymer Modified Emulsion (PME) (or similar) will retard the aging process and potentially delay the timing of major maintenance treatments.

Figure 2-1

Cross Section of a Typical Pavement Construction



Base courses tend to comprise high quality well graded fine crushed rock, with lower quality material used as sub-base at lower depth in the pavement. The base course typically has the largest nominal diameter of the aggregate being 20mm and in older pavements it is not uncommon to find natural rounded river gravel in sub-base layers. Base courses can also consist of cement treated aggregate or bituminous bases.

Further guidance on the design of flexible pavements with aggregate, cement treated and bituminous bound bases can be found in US FAA AC150/5320-6E.

2.4.3 Concrete Pavements

Australian practice with respect to concrete airfield pavements has always been to use unreinforced jointed concrete slabs. Slab sizes of up to 7.6m have been used in the past but smaller sizes of 5m to 6m are now favoured and used because they have a lower risk of mid slab cracking due to warping stresses.

A typical cross section of a concrete pavement construction is shown in Figure 2-1.

Load transfer between concrete slabs is provided by dowels (or keyed joints in older pavements) at longitudinal and at transverse construction joints by aggregate interlock with saw cut joints. Concrete mixes typically contain nominal 40mm maximum size aggregates to improve this load transfer, and are placed at relatively low slumps of 20-50mm to assist with maintain cross fall grades and reduce risk of shrinkage cracking after placement.

Base courses typically consist of 200mm thickness of Fine Crushed Rock (FCR) such that it is not susceptible to pumping. More recently, lean-mix concrete or cement treated aggregate base courses (typically 150mm thickness) have also been used and have the benefits of improved load transfer between joints and provide a better working platform than FCR.

Joints in concrete pavements are now entirely sawn (not formed), and the general policy with respect to joint sealing is evolving towards an open (narrow sawn) joint approach and joint sealing is undertaken only when justified by specific circumstances such as on aprons where refuelling may occur, or where sweeping is undertaken less frequently. These circumstances are identified more fully in Section 5.4. The slab joints in many older pavements were sealed with self-expanding cork, synthetic rubbers, tar/bitumen compounds (hot poured), and more recently silicone.

Concrete slab thicknesses can be up to 500mm for the heaviest aircraft loading cases, though 350mm to 450mm is more typical, both in Australia and overseas, to cater for most modern large aircraft, though it is noted that the concrete flexural strength used in the design is a significant factor in determining the slab thickness. These thicknesses compare with 230mm to 250mm thick slabs typically used for major highway pavements.

Concrete pavements normally have a design life and subsequently functional life in the order of 40 years, after which time removal and replacement may be required.

Further guidance on the design of concrete pavements with aggregate, cement treated and bituminous bound bases can be found in US FAA AC150/5320-6E.

2.4.4 Interlocking Concrete Block Pavements

In recent years, some Interlocking Concrete Block Pavements (ICBP) has been successfully used, mainly on aprons in Australia (eg RAAF Bases Pearce, Tindal and Scherger, Sydney and Cairns Airports). The use of blocks in areas where aircraft operate near full jet thrust remains of concern due to the potential for dislodgement despite block and jointing sand sealants being used. This follows a failure overseas (in the UK) under these conditions where; inadequate maintenance of the joints between the blocks enabled the suction and thrust of an aircraft engine on take-off to dislodge the blocks.

However, blocks can provide an excellent solution to common pavement problem areas. They provide a fuel and creep resistant surface, though successful performance relies on a good standard of detailing, close tolerance of manufacturing, a cement treated base, high quality bedding sand and good construction workmanship. Also, as the pavement is segmental, its ability to articulate and thus compensate for differential settlement means that flexible pavements are no longer the only solution to sites that may experience settlement.

Notwithstanding that ICBP can be lifted and replaced, such practice is manually intensive and there can be difficulties in replacing the blocks due to creep and due to minor dimensional changes in the block sizes.

Routine maintenance will typically include refilling the jointing sand and applying a joint filling sand sealant as noted in Section 12.

3. Airfield Pavement Maintenance Management

3.1 Introduction

The life of a pavement depends not only on the adequacy of the design and quality of construction but also on the adequacy of pavement maintenance. A pavement is subject to both the rigours of the harsh elements of weather and climate in addition to the repetitive wheel loads and tyre pressures applied by aircraft and other vehicles.

Under service conditions:

- Minor settlements occur;
- Cracks develop on the surface;
- Surface abrasion and/or erosion occurs under trafficking and through environmental aging;
- Line markings fade;
- Water ponds along pavement edges and also in areas that lose shape due to load deformation or settlement; and
- Weed growth to neglected areas.

These defects can develop into major repairs but can also affect the safety of aircraft operations if not arrested in the initial stages. Time and money spent in carrying out day to day maintenance activities ensures that the pavement is kept in a satisfactory condition for safe aircraft operations, throughout its functional life. Money spent on maintenance activities is not a waste but a saving in the long run. It must be remembered that maintenance is intended to reinstate a distressed area to at least the standard of the adjacent pavement and must not be inferior to or weaker than the parent pavement. There does however become a point in time where maintenance and repair need to be compared in terms of value for money as maintenance is intended to manage an ageing pavement, whereas replacement is intended to reinstate it. The operational requirement and location will largely dictate the action taken to a distressed area as there is often no point replacing a section surrounded by ageing sections with something new, but on the same hand it is not always considered to be operationally acceptable to have a deteriorating section in between two fully serviceable areas.

Figure 3-1 illustrates a theoretical pavement life cycle and some general observations about costs during a pavement's life (Ref. Alaska State Airport Condition Report, 1999).

3.2 Pavement Defects

A pavement suffers defects due to a number of common reasons. They include:

- Poor pavement construction or maintenance;
- Subgrade weakness;
- Higher than designed for wheel loads and tyre pressures;
- Increase in load repetitions compared to the design predictions;
- Disintegration of pavement materials;
- Climatic conditions;

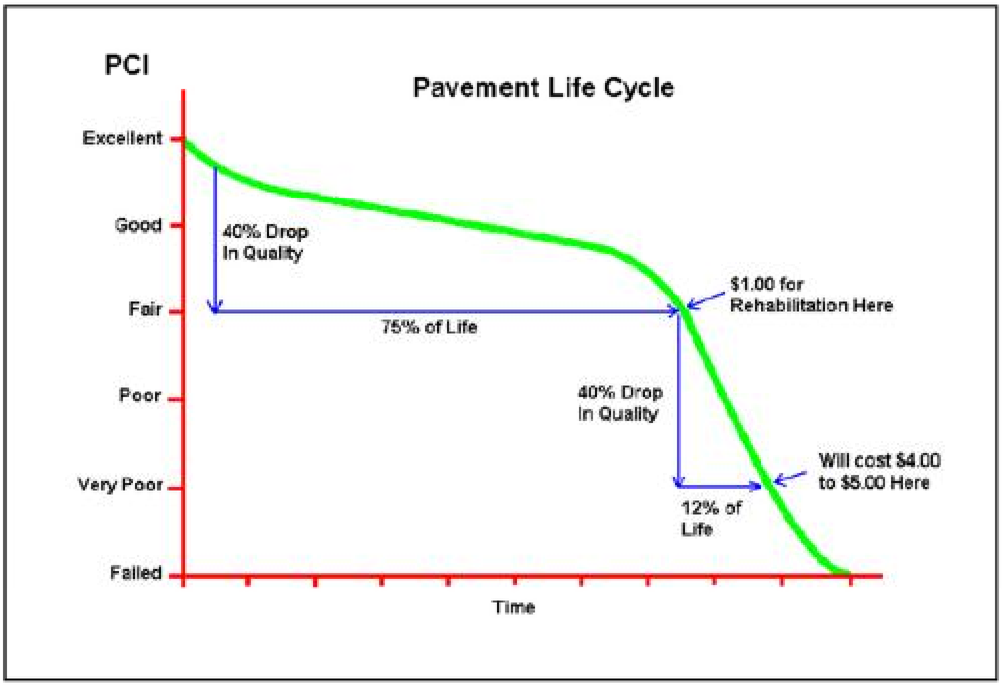
- Environmental conditions; and
- Age.

Before carrying out pavement maintenance repairs, it is essential that the engineer / inspector / foreman has an understanding of the types of pavement defects that may occur as well as their significance. It is important to ascertain which types of distress are progressive and eventually lead to failure, and which types are non-progressive and cause less damage. It is also important to determine the cause of failure so that the cause can be treated and not just the symptom.

The types of defects that may be encountered in airfield pavements are identified in Sections 4 to 7 of this Manual for flexible pavements, concrete pavements and interlocking concrete block pavements, respectively.

Figure 3-1

Pavement Life Cycle



The intent of any pavement management system is to time the expenditure of money such that the maximum benefit is received while limiting the amount of money that must be spent.

3.3 Pavement Maintenance Categories

Pavement maintenance may be grouped into the following categories:

(a) Routine maintenance;

(b) Preventative maintenance; and

(c) Reactive (urgent) maintenance.

3.3.1 Routine Maintenance

Maintenance activities that are carried out in a regular fashion are termed “routine maintenance”. These include grass cutting, sweeping, cleaning drains, etc. They can be carried out when the runway, taxiway, and the parking aprons are free and do not impinge on aircraft operations.

A description of various routine maintenance activities is included in Sections 7.2 to 7.5.

3.3.2 Preventative Maintenance

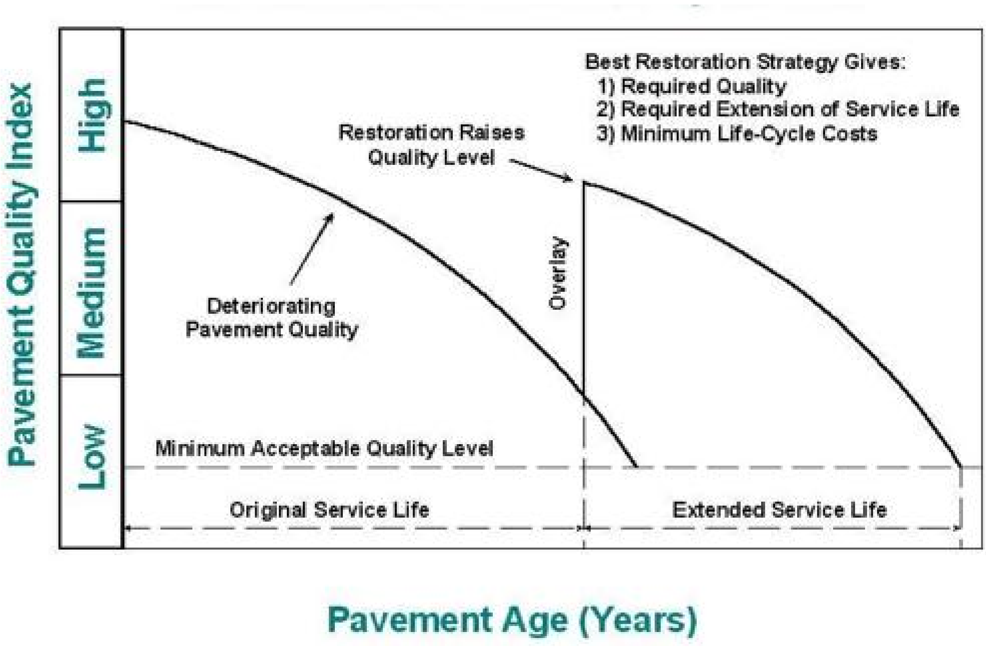
Preventative maintenance is maintenance carried out on minor defects to prevent such defects becoming a major safety issue, affecting the functional performance of the pavement, or requiring major disruptive maintenance following their occurrence.

Activities such as patching, crack sealing, rectifying ponding, resealing, improving poor drainage, overlaying, etc all fall into this category. If properly planned most of these repairs can be carried out without interrupting aircraft operations.

Figure 3-2 shows how the service life of a typical flexible pavement can be extended with an asphalt overlay.

Figure 3-2

Pavement Performance – Quality versus Time



3.3.3 Reactive Maintenance

Sometimes action is taken to repair pavements only after structural failure has occurred and the pavement is found to be unacceptable for aircraft operations. This is called reactive maintenance.

Reactive maintenance is unplanned maintenance and involves immediate closure of the affected section of the pavement, if not the whole airfield, with the resultant disruptions to airfield operations. It costs more and requires more time to organise the repairs on account of its unplanned nature.

Reactive maintenance can be avoided by carrying out frequent pavement maintenance inspections, and routine and preventative maintenance activities. The only exception should be damage caused by natural disasters.

3.4 Pavement Inspections

3.4.1 Pavement Inspections

National Inspection Program

The National Inspection Program is undertaken on an annual basis by Design Consultants (in the company of DEEP personnel) from the Defence Infrastructure Airfield Pavement Panel for the major airfields and less frequently for the smaller and remote airfields.

At the time of the inspection, immediate, short term and longer term preventative maintenance is identified and reported in the Pavement Inspection Report (PIR). The inspection also monitors the effectiveness of the regional minor maintenance works.

The reactive maintenance identified by the inspection should be undertaken as soon as possible by the base. The preventative maintenance will be identified and packaged up by the Design Consultant and undertaken by one of the National Airfield Pavement Maintenance Contractors and will be managed by National Airfield Maintenance Program (NAMP). Major airfield pavement maintenance works will be managed by National Capital Works (NCW) Program and will be undertaken by specialist airfield pavement contractors.

The inspection and reporting process is detailed further at Section 9. In 2011, a simple Airfield Pavement Condition Rating System (APCRS) was introduced by DEEP and further details can be found at Section 8.

Local Inspections

It is necessary for each airfield to carry out regular pavement maintenance inspections on a daily/weekly/monthly/yearly basis, to detect and avoid distress. The level of inspection and the composition of the inspection party need to be adjusted for monthly and yearly inspections.

Base personnel should undertake routine inspections of the airfield and should report defects and submit their inspection findings to DEEP on a routine basis. Where issues or defects are identified which have a safety implication or immediate loss of operational capability these should be rectified locally by the base. Advice on the severity of defects and available repair methods and materials are contained within this Manual and advice can be provided by DEEP personnel in Canberra (refer to Section 1.5 for contact details).

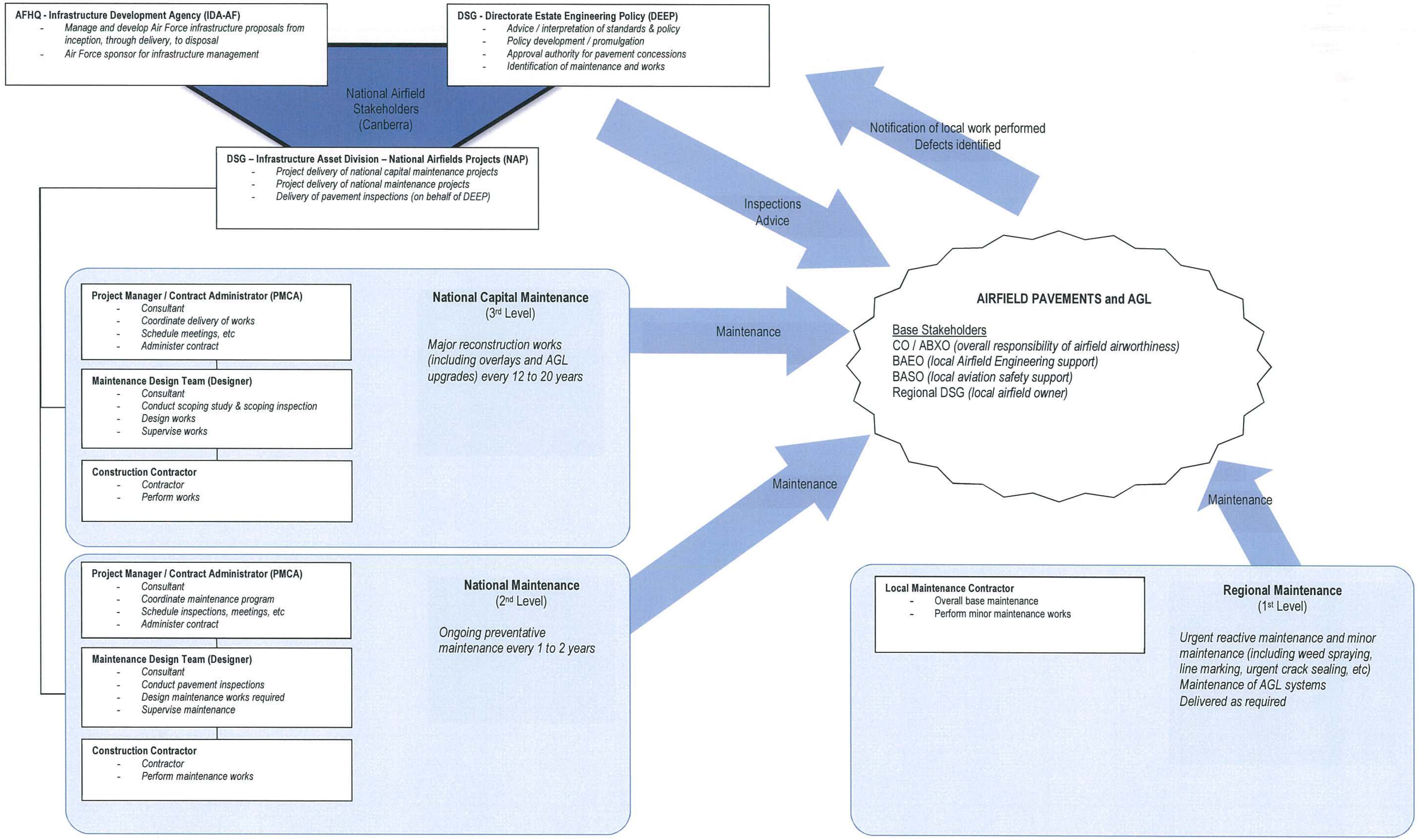
Procedures for reporting defects are detailed further in Section 9 Airfield Pavement Inspection and Reporting.

3.4.2 Database

A centralised depository database is located on the Defence Intranet's Document Records Management System (DRMS) for the collection of all technical information concerning the construction, management and maintenance of the ADF's airfield pavements. This database is managed by DEEP but is accessible by all Defence stakeholders.

Figure 3-3 Defence Airfield Maintenance

Stakeholder roles and relationships



3.5 Records

All inspections should be recorded with a time and date in a diary noting any important observations and giving the location and description on a plan. This plan should be kept by those who undertake the inspection. Some things to be noted are areas of distress, action taken, performance of the repair, water ponding on the pavements and close to the pavements, bird sightings, bird carcasses and safety matters etc.

3.6 Summary

Pavement performance has long been recognised as being related to climate and environment and this means that defects and performance can be peculiar to the location of the airfield.

In order to prolong the life of a pavement and to avoid the occurrence of reactive maintenance works, the following pavement maintenance plan is recommended:

(a) Carry out regular pavement inspections;

(b) Carry out routine maintenance;

(c) Carry out preventative maintenance; and

(d) Carry out major maintenance activities programmed to suit operations.

4. Flexible Pavement Defects

4.1 Introduction

This Section covers flexible pavement defect definitions in the following categories:

- Cracks;
- Surface Defects;
- Deformation;
- Edge Defects and;
- Groove Damage

It provides a photograph, description, a list of possible causes and recommended treatments for a range of common defects in the above categories. It also provides details of severity levels so that the significance of the various defects can be assessed and appropriate treatments determined based on the severity level.

Section 10 provides details of the criteria for undertaking repairs together with the recommended repair treatments.

4.2 Cracking

Cracking in a flexible pavement surface can result from a number of causes and has many detrimental effects. The primary detrimental effect is the loss of waterproofing which usually leads to accelerated deterioration of the underlying pavement layers and subgrade and provides a potential source of loose particles (FOD). The following sections describe the possible or most likely cause of the cracking and detail the preferred methods of repair. The repair method selected will depend on the environment, materials and techniques available and operational constraints such as available durations for access or airfield closures if required.

Severity levels for cracks in flexible pavement surfaces are defined as:

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
CRACKS	LOW	− Crack of hairline width or barely visible (typically less than1mm wide) AND/OR − Spalling commencing but little or no potential for dislodgment of particles (typical spall width less than 25mm).	
	MEDIUM	− Crack width clearly indicates potential for further movement (typically 1mm to 5mm wide) AND/OR − Potential for material to become dislodged after further trafficking and create a FOD problem (typical spall width 25mm to 50mm).	
	HIGH	− Crack width likely to allow water penetration (typically greater than 5mm wide) AND/OR − High potential for material to become dislodged and create a FOD problem (typical spall width greater than 50mm).	

If cracks remain untreated they made lead to:

- Ongoing cracking and pavement deterioration with age with the potential of FOD; and/or
- Deterioration and disintegration of pavement through the infiltration of water.

Section 10.2 provides details of the techniques used for sealing cracks in flexible pavements.

4.2.1 Age Cracking

Description

Age cracking is characterised by short and tight (and sometimes interconnected) cracks forming a block pattern and extending over the full pavement.

Possible Causes

Age cracking is not load associated and is generally caused by shrinkage of the asphalt (bitumen shrinks with age due to evaporation of volatiles and becomes more brittle) and daily temperature cycling (which results in daily stress/strain cycling). Age cracking is symptomatic of asphalt having reached the end of its useful life, and requiring either removal and replacement or overlay.

Recommended Treatments

Whilst consideration may be given to resurfacing with a bitumen emulsion and sand treatment (refer to Section 10.3.2.2) or PME (refer to Section 10.3.2.3), in general once the asphalt is age cracked such treatment is largely ineffective. More importantly any delay to the timing of an asphalt overlay will cause further embrittlement and increased unsuitability or retention of the asphalt as a substrate for subsequent overlays. The resurfacing should be undertaken before aging of the bitumen develops to an extent where the cracks will subsequently cause reflection cracks in the new surface, and before the edges of the cracks warp upwards which may lead to rapid fragmentation by traffic and render repair difficult.

Objective of Repair

The objective is to prevent water ingress, stop further binder shrinkage and to prevent the generation of FOD.

4.2.2 Block Cracking

Description

Block cracking is characterised by interconnected cracks forming a block pattern, approximately rectangular in shape. It commonly extends over the full pavement. The blocks generally range in size from 0.25m by 0.25m to 3m by 3m. Joints or cracks in underlying pavement layers may reflect through the surface layer. These may appear as regular rectangular blocks in the case of concrete pavements that have been overlaid with asphalt, and irregular blocks in the case of cement treated base courses that have been overlaid with asphalt. Block cracking usually occurs over a large portion of pavement area, but sometimes will occur only in non-trafficked areas.

Block cracking differs from crocodile cracking as crocodile cracking forms smaller, many-sided pieces with sharp angles and is caused by repeated traffic loadings.

Block cracking differs from reflective cracking which is described in Section 4.2.6.

Possible Causes

Block cracking is not load associated and is generally caused by:

- Shrinkage of the asphalt (bitumen shrinks with age due to evaporation of volatiles and becomes more brittle) and daily temperature cycling (which results in daily stress/strain cycling); or
- The reflection of shrinkage cracks from the underlying bound pavement layers.

Recommended Treatments

The preferred treatment is to resurface the area affected by block cracking with an asphalt overlay/asphalt patches. The resurfacing should be undertaken before aging of the bitumen develops to an extent where the cracks will cause reflection cracks in the new surface, and before the edges of the cracks warp upwards which may lead to rapid fragmentation by traffic and render repair difficult.

Where funding for resurfacing works is not available the area should be treated with PME (refer to Section 10.3.2.3) and open cracks sealed with RBB (refer to Section 10.2.3).

If the areas are widespread, then a Stress Alleviating Membrane Interlayer (SAMI) or a proprietary asphalt reinforcing geogrid (such as Tensar ARG, GlassGrid or Hatelit etc) may be applied followed by an asphalt overlay. The SAMI will act as a masking layer to prevent propagation of cracking into the above layers.

Objective of Repair

The objective is to prevent water ingress, stop further binder shrinkage and to prevent the generation of FOD.

4.2.3 Crocodile Cracking

Description

Crocodile cracking is characterised by interconnected cracks forming a series of small, approximately straight-sided polygons. These cracks are caused by fatigue failure of the asphalt surface under repeated traffic loading, and hence, are likely to be found within wheel paths and other frequently trafficked areas. The cracking initiates at the bottom of the asphalt surface (or stabilised base) where tensile stresses and strains are highest under a wheel load. The cracks propagate to the surface initially as a series of parallel cracks. After repeated traffic loading the cracks connect, forming many-sided, sharp angled pieces or cells that are generally less than 150mm across, but may range up to 300mm. The defect is characterised as crazing when the cracks are hair line and the polygons are smaller than crocodile cracking.

Possible Causes

- Flexural fatigue of the asphalt surfacing;
- Inadequate pavement thickness (overloading) or excessive pavement deflection;
- Soft subgrade or wet base course;
- Shrinkage/brittle nature of age hardened bitumen; or
- Exceptionally low temperatures.

Recommended Treatments

In most cases, the appropriate treatment will be to profile off the existing surface and replace with new asphalt or “deep lift” patching (where multiple layers of asphalt are used). Where the pavement material is wet and/or the subgrade is soft in localised areas, a patch should be constructed (refer to Section 10.4.2.1). If the areas are widespread, then a SAMI or geogrid may be applied followed by an asphalt overlay, or the cracked asphalt should be removed and the base course stabilised or replaced prior to replacing the asphalt. In severe cases a modified binder could be used within the asphalt to retard reflection cracking and/or consideration by given to the use of a membrane seal.

Objective of Repair

The objective is to prevent water ingress and to prevent the generation of FOD.

4.2.4 Longitudinal Cracking

Description

Longitudinal cracks generally run parallel to the pavement centreline or in the direction of traffic. Longitudinal cracks may occur mid paving lane or commonly on construction (lane) joints. If the cracks are load induced they will only occur in aircraft wheel paths and will be characterised by their close spacing and generally parallel orientation with limited branching. Some staining about the longitudinal joint may be evident.

Possible Causes

Longitudinal cracking is likely to be caused by poor joint construction (ie cold joints), shrinkage, binder aging or deterioration and fatigue in the asphalt surfacing. However, these types of cracks are not usually load associated. If the pavement is fragmented along a crack, the crack is said to be spalled. The possible causes include:

- Reflection of a crack or a joint in an underlying base (commonly Portland Cement Concrete slabs, cement treated base course or previously cracked asphalt surface);
- Poorly constructed paving lane joint in asphalt surfacing;
- Shrinkage of the surface due to daily temperature cycles or asphalt hardening; or
- Opening of a joint due to movement of the pavement.

The possible causes for cracks occurring as a series are:

- Seasonal moisture changes of expansive clay subgrades;
- Cyclical weakening of pavement edge; or
- Differential settlement between cut and fill.

Recommended Treatments

The cracks should be sealed in accordance with Section 10.2.3 for medium severity cracks and Section 10.2.4 for high severity cracks.

Objective of Repair

The objective is to prevent water ingress and to prevent the generation of FOD.

4.2.5 Random Cracking

Description
Random cracks may be either isolated (singular) or a series of cracks that are generally irregular, unconnected and vary in direction.

Possible Causes
- Cracks caused by random effects such as irregularities in underlying materials/layers;
- Reflection of a shrinkage crack in underlying cemented material or certain fine grained granular materials;
- Poor construction leading to fill or embankment differential settlement;
- Weakening of the pavement edge by moisture entry; or
- Presence of backfilled trenches, ducts, old patches and other sub-surface structures.

Recommended Treatments
The cracks should be sealed in accordance with Section 10.2.3 for medium severity cracks and Section 10.2.4 for high severity cracks.

Objective of Repair
The objective is to prevent water ingress and to prevent the generation of FOD.

4.2.6 Reflection Cracking

Description
Reflection cracks are caused by movement at joints or cracks in the underlying concrete slab, cement stabilised layer or previous asphalt surface.

Possible Causes
- Reflection cracks are generally caused by thermal and moisture movements at joints or cracks in the underlying layer and are not normally load related. However, traffic loading may cause a breakdown of the asphalt wearing course near the crack, resulting in spalling and FOD potential;
- Differential traffic-induced vertical movements across joints or cracks in underlying pavement; or
- Severity of cracking may be increased by large slab sizes in underlying concrete, poor load transfer across concrete slab joints; thin asphalt overlay thickness or wide underlying cracks or joints in old asphalt.

Recommended Treatments
The treatment depends on the extent of fragmentation, incidence of pumping and presence of water-susceptible pavement materials. Options range from sealing using cutback bitumen, over banding or rubberised bitumen bandaging, “trench” profiling and patching, to thick asphalt overlay which might also incorporate a Strain Alleviating Membrane Interlayer (SAMI) or geogrid reinforcing.

Further guidance can be found in Austroads AAPTP Research Report AAPTP 05-04 “Techniques for Mitigation of Reflective Cracks”.

The cracks should be sealed in accordance with Section 10.2.3 for medium severity cracks and Section 10.2.4 for high severity cracks.

Objective of Repair
The objective is to prevent water ingress and to prevent the generation of FOD.

4.2.7 Roller Cracking

Description

Roller cracks are characterised by a pattern of fine, parallel, transverse cracks (generally perpendicular to the direction of paving) formed during spreading and/or steel wheel rolling of asphalt. Most common in thin layers, tender asphalt mixes and when the asphalt being laid is excessively hot or cold.

Possible Causes

- Rolling asphalt that is either a tender mix or too hot or cold at the time of rolling;
- Rolling asphalt over a base that deflects excessively (weak base); or
- Excessive steel drum rolling.

Recommended Treatments

The affected area should be treated with an application of PME in order to seal the fine cracking and stabilise the area. Very badly affected areas or areas that are degrading quickly (particularly when cracks are rapidly progressing and show signs of joining up leading to pavement failure) should be removed and patched with new asphalt. Any significant cracking still visible after the PME application should be sealed with RBB in accordance with Section 10.2.3.

Objective of Repair

The objective is to stabilise the area, prevent water ingress and to prevent the generation of FOD.

4.2.8 Slippage Cracking

Description

Slippage cracks are half-moon or crescent shaped cracks, commonly associated with the slippage and deformation of the wearing course under horizontal wheel loads (braking and/or turning of aircraft). Cracks occur in a closely spaced parallel group, confined within the slipped asphalt layer. Also refer to Section 4.4.3 – Heaving and Shoving.

Possible Causes

- Poor bond between asphalt surfacing and underlying layer;
- Low strength surface mix or thin wearing course;
- High horizontal stresses due to aircraft braking and turning;
- Smooth un-textured interface between asphalt surfacing and underlying layer; or
- Dragging by the paver during the time of laying when asphalt temperatures were low.

Recommended Treatments

The area should be patched in accordance with Section 10.4.2.1.

Objective of Repair

The objective is to prevent water ingress and delamination and to prevent the generation of FOD.

4.2.9 Transverse Cracking

Description

Transverse cracks generally running perpendicular to the pavement centreline and the direction of traffic (or direction of paving). Transverse cracks normally occur in isolation and are unconnected with limited branching.

Possible Causes

- Transverse cracks are not usually load associated, except when they occur in conjunction with reflection cracks from joints in underlying layers when aircraft loadings induce the crack by causing differential movement across the underlying discontinuity. If the pavement is fragmented along a crack, the crack is said to be spalled;
- Reflection of a shrinkage crack or joint in an underlying base (commonly Portland Cement Concrete slabs or previous asphalt surfaces);
- Poorly constructed transverse joint in asphalt surfacing;
- Underlying services trenches;
- Shrinkage of the surface due to daily temperature cycles or asphalt hardening; or
- Opening of a joint at due to movement in pavement.

Recommended Treatments

Cracks should be sealed in accordance with Section 10.2.3 for medium severity cracks and Section 10.2.4 for high severity cracks.

Objective of Repair

The objective is to prevent water ingress and to prevent the generation of FOD.

4.3 Surface Defects

Surface defects can result from a number of causes, and may affect the functionality of the pavement in various ways and generate FOD.

Surface texture deficiencies relate to the loss of material from the pavement wearing course surface, the development of inadequate or excessive surface texture and surface friction deficiencies. While such defects do not affect the pavement load carrying capacity, they have a significant influence on the serviceability of a pavement (especially skid resistance and potential FOD). Some surface defects, if not corrected, may subsequently lead to a loss of pavement integrity.

Surface softening generally occurs when bituminous surfaces are subjected to fuel or hydraulic oil spills. They may be damaged and become soft and unstable depending on the nature and size of the spillage. If the spill consists of a large volume or occurs in a trafficked area or consists of leakage by dripping, significant degradation and loss of surface integrity of the pavement is likely to occur. As a consequence, the pavement may become unserviceable.

Fuel spills can affect asphalt surfaces more severely than concrete due to the contaminant soaking into the pavement. Sprayed seals tend to resist the penetration of contaminants which evaporate over time leaving only a stain, provided the contaminated area is not disturbed or trafficked.

Severity levels for surface defects in flexible pavements are defined as:

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
SURFACE DEFECTS	**LOW**	Loss of wearing surface (frictional characteristics), pop outs or spalling commencing but little or no potential for dislodgment of particles (typically spall width less than 25mm).	
	MEDIUM	Loss of wearing surface (frictional characteristics) advancing and potential for material to become dislodged after further trafficking and create a FOD problem (typically with a spall width of 25mm to 50mm).	

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
	HIGH	Loss of wearing surface (frictional characteristics) extensive and high potential for material to become dislodged and create a FOD problem (typically with a spall width greater than 50mm).	

Severity levels for **potholes** in flexible pavements are defined as:

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
SURFACE DEFECTS – POTHOLES	**LOW**	Loss of material from the surfacing with little or no potential for further dislodgment of particles (typical defect width and depth less than 25mm).	
	MEDIUM	Loss of material from the surfacing with potential for material to become dislodged after further trafficking and create a FOD problem (typical defect width and depth 25mm to 50mm).	

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
	HIGH	Loss of material from the surfacing with high potential for further material to become dislodged and create a FOD problem (typical defect width and depth greater than 50mm).	

Severity levels for patches in flexible pavements are defined as:

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
SURFACE DEFECTS – PATCHES	**LOW**	Spalling commencing but little or no potential for dislodgment of particles (typical with a spall width of less than 25mm) AND/OR Faulting with minimal evidence of discontinuity in patch and pavement levels (typically no discontinuity felt under foot).	
	MEDIUM	Spalling or cracking with potential for material to become dislodged after further trafficking and create a FOD problem (typical spall with a width of 25mm to 50mm) AND/OR Faulting clearly evident but unlikely to adversely affect aircraft riding quality and/or represent a trip hazard (typically less than 25mm on runways and taxiways and less than 10mm on aprons).	

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
	HIGH	Spalling or cracking with high potential for material to become dislodged and create a FOD problem (typical with a spall width greater than 50mm) AND/OR Faulting likely to adversely affect aircraft riding quality and/or represent a trip hazard (typically in excess of 25mm on runways and taxiways and 10mm on aprons).	

4.3.1 Delamination

Description
Delamination normally involves the loss of discrete and large areas of the asphalt surfacing, and is usually characterised by a clear delineation between the wearing course layer and the underlying layer.

Possible Causes
- Asphalt surfacing thickness is too thin in relation to asphalt mix size;
- Inadequate cleaning, texturing or tack coat application before the placement of surfacing layers;
- Water seepage through asphalt (cracks) breaking the bond between surface and lower layers;
- Weak or loose surface on the base course immediately underlying the surfacing;
- Plucking-out of localised surface binder spots ("fatty" areas) due to adhesion to aircraft tyres; or
- Polished or heavily painted underlying surface.

Recommended Treatments
If the delaminated surface (interface) is on a previously sealed surface, the remaining delaminated surfacing should be removed by profiling to a depth of at least 50mm, cleaning the exposed surface, texturing, applying a tack coat and then replacing the surface with a suitable asphalt mix. If the delaminated surface (interface) is on a previously unsealed surface a prime coat or primer seal should be applied before patching with asphalt. If the base course immediately under the surfacing is weak or loose, consideration should be given to in-situ stabilisation prior to constructing a new surfacing.

If the delamination is due to plucking-out of 'fatty' surface binder due to adhesion to aircraft tyres, then the asphalt surface should be overlaid or removed and replaced with an appropriate surfacing material. For sprayed seals, the affected areas should be resealed using an appropriate binder, or if the affected areas are localised, apply further aggregate and roll.

Objective of Repair
The objective is to prevent further delamination and to prevent the generation of FOD.

4.3.2 Flushing (Bleeding) of Sprayed Seal – can also occur in asphalt surfaces

Description

The pavement surface is considered to be bleeding when excess binder accumulates on the pavement surface. Bleeding is often an advanced form of flushing and both conditions result in a loss of skid resistance. Flushing is the condition when all the surface texture has been lost and the pavement surface is smooth

The migration of the bituminous binder from a sprayed seal onto the surface may result in partial or complete immersion of the aggregate component into the binder. In asphalt surfaces bleeding can occur as a result of the combination of excessive bitumen in the mix and heavily channelized traffic or stripping of the underlying layers of asphalt.

The excess binder on the surface may create a shiny, glass like, reflective surface that can become quite sticky, especially in hot weather.

Possible Causes

- Excessive application rate of binder in relation to stone size;
- Excess binder in an underlying patch or previously flushed area;
- Stripping of an underlying layer of asphalt;
- Penetration of the seal cover aggregate into a low strength base course; or
- Concentration of slow moving traffic loads.

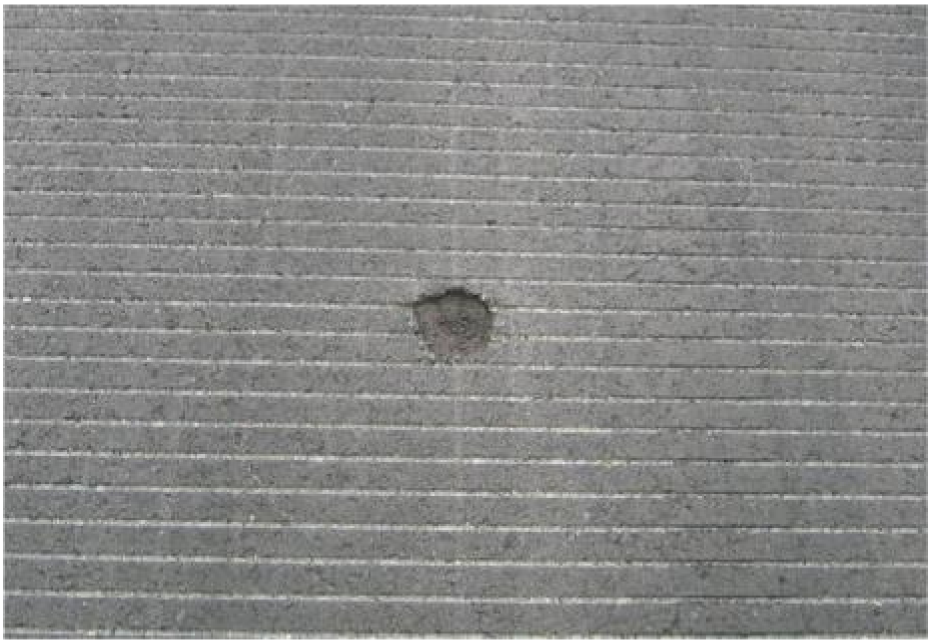
Recommended Treatments

For localised repairs apply coarse sand/fine aggregate and roll and sweep during hot weather. Do not use fine sand as this will exacerbate the problem by being “absorbed” by the bitumen. For larger scale repairs, reseal with a reduced binder application rate over the flushed areas and cover with a single layer of fresh aggregate of the appropriate size to match existing.
For large areas asphalt patch repairs after profiling may be required (refer to Section 10.4.2.1).

Objective of Repair

The objective is to reinstate the surface texture and skid resistant properties of the surfacing.

4.3.3 Lightning Strike



Description

Lightning strikes are common on airfield pavements. They are characterised by a steep sided or bowl shaped cavity with fretted edges that extends into the pavement wearing surface. Cavities are approximately circular with diameters ranging from 25mm to 150mm and depths up to 30mm to 50mm.

Appearance is similar to "pock" marking defects which are caused due to the erosion of secondary minerals with in the asphalt mix.

Possible Causes

- Lightning strike on the surface of the pavement.

Recommended Treatments

Small cavities may be left unrepaired or can be filled with rubberised bitumen.

For larger cavities, excavate (or core) an area slightly greater than the affected area and to the depth required (50mm minimum). Remove loose particles, tack coat internal surfaces and backfill with either hot asphalt (10mm size) or a proprietary premixed asphalt patching material. The edges of the excavation should be cut vertically and the pothole backfilled in one or more layers (if required) each approximately 50mm thick and thoroughly compacted. It may be necessary to over seal the patch repair with bitumen emulsion and sand or a PME application to prevent water ingress.

Objective of Repair

The objective is to prevent the generation of FOD.

4.3.4 Patches

Description

A defective asphalt patch is an area of pavement where the original pavement has been replaced and is exhibiting deterioration. The deterioration may include defects such as those described in Section 4. This may be an indicator of deficient pavement strength or severe underlying layer deterioration. Expedient patches are often small with irregular sides that have made it difficult to achieve compaction and adhesion to the existing surface. Properly reconstructed asphalt patches generally have straight edges allowing placement of new asphalt via paving machine allowing much greater control over asphalt placement and a higher quality patch.

Possible Causes

- Inadequate rectification of previous surface deficiencies;
- Improvement of pavement strength where load associated damage has occurred;
- Incorrect materials used in initial patch, poor workmanship, inadequate compaction (noting that it is difficult to achieve original compaction adjacent and existing pavement) or ingress of water; or
- General failure of a repair (patch) in a pavement.

Recommended Treatments

Investigate and determine the cause. This may require core samples to be obtained.
Remove the existing asphalt patch by profiling and replace (refer to Section 10.4.2.1). Small patches laid by hand may have an open and coarse surface appearance and these should be treated with PME. The perimeter of the patch shall be treated with RBB.

Every attempt should be made to achieve good compaction levels of the asphalt (ie a minimum of 98% of Marshall density).

If the cause of the failure is apparent, ensure that adequate attention is given to the replacement patch to avoid a reoccurrence.

Objective of Repair

The objective is to rectify the deficiencies in the existing patch.

4.3.5 Potholes


Description

Potholes are typically localised steep sided bowl shaped cavities in the pavement surface that extend into the underlying layers. Potholes result from either the loss of asphalt surfacing material and base course erosion as a consequence of traffic and water action or advanced cracking. Potholes generally occur in pavements that are inadequately maintained. It is uncommon for any significant potholes to develop in airfield pavements due to the need to have them repaired for operational reasons.

Possible Causes

- Loss of surface course;
- Repeated traffic loadings resulting in surface cracking and fragmentation which allows moisture entry into the base course;
- Load associated degradation of the base; or
- Pickup of asphalt surfacing caused by binder adhesion to tyres.

Recommended Treatments

For localised potholes, excavate an area slightly greater than the affected area and to the depth required (50mm minimum). Remove loose particles, tack coat internal surfaces and backfill with either hot asphalt (10mm size) or a proprietary premixed asphalt patching material.

The edges of the excavation should be cut vertically and the pothole backfilled in one or more layers (if required) each approximately 50mm thick and thoroughly compacted. It may be necessary to over seal the patch repair with bitumen emulsion and sand or a PME application to prevent water ingress.

Objective of Repair

The objective is to prevent further pavement deterioration and to prevent the generation of FOD.

4.3.6 Ravelling

Description

Ravelling, which is also commonly referred to as weathering, is the progressive deterioration of the bituminous surfacing (wearing course) caused by the fretting and dislodging of aggregate particles and loss of binder leaving pitted holes and a rough surface.

Possible Causes

- Deterioration of binder by oxidation, ageing or weathering;
- Loss of adhesion between binder and the aggregate (stripping);
- Deficient binder content (inferior asphalt mix design) or application rate;
- Inadequate compaction; or
- Poor quality aggregates (typically excessive amount of unsound or soft friable particles).

Recommended Treatments

Localised areas should be treated with bitumen emulsion and sand (refer to Section 10.3.2.2) or an application of PME. Larger areas should be treated with a PME or rejuvenation treatment (refer to Section 10.3.2.3), or resealed (for existing sprayed seal surfaces) or overlaid with asphalt (for existing asphalt surfaces).

Objective of Repair

The objective is to prevent further pavement deterioration and to prevent the generation of FOD.

4.3.7 Rubber Build Up

Description

Rubber build up results from the deposit of rubber from aircraft tyres, primarily in the runway Touch Down Zone (TDZ) areas. As noted in Section 7.4, the quantity of rubber deposited depends on a number of variables including; ambient temperature, texture of the runway surface, size and number of aircraft tyres per aircraft, tyre pressure, types of braking system, and the number of aircraft movements.

The rubber may mask the texture of the runway surface, reducing skid resistance in wet conditions. It may also obscure the airfield ground markings. However, the film of rubber on the pavement surface is continually degraded by weathering and on many runways may not build up significantly if traffic volumes are low.

Possible Causes

- Rubber from aircraft tyres in runway Touch Down Zones as a result of "aggressive" landings and increased movements.

Recommended Treatments

When the rubber build up is sufficient to affect the frictional characteristics of the runway surface, it should be removed by chemical treatment, controlled water cutting techniques, scrubbing/high pressure blasting or dry abrasive blasting (refer to Section 7.4). Chemical treatment is currently considered to be the least preferred method due to the potential environmental impacts.

Care must be taken not to damage the pavement surface while undertaking rubber removal. Particular attention should be paid around joints on concrete pavements. A trial should be conducted on a section of pavement of reduced importance. One objective of friction testing at airports is generally to minimise the regularity of rubber removal activities in order to reduce wear on the pavement surface.

Also refer to the ADF Friction Policy Manual V1.2 May 2011 available at the following website:
http://www.defence.gov.au/im/policy/technical/adf_friction/ADF%20Friction%20Policy%20Manual.DOC

Objective of Repair

The objective is to restore the frictional characteristics of the runway surface.

4.3.8 Scuffing

Description

Scuffing is mechanical damage or localised marks in the pavement surface.

Possible Causes

- Initial 'tenderness' of new asphalt surfacing due to excessive temperature sensitivity of the binder;
- Tight turns or heavy braking by aircraft and/or ground support equipment;
- Aircraft hooks during an arrest;
- An accident/incident (such as a tyre blow out); or
- High pavement surface temperature/hot climate.

Recommended Treatments

The appropriate form of treatment is dependent upon the extent of the damage, and ranges from 'do nothing' to bitumen emulsion/sand sealing or a PME surface treatment or patching with a suitable premix or hot-mix asphalt. In many instances it is sufficient to just remove the dislodged particles from the damaged area to prevent ingestion by aircraft engines.

Objective of Repair

The objective is to restore surface integrity and to prevent the generation of FOD.

4.3.9 Softening of Surface

Description

The contamination of an asphalt or spray sealed surfacing with any hydrocarbon fuel or hydraulic or lubricating oil will soften the bitumen binder and may result in damage or disintegration of the surfacing. Spilt fuel is a fire hazard and as such could endanger aircraft and personnel. All fuel spills must be cleaned up immediately by containment, absorption and/or washing of the pavement.

Large fuel spills will require involvement of the Regional Environmental Officer (REO) and Fire Service to pump out sumps/interceptor traps and thoroughly wash the contaminated pavement as a matter of urgency due to the potential for a fire in the vicinity of aircraft, not to mention the potential for pavement softening.

Possible Causes

- Accidental spilling of fuel or hydraulic oil on the pavement surface;
- Leaks from ground support equipment or aircraft; or
- Incorrect application of rejuvenating agents or fuel resistant surfaces.

Recommended Treatments

All spills must be reported to the REO.

Small spills should be cleaned up by washing with detergent and flushing with clean water. It is essential to flush the detergent/fuel mix off the pavement with plenty of water otherwise it will re-contaminate the pavement when the detergent dries.

Larger spills must be contained using bunds and/or absorbent material (e.g. sand, soil, saw dust or proprietary absorbent materials). The spilt liquid should be mopped up as soon as possible and the contaminated area washed with detergent and flushed with water. The washing and flushing should be repeated until the area is clean but care should be exercised not to erode/abrade the surfacing during the cleaning operation.

If the surfacing has been softened or eroded/abraded, the area should be isolated from traffic (if possible) and the contaminant allowed to evaporate. Reinstatement of the surface integrity of the pavement may then be carried out using bitumen emulsion and sand (refer to Section 10.3.2.2) or PME but severely damaged asphalt may require removal and patching (refer Section 10.4.2.1).

Consideration should be given to the treatment of the asphalt surface with a Fuel Resistant Membrane (FRM) (refer to Section 7.3) if the area is to be used regularly for aircraft refuelling.

Spill kits are to be kept in the vicinity of all aircraft refuelling operations.

Objective of Repair

The objective is to restore surface integrity, prevent the potential for softening and subsequent generation of FOD.

4.3.10 Stripping of Asphalt

Description

Stripping is the breakdown of the bitumen-to-aggregate adhesive bond within the asphalt layer. Stripping can be present without any noticeable surface manifestation of the distress if the affected pavement area is not subject to heavy traffic loadings. However, if subjected to heavy traffic it is usually first indicated by localised flushing of the surface or the bleeding of bitumen on the surface in small spots or localised patches. In very heavily trafficked areas, this phenomenon may also be indicated by significant plastic deformation (horizontal crack-free deformation as shown in the photograph), and/or rutting during hot weather, also usually without cracking. Stripping has only been observed to occur to date in asphalt in which conventional bitumen has been used. It is thought that only the conventional bitumen from some refineries, or manufactured by a particular process, is susceptible to stripping. Insufficient knowledge is available to confirm the exact cause of the stripping in asphalt at Australian airports.

Possible Causes

- Poor affinity of aggregate for the bitumen (acid rock type);
- Hydrated lime filler not used in asphalt mix;
- Presence of moisture condensate within the permeable voids in the asphalt, particularly at the interface of multiple layers;
- Concentrated heavily loaded, slow moving aircraft, especially on taxiways and departure runways and/or in braking and turning areas, probably in conjunction with high water tables, hot and/or wet weather; or
- Use of poor quality or inappropriate binders.

Recommended Treatments

The condition of the asphalt should be closely monitored as stripped asphalt may continue to perform adequately in dry weather and/or at lower ambient temperatures for several years. If the asphalt is badly deteriorated then it should be removed and replaced with asphalt containing a Styrene–Butadiene-Styrene (SBS) type PMB binder. An overlay of the stripped asphalt using a 70mm minimum thickness of asphalt containing A10E PMB binder has been shown to retard the onset of distress, but experience has shown that the stripped bitumen can bleed through the PMB overlay.

Objective of Repair

The objective is to ensure that the asphalt surfacing remains suitable for aircraft traffic.

4.3.11 Stripping of Sprayed Seal

Description

Stripping is the loss of cover aggregate from a sprayed seal resulting in exposure of the binder to traffic. This may be evidenced by the loss of individual stones, or (more commonly) by the complete loss of stone in a localised (or larger) area.

Possible Causes

- Poor adhesion of stone to binder due to dusty or hydrophilic aggregates, ineffective/deficient pre-coating, wet aggregate, etc);
- Excessive delay in rolling or inadequate rolling;
- Inadequate binder application rates;
- Absorption of binder into base;
- Aging of binder;
- Insufficient curing of bitumen emulsion seals prior to opening to traffic; or
- Sharp aircraft turning movements or high traffic stress.

Recommended Treatments

- Re-seal area with appropriate binder and aggregate;
- Apply additional pneumatic tyred rolling during hot weather;
- Apply bitumen emulsion/sand seal; and/or
- Instigate large radius turns and reduced breaking through the NOTAM and ERSA process.

Objective of Repair

The objective is to reinstate the protective cover of aggregate.

4.3.12 Surface Abrasion

Description

Surface abrasion occurs under traffic and is normally restricted to aircraft wheel track areas. In flexible pavements abrasion due to pneumatic tyres is usually not significant; however, abrasion under helicopter skids and/or solid-tyre GSE can be severe and rapid. Indents can be caused by static aircraft loads during high temperature conditions.

A special case of surface abrasion occurs in association with the deployment of arrester barriers (refer to Section 7.6)

Possible Causes

- Mechanical damage due to trafficking by solid tyred vehicles and/or helicopter skids;
- Sharp aircraft turning movements or high traffic stresses under pneumatic-tyred aircraft or ground support vehicles.

Recommended Treatments

The appropriate form of treatment is dependent upon the extent of the damage, and ranges from 'do nothing' to bitumen emulsion/sand sealing or patching with a suitable premix asphalt. In many instances it is sufficient to just remove the dislodged particles from the damaged area to prevent ingestion by aircraft engines.

Surface abrasion can be avoided at facilities where helicopters with skids operate by constructing concrete pavements.

If surface abrasion is a significant issue, operators should be requested to avoid tight turns and/or heavy breaking where possible.

Objective of Repair

The objective is to ensure that the surface remains suitable for aircraft operations.

4.3.13 Surface Inclusions ("Pock" Marking)

Description

Surface inclusions generally comprise of any foreign matter, material contaminant or concentrated impurity found within the asphalt surfacing that causes a surface defect (normally loss of material).

In many instances such inclusions can remain undetected in the asphalt for its entire life without any detrimental effect.

Possible Causes

- Surface inclusions within the asphalt surfacing are caused by a number of things including, but not limited to wood, clay balls, dust balls, rubber, nuts and bolts, tree debris and rubbish.

Recommended Treatments

Inclusions that can easily be removed, shall be removed and the remaining hole backfilled with joint sealer on concrete pavements and RBB on asphalt pavements.

Small inclusions (less than 100mm) can be removed by coring, and the core hole reinstated with a proprietary premix asphalt product or hot mix asphalt with a PME surface treatment.

Objective of Repair

The objective is to fill the void and prevent the generation of FOD.

4.3.14 Weathered Aggregate

Description
Weathering of unsound coarse aggregate in the surface of asphalt leaves pitted holes and sometimes, rust staining.

Possible Causes
- Excessive amounts of unsound, weak or soft friable particles of coarse aggregate in the asphalt mix results in disintegration and the appearance of pock marks (small holes in the pavement where the weaker aggregate has eroded) on the surface.

Recommended Treatments
It is difficult and impractical to repair/rectify many small "pock marks" in an asphalt surface, particularly if it is grooved or consists of open graded friction course. The soft particles usually disintegrate rapidly and the remaining pits are generally stable.

Small cavities (less than 100mm) may be repaired by coring, and the core hole reinstated with a proprietary premix asphalt product or hot mix asphalt. Large voids should be cleaned out and patched using a proprietary asphalt premix or hot mix asphalt.

Over large areas the use of a PME surface treatment (refer to Section 10.3.2.3) should be considered.

Objective of Repair
The objective is to fill the void and to prevent the generation of FOD.

4.3.15 Coarse Surface/Open Appearance

Examples of Coarse Open Texture

Examples of Close Texture

Description

A coarse, open or inconsistent surface appearance may be prone to holding surface water and ravelling resulting in FOD. The sand patch test as described at Section 9.4.2 can be used to measure the texture depth to determine areas which are excessively coarse or open.

CASA MoS 139 Chapter 6.2.9.1A notes that he surface of a bitumen seal, asphalt or concrete runway must have an average surface texture depth of not less than 1mm over the full runway width and runway length and in the case of asphalt surfaces this can generally only be achieved by grooving.

Possible Causes

- Poor asphalt mix design
- Asphalt segregation during transport
- Poor placement, finishing and rolling

Recommended Treatments

The use of a PME surface treatment (refer to Section 10.3.2.3) should be considered.

Objective of Repair

The objective is to fill the surfaces void, improve the durability and integrity of the surface and to prevent the generation of FOD.

4.4 Deformation

Deformation is the change in the shape of a pavement surface from the constructed (intended) profile. Such deformations may be caused by deficiencies in the subgrade or the pavement layers, environmental factors or traffic loadings. Excessive surface deformations directly influence the riding quality of a pavement due to increased roughness and/or unacceptable vertical acceleration. Due to the flat grades on airfield pavements, surface deformations often result in water ponding that can inhibit skid resistance, and in some cases negatively impact the structural integrity.

CASA MoS 139 (2012) Chapter 6.2.9.1 notes that he surface of a bitumen seal, asphalt or concrete runway must not have irregularities that would result in the loss of frictional characteristics or otherwise adversely affect the take-off or landing of an aircraft. It further notes that the finish of the surface of a runway should be such that, when tested with a 3m straight-edge placed anywhere on the surface, there is no deviation greater than 3mm between the bottom of the straight-edge and the surface of the runway pavement anywhere along the straight-edge.

Severity levels for **deformations** in flexible pavement surfacing are defined as:

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
	LOW	Minimal depression or barely evident discontinuity in pavement levels (typically no discontinuity felt under foot)	
DEFORM -ATION	**MEDIUM**	Depressions or discontinuity in pavement levels unlikely to adversely affect aircraft riding quality and/or represent a trip hazard (typically less than 10mm under 3m straight edge)	
	HIGH	Depressions or discontinuity adversely effecting riding quality or causing ponding of water in aircraft wheel track areas (typically greater than 10mm under 3m straightedge). CASA MoS 139 Chapter 6.2.9.1 has a restriction on the allowable deformation for runways.	

4.4.1 Blistering (Bubbling)

Description

Blistering/bubbling is characterised by an upward, circular bulge in the bituminous surface (commonly a sprayed seal but may also occur in asphalt surfaces). The swelling may occur sharply over a small area or as a longer, gradual wave. Either type of swelling may be accompanied by surface cracking and spalling, possibly exposing the underlying material.

Possible Causes

- Build-up of moisture vapour pressure under a bituminous seal or asphalt surfacing by a rapidly rising groundwater table after a large rainfall event;
- Rapid reduction in atmospheric air pressure above the seal;
- Poor bond of seal to base course;
- Large widths of sealed pavement (runway widths relative to road widths); or
- Swelling is sometimes caused by frost action in the subgrade (unlikely at most Australian airports) or by volume changes associated with moisture effects in expansive soils.

Recommended Treatments

The bubble can be punctured (with a steel nail) to release the entrapped air, and then the puncture sealed with bitumen emulsion and sand or a PME application. To avoid any re-occurrence the drainage system should be improved to avoid the build-up of moisture vapour under the surface.

Objective of Repair

The objective is to restore the pavement to the original shape and to avoid reoccurrence of the problem.

4.4.2 Depressions

Description

Depressions are localised pavement surface areas having elevations slightly lower than those of the surrounding pavement surface plane. Depressions usually occur randomly, however they may also be load related, and hence occur within wheel paths. In many instances, shallow depressions are not noticeable until after a rainfall event, when ponding water creates "birdbath" areas. Depressions can sometimes also be identified from surface stains created by ponding.

Possible Causes

- Volume changes within the subgrade materials due to environmental influences (e.g. shrink/swell of expansive soils);
- Long term consolidation/settlement of deep underlying compressible soils due to construction of a poorly compacted fill embankment on which the pavements are founded, or instability of this fill; or
- Consolidation/settlement under aircraft traffic within pavement materials and/or subgrade.

Recommended Treatments

If the subgrade material is subject to seasonal changes in moisture content, subsoil drains should be provided. If the soil is expansive, pave and seal beyond the edges of the usable pavement.

Spray seal pavements may be corrected by applying multiple seals or by an asphalt overlay if the extent and severity of the problem warrants.

Asphalt surfaces can only be corrected by patching or by an asphalt overlay.

Objective of Repair

The objective is to restore the ride quality of the pavement and to avoid ponding of water (aqua-planing and the attraction of birds/wildlife).

4.4.3 Heaving and Shoving

Description

Heaving is usually associated with a shear failure and is characterised by bulging of the pavement surface parallel to the direction of traffic. Shoving is the result of horizontal pressures due to turning and braking and usually only affects the surfacing material (displacement) or the upper portion of the base course or asphalt layer – this can be readily seen where the asphalt surface is grooved.

Possible Causes

- Deficiencies (inadequate strength or low stiffness mix) in the surfacing material or its adhesion to the underlying base course or asphalt layer;
- Poor bond between pavement layers;
- Horizontal aircraft traffic turning or braking forces;
- Lack of containment of pavement edge;
- Inadequate pavement thickness;
- Soft/wet pavement edge; or
- Excessive moisture in the subgrade.

Recommended Treatments

The area of heaving should be patched to an appropriate depth using a higher strength pavement material, (e.g. asphalt) to match the surrounding pavement levels. If the strength of the base course is deficient, the affected area should be removed and replaced with suitable “deep lift” asphalt or stabilised material. If there is excessive moisture in the subgrade at the pavement edge, then subsoil drainage should be installed.

The area of shoving should be profiled out to at least the depth of the upper layer and at least 10mm in to the underlying asphalt layer of base course to provide a sound mechanical key. The profiled surface should be tack coated or primed. In areas of high turning or braking forces considered should be given to a high stability asphalt mix with a PMB such as A10E or A15E.

Objective of Repair

The objective is to restore the pavement integrity, to restore the ride quality of the pavement and to avoid ponding of water.

4.4.4 Rutting


Description

Rutting comprises longitudinal deformation characterised by small/sharp radius of curvature within the wheel paths and trafficked areas of a pavement. Pavement uplift may occur along the sides of the rut. In many instances ruts are noticeable only after a rainfall event when the wheel paths hold water. For further details on surface

Possible Causes

- Rutting stems from permanent deformation in any of the pavement layers or subgrade usually caused by consolidation or lateral movement of the materials due to traffic loads;
- Inadequate strength in the asphalt surfacing layer (thickness, instability and possibly plastic deformation);
- Insufficient thickness of pavement;
- Inadequate compaction in the pavement layers, particularly in the base course; or
- Deterioration in lower pavement courses.

Recommended Treatments

If the asphalt surfacing is defective, it should be removed and replaced with a suitable mix. If the strength of the base course is deficient, the affected area should be removed and replaced with suitable deep lift asphalt or stabilised material.

Objective of Repair

The objective is to restore the pavement integrity, to restore the ride quality of the pavement and to avoid ponding of water.

4.5 Edge Defects

Edge defects occur along the outer edge of a sealed pavement or shoulder and affect the integrity of the surfacing/wearing course.

Severity levels for **edge defects** in flexible pavement surfaces are defined as:

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
EDGE DEFECTS	**LOW**	Spalling commencing but little or no potential for dislodgment of particles (typically with a spall width of less than 25mm) AND/OR Minimal edge drop-off or barely evident discontinuity in pavement levels (typically no discontinuity felt under foot).	
	MEDIUM	Potential for material to become dislodged after further trafficking and create a FOD problem (typically with a spall width of 25mm to 50mm) AND/OR Edge drop-off clearly evident but unlikely to adversely affect aircraft riding quality and/or represent a trip hazard (typically less than 25mm).	
	HIGH	High potential for material to become dislodged from spalling and create a FOD problem (typically with a spall width greater than 50mm) AND/OR Edge drop-off likely to adversely affect aircraft riding quality and/or represent a trip hazard and/or excessive vertical height difference representing a non-compliance with CASA Standards (MOS Part 139) (in excess of 25mm for runways – refer to Section 6.2.12(e))	

4.5.1 Edge Breaks

Description
An edge break is where the edge of the bituminous surfacing is fretted, broken, irregular, cracked or spalled.

Possible Causes
- Inadequate edge support (possibly through ingress of water);
- Thin sprayed seal coat;
- Loss of adhesion to the base;
- Undermining of the edge of the surfacing by water/jet blast erosion of the adjacent (unsealed) surface; or
- Trafficking of poorly supported edges.

Recommended Treatments
The broken edge should be patched using hot asphalt or a suitable premix asphalt, and the adjacent surface should be built up using a plastic gravel (if the shoulder is to remain unsealed) or suitable top soil and grass (if no shoulder is provided).

If the edge break is minor, consideration should be given to a RBB treatment.

Also refer to Section 7.9.

Objective of Repair
The objective is to restore the pavement integrity and to prevent the generation of FOD.

4.5.2 Edge Drop-Offs

Description

An edge drop-off is an excessive (greater than 25mm) vertical height between the surface of the pavement edge and the surface of the shoulder or flank. CASA MOS Part 139 Chapter 6.2.12 has a maximum requirement of 25mm on runway edges.

Possible Causes

- Shoulder material having inadequate resistance to erosion and abrasion;
- Erosion by jet engine exhaust blast and wing tip vortices, particularly adjacent to aircraft take-off rotation points;
- Excessive asphalt overlay thickness on pavement and/or shoulder (including resulting height of rolled over edge in new surfacing construction); or
- Sheet flow run-off (eg RAAF Base Darwin Runway 11-29 and OLAs).

Recommended Treatments

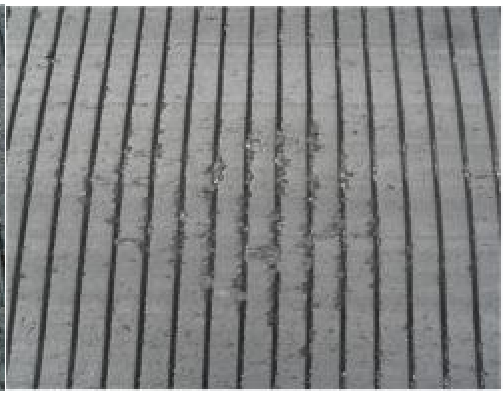
The drop-off should be removed by building up the adjacent area using asphalt, a plastic gravel (if the shoulder is to remain unsealed) or suitable top soil and grass / turf fixed with netting and pegs. If the shoulder material is inherently subject to erosion, consideration should be given to either stabilising with a suitable binder, re-sheeting with a plastic natural gravel or sealing with a hot bitumen sprayed seal or asphalt. Alternatively, additional asphalt paved shoulders could be provided.

The type of topsoil/turf at each base should be determined after consultation with the Base Environmental Officer and/or REO and if required, a Horticulturalist/Ornithologist.

Objective of Repair

The objective is to ensure changes in height are minimised in the event of an aircraft leaving the runway and compliance with geometric standards which require the maximum step height to be less than 25mm. Surfaces that are flush are preferable.

4.6 Groove Damage and Closure

Description
Closure or breaking of the groove edges.

CASA MoS 139 (2012) Chapter 10.15.3.1 notes that when a runway pavement surface has been grooved, the aerodrome operator should periodically check the condition of the runway grooves in accordance with the US Federal Aviation Administration (FAA) advice set out in the FAA Advisory Circular AC 150/5320-12C. The Advisory Circular states that when 40 per cent of the grooves in the runway are equal to or less than 3mm in depth and/or width for a distance of 457m, the effectiveness of the grooves for preventing hydroplaning will have been considerably reduced. The aerodrome operator should take immediate corrective action to reinstate the 6 mm groove depth and/or width.

Possible Causes
- Turning and breaking action of aircraft tyres
- Tender or weak asphalt mixes

Recommended Treatments
Patch or overlay the failed area with new asphalt and re-groove the area. A period of four (4) to eight (8) weeks should be allowed for the new asphalt to fully cure before grooving commences.

Objective of Repair
The objective of the repair is to increase the surface texture depth to required minimum standards.

5. Concrete Pavement Defects

5.1 Introduction

This section covers concrete pavement defect definitions in the following categories:

- Cracks;
- Joint and Edge Defects;
- Joint Sealing Defects; and
- Surface Defects; and
- Poor Compaction/Honeycombing.

This section also provides a photograph, description, a list of possible causes and recommended treatments for a range of common defects in the above categories. It also provides details of severity levels so that the significance of the various defects can be assessed and appropriate treatments determined based on the severity level.

Section 11 provides details of the criteria for undertaking repairs of defects in concrete pavements together with the recommended repair treatments.

5.2 Cracks

Cracking in concrete pavements can result from a number of causes and has many detrimental effects. The primary detrimental effect is that cracks generate loose particles that will endanger the safety of aircraft. Maintenance action will also usually be justified when cracks extend progressively with time into adjacent undamaged slabs. Pumping of fines up through a crack may undermine slabs (erode the base course material) and eventually lead to faulting across the crack (or further cracking) so maintenance action is needed. Treatment of cracks to prevent water ingress is rarely warranted if the base course and underlying layers are not sensitive to moisture. However, if the base course consists of natural gravel, and/or the subgrade is of high plasticity or highly expansive soils (including black soils) moisture ingress should be prevented.

Many cracks extend to only a limited depth beneath the surface of the concrete and require no treatment because they are 'inactive' or cosmetic and generate no loose particles.

Others are full-depth cracks and, if they extend fully across a slab, they constitute a complete break in the slab. The crack will then act as an unplanned joint. The movements and rotations that occur at the crack due to traffic loading and thermal movements are then likely to produce spalls along the crack (refer to Section 5.3 for further details on spalling). If monitoring shows that this is occurring, it is necessary to provide a separation between the top edges of the crack. This is usually done by routing the crack to a depth of about 30mm and installing a poured joint sealant (with backer rod).

The routing process can sometimes cause minor cracking in the immediately adjacent concrete (undetected at the time) which may lead to further minor spalling. However, provided the sealant adheres well to the concrete (this will depend on the cleanliness of the joint faces), new spalls that develop are usually retained in place, and may not constitute a FOD problem.

If a full-depth crack in one slab demonstrates that it is 'active' by extending into an adjacent uncracked slab, consideration should be given to isolating or replacing the two cracked slabs. Whilst such action may seem to be extreme, unless it is done the crack may extend further, which is common. This is because the crack functions as a joint. Rotations along the line of the crack due to traffic loads or temperature changes produce a concentration of stress opposite the ends of the crack in the adjacent uncracked slab that causes it to crack. In one extreme example, one longitudinal crack in a runway slab gradually extended over years along the runway through 18 slabs. Attempts have been made at various times to arrest the progress of cracks by coring at the extremities, but these have generally been unsuccessful.

Removal and replacement of slabs containing 'working' or 'active' cracks is the preferred option because load sharing between the new and old slabs can be re-established using dowels. Isolation of the cracked slab by full depth sawing of the perimeter joints (which will be dowelled, keyed or have interlocking aggregate faces) is less satisfactory because there is then no load sharing across joints and consequently edge stresses are significantly increased. It is essential to monitor cracks as part of successive pavement inspections to decide what maintenance action is appropriate. It is likely that in many cases, no action will be warranted at all or at least for some years.

Severity levels for cracks in concrete pavements are defined as:

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
CRACKS	**LOW**	Crack of hairline width or barely visible (typically less than 1mm wide) AND/OR Spalling commencing but little or no potential for dislodgment of particles (typical with a spall width of less than 25mm).	
	MEDIUM	Crack width clearly indicates potential for further movement (typically 1mm to 5mm wide) AND/OR Potential for material to become dislodged after further trafficking and create a FOD problem (typical spall width 25mm to 50mm).	

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
	HIGH	Crack width likely to result in reduced load transfer and/or allow water penetration (typically greater than 5mm wide) AND/OR High potential for material to become dislodged and create a FOD problem (typical spall width greater than 50mm).	

If cracks remain untreated they made lead to:

- Continuing cracking and pavement deterioration with age; and/or
- Deterioration and disintegration of pavement through the infiltration of water into the pavement.

Section 11.2 provides outline details of the techniques used for sealing cracks in concrete pavements.

5.2.1 Corner Cracks

Description
A corner crack is a diagonal crack intersecting two (2) edges or joints of a concrete slab to form a triangular shape. There are two distinct situations. Larger triangles are likely to be corner 'breaks' in which case the diagonal crack extends through the full slab thickness. Smaller triangles are likely to be corner 'spalls' in which case the crack intersects the joint at an angle. The significance of the distinction is that corner spalls are more likely to dislodge and produce FOD.

Possible Causes
- Overloading the pavement slabs at or near the corners;
- Unstable foundation;
- Voids formed because of loss of base course material under the slab;
- Misaligned dowels;
- Overworked concrete slurry; or
- Trafficking of warped slabs.

Recommended Treatments
If the spall is not loose and the crack is not producing secondary spalls (chips), no action needs to be taken, but the spall should be regularly monitored.

If a small spall becomes dislodged, joint sealant can be used in the "hole".

If the spall is unstable, the corner of the slab should be excavated to a depth of approximately 100mm and filled with a flexible repair material e.g. hot asphalt or a cold bituminous "instant repair" material such as "Perma-Patch" or SRE(S).

Objective of Repair
The objective is to restore the integrity of the slab and to prevent the generation of FOD.

5.2.2 Diagonal Cracks

Description
A diagonal crack is a crack or break approximately diagonally to the pavement centreline.

Possible Causes
- Overloading;
- Lack of foundation support;
- Excessive slab length or width;
- Mismatched joint; or
- Possibly late sawing of joints (particularly if located close to a joint).

Recommended Treatments
Diagonal cracks should be monitored and if spalling is evident, they should be routed or saw cut and sealed with an appropriate flexible sealant (refer to Section 11.2).

In cases where excessive cracking prevents practical and effective repairs, the slab should be removed and replaced with new concrete paving.

Objective of Repair
The objective is to restore the integrity of the slab, to prevent the generation of FOD and to prevent crack extending into adjacent uncracked slabs.

5.2.3 Longitudinal Cracks

Description
A longitudinal crack is a crack or break approximately parallel to the direction of placing (commonly parallel to the pavement centreline and typically mid-slab).

Possible Causes
- Traffic induced fatigue;
- Overloading;
- Lateral contraction;
- Lateral warping due to large slab sizes;
- Poor load transfer across transverse joints; or
- Induced by the use of internal (needle) vibrators during construction.

Recommended Treatments
Longitudinal cracks should be monitored and if spalling is evident, they should be routed or saw cut and sealed with an appropriate flexible sealant (refer to Section 11.2).

If the crack is 'active' and extends into an adjacent uncracked slab, consideration should be given to isolating or replacing the cracked slabs. This action may seem to be extreme but, unless it is done the crack may extend indefinitely. Removal and replacement is the preferred option because load sharing between the new and old slabs can be re-established using dowels.

Where excessive cracking occurs, as can be the case with vibrator induced cracking (close spaced and parallel), economical repair of all the cracks may not be warranted and a temporary over banding with rubberised bitumen bandage (RBB) may be appropriate to contain small spalls. Eventually the slab may require replacing with new paving – consideration to smaller slab sizes should be made.

Objective of Repair
The objective is to restore the integrity of the slab, to prevent the generation of FOD and to prevent crack extending into adjacent uncracked slabs.

5.2.4 Plastic Shrinkage Cracks

Description

Plastic shrinkage cracks are short, fine, generally shallow isolated cracks that form on the surface of freshly placed concrete. The severity of the cracking (and spalling) can vary.

Possible Causes

- Usually associated with hot weather concreting when the surface dries out rapidly (particularly with high winds);
- Rapid evaporation of moisture (when evaporation exceeds the rate of which bleed water rises to the surface); or
- Can be associated with differential settlement of fresh concrete above reinforcement.

Recommended Treatments

Plastic shrinkage cracks are generally shallow cracks of limited length that do not normally show any significant movement (opening and closing), and do not normally deteriorate significantly with time. Accordingly as distinct from other forms of cracking that do open and close, sealing with a flexible sealant to accommodate movement is not appropriate. Plastic shrinkage cracks that are short and narrow (generally low to medium severity) do not need to be treated.

Larger cracks (generally medium to high severity) can be injected with epoxy to close and seal the crack, however if the crack is deep or has propagated through the depth of the slab it should be removed and replaced. Other alternatives include rout and seal; SRE(S) and RBB treatments.

In cases where excessive cracking prevents practical and effective repairs, the slab should be removed and replaced with new concrete paving or (subject to the outcome of satisfactory trials) profiling and replacement with asphalt to a depth of approximately 120mm.

Objective of Repair

The objective is to monitor the surface condition to ensure that the plastic shrinkage cracks do not cause a subsequent spalling or FOD problem.

5.2.5 Random Cracks

Description

A random crack is a crack or break that occurs in no particular orientation or pattern.

Possible Causes

- May be associated with construction (for example, initiated by a misaligned dowel);
- Overloading;
- Unstable or non-uniform support; or
- Localised heave of expansive clay subgrades due to moisture changes.

Recommended Treatments

Random cracks should be monitored and if spalling is evident, they should be routed or saw cut and sealed with an appropriate flexible sealant (refer to Section 11.2).

In cases where excessive cracking prevents practical and effective repairs, the slab should be removed and replaced with new concrete paving.

Objective of Repair

The objective is to restore the integrity of the slab, to prevent the generation of FOD and to prevent crack extending into adjacent uncracked slabs.

5.2.6 Transverse Cracks

Description
A transverse crack is a crack or break approximately perpendicular to the direction of placing (commonly perpendicular to the pavement centreline).

Possible Causes
- Overloading;
- Late sawing of transverse joint (contraction joint) during construction, or inadequate depth of sawn joint;
- Excessive slab length relative to slab width; or
- Failure to match a transverse joint in an adjacent slab.

Recommended Treatments
Transverse cracks should be monitored and if spalling is evident, they should be routed or saw cut and sealed with an appropriate flexible sealant (refer to Section 11.2).

High severity spalling can be treated with SRE(S).

In cases where excessive cracking prevents practical and effective repairs, the slab should be removed and replaced with new concrete paving.

Objective of Repair
The objective is to restore the integrity of the slab, to prevent the generation of FOD and to prevent crack extending into adjacent uncracked slabs.

5.2.7 Vibrator Cracks

Description

Vibrator cracks are cracks formed in the pavement as a result of submerged needle (poker) vibrators being dragged through the concrete. The photo above results from dragging immersion vibrators mounted on the paving machine through the freshly placed concrete (this is no longer practiced).

The cracks almost invariably manifest as fine parallel (hairline) cracks that generally do not penetrate to the full depth of the slab. They can remain innocuous for many years and commonly little or no deterioration occurs if the pavement is only lightly trafficked.

Since this compaction technique was only used on large (7.5m by 7.5m) slabs, the central vibrator cracks may break the slab along the centre due to thermal stressing with associated major spalling.

Possible Causes

- Non-uniform compaction; or
- Disturbance of the freshly placed concrete by dragging vibrators.

Recommended Treatments

Vibrator cracks in heavily trafficked pavements may eventually progress to full depth working cracks and spalling may become a serious problem.

Such cracking requires sealing progressively to minimise the incidence of spalling and consequent FOD problems. In some instances the cracks have been repaired with SRE(S) and asphalt trench repairs. In severe cases, the worst effected slabs will need to be replaced.

Objective of Repair

The objective is to restore the integrity of the slab, to prevent the generation of FOD and to prevent cracking extending into adjacent uncracked slabs.

5.3 Joint and Edge Defects

Asphalt consists of a mixture of crushed stones and sand bound together with bitumen, a flexible glue that can accommodate stresses due to shrinkage and temperature variations. Therefore, unlike concrete pavements, asphalt pavements need no joints.

Concrete consists of similar crushed stones and sand as used in asphalt, but they are bound together with a rigid glue composed of cement (usually Portland cement) and water. Because the glue shrinks as it hardens, unless pavements are heavily reinforced, they must be divided into panels by providing joints at regular intervals, typically 3.75m to 7.5m, but now more commonly 5m to 6m. Unless this is done, full-depth shrinkage cracks break the pavement in an uncontrolled pattern, resulting in cracks that are difficult to maintain. Joints control concrete shrinkage essentially by providing straight cracks that can be maintained.

Because the glue in concrete pavements is rigid, all thermal expansions and contractions of the slabs are concentrated at the joints. The joints also function as hinges that accommodate the small rotations produced by traffic loadings and thermal warping. Consequently the joints must be wide enough at the top (i.e. recessed) to provide clearance between the top edges of the slabs, otherwise the edges will bear against each other and break off. These concrete fragments (spalls) are a form of FOD and potentially a danger to aircraft.

Concrete Spalls

Spalling produces concrete fragments (spalls) (FOD) that may damage aircraft through propeller or skin damage, or by ingestion into jet engines. In practice it is often difficult to decide whether potential spalls should be prised loose or left in place. Because of the cost and difficulties (primarily time and access) in making permanent repairs to spalled areas, the voids resulting from spalling should generally be left unrepaired if the unevenness of the pavement surface can be tolerated from an operational viewpoint. Rigid patching materials usually de-bond from the concrete due to the shrinkage they undergo while curing, or because their thermal expansion characteristics differ from that of the parent concrete. They then also become a spall and are equally a danger to aircraft. As it is often not tolerable to leave a void, alternative flexible patching materials such as asphalt, rubberised poured sealants and instant bituminous repair materials (e.g. “Perma-Patch”) are often effective, but may be subject to attack by spilt fuels, particularly on aprons. More recently, Semi Rigid Epoxies with Sand (SRE(S)) have been increasingly used where bitumen based patching is unsuitable, but they are relatively expensive and should be used judiciously.

Concrete Pumping

Pumping of fines from the base course or subgrade can undermine concrete slabs but this is far less of a problem on airfields than it is on roads due to the much lower frequency of loading.

Concrete Growth

Pavement ‘growth’ involves progressive opening of joints due to the slabs jacking themselves apart as thermal expansion and contraction occurs. This can happen if the wider gaps that exist between slabs at low temperatures are filled with sand and other incompressible debris. High temperatures then cause the slabs to expand, push against the incompressible fill and the pavement ‘grows’ in length and width. The same mechanism leads to spalling of joint edges if stones are tightly lodged in the joints when they are at their widest (during cold weather). However, most airfield pavements are significantly thicker than road pavements (typically 350m to 450mm to cater for large aircraft, compared with 230mm to 250mm used for major highway pavements). Because temperature variations are much reduced with depth below the surface, the restraint provided by the temperature-stable lower part of thick slabs dramatically reduces the amount by which joints open and close. Consequently, in Australia, where extremes of temperature and frost do not occur, the theoretical concerns related to thermal movements do not appear to be significant in practice for airfield pavements that are kept relatively clean (swept regularly).

Severity levels for joint defects in concrete pavements are defined as:

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
JOINT / EDGE DEFECTS	**LOW**	Spalling commencing but little or no potential for dislodgment of particles (typically with a spall width of less than 25mm) AND/OR Minimal edge defect or barely evident discontinuity in pavement levels (typically no discontinuity felt under foot).	
	MEDIUM	Potential for material to become dislodged after further trafficking and create a FOD problem (typically with a spall width of 25mm to 50mm) AND/OR Edge drop-off clearly evident but unlikely to adversely affect aircraft riding quality and/or represent a trip hazard (typically less than 25mm).	
	HIGH	High potential for material to become dislodged from spalling and create a FOD problem (typically with a spall width greater than 50mm) AND/OR Edge drop-off likely to adversely affect aircraft riding quality and/or represent a trip hazard and/or excessive vertical height difference representing a non-compliance with CASA Standards (MOS Part 139 Chapter 6.2.12) (in excess of 25mm for runways).	

Section 11.4 provides details of the techniques used for repairing spalling in concrete pavements.

5.3.1 Spalling

Description

Spalling is the break down, chipping or disintegration of concrete at joints, edges or cracks, usually resulting in the removal of material, and in the formation of an elongated cavity. Spalling commonly commences as crack formation adjacent to joints, cracks or edges and progresses as material is lost through trafficking.

Spalling differs from slab breaks in that the cracks forming the spalls do not extend through the full depth of the slabs (i.e. they are close to horizontal).

Possible Causes

- Breakdown of joint and crack edges due to trafficking;
- Possibly weakening of slab surface due to over-finishing at joints;
- Dislodgement of weakened concrete at joints and cracks during temperature expansion and contraction, particularly if incompressible material (stones and hard objects) is trapped in the joint or cracks;
- Sawing of joints in concrete too early during construction; or
- Damage during construction caused by levering against concrete to remove formwork.

Recommended Treatments

Spall repair treatments are dependent on the size of the spalling as detailed in Table 11-1.

Patch the spalled area in accordance with the procedure contained in Section 11.4 using an appropriate patching material or SRE(S) depending on the location and size of the spall.

Objective of Repair

The objective is to restore ride quality and to prevent the generation of FOD.

5.3.2 Buckling/Blow Ups

Description

Buckling (or blow ups), which may also be known as tenting, is localised upward bending of a slab, usually occurring at a transverse crack or joint. Buckling is usually confined to thin slabs such as those used in footpath construction. Thick concrete slabs, as typically used on airfield pavements, are more temperature stable than the thinner slabs used for roads and footpaths. Also, extreme high temperatures continuing over extended periods are uncommon in Australia. Consequently, buckling of airfield pavements is not a concern in practice in Australia, and expansion joints are not normally provided except where a pavement abuts fixed structures and changes in shape and thickness.

Possible Causes

- Excessive expansion of a pavement in hot weather when insufficient expansion joints have been provided; or
- Contraction joints filled with incompressible material preventing the joints from closing during thermal expansion of the slab.

Recommended Treatments

Remove defective portion of pavement and replace with new paving, including an expansion joint. Clean out joints and seal them if they are likely to accumulate debris.

Objective of Repair

The objective is to restore ride quality.

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5.3.3 Faulting

Description

Faulting is the differential residual vertical displacement across joints and cracks and at pavement edges, creating a step.

Possible Causes

- Poor sub-base and/or subgrade support;
- Loss of sub-base material due to pumping;
- Rocking due to uneven support, or warping/curling of slab due to temperature gradient;
- Differential foundation settlement; or
- Subgrade volume change.

Recommended Treatments

The appropriate repair action depends upon the magnitude of the step created by the faulting, and its acceptability having regard to its location and the type of aircraft or vehicles using the area.

Options for treatment are to monitor only; ramp the step with fine asphalt (tack coat the surface of the concrete well using bitumen emulsion); grinding; grouting (slab jacking) or breaking out and replacing the faulted slab.

Objective of Repair

The objective is to restore the ride quality of the pavement and to remove a trip hazard (on aprons).

5.3.4 Pumping

Description

Pumping is a dynamic phenomenon in which water or slurry from saturated base courses is ejected through joints or cracks under pressure due to traffic-induced slab deflection. Fines from the base course carried in the water are lost, ultimately resulting in the formation of voids and undermining at the joints or cracks.

Pumping requires a saturated base course and frequent loading to generate sufficient pressure to cause ejection of the water and fines;

Possible Causes

- Insufficient slab support from water saturated base course or subgrade; or
- Use of base course material susceptible to loss of fines and development of pore water pressures.

Recommended Treatments

Improve drainage of base course if possible by installing sub-soil drains at the edges of the pavement and seal joints in the slab to limit further water movement and associated loss of fines.

If an investigation shows the slab to be severely undermined, filling of cavities by grout injection through drilled holes (slab-jacking) may be warranted.

Objective of Repair

The objective is to restore the ride quality and the structural integrity of the pavement and to restrict the further loss of fines.

5.3.5 Staining

Description
Staining of the pavement surface occurs when material is pumped from joints or cracks.

Possible Causes
- Exuding (seeping) groundwater through joints and cracks in low lying areas of pavement; or
- Evidence of pumping of base course fines.

Recommended Treatments
Treatment is usually not warranted. The staining can be removed with proprietary concrete cleaning chemicals or light shot blasting only if required for aesthetic reasons.

The presence of staining usually indicates a saturated base course and consideration should be given to improving upstream drainage if practical.

Objective of Repair
The objective is to stabilise saturated base course by improving up stream drainage.

5.3.6 Warping

Description

Warping (also known as curling) is slab bending due to temperature or moisture differentials. Warping of slabs is a dynamic phenomenon and is only considered as a pavement defect when its magnitude is such that it affects the ride quality of the pavement, or it leads to another form of defect (e.g. transverse cracking).

Possible Causes

- Uneven expansion or contraction of the top and bottom slab surfaces caused by large temperature or moisture differentials. It may be accentuated when slab plan dimensions are large relative to slab thickness; or
- Absence of load transfer across joints.

Recommended Treatments

Where the pavement riding quality is affected, a fine mix asphalt should be used to provide localised shape correction by ramping (only suitable in isolated occurrences and the least preferred option), or the steps should be ground or profiled flush with the adjacent edge or surface.

Where excessive cracking has resulted, the defective portion of pavement should be removed and replaced with new paving, including re-establishing load transfer across joints.

Objective of Repair

The objective is to restore ride quality and the structural integrity of any slabs that have cracked.

5.4 Joint Sealing Defects

Until the early 1980s, the joints in concrete airfield pavements in Australia were either sealed (with bitumen/tar based hot poured sealant) or filled with a self-expanding cork filler. . The joints (usually only contraction joints) are now sawn to a narrow width of 3mm to 5mm and left unsealed. Construction joints are usually sealed but some have been treated similarly to contraction joints and left as a saw cut. Increasingly, joint sealing and also resealing of older joints is now undertaken only when justified by the circumstances of particular situations. Some aerodromes around Australia currently opt to seal all joints as this can be beneficial when regular sweeping is not undertaken.

The original Australian joint sealing practices had developed in part from highway experience and also from aircraft pavement performance in countries subjected to extremes of temperatures, including freeze-thaw conditions. Joint sealing had been justified in Australia partly to restrict water ingress (although effective waterproofing over time was rarely achieved in practice), to prevent pumping, but mainly to prevent stones and other hard objects lodging in the joints and causing spalling and 'pavement growth' as the joints tried to close up in hot weather.

The practice of leaving joints in an open state developed in the late 1970s to early 1980s as evidence mounted that older pavements that were initially constructed with sealed joints continued to operate successfully after the joint sealant had been lost or removed. This demonstrated that the theoretical reasons for sealing joints were not necessarily of practical importance in many situations.

The case for sealing or not sealing joints in concrete pavements must be assessed on a project by project basis. In many situations, if pavements are kept relatively free of loose particles, and particularly if suction sweepers are used that effectively remove loose particles from open joints (and this should be verified as some suction sweepers are not capable of doing this), the need to seal joints is much reduced.

Most older airfield pavements were constructed when there was a clear policy to seal joints. Self-expanding cork, rubberised bitumen and various other sealants were favoured and trialled from time to time. Joints had to be fairly wide (typically 13mm to 20mm) to enable the sealants to accommodate thermal joint movements without fracturing, separating from the concrete (de-bonding), or being extruded from the joint. Also, some joints were wet-formed in plastic concrete rather than by sawing the hardened concrete. This process and the associated 'over finishing' of the joints that often occurred created weakened zones that are now known to lead to considerably more spalling than that which results when joints are sawn. Consequently, in the past, joint deterioration and spalling commonly developed along wet-formed joints after a few years' service.

Self-expanding cork relied on the expansion (primarily due to moisture) of the cork to hold it in place. Over time cork loses its expansive properties and resilience to wet/dry cycles, which results in the material no longer filling the joint and eventually becoming dislodged.

In cases where the joints had become uneven due to only moderate spalling of the weakened edges, the joints could be resealed using a poured sealant. The sealant flowed into the irregularities and had the added advantage that provided it adhered well to the concrete, new spalls that developed were usually retained in place, and were not a hazard to aircraft. The method was relatively cheap but some sealants quickly lost their elasticity and adhesive qualities, and became a source of FOD themselves.

An alternative involved sawing the joint wider to remove the moderate edge irregularities, then resealing with wider cork. This method was expensive, and it was difficult to glue the new cork to the sawn concrete. When the spalls were wider, a third alternative was sometimes tried. The joint was significantly widened by sawing both sides to remove spalled zones, rebuilt with a rigid material, and then a new sealed joint was centrally re-established. In some cases the rigid repair materials de-bonded and fragmented in service, and so became a source of FOD and had to be removed. This then left a very wide joint that was usually filled with a stiff pourable sealant or (commonly) with asphalt.

Construction joints are preferably sealed using poured sealants, usually silicon or single component polyurethane. Increasingly, joint sealing and also resealing of older joints is now undertaken only when justified by site specific circumstances. There are a number of factors to be considered. For example, open joints may not be acceptable in areas where loading and servicing of aircraft is performed, or where there is significant pedestrian movement. Also, wider joints are more likely to spall under aircraft wheel loadings, particularly when subjected to the hard (solid or high pressured) wheels and steel stabilising feet of servicing vehicles. In such instances consideration should be given to chamfering the edge of all new joints. A further factor in the assessment is that wide joints can harbour larger stones that are more dangerous to aircraft. In addition, where pavements are underlain by water-susceptible base courses and expansive subgrades, an attempt to prevent water ingress may be warranted. Finally, the degree of pavement cleanliness that is achievable in practice is important in deciding whether joints should be sealed. This often depends upon the source of debris and the resources available for pavement monitoring and sweeping.


Example of "Good" Concrete Joint Sealing


Chamfered Concrete Joint

Severity levels for joint sealing defects in concrete pavements are defined as:

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
JOINT SEALING DEFECTS	**LOW**	Minimal potential for joint sealant and/or incompressible material to create a FOD problem (typically joint sealant failure by adhesion, cohesion, intrusion, extrusion and chemical damage up to 25% of the joint length) AND/OR Joint sealant not providing satisfactory seal by allowing ingress of water and/or incompressible debris (typically joint sealant missing or ineffective up to 25% of joint length)	

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
	MEDIUM	Potential for joint sealant and/or incompressible material to create a FOD problem (typically joint sealant failure by adhesion, cohesion, intrusion extrusion and chemical damage up to 50% of the joint length) AND/OR Joint sealant not providing satisfactory seal by allowing ingress of water and/or incompressible debris (typically joint sealant missing or ineffective up to 50% of joint length)	
	HIGH	High potential for joint sealant and/or incompressible material to create a FOD problem (typically joint sealant failure by adhesion, cohesion, intrusion extrusion and chemical damage greater than 50% of the joint length) AND/OR Joint sealant not providing satisfactory seal by allowing ingress of water and/or incompressible debris (typically joint sealant missing or ineffective over 50% of joint length)	

Section 11.3 provides outline details of the techniques used for sealing joints in concrete pavements.

5.4.1 Joint Sealant Failure – Adhesion

Description

Joint sealant adhesion failures occur when the bond is lost between the joint sealant and the concrete joint face.

Possible Causes

- Inadequate bond strength between the sealant and the concrete;
- Incompatibility between successive joint sealants;
- Contaminated or inadequately cleaned joint faces;
- Excessive joint movement relative to the width of the joint sealant; or
- Aging of the joint sealant affecting bond strength.

Recommended Treatments

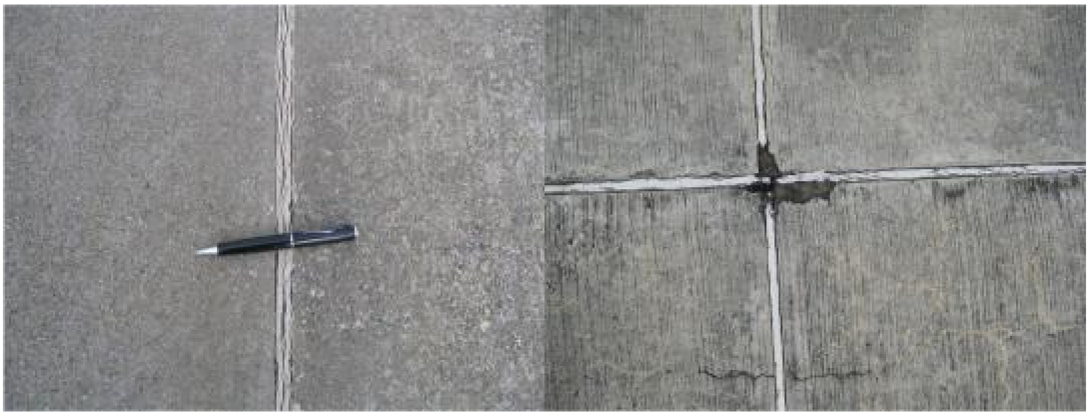
Preformed filler/sealant type material (e.g. self-expanding cork) can be left in place if it shows no tendency to come out of the joint and create a FOD problem. Note that loose cork filler may float up out of joints if flooding occurs across the pavement during rainstorms.

Field moulded (poured or gunned) joint sealants should be removed, the joints shall be thoroughly cleaned by water blasting and the sealant replaced with new sealant (refer to Section 11.3).

Objective of Repair

The objective is to restore the integrity of the joint sealant to minimise the entry of water and incompressible materials (if warranted), and to reduce the generation of FOD.

5.4.2 Joint Sealant Failure – Cohesion



Description

Joint sealant cohesion failures occur when the bonding force at the joint face is greater than the tensile strength of the sealant which results in an internal rupture

Possible Causes

- Excessive joint movement relative to the width of the joint sealant; or
- Aging of the joint sealant affecting cohesive strength.

Recommended Treatments

The joint sealant can be left in place if it is still performing its function, otherwise defective portions should be removed and replaced if it is determined that joint sealant is still required in the subject location (refer to Section 11.3).

Objective of Repair

The objective is to minimise the entry of water and incompressible materials and to reduce the generation of FOD.

5.4.3 Joint Sealant Failure – Chemical

Description

Joint sealant chemical failures occur when the joint sealant is attacked by fuel, oil or other chemicals that have been spilt on the pavement.

Cork joint filler/sealer is not affected by fuel or other chemicals likely to be spilt on airfield pavements. Polysulphide and polyurethane sealants are also not affected by aviation fuel. Silicone sealants swell when immersed in aviation turbine fuel and this is the reason that it is important to recess such sealants adequately below the pavement surface. Even so, if silicone sealants are softened by a fuel spill, it is not normally necessary to replace the sealant. After washing and flushing the fuel spill with water, the affected area should be isolated from traffic and the fuel in the sealant is allowed to evaporate.

Only old bitumen based joint sealants are affected by fuel and aircraft engine lubricants and these materials will normally require replacement if softened by contaminants.

Possible Causes

- Joint sealant exposed to attack by aviation fuel or other chemical agents.

Recommended Treatments

The joint sealant can be left in place if it is still performing its function, otherwise defective portions should be removed and replaced (refer to Section 11.3).

Objective of Repair

The objective is to restore the integrity of the joint sealant to minimise the entry of water and incompressible materials (if warranted), and to reduce the generation of loose fragments of sealant.

5.4.4 Joint Sealant Failure – Extrusion

Description

Joint sealant extrusion failures occur when the sealant is compressed to such an extent that it bulges up or protrudes above the pavement surface and under the action of wheel loads, is folded and flattened onto the pavement surface. It may also be a result of the initial overfilling of the joints.

Possible Causes

- Excessive joint sealant application (overfilling);
- Joint too narrow to accommodate slab expansion; or
- Volume change in joint sealant.

Recommended Treatments

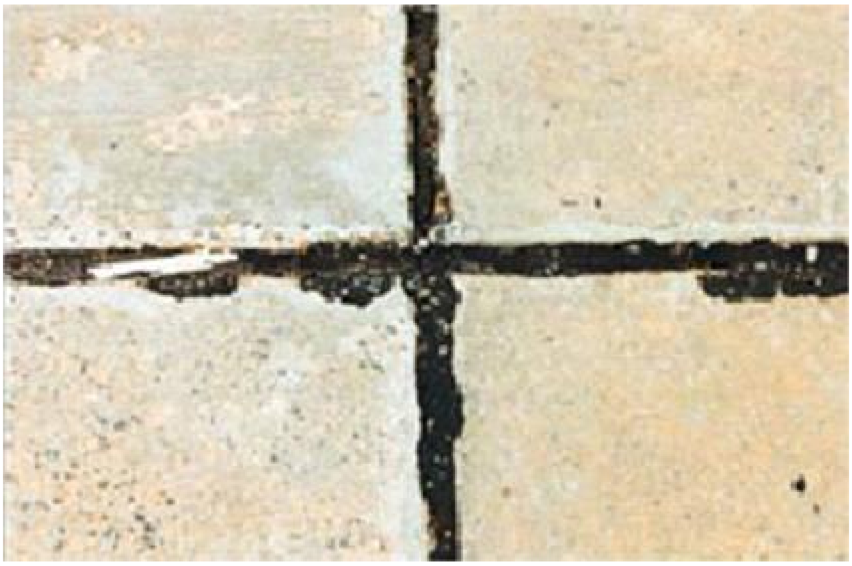
The joint sealant can be left in place if it is still performing its function and not adhering to tyres. Otherwise defective portions should be removed and replaced if circumstances warrant.

If the joint has insufficient width, making the percentage compression of the sealant excessive, the joint should be widened by sawing and the sealant replaced (refer to Section 11.3).

Objective of Repair

The objective is to remove the extruded sealant so that it does not cause a riding quality problem and does not adhere to aircraft tyres.

5.4.5 Joint Sealant Failure – Intrusion



Description

Joint sealant intrusion failures occur when aggregate particles or similar foreign materials are incorporated into the joint sealant and cause spalling when the concrete pavement expands and the joint width is reduced.

Possible Causes

- Joint sealant non-resilient or soft; or
- Intrusion of foreign material in the joint sealant following cohesion or adhesion failures.

Recommended Treatments

The joint sealant can be left in place if it is still performing its function and not causing spalling or providing a potential source of FOD. Otherwise defective portions should be removed and replaced if circumstances warrant (refer to Section 11.3).

If the joint has insufficient width, making the percentage compression of the sealant excessive, the joint should be widened by sawing and the sealant replaced.

Objective of Repair

The objective is to remove the intruded sealant so that it does not cause a subsequent spalling or FOD problem.

5.5 Surface Defects

Surface defects can result from a number of causes, and may affect the functionality of the pavement in various ways. In general surface deficiencies do not affect the structural performance of the pavement.

Severity levels for surface defects in concrete pavements are defined as:

DEFECT TYPE	SEVERITY	DESCRIPTION	PHOTOGRAPH
SURFACE DEFECTS	**LOW**	Cracks of hairline width or barely visible (typically less than 1mm wide) AND/OR Loss of wearing surface (frictional characteristics), pop outs or spalling commencing but little or no potential for dislodgment of particles (typical defect width less than 25mm)	
	MEDIUM	Cracks of width which clearly indicates potential for further movement (typically 1mm to 5mm wide) AND/OR Loss of wearing surface (frictional characteristics) advancing and potential for material to become dislodged after further trafficking and create a FOD problem (typical defect width 25mm to 50mm)	
	HIGH	Crack width likely to result in reduced load transfer and/or allow water penetration (typically greater than 5mm wide) AND/OR Loss of wearing surface (frictional characteristics) extensive and high potential for material to become dislodged and create a FOD problem (typical defect width greater than 50mm)	

5.5.1 Alkali Silica Aggregate Reaction

Description

A reaction between a form of silica present in some concrete aggregates and the alkalis present in some cements produces internal volume expansions that may cause a pattern of surface cracks (map cracking) that typically extends throughout a concrete slab, or may result in the closure of joints. Alkali-aggregate reaction is distinct from sulphate attack in that it involves large expansion without the softening that occurs with sulphate attack (also called alkali-silica reaction). The gradual expansive reaction may be expected to continue, and will eventually produce surface debris (spalls).

ASR tends to develop "map cracking" with predominantly longitudinal cracks and continue across transverse joints. ASR induced may contain deposits that range from white to transparent and may be waxy to hard. ASR cracking can be easily confused with plastic shrinkage cracking. Plastic shrinkage cracking forms immediately after construction and is usually noticeable after a few days whilst ASR cracking does not appear for a number of years. Plastic shrinkage cracking is typically very shallow whilst ASR cracking can be for the depth of the slab.

For further details refer to US FAA AC150/5380-8 "Handbook for Identification of Alkali- Silica Reactivity in Airfield Pavements" and US Department of the Air Force Engineering Technical Letter (ETL) 06-2: Alkali-Aggregate Reaction in Portland Cement Concrete (PCC) Airfield Pavements.

Possible Causes

- Use of incompatible aggregates and cements.

Recommended Treatments

No effective remedial treatment is known. The deterioration process is gradual, so the defective areas of pavement should be monitored for the onset of release of fragments, and the pavement maintained clean of loose particles.

If joints close, they should be re-sawn to at least a 3mm to 5mm wide and 50mm deep to minimize spalling. SRE(S) repairs to high severity isolated cracking should be considered, however if the cracking is over the majority of the slab, then slab replacement or asphalt overlay should be considered.

Objective of Repair

The objective is to monitor the surface condition to ensure that the affected surface or closed joints do not cause a subsequent spalling or FOD problem.

5.5.2 Crazing

Description
Crazing comprises a pattern of shallow, hairline cracks on the concrete surface, tending to intersect at angles between 90° and 120° forming a chicken-wire pattern. Crazing is largely a cosmetic effect and it is very rare for this phenomenon to produce distress in concrete pavements. Even in the most severe cases, where cracks have opened and the edges have eroded, no significant spalling has occurred.

Possible Causes
- Shrinkage of the surface of the concrete usually due to excessively rapid drying during hot and/or windy weather; or
- Excessive cement or slurry content in the surface layer due to over-working.

Recommended Treatments
There is generally no need to carry out repairs. Any loose particles that may be shed should be cleaned off the pavement surface.

Objective of Repair
The objective is to monitor the surface condition to ensure that the crazed surface does not cause a subsequent spalling or FOD problem.

5.5.3 Disintegration

Description

Disintegration is the deterioration of the concrete into small fragments or particles. This condition may result from neglected maintenance, from continued overloading, from the use of "poor" quality aggregates, or from degradation of the cement due to environmental factors.

Possible Causes

- Severe weathering;
- Alkali/aggregate reaction (poor quality aggregates);
- Chemical attack;
- Gross overloading; or
- Neglected maintenance.

Recommended Treatments

Monitor for loose particles. Remove affected pavement and replace or reconstruct. Consider localised SRE(S) repairs.

Objective of Repair

The objective is to restore the structural integrity of the pavement, to prevent further spalling and the subsequent generation of FOD.

5.5.4 Pitting


Description

Pitting is small surface cavities caused by loss of matrix and fine aggregates through weathering.

Possible Causes

- Weathering of unsound, aggregate at or near the surface;
- Disintegration of the finer aggregate particles; or
- Severe weathering.

Recommended Treatments

Maintenance is rarely required, except the surface should be kept clean.

Consider localised SRE(S) repairs. In extreme cases the pavement may require resurfacing with an asphalt overlay.

Objective of Repair

The objective is to maintain ride quality and prevent the generation of FOD.

5.5.5 Pop Outs

Description
Pop outs occur when a cavity is formed resulting from a small piece of concrete or a foreign object (typically 25mm to 100mm diameter) breaking loose from the pavement surface.

Possible Causes
- Expansion of a piece of underlying coarse aggregate or other introduced material such as clay, wood etc.

Recommended Treatments
Pavements that are known to be subject to pop outs should be regularly inspected and any loose particles that are produced should be removed back to sound concrete.

For cavities with diameter greater than 100mm, the surface of the pop out recess should be cleaned, primed and filled with an instant bituminous repair material or hot mix asphalt, but such repairs are rarely justified. Alternatively, joint sealing material, SRE(S) or RBB could be considered.

Objective of Repair
The objective is to monitor the surface condition to ensure that the pop outs do not cause a subsequent spalling or FOD problem.

5.5.6 Scaling

Description

Scaling is the progressive disintegration and loss of concrete wearing surface, usually in shallow sections. A particular case is the loss of mortar resulting from a chemical reaction between cement and lubricants/hydraulic fluids leaking from parked aircraft.

Possible Causes

- Weakened surface caused by over finishing. Over finishing brings water towards the surface, locally increasing the water to cement ratio to produce a very low-strength, high shrinkage mortar;
- Weathering;
- Progressive deterioration of a craze cracked surface;
- Chemical reaction between cement and lubricating oils/ hydraulic fluids spilled from parked aircraft. The cyclic heating of the concrete surface by downward-directed auxiliary power unit (APU) of the aircraft greatly accelerates the reaction.

Recommended Treatments

Shallow scaling usually has little effect on the functional performance of the pavement and can be left untreated, except that any loose particles that have delaminated should be removed. Where extensive scaling exists, the affected slabs should be removed and replaced. Bonded toppings have rarely been applied and specialist advice is required, since this is not a common problem in Australia.

On the Air Movements Apron at RAAF Base Tindal, a number of scaling repairs have been undertaken adjacent to both the longitudinal and transverse joints. Treatments have included SRE(S) and asphalt patch (trench) repairs (typically 50mm to 75mm deep) with a PME surface treatment.

For areas damaged by fuel spills, the spilt oils and fluids should be cleaned off, and the contaminated area protected from direct APU exhaust to prevent further damage. Repair by application of a thin bonded topping is very difficult and not recommended. Prevention of the damage by use of a proprietary sealant to prevent spilt oils from penetrating the concrete is the preferred option.

Objective of Repair

The objective is to prevent further deterioration of the pavement and to prevent the generation of FOD.

5.6 Groove Damage

Description
Loss of groove edges and polishing of the concrete surface resulting in a loss of friction level.

Possible Causes

- Aircraft traffic and aging of the concrete.
- Aggressive rubber removal.

Recommended Treatments
Grooves are not able to be easily re-cut in concrete pavements. Where grooves have worn to the extent that possible friction or control issues due to hydroplaning may arise, slab replacement is generally the most practical option.

It is noted that aircraft braking systems function best on pavements with consistent frictional characteristics. As such changes from grooved to un-grooved pavement and vice versa are un-desirable, particularly if not consistent across the width of the runway.

Objective of Repair
The objective is to restore the grooving/friction properties of the runway surface.

5.7 Poor Compaction and Honey Combing

Description
Poorly distributed aggregate throughout the depth of the slab (in particular, coarse aggregate slump to the bottom of the slab). Inadequate compaction (particularly at slab edges) causing voids and possible low strength.

Possible Causes
- Deposition technique
- Poor compaction/vibration
- Poor mix design and wet (high slump) concrete mix with inadequate cement content

Recommended Treatments
These issues are generally noted and recorded at the time of construction. Where the issue is severe and outside the limitation of the project specification, slabs would generally be replaced as part of the construction project. Where this doesn't occur slabs will need to be monitored over their serviceable life as they will be more susceptible to cracking, spalling and warping.

These defects should be rectified in the standard manner set out in the sections of this Manual. If the scale is severe, break out and replacement of the slab is required.

Objective of Repair
Maintain serviceable concrete pavement and remove unsound slabs where required.

6. Interlocking Concrete Block Pavement Defects

6.1 Introduction

Interlocking Concrete Block Pavers (ICBP) bedded on a thin (20mm) layer of sand on a Cement Treated Base (CTB) has been used successfully as a surfacing course on flexible pavements for aircraft. This type of surfacing is suitable for aprons and taxiways (except Rapid Exit Taxiways), but is not recommended for use on runways because of "poor" rideability (however, at least one runway (Thevenard Island, WA)) has been constructed with ICBP). A number of airfields have ICBP aprons, namely RAAF Bases Pearce, Tindal and Scherger and Sydney and Cairns Airports. A short length of taxiway at Melbourne Airport is paved with ICBP. ICBP has also been used at Hong Kong International Airport and a number of major civil and defence airfields in the UK.

Pavements surfaced with ICBP exhibit many of the desirable surface characteristics of concrete pavements such as resistance to fuel spills, indentation by stationary aircraft wheel loads, creep loading resistance, scuffing and abrasion.

In 1990, when ICBP was first used on airfield pavements in Australia, spacing nibs were designed for the block edges to maintain a minimum joint spacing (nominally 2mm). Only pavers with spacing nibs should be used to repair interlocking concrete block paving on airfield pavements.

This section covers ICBP defect definitions comprising:

- Broken Pavers;
- Lipping;
- Loss of Edge Restraint;
- Loss of Joint Filling Sand;
- Surface Erosion;
- Surface Depressions; and
- Weed and Moss Growth.

This section also provides a photograph, description, a list of possible causes and recommended treatments for the above defects.

Section 12 provides details of the criteria for undertaking repairs together with the recommended repair treatments.

6.2 Broken Pavers

Description

Broken pavers are characterised by either cracks through the units, or broken, chipped or spalled edges.

Possible Causes

Broken pavers (or spalled pavers) are usually caused by the paving block units rotating under load due to loss of jointing sand or inadequate joint width, and bearing against each other at the top edges. Sometimes loss of support beneath the paving block layer due to subsidence in the subgrade can result in blocks breaking under wheel loads. In this case, the cracks occur vertically at about the middle of the block.

Cracking may occur if the blocks are subjected to high point loads such as those that may be imposed by small steel plates or wheels on GSE.

Recommended Treatments

Cracked blocks may continue to perform satisfactorily, without replacement, because the cracks usually remain tightly closed due to the built-in compression in the block layer. If significant movement occurs at the cracks, spalling of the block edges will eventually occur and the blocks will begin to fragment. Conversion of the cracks into joints by opening and filling with jointing sand may prevent subsequent deterioration (refer to Section 12.2). Otherwise the cracked or spalled blocks should be replaced.

Objective of Repair

The objective is to minimise further deterioration of pavement and associated FOD generation.

6.3 Lipping

Description

Lipping is characterised by a change of level between one paving block and the adjoining paving block.

Lipping constitutes a trip hazard, and if severe enough may affect the ride quality and cause a problem for aircraft tyres.

Possible Causes

Lipping may result from:

- Differential compaction of bedding sand;
- Differential thickness of bedding sand; or
- Poor installation.

Recommended Treatments

The blocks should be removed, the bedding sand replaced to uniform thickness and compaction and the blocks re-laid. The joint filling sand should also be replaced.

Objective of Repair

The objective is to reinstate the pavement shape to eliminate trip hazards and to improve the ride quality.

6.4 Loss of Edge Restraint

Description

Interlocking concrete block paving requires edge restraints to prevent the lateral movement of the paving units, particularly at pavement edges. Lateral movement allows pavers to move under load, resulting in larger joints and an unstable surface.

The interface between interlocking concrete block paving and asphalt or concrete pavements, provide satisfactory edge restraint. Interfaces with concrete pavements that are subject to traffic loadings require that the abutting concrete slab edges be thickened (by 25%) as is normal for the free edges of such pavements. Asphalt surfaced pavements abutting interlocking concrete block paving require thickening of the asphalt adjacent to the blocks to not less than 100mm, or preferably provision of a reinforced concrete edge beam. However, concrete edge beams may crack and spall (despite the inclusion of reinforcement and joints).

Possible Causes

The loss of edge restraint may result from an inappropriate or inadequate edge restraint being constructed, from subsequent disintegration of a constructed edge restraint, or from poor laying of the pavers adjacent the edge restraint.

Recommended Treatments

Remove and replace the edge restraint with a more suitable restraint as required by the particular application. If the spalling is minor, repair by patching with a suitable epoxy (concrete), SRE(S) or special premixed asphalt. Replacement of cut pavers adjacent the edge restraint may also be required to ensure a smooth transition,

Objective of Repair

The objective is to repair the edge restraint so as to minimise further deterioration of the pavement and associated potential FOD generation.

6.5 Loss of Joint Filling Sand

Description

Erosion of the joint filling sand, either generally or localised, from the joints between the paving units may result in the units rotating, spalling or becoming loose.

Possible Causes

The loss of joint sealing sand generally results from erosion through the action of rain, water erosion (from hangar/shed drip lines (eg RAAF Base Pearce RSAF Apron)); wind and/or jet blast.

Recommended Treatments

Replace lost jointing sand ('top-up') with new joint filling sand complying with the particle size distribution specified in Section 12.3 and seal. Alternatively, proprietary stabilised sands such as 'SuperSand', 'Pave-Lok' or 'Gap Sand' may be used. Liquid applications such as ACM Pavseel and Resiblok 22 can also be used to seal the filling sand.

Objective of Repair

The objective is to reinstate the lost jointing sand, thereby preventing further deterioration of the pavement and preventing potential FOD generation.

6.6 Surface Depressions

Description
Localised depressions may occur due to subsidence in the subgrade, inadequacies in the compaction of underlying pavement and/or subgrade layers, loss of bedding sand, loss of interlock from cut AGL slots, or incorrect pavement design and/or construction. Shallow surface depressions hold water and silt and reduce the riding quality of the pavement surface, but should not affect the load carrying capacity.

Possible Causes
Loss of shape in block paving may result from:

- Subsidence of underlying pavement layers or subgrade;
- Overloading of the pavement resulting in permanent (plastic) deformations in the subgrade or the pavement layers, underground service installation settlement, particularly if unsuitable pavement materials have been used or compaction is inadequate.
- Loss of bedding sand from migration.

Recommended Treatments
Where the subsidence causes water ponding, the blocks should be removed, the shape of the base corrected and the blocks re-laid. The pavement shape should not be improved solely by the addition of bedding sand as this will result in differential compaction and/or settlement. Instead, the bedding sand should be removed, the base course shape corrected with lean mix concrete, the bedding sand replaced to constant depth, and the blocks then re-laid. Any damaged blocks should be replaced.

If the bedding sand has pumped or has migrated, then the blocks should be removed, the problem fixed and the blocks replaced and joint filling sand sealed (refer to Section 12.6).

Objective of Repair
The objective is to reinstate the pavement shape to eliminate water ponding and to improve the ride quality.

6.7 Weed Growth


Description

Weed growth within the joints. Moss, mould and silt build up on the surface of the blocks which can be an OH&S issue.

Possible Causes

- Loss of joint filling sand allows wind borne grass seed to germinate and grow especially in the presence of water (ie along aircraft shed drip lines) and low lying areas.
- Lack or loss of joint filling sand stabiliser also allows wind borne grass seed to germinate and grow.
- Localised depressions or flat areas holding water.

Recommended Treatments

Treat weeds with a base approved weed “killer”.

Remove moss and mould by either sweeping (tractor brush) or controlled water blasting. The use of water blasting will likely remove the upper depth of joint filling sand and this should be re-filled and sealed.

Replace lost jointing sand (‘top-up’) with new joint filling sand complying with the particle size distribution specified in Section 12.3 and seal. Alternatively, proprietary stabilised sands such as ‘SuperSand’, ‘Pave-Lok’ or ‘Gap Sand’ may be used. Liquid applications such as ACM Pavseel and Resiblok 22 can also be used to seal the filling sand.

Objective of Repair

The objective is to reinstate remove weeds, moss, silt and mould to reduce the potential for pedestrian slippage.

7. Miscellaneous Defects and Repairs

7.1 Introduction

This section covers miscellaneous defects, repairs and investigation techniques including general maintenance requirements, house-keeping issues and unusual defects.

Items covered comprise:

- Pavement line markings;
- Fuel and oil spills;
- Rubber removal;
- Pavement sweeping and cleaning;
- Surface abrasion by arrester cables;
- Grated trench drains and pits;
- Utility/service trench repairs;
- Runway and taxiway strip (flank) stabilisation;
- Unsealed pavements;
- Expedient repairs;
- Weed control;

Refer to Section 13 for a list of airfield pavement maintenance products.

7.2 Pavement Line Markings

7.2.1 Layout and Colour of Line Markings

For the safety and guidance of aircraft while manoeuvring on the ground, taking off and landing, airfield pavements are marked with airfield pavement markings in accordance with ADFP602 and Chapters 8 and 13.1 of CASA MOS139.

Where an airfield is used jointly by military and civilian operators, some differences between the standard marking patterns set-out in ADFP 602 and the CASA Manual of Standards Part 139 - Aerodromes may occur. The currency of existing marking standards must be validated on each occasion that markings are repainted, such as maintenance works, overlays and new construction, as these standards are amended from time to time.

Helicopter landing sites are marked for the exclusive use by helicopters and specific standard marking patterns apply.

7.2.2 Line Marking Visibility

Line markings must be clearly visible against the background upon which they are placed. Therefore if line marking is not clearly visible and able to safely provide guidance to aircraft while landing, taking off or manoeuvring on the ground, the line marking should be re-marked. In some instances, particularly on concrete, a black line may need to be painted as a border to highlight the line marking.

Most line markings should be safely visible for approximately two (2) to three (3) years from the time of application, depending on the paint used, existing surface preparation, method of application, existing surface material, extent of aircraft trafficking and the local environment. Centreline markings in Touch Down Zones on heavily used runways will require replacement on an annual basis. It should be noted that in general white remains more visible than other line marking colours.

In order to prevent confusion, if a portion of a runway is being repainted, it is generally good practice to repaint the entire runway. Ideally you would repaint the entire airfield, but this is not always feasible.

7.2.3 Line Marking Paints

MoS139 outlines the colours of paint markings to be used on airfields (Chapter 8.1.3).

MoS139 Section 8.3 requires runway markings must produce a non-skid surface of similar coefficient of friction to the surrounding surface to reduce the risk of uneven breaking action. Typically only water based latex emulsion paints are used on runways. These paints are 'self-cleaning' and maintain their conspicuousness by the surface of the paint weathering continuously. They also do not significantly affect the skid resistance of the pavement or the uniformity. The water based synthetic latex emulsion paints may also be used on other airfield pavements, but this is not mandatory. They are typically less durable than other paint types.

Taxiways, aprons and other pavements may be marked with the latex emulsion paint or with acrylic or solvent (oil) based road marking paints.

Suitable airfield pavement marking paints of all types are manufactured by Dulux and Wattyl ("AIRPAVE"), although there are other (smaller) manufacturers.

7.2.4 Line Markings on Asphalt Surfaces

The paints used on asphalt surfaces are either latex emulsion or acrylics (both water based). Solvent based paint has been used but it is usually not preferred as it can shrink and induce cracking in the asphalt. A thick build-up of the water based paint can also lead to cracking of the asphalt (particularly on runway centrelines) although this is usually at the edge of the paint marking. For runways and high speed exit taxiways especially, the build up of paint can present an operational problem due to flaking and loss of surface macro texture. The paint should be removed using water blasting (can be undertaken concurrently with rubber removal activities) and the markings repainted.

Thermoplastic paint also shrinks and cracks and may flake-off since it is applied in a thick layer. Chlorinated rubber paint is more flexible but its use on airfield pavements is not widespread. Both these paints are expensive and clean-up of the spraying equipment is more difficult than for water based paints. Generally, the use of these paints is not recommended.

Epoxide resin paint (road line marking paint) should not be used on airfield pavements as it can flake off in sections large enough to represent a FOD risk.

Line markings shall be applied by specialist sub-contractors.

7.2.5 Line Markings on Concrete Surfaces

Latex emulsion paint should be used on concrete surfaces on runways. Other concrete pavements, including interlocking concrete block paving, may be painted with latex emulsion, acrylic or solvent based paints, or even thermoplastic paint with or without glass beads. Glass beads on apron markings can be a potential slip hazard to ground personnel and should be avoided where possible.

Again, line markings must be clearly visible against the background upon which they are placed. Therefore markings on concrete should be applied with a background of adequate width and visibly contrasting colour (refer to Chapter 8.1.4 of MoS139).

Line markings shall be applied by specialist sub-contractors.

7.2.6 Removal of Existing Line Markings

It may be necessary to remove existing markings:

(a) To correct an incorrectly located or changed marking;

(b) Prior to remarking when the existing markings are excessively thick or are flaking;

(c) Prior to asphalt resurfacing;

(d) Prior to sealing; or

(e) Prior to application of a PME or SEST (unless they are in a "good" condition and then they should be masked).

Line markings shall be removed by specialist sub-contractors.

It may not be necessary to remove every trace of paint if the surface is to be repainted or resurfaced. Where existing markings on asphalt have to be obliterated because of a change in marking pattern or position, then after removing the bulk of the marking material by the methods described below, over-painting with black paint may be expedient.

The recommended methods of removing existing markings from concrete surfaces are dry abrasive blasting (preferably shot blasting) or high pressure water jetting using a rotating jet. The water pressure used must be adjusted to suit the particular surface to avoid erosion damage. When used on asphalt surfaces, it can easily erode the fine aggregate and binder from the surface and dislodge coarse aggregate from segregated areas (e.g. at joints). On concrete pavements, joint sealant (including cork) is severely damaged by this removal technique and it is essential to either protect the sealant from the water jet (perhaps by masking with a steel plate) or avoiding traversing across the sealed joints.

A vacuum sweeper should always be in attendance during paint removal operations, particularly dry abrasive blasting, to remove paint residue, used sand, grit and/or the steel ball abrasives. Particular care is needed to prevent the paint residue from entering the stormwater drainage system.

Trials with different sands or grits and water pressures may be necessary before deciding which technique is the most effective for a particular pavement.

Desirably the blasting machine should be fitted with an integral suction device so that the paint residue is removed immediately. To attempt to remove all traces of paint from an asphalt surface in particular will usually cause damage to the surface and such practices are not necessary.

7.2.7 Preparation of Surfaces for Re-Marking

For airfield ground markings to be durable, the pavement surfaces must be clean and dry before the markings are applied.

If cleaning is necessary, the methods described in Section 7.4 may be used. The removal of rubber from paint markings is not usually necessary or practical. If markings become contaminated with rubber to the extent that their visibility is considered to be inadequate (e.g. on runway centrelines), they should be lightly repainted.

Where existing markings are to be over-painted or touched up, all loose paint should be removed. If only localised touching up is proposed, loose and flaking paint should be removed with a stiff wire brush, preferably power driven. Paint build-up in excess of 5mm thick may be prone to flake and the integrity should be checked before repainting.

All paint residues must be swept up and removed from the pavement.

If new concrete pavement is to be marked, all traces of the curing compound within the areas of the paint markings must be removed using a stiff wire brush.

Immediately prior to the application of the markings, surfaces should be cleaned and dried using oil-free compressed air. Use of heating equipment to dry the pavements should not be permitted because of its potential for damaging the surfaces.

7.3 Fuel and Oil Spills

Aviation fuels (AVTUR and AVGAS), other hydrocarbons used in the aviation industry, and hydraulic oils are solvents for bitumen.

Aviation fuel is often spilt onto pavement surfaces. There are many possible causes for this, including surge in the fuel tanks of moving aircraft, venting from full tanks of aircraft parked on aprons as ambient temperatures rise, accidental leaks during refuelling, etc. All spilled fuel on asphalt or sprayed bituminous seals will dissolve the bitumen binder. Large spills are a fire hazard and the clean-up operation is more likely to damage the bituminous surfacing than the fuel itself. Smaller spills, if not disturbed, will evaporate and usually do not cause significant damage. Asphalt surfaces are more prone to damage by fuel spills than seals because they are permeable and fuel soaks into the material.

When spilt on asphalt, aviation fuels will cause bitumen to soften or to disintegrate, particularly if the spillages recur at frequent intervals. An isolated fuel spillage on a dense, sound asphalt surface will generally cause only superficial and temporary softening. Once the excess fuel has either drained away or has evaporated from the surface, further drying will enable the bitumen to reharden and the surface to be serviceable again. Sweeping, pressure hosing or other abrasive pavement cleaning while the bitumen is in a softened condition can lead to the finer aggregate particles easily being dislodged, and should be avoided.

Hydraulic and lubricating oils are heavier than fuels and will not evaporate readily. All aircraft leak oil of one sort or another (some even bleed off hydraulic oil) and jet engine lubricating oils are very aggressive solvents of bitumen. Oil contamination will soften bituminous surfaces and make any pavement surface slippery and hazardous for pedestrians, particularly if wet.

7.3.1 Remedial Treatment

As soon as a fuel spillage of any size is observed, it should be contained, isolated and absorbed or recovered in accordance with the Airport Emergency Spillage Plan. Proprietary items such as 'Floor Sweep', sand, saw dust or any other absorbent material can be used to absorb the spillage. All necessary actions must be taken to prevent contamination of adjacent soil, watercourses and aquifers by the spilt fuel. Thereafter, sweepers and, if possible, traffic should be kept clear of the damaged area of surfacing until evaporation of the volatiles has occurred allowing the bitumen to reharden.

All fuel spills must be reported to the REO. Small fuel spills (less than 50 litres) should be treated immediately by the personnel on-hand. Larger fuel spills should be attended by the fire service.

The fuel spill should be contained by bunding using absorbent “sausages” (if available) or dry sand or soil. Absorbent material (proprietary products or dry sand or soil) should be spread on the spill if it has pooled. The fuel saturated materials can then be picked up and removed. The contaminated surface can then be washed with detergent and flushed with water or allowed to dry by evaporation.

If the fuel or oil is dispersed and/or soaked into the surface, the contaminated area should be washed with a suitable detergent and flushed with water or allowed to dry by evaporation. The detergent must be approved by the REO prior to use. The washing and flushing should be repeated until a suitable state of cleanliness has been achieved. Statutory and local pollution control regulations must be observed with respect to disposal of contaminated wash water.

High pressure water jetting is not preferred. If this method is used, the water pressure must be controlled and adjusted to suit the particular surface type/condition. Only rotating head machines are acceptable as hand held lances are hazardous to both operating personnel and the pavement surface. Great care must be exercised to ensure that the surface is not damaged, particularly joint sealants, painted pavement markings and fuel resistant membranes. Patch repairs should be inspected for loosening/erosion and replaced or repaired if required.

If the pavement surface suffers more than superficial disturbance while the bitumen is soft, the damaged area of wearing course should be removed and replaced by patching as detailed in Section 10.4.2.1.

However, if the bitumen re-hardens and the loss of fine aggregate has occurred in the contaminated area, or it has a 'hungry' appearance with coarse aggregate standing proud, then a bitumen emulsion and sand treatment should be applied to the damaged area as detailed in Section 10.3.2.2. A period of at least one month should be allowed prior to treatment to enable all solvents to evaporate.

7.3.2 Preventative Treatment

Routine good housekeeping practices by all personnel responsible for operating and servicing aircraft should be established and enforced because the repair of pavements damaged by fuel and oil spills can be very expensive.

The following housekeeping practices should be observed:

- All fuel spills must be cleaned up immediately;
- Spill kits must be located around areas used for maintenance and refuelling;
- Drip trays should be used wherever possible when servicing aircraft or when leakage of fuel or oil is anticipated;
- Oil contamination should be regularly cleaned off pavement surfaces; and
- The Aerodrome Emergency Plan should include actions in the event of a fuel spill.

The airfield must have a fuel spill response plan setting out the actions to be taken depending on the size of the spill. Suitable equipment and materials must be available and readily accessible for containing and cleaning up spills, including:

- Absorbent materials and bunding "sausages";
- Detergent, water and soft brooms;
- Sump pumps and hoses;
- Water tanker; and
- Access to a fire service.

Where asphalt pavements are likely to come into contact with fuel or hydraulic oil the pavement surface should be treated with a fuel resistant surfacing (a Fuel Resistant Membrane).

These pavement areas include aircraft parking bays, refuelling areas, maintenance areas, special purpose aprons, and engine testing (run-up) bays. Several fuel resistant surfacing treatments are available as identified in Section 13.

When applying FRM surface treatments it should be noted that:

- New asphalt and spray sealed surfaces need to age for up to 20 days to allow volatiles in the bitumen to escape;
- The surface of existing asphalt needs to be cleaned free of dust, spilt fuel, grease and oil deposits, and should be free of cracks; and
- The manufacturer's recommended procedures must be accurately followed.
- The FRM surface can be prone to be more slippery than adjacent pavement areas and is prone to fine surface cracking.

7.4 Rubber Removal

Rubber from aircraft tyres is deposited on runway surfaces during landings. The quantity of rubber deposited depends on a number of variables including; ambient temperature, texture of the runway surface, size and number of aircraft tyres per aircraft, tyre pressure, types of braking system, and the number of aircraft movements. The rubber may mask the texture of the runway surface, reducing skid resistance in wet conditions. It may also obscure the airfield ground markings and especially runway centreline in TDZs. However, the film of rubber on the pavement surface is continually degraded by weathering and on many runways may not build up significantly if traffic volumes are low. Rubber removal on an annual basis is only likely to be required at the busiest ADF Airfields. The decision to remove rubber should be based on the results of friction testing and following the guidance of ADF Friction Policy Document dated May 2011.

There are two (2) methods currently in use for the removal of tyre rubber deposits on all types of runway surfaces.

The first method employs chemicals combined with high/medium pressure water jetting. This is currently Defence's least preferred option due to the potential environmental risks.

Rubber deposits are not easy to remove, particularly on asphalt surfaces, without damaging (eroding) the surface because it is altered by the high temperatures generated during wheel spin-up. Chemicals are used to soften the rubber and it is then dislodged from the surface using pressurised water and collected by vacuum sweeping. Some chemicals are more effective than others and different types of water jetting and collection systems are used by the various contractors.

The general rubber removal procedure using detergents or chemicals involves:

- Application of the diluted chemical;
- Brushing the surface with a stiff bristle broom to loosen the hard rubber;
- Medium pressure, warm water jetting to remove the softened rubber from the surface; and
- Collection of the rubber and chemical residue by vacuum pick-up.

Other methods of removing rubber may use less effective chemicals, controlled water cutting and higher water pressures that tend to produce some surface erosion depending on the age and condition of the asphalt and can damage concrete joint sealant.

A further method is based on dry abrasive blasting (shot blasting). In this method, a high performance, airless, centrifugal or paddle wheel propels the blast media at high velocity in a controlled pattern and direction. The media strikes the surface and rebounds along with the removed rubber into a recovery chamber (separator). The dust collector removes pulverized abrasive, dust and contaminants. Very little abrasive is lost and the usable media is returned to the storage hopper for recirculation by the blast wheel. Different degrees of surface removal (and resultant texture) can be achieved by varying the shot size, shot flow rate and/or machine speed.

Specialist operators are available in Australia to undertake rubber removal using dry abrasive blasting.

The most common method used is controlled high pressure water blasting.

7.5 Routine Pavement Sweeping and Cleaning

CASA MoS139 (2012) Chapter 10.15.1 notes that all paved runway, taxiway and apron surfaces must be kept clear of foreign objects or debris that may cause damage to aircraft and further that, runways, taxiways and apron pavement used by air transport jet aircraft with reference code numbers 3 or 4, must be cleaned of foreign objects on a regular basis.

Pavements should be swept regularly to ensure that no loose and/or foreign particles remain on the surface that could result in FOD. Vacuum sweepers should be equipped with a wide suction nozzle at least the width of the machine. Rotary brooms are not necessary but if fitted they must not have metallic bristles.

Particular care should be taken by vacuum sweepers not to damage Airfield Ground Lighting (AGL) fittings.

Sweeping should be programmed such that each pavement area is swept at least once per week depending on the volume of traffic. Airfields with regular traffic should consider nightly sweeping. Preference should always be given to the runways.

At least one sweeper should be available on a 24 hour basis in case FOD is discovered and there is an accident or poor weather.

Sweeping should be increased whenever airfield works are occurring to ensure that surfaces are not contaminated.

Further guidance on airfield pavement sweeping and cleaning is provided in US FAA Advisory Circular AC150/5380-5B – "Debris Hazards at Civil Airports". There is currently no known USAF published guidance on sweeping operations.

A number of agencies and organisations (eg ACI) recommended to collect and measure the amount of FOD found on the airside at regular intervals.

7.6 Surface Abrasion by Cable Arrester Systems

Most major ADF Airfields have permanent cable arrester systems installed and these are usually BAK 14 types that are located in a steel housing within the runway pavement. A number of unmanned airfields are provided with facilities to enable a temporary aircraft arrester cable system to be installed during flying operations (usually exercises). This system will usually be a BAK12 type. The BAK12 utilises a cable of approximately 40mm diameter stretched across the runway surface and supported at intervals by rubber discs (or grommets) threaded onto the cables to hold it clear of the runway surface. This enables the arrester hooks fitted to aircraft to engage onto the cables.

Often the stem is installed and the cable is not connected but is laid along the runway edge until it is required. Once the cable is connected, all aircraft using the runway will traverse the cable and this action grinds and rubs the cable on the pavement surface. Over a period this abrasion may cause grooves to wear in the runway surface beneath the cables which may then not stand sufficiently clear of the surface for the hook engagement to be assured, even with the grommets in place.

The acceptable depth of wear in the surface before reinstatement is required has not been established. If repair is required, the worn areas should be planed to a depth of not less than 50mm and reinstated with SRE(S) in concrete pavements or 14mm size dense graded hot mixed asphalt in flexible pavements. The repairs should be carried out generally in accordance with Sections 10 and 11.

7.7 Grated Trench Drains and Pits

Grated trench drains and pits are used on aprons to collect storm water run-off and spilt fuel. Because they can be trafficked by aircraft, the continuous trench drains, pits and grates are designed to withstand relatively heavy loads. Standard heavy duty grated trench drain and pit designs have been prepared. The structures comprise reinforced concrete walls on a concrete base which may be extended if the bearing capacity of the ground is low. The top of the grated trench drains and pits are fitted with seating angles on which the grates are fitted and bolted down to avoid movement under traffic.

Major problems have occurred when the grates and/or pit walls have been compressed (and sometimes crushed) when the adjacent pavements have migrated (generally down the apron slope). This is more common in concrete pavements because flexible pavements tend to relieve the pressure by displacement (heaving) rather than by crushing the adjacent pit or grates.

In flexible pavements, movement adjacent to drains and pits is best treated by removal and replacement of the affected areas. This would normally involve profiling the existing pavement and paving asphalt to the levels required to match the trench drain or pit.

In concrete pavements the repair is more difficult and the method must be selected to address the cause of the problem rather than the effect. If crushing of the drain or pit has occurred, reconstruction is likely to be required. Such reconstruction will probably involve the installation of new isolation joints to relieve any further compression forces that will impinge upon the trench drain or pit.

By far the most common problem associated with drains and pits is opening of the interface between the structure itself and the adjacent pavement. As drains and pits are located in low points, such openings can allow the entry of water. In pavements constructed over clean sand, this may not be an issue. However, in pavements constructed over clay or silt materials, the change in moisture content can lead to softening of the subgrade with associated pavement strength and level problems. In highly expansive clays, the entry of water can lead to significant heaving. There have been examples where such heaving has resulted in the trench drain or pit not being at the lowest point in the pavement.

Sealing of the interface between the drain or pit and the adjacent pavement should be a high priority maintenance item. In concrete pavements, this interface should be sealed as for a crack or joint (ie: using a flexible joint sealant). In flexible pavements, the opening should be sealed as for a crack, or alternatively, the interface should be subjected to RBB (over banding).

On some recent apron reconstruction projects Gatic Slot Drains have been used (eg RAAF Bases Williamtown and Edinburgh).

7.8 Utility/Service Trench Repairs

Trenches may have to be constructed across existing pavements for the installation of new services, or may result from the removal of existing services (e.g. the removal of an arrester barrier system). Compaction in relatively deep trenches of limited width is difficult due to the impracticality of using heavy or suitable compaction equipment. If high levels of compaction are not achieved, subsequent consolidation under traffic and under the self-weight of the material will lead to subsidence in the trench backfill with associated detrimental effect on ride quality. This can be critical to the safe operation of aircraft in high speed areas such as on runways.

To avoid the effects of poor compaction in the backfill of trenches, strong consideration should be given to the use of materials that do not require high levels of compaction for volume stability. Such materials include stabilised sand, lean mix concrete, and to a lesser extent cement treated crushed rock. Stabilised sand and lean mix concrete have the advantage that they can be vibrated to achieve compaction without relying on rollers, wheeled vehicles or compacting plates, all of which may be impractical in a trench situation.

7.9 Runway and Taxiway Strip (Flank) Stabilisation

Flanks are the grassed areas adjacent to the sealed high strength or shoulder pavements within runway or taxiway strips. These areas are required to support the occasional aircraft (during an incident) and airfield vehicles such as fire tenders, and must be well grassed to avoid dust and erosion from jet blast, rain, water run-off and wind.

In order to meet these functional requirements, special grassing methods such as turfing and/or hydro-mulching must be employed.

If turfing is used, the turf must be rolled out and staked to the surface with netting and pins so that it cannot be displaced. Commonly turfing is not successful on airports, especially in dry climates, due to the lack of watering.

As an alternative to turfing, seeding by hydro-mulching is used. The hydro-mulch should not contain any material likely to constitute a hazard to aircraft. Mulched paper has proven to be satisfactory, but straw based hydro-mulches can be a problem if the straw is not well retained. Following the hydro-mulching, an application of bitumen emulsion succeeds in restricting the opportunity for loose particles whilst assisting with the germination of the seed.

The risk of seeding options acting as a bird attractant must be assessed. Commonly application of bitumen emulsion reduces this risk, however any such works will need to be monitored and should they show potential to become a bird attractant the works are not suitable to remain within the runway/taxiway strip and should be removed immediately.

Advice needs to be sought on the preferred seed and fertiliser mixture for each specific project, and this can commonly be obtained from the REO or a local horticulture expert.

In special circumstances, especially where grassed flanks are subject to traffic by aircraft with wing mounted engines overhanging the grassed areas, consideration should be given to providing sealed blast protection pavements beyond the sealed shoulders (guidance on the sealing of blast protection shoulders is given in CASA MoS 139 (2012) Chapters 6.2.11 and 6.2.14 with thickness design guidance contained in Chapter 7 of AC150/5320-6E)).

In some extreme cases where surface water run-off is high, reinforced concrete aprons have been provided (eg RAAF Base Darwin) to minimise erosion and scour. Rock gabion solutions may also be considered to minimise erosion and scour.

7.10 Unsealed Pavements

The philosophy behind the design of unsealed pavements is completely different to the design of sealed pavements. In unsealed pavements, advantage can be taken of the ability to add material, re-shape and re-compact the wearing course should any defects or damage occur.

Additionally, the properties of materials used in unsealed pavements are necessarily different to the properties of materials used in sealed pavements. In sealed pavements the plasticity of the base course must be limited so that the material has limited potential for mobility when wet. However, in unsealed pavements the material must have some plasticity to avoid erosion from wind and water, as well as traffic effects.

Unsealed pavements are most susceptible to rapid deterioration as a result of loss of material and damage due to water and wind. Defects are usually the result of interactions between pavement materials, traffic, climatic conditions and construction methods.

Common defects include corrugations, potholes, rutting, slippery surface, scouring, softening, ravelling and loose particles. Where the functionality of an unsealed pavement is affected by these defects, the same material or a material with similar properties to the parent material should be added. The pavement should then be re-shaped and re-compacted as appropriate in layers not greater than 100mm in thickness.

Characteristics of good wearing course materials for unsealed pavements include low permeability, stability in the climatic conditions predominant in the area, resistance to ravelling and scouring, and appropriate friction. These characteristics are most influenced by particle size distribution and plasticity. The most suitable materials for wearing courses on unsealed pavements are well-graded gravel-sand mixtures with a small proportion of clayey (plastic) fines. Gravels and sands that are low in fines will be porous, lack stability when dry and will ravel under traffic. However, fines in the form of a sand-clay may be incorporated into these materials to provide added stability.

The least desirable materials are those with silty fines, lacking gravel-sized particles (viz: silts and silty sands). These materials are likely to be porous and unstable and will ravel under traffic. They also tend to generate considerable dust.

Predominantly clay soils can provide a good dry-weather surface but will be slippery and/or may rut when wet.

The following properties are important in the consideration of materials for unsealed pavements:

- A high Plastic Limit may indicate the presence of an undesirable amount or type of clay;
- The Liquid Limit of a soil generally increases with an increase in the amount of flaky, fibrous or organic particles which can affect the packing, interlocking and cohesion of the soil particles leading to poor stability of the compacted soil;
- The Plasticity Index provides a measure of the cohesive binding qualities of the clay content, as well as an indicative measure of the amount of swelling and shrinkage that will result from wetting and drying; and
- Linear Shrinkage provides an indication of the volume change that is likely to occur when the moisture content changes. It is a useful test for soils with low clay contents on which the Liquid Limit, Plastic Limit and Plasticity Index are difficult to measure.

In general terms, the material should comply with the following:

(a) 100% passing a 26.5mm sieve;

(b) Between 20% and 60% retained on a 2.36mm sieve;

(c) Fines to sand ratio within the range of 0.20 to 0.40;

(d) Plasticity Index within the range of 4% to 15% (with the lower end of the range applicable to wetter climates); and

(e) Linear shrinkage within the range of 2% to 8% (with the lower end of the range applicable to wetter climates).

If no suitable materials are available, then consideration should be given to the stabilisation of in-situ or selected materials.

For further details on the maintenance of unsealed pavements refer to Section 10.6.3. US Department of Defense UFC 3-26002 (June 2001) and TM5-822-12 provides some further guidance on the design and maintenance of unsealed aggregate surfaced pavements.

7.11 Expedient Repairs

For a number of different reasons, it may, on occasions, be necessary to undertake emergency repairs of an expedient nature using materials that can either be trafficked immediately or within a very short time in order to enable aircraft operations to continue. The type of material depends on a number of variables including the material being used and the local weather conditions.

The intent of expedient repairs is to return the pavements to operational condition within a minimum time-frame, albeit with limitations on the life of the repair. The key functional elements of the repair are:

- To provide a surface that is intact and unlikely to create safety issues for operating aircraft due to the potential for FOD;
- To improve the riding quality of the surface to acceptable levels for the operation of aircraft (more important in high-speed areas such as runways than in low-speed areas such as on taxiways and aprons); and
- To provide appropriate friction characteristics of the surfacing to facilitate braking and to avoid the potential for yawing due to differential braking action (again more important on runways).

Expedient repairs usually have to be done with minimum preparation; however, all loose and damaged material must first be removed before repairs are undertaken.

In most instances, any surface defects can be repaired by installing an “instant” repair material such as cold mix asphalt or a similar proprietary product. These materials can be used on all types of pavements that contain cavities including concrete and interlocking concrete block pavements.

If the cavity is relatively small, the material can be applied directly provided that the surface has been cleaned and is dry. The repair material should be compacted as best as possible with a rubber mallet. Feathered edges must be avoided because the material will not be retained under traffic and will constitute a FOD hazard.

For larger defects, the cavity should be excavated to form a rectangular or square shape of constant depth of at least 50mm deep. If the cavity exceeds 50mm in depth, the repair material should be placed in layers with each layer being fully compacted prior to placing the next layer. The maximum layer thickness depends on the material being used and the equipment available for placing. If mechanical tools (such as a vibrating plate or “wacker-packer”) are not available, the repair material should be compacted as best as possible with a rubber mallet (for smaller cavities) or by using a hand tamper or the back of a shovel (for larger cavities).

The repair material should be placed slightly higher than the surface of the surrounding pavement to allow for compaction. Once the repair is completed, the area should be thoroughly swept and cleaned, and the repair should be monitored to ensure that newly placed material does not dislodge.

Further guidance on expedient repairs is included within UFC 3-270-07 "O&M: Airfield Damage Repair" and AFPAM 10-219 Volume 4 "Airfield Damage Repair Operations".

7.12 Grass/Weed and Foreign Matter Removal

All foreign matter such as grass/weeds, loose stones/spalls and soil should be removed from pavement and shoulders on a regular basis. A weed eradication program should be undertaken as required, but not less than annually in all pavement areas to reduce/eliminate infestations.

7.13 Surface Irregularities

CASA MoS 139 (2012) Chapter 10.15.4. notes that aerodrome operators must maintain the surface of paved runways in a condition such as to preclude excessive bouncing, pitching, vibration or other difficulties with control of aircraft and further notes that paved runway surfaces should be maintained so that standing water is neither formed nor retained. Birdbath depressions should be repaired at the earliest opportunity.

CASA MoS 139 (2012) Chapter 6.2.9.1 also provides limits of surface regularity on runways and notes "the finish of the surface of a runway should be such that, when tested with a 3m straight-edge placed anywhere on the surface, there is no deviation greater than 3mm between the bottom of the straight-edge and the surface of the runway pavement anywhere along the straight-edge".

The "ride quality" of a pavement can be measured by use of National Association of Australian State Road Authorities (NAASRA) testing to determine a NAASRA Index or International Ride Index (IRI). This is the roughness index most commonly obtained from measured longitudinal pavement profiles. It is calculated using a quarter-car vehicle math model, whose response is accumulated to yield a roughness index with units of slope (in/mi, m/km, etc).

7.14 Ground Penetrating Radar (GPR)

Ground Penetrating Radar (GPR) can be used to detect voids under a pavement; the boundaries between layers of material (if the properties of the materials are substantially different); the presence of discrete elements such as pipes or ducts and the thickness of asphalt layers and de-bonding.

It is non-destructive, relatively quick, and cost-effective, but may require calibration against cores taken through the pavement. However results are variable and can be significantly affected by the presence of reinforcement in concrete pavements, the location and depth of engineering services and by varying moisture conditions.

GPR operates by transmitting short pulses of electromagnetic energy into the pavement using an antenna attached to a survey vehicle. These pulses are reflected back to the antenna with an arrival time and amplitude that is related to the location and nature of dielectric discontinuities in the materials. The reflected energy is captured and may be displayed on an oscilloscope to form a series of pulses that are referred to as the radar waveform. The waveform contains a record of the properties and thicknesses of the layers within the pavement. The presence of discontinuities in the pavement structure (such as voids and thickness variations) is reflected in the waveform.

Specialist operators are available in Australia to undertake GPR testing.

8. Airfield Pavement Condition Rating System

8.1 Introduction

In order to assist in the improved management and monitoring of airfield pavement conditions throughout Australia, a simple visual Airfield Pavement Condition Rating System (APCRS) has been developed and its use has been trialled by Beca Consultants Pty Ltd in late 2011 and during 2012 as part of the annual airfield pavement inspection programmes.

Ten (10) condition ratings on a scale of 10 ("Very Good") to 1 ("Failed") have been developed for asphalt, concrete and ICBP pavements and descriptions of the ratings can be found in Tables 8.2 to 8.4.

At the time of the annual inspection, it is intended that for each discrete element of the airfield, the Inspection Team use the guidance of the APRCS coupled with their engineering judgement to determine a condition rating. Following feedback from the Inspection Teams on the use of the APCRS, the ratings and their descriptions will be reviewed and updated for inclusion in later versions of this Manual.

The APCRS is intended to be use by experienced airfield pavement engineers to provide a relative condition rating of each airfield element. The rating of each airfield element is not intended to take any significant amount of (or extra) time (or cost) in determining the relative condition and it is not intended to replace the ASTM D5340-11 Pavement Condition Index (PCI) system (which produces more consistent results but takes significantly longer to collect field data and assess condition via MicroPAVER) or the US FAA PASER system.

It is intended with time, that the APCRS will form part of the Airfield Pavement Management System (APMS) and be used at each airfield as part of a standard report to monitor the condition of the pavements in an attempt to better predict deterioration rates and to assist in determining the timing of major maintenance treatments.

Table 8.1 below provides some preliminary guidance on intervention levels for major airfield maintenance.

Table 8.1 – Recommended Intervention Levels for Major Airfield Maintenance

Airfield Element	Main Operating Bases	Major Airfields	Minor Airfields
	Amberley, Williamtown, Darwin, Townsville, Pearce, Richmond and, Edinburgh	Woomera, Oakey, Albatross, Curtin, Scherger, Learmonth, , Holsworthy and Gin Gin	Mt Bundey, Samuel Hill, Williamson, Wyoming, Stirling, Jervis Bay, Robertson Barracks
	Condition Rating Intervention Level		
Main Runway	6.5	6.0	4.5
Secondary Runway	5.5	5.0	4.0
Primary Taxiways	5.5	5.0	4.0
Supporting Taxiways	5.0	4.5	4.0
Main Aprons	5.5	5.0	4.0
Support Aprons	5.0	4.5	3.5

8.2 Visual Condition Rating System

Table 8.2 to 8.4 below provide details on the visual surface rating condition for asphalt surfaced pavements (Table 8.2), concrete pavements (Table 8.3) and ICBP surfaced pavements (Table 8.4).

Table 8.2 – Asphalt Pavements – Visual Condition Rating System

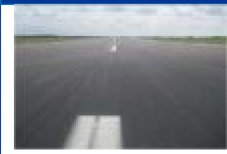
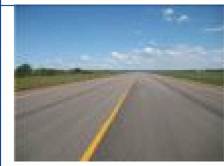
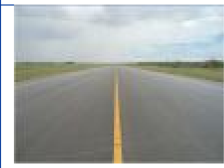
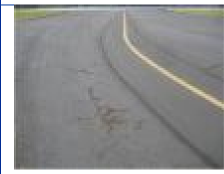
Asphalt Pavement Rating	Condition/Visible Distress	Maintenance Treatments	Photograph
10 – Very Good	Few visible defects - new pavement	None Minor maintenance only – very localised RBB and PME surface treatment only	
9 – Good to Very Good	Few visible defects	Minor maintenance only – very localised RBB and PME surface treatment only	
8 - Good	No surface deformation Minimal longitudinal and transverse cracking Some open longitudinal joints Some localised open coarse areas.	Minor maintenance only – localised RBB and PME surface treatment.	
7 – Good to Fair to Good	Very early signs of surface deformation (with bleed spots) Minimal longitudinal and transverse cracking Some open longitudinal joints Some localised open coarse areas.	Monitor surface deformation RBB treatment to open joints and cracks PME surface treatment to coarse areas	
6 – Fair to Good	Early signs of surface deformation (with bleed spots) (less than 5% of total area in wheel-paths) Longitudinal and transverse cracking (less than 5% of total length) Some alligator cracking (less than 5% of total area) Over 25% open longitudinal joints Localised open coarse areas (less than 10% of total area).	Localised asphalt patch repairs to areas of deformation and alligator cracking RBB treatment to open joints and cracks PME surface treatment to coarse areas	
5 - Fair	Early signs of surface deformation less than 10mm (with bleed spots) (less than 5% of total area in wheel-paths) Longitudinal and transverse cracking (less than 10% of total length) Some alligator cracking (less than 5% of total area) Over 50% open longitudinal joints Localised open coarse areas (less than 25% of total area).	Major asphalt patch repairs to areas of deformation and alligator cracking Extensive RBB treatment to open joints and cracks Numerous PME surface treatment to coarse areas Monitor condition – overlay likely in the next two to five years.	
4 – Poor to Fair	Surface deformation evident less than 20mm (with bleed spots) (less than 15% of total area in wheel-paths) Longitudinal and transverse cracking (less than 25% of total length) Some alligator cracking (less than 10% of total area) Between 50% and 75% open longitudinal joints Localised open coarse areas (more than 50% of total area)	Potential FOD Risk Numerous asphalt patch repairs to areas of deformation and alligator cracking Extensive RBB treatment to open joints and cracks Widespread PME surface treatment to coarse areas. Monitor condition – overlay likely within the next one to two years.	
3 - Poor	Surface deformation evident less than 25mm (with bleed spots) (less than 25% of total area in wheel-paths) Longitudinal and transverse cracking (less than 50% of total length) Some alligator cracking (less than 10% of total area) Over 75% open longitudinal joints Localised open coarse areas (more than 50% of total area)	Likely FOD risk Major asphalt patch repairs to areas of deformation and alligator cracking Extensive RBB treatment to open joints and cracks Widespread PME surface treatment to coarse areas. Overlay entire area	
2 – Very Poor	Surface deformation (and rutting) greater than 25mm under a 1.2m straightedge (less 25% of total area in wheel-paths) Cracking with ravelling Significant alligator cracking (between 10% and 25% of total area) with pot holes Over 75%% open longitudinal joints Localised open coarse areas (more than 50% of total area) Loose material evident on the surface	FOD risk Pavement may limit safe aircraft operations Reconstruction likely to be required in the near future.	
1 – Failed	Surface deformation (and rutting) greater than 25mm under a 1.2m straightedge (more than 25% of total area in wheel-paths) Widespread cracking with ravelling Significant alligator cracking (more than 25% of total area) with pot holes Over 75% open longitudinal joints Localised open coarse areas (more than 50% of total area) Loose material evident on the surface	FOD risk Pavement may limit safe aircraft operations Reconstruction required.	

Table 8.3 – Concrete Pavements – Visual Condition Rating System

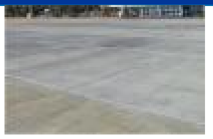
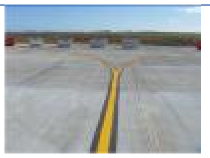
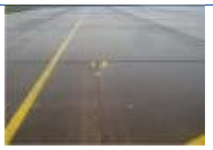
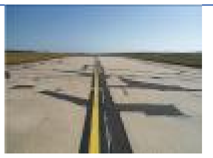
Concrete Pavement Rating	Condition/Visible Distress	Maintenance Treatments	Photographs
10 – Very Good	Few visible defects - new pavement	None Monitor condition	
9 – Good to Very Good	Few visible defects	Minor maintenance only – very localised RBB and PME surface treatment only	
8 - Good	Minor slab cracking (less than 1mm wide) Minor crack or joint spalling Minor loss/lack of adhesion of joint sealing (less than 5% of total length) Few pock marks Good brush texture (greater than 1mm) No scaling evident. No faulting	Monitor cracks (or consider RBB holding treatment) Localised removal and resealing of joint sealant Monitor pock marks Monitor scaling and faulting	
7 – Good to Fair to Good	Cracking (less than 3mm wide) in less than 5% of slabs Crack or joint spalling (between 5% and 10% of joint/crack length) Minor loss/lack of adhesion of joint sealing (less than 10% of total length) Few pock marks Fine brush texture (less than 1mm texture depth) Some minor scaling evident. Some minor faulting evident	Monitor cracks (or consider RBB holding treatment) Localised removal and resealing of joint sealant Monitor pock marks Monitor scaling and faulting	
6 – Fair to Good	Cracking (less than 3mm wide) in less than 5% of slabs Crack or joint spalling (less than 10% of joint/crack length) Minor loss/lack of adhesion of joint sealing (less than 10% of total length) Few pock marks Fine brush texture (less than 1mm texture depth) Some minor scaling evident. Some minor faulting evident	Monitor cracks (or consider RBB holding treatment) Localised removal and resealing of joint sealant Monitor pock marks Monitor scaling and faulting	
5 - Fair	Cracking (less than 3mm wide) in less than 10% of slabs Crack or joint spalling (less than 15% of joint/crack length) Minor loss/lack of adhesion of joint sealing (less than 15% of total length) Few pock marks. Fine brush texture (less than 1mm texture depth) Some scaling evident. Some faulting evident (less than 10mm)	Rout and seal cracks. Undertake crack and joint spall repairs with SRE(S) Localised removal and resealing of joint sealant Monitor pock marks (or consider infill with RBB or SRE(S)) Monitor scaling and faulting. Localised slab replacements	
4 – Poor to Fair	Slab cracking (more than 3mm wide) (evident in more than 10% of slabs) Crack or joint spalling (more than 25% of joint/crack length) Loss/lack of adhesion of joint sealing (more than 25% of total length) Extensive pock marks. Fine brush texture (less than 0.5mm texture depth) (in over 25% of slabs) Scaling evident Faulting evident (less than 10mm) in over 5% of slabs. Faulting evident (greater than 10mm)	Potential FOD Risk.. Rout and seal cracks Undertake crack and joint spalls with SRE(S) Undertake larger crack and spall repairs with asphalt patching (and PME surface treatment). Major removal and resealing of joint sealant Fill pock marks with RBB or SRE(S). Rectify scaling and faulting. Localised slab replacements	
3 - Poor	Slab cracking (more than 3mm wide) (evident in more than 25% of slabs) Crack or joint spalling (more than 25% of joint/crack length) Loss/lack of adhesion of joint sealing (more than 25% of total length) Extensive pock marks Fine brush texture (less than 1mm texture depth) (in over 25% of slabs) Scaling evident. Faulting evident (greater than 10mm) in over 5% of slabs	FOD risk. Rout and seal cracks Undertake crack and joint spalls with SRE(S) Undertake larger crack and spall repairs with asphalt patching (and PME surface treatment). Major removal and resealing of joint sealant Fill pock marks with RBB or SRE(S) Rectify scaling and faulting. Extensive localised slab replacements	
2 – Very Poor	Slab cracking (more than 3mm wide) (evident in between 25% and 50% of slabs) Crack or joint spalling (more than 25% of joint/crack length) Loss/lack of adhesion of joint sealing (more than 25% of total length) Extensive pock marks Fine brush texture (less than 0.5mm texture depth) (in between 25% and 50% of slabs) Scaling evident. Faulting evident (greater than 10mm) in less than 10% of slabs	FOD risk Pavement may limit safe aircraft operations Reconstruction likely to be required in the near future.	
1 – Failed	Slab cracking (more than 3mm wide) (evident in more than 50% of slabs) Crack or joint spalling (more than 25% of joint/crack length) Loss/lack of adhesion of joint sealing (more than 25% of total length) Extensive pock marks Fine brush texture (less than 0.5mm texture depth) (in over 50% of slabs). Scaling evident Faulting evident (less than 10mm) in over 15% of slabs. Faulting evident (greater than 10mm) in over 10% of slabs	FOD risk Pavement may limit safe aircraft operations Reconstruction required.	

Table 8.4 – ICBP Pavements – Visual Condition Rating System

ICBP Pavement Rating	Condition/Visible Distress	Maintenance Treatments	Photograph
10 – Very Good	Few visible defects - new pavement	None Monitor condition	
9 – Good to Very Good	Few visible defects	Monitor condition	
8 - Good	Occasional cracked or chipped block Minor lipping (less than 5mm) Minor loss of sand (less than 5% of total area loss) Minor surface deformations (less than 5mm)	Monitor condition Localised re-sanding and resealing of joints	
7 – Good to Fair to Good	Occasional cracked or chipped block Minor lipping (less than 5mm) Minor loss of sand (between 10% and 25% of total area loss) Minor surface deformations (less than 5mm)	Monitor condition Localised re-sanding and resealing of joints	
6 – Fair to Good	Occasional cracked or chipped block Minor lipping (less than 5mm) Minor loss of sand (between 10% and 25% of total area loss) Minor surface deformations (less than 5mm)	Monitor condition Localised re-sanding and resealing of joints	
5 - Fair	Occasional cracked or chipped block Minor lipping (less than 5mm) Loss of sand (less than 25% of total area loss) Localised surface deformations (less than 10mm)	Replace localised cracked blocks Re-sanding and resealing of joints Monitor surface depressions	
4 – Poor to Fair	Cracked or chipped blocks (less than 5% of total blocks) Lipping (greater than 5mm) Loss of sand (more than 25% of total area loss) Localised surface deformations (less than 10mm)	Potential FOD Risk Replace areas of cracked and lipping blocks Localised Re-sanding and resealing of joints Replace localised areas of high surface deformation	
3 - Poor	Cracked or chipped blocks (more than 10% of total blocks) Lipping (greater than 5mm) Loss of sand (more than 25% of total area loss) Localised surface deformations (more than 10mm)	Likely FOD risk Replace areas of cracked and lipping blocks Extensive Re-sanding and resealing of joints Replace areas of high surface deformation	
2 – Very Poor	Cracked or chipped blocks (more than 25% of total blocks) Lipping (greater than 10 to 15mm) Loss of sand (more than 25% and less than 50% of total area loss) Localised surface deformations (more than 10mm and less than 25mm)	FOD risk Pavement may limit safe aircraft operations Reconstruction likely to be required in the near future.	Not available
1 – Failed	Cracked or chipped block (more than 25% of total blocks) Lipping (greater than 15mm) Loss of sand (more than 50% of total area loss) Localised surface deformations (more than 25mm)	FOD risk Pavement may limit safe aircraft operations Reconstruction required.	Not available

9. Airfield Pavement Inspection and Reporting

9.1 Purpose

The ability to identify the aging signs of an airfield pavement is quite a specialised skill and this skill is not available at every Defence airfield location in Australia. The responsibility for the monitoring of Defence's airfield pavement's condition rests with the Directorate of Estate Engineering Policy (DEEP). DEEP along with its specialist airfield pavement consultants, inspect each of Defence's major airfields on an annual basis and smaller airfields on a less frequent basis (two (2) to three (3) years).

These inspections are visual only and not only report on the condition of the airfield pavements but they make recommendations on the type and extent of repair and maintenance works that are required in order to maximise pavement life. The Pavement Inspection Reports (PIRs) deliberately do not attempt to provide a specification for each maintenance recommendation. Minor maintenance work can be performed using the techniques and products recommended in Section 13. Larger maintenance works will require a separate specification to be developed by airfield pavement consultants once the works are identified in the Directorate National Airfields Projects (DNAP) maintenance program.

9.2 Airfield Pavement Inspection Procedures

These inspections of the pavement condition usually take between one and two days per airfield (at larger joint user bases such as RAAF Base Darwin, and dependent on weather conditions this can take up to three (3) days) and involve recording and describing the following:

(a) Photographs of typical defects found;

(b) Photographs of specific defects found;

(c) Photographs of typical condition(s);

(d) Assessment of transverse shape;

(e) Assessment of drainage adequacy;

(f) Surface integrity and FOD potential;

(g) Condition of concrete slabs and joints:

(h) Condition of asphalt pavements and joints

(i) Condition of ICBP;

(j) Presence of weeds growing through cracks;

(k) Pavement markings;

(l) Condition of ancillary equipment:

- Interface of cable arresters with pavement;
- Integrity of airfield ground lighting cables cut into pavement surface;
- Aircraft tie-down points; and
- Physical condition of earthing points (electrical resistance checks are conducted by others);

(m) Condition of RESA, stop ways and clearways;

(n) Condition of stabilised, graded and vegetated horizontal areas of flight strip including edge drop offs and surface scour.

(o) Assessment of pavement ride quality;

(p) Visual assessment of runway rubber build-up;

(q) Overall condition rating of each element of the airfield as per the detailed pavement condition rating criteria– refer to Section 8 (Airfield Pavement Condition Rating System); and

(r) Comparison of condition with respect to the previous works and maintenance works that have occurred

Prior to the inspection being undertaken a stakeholder briefing takes place between DEEP personnel, NAMP personnel, the Design Consultant , the regional personnel responsible for maintenance (BSM, BASO, BAEO) and the Senior Air Traffic Control Officer (SATCO). The objective of this briefing is to identify particular existing areas of concern and known defects.

Immediately following the inspection, DEEP personnel debrief the regional personnel responsible for maintenance and the SATCO on any issues that require immediate attention to maintain aircraft operational safety. The debriefing also provides these personnel with an overall indication of the pavement's condition and some insight into how the pavement has performed since the last inspection.

Within five (5) days of the inspection, the Design Consultant will produce an Exit Report highlighting the key findings of the inspections and any defects requiring immediate attention by the base.

Upon completion of the inspections a Pavement Inspection Report (PIR) is produced which summarises the findings of the inspection, recommends future maintenance works (including a proposed program/timeframe and indicative cost) and reconfirms scheduled maintenance works. Upon receipt of the report the regional office is required to undertake the works recommended for immediate attention and to submit bids for funding of those works recommended for completion in the next financial year.

Some of Defence's airfields (e.g. RAAF Bases Darwin, Townsville and Williamtown) are jointly used and funded by civilian aviation organisations. In order to ensure the civilian organisations are financing their use of the airfield facilities, Joint User Agreements have been developed between Defence and the non-Defence users of the airfield. These agreements contain mathematical models that are used to determine what portion of the maintenance costs the non-Defence organisation should finance. In order to avoid disagreement with respect to the extent and cost of maintenance works required to be undertaken at a joint user airfield, it is beneficial to have the non-Defence users participate in the biennial inspection process. This participation includes agreeing on the nominated specialist pavement consultant who will undertake the inspection; providing a representative on the inspection party itself; and even working with Defence to agree on the products to be used in the repair process and the timeframes in which the works can be undertaken.

The following provides a general step by step guide on the rectification process for defects based on particular defect severity and airfield operation risk levels. The process below aims to categorise the risk and potential consequence of specific defects on the airfield. This is distinct from the APCRS (as set out in Section 8) which is a higher level tool that asses the overall condition of wider areas of pavement often comprising numerous types of defects at varying severity levels.

General Aircraft Pavement Maintenance Risk Assessment Process

Step 1

CONSEQUENCE : IMPACT ON AIRFIELD OPERATIONS		
1	Catastrophic	Operations unavailable. Alternatives not available
2	Major	Operations potentially unavailable. Alternatives not available
3	Moderate	Operations disrupted, however alternative pavements (movement areas) are available
4	Minor	Operations potentially disrupted, however alternative pavements (movement areas) are available
5	Insignificant	No potential impact on operations

When assessing impact on airfield operations, consider:

- Type of operations – Airfield specific, eg Defence operations, Defence exercises, Defence pilot training, joint user operations etc;
- Rate of operations – Airfield specific, eg daily RPT operations, frequent use during Defence exercises, flying training etc;
- Location of defect – eg operational runway, taxiway, apron, runway end safety area, engine run-up bay, OLA etc; and
- Access to alternatives – eg apron defect with alternative parking position available, one of two taxiways to a parking apron etc.

⇩

Step 2

LIKELIHOOD : FREQUENCY OF IMPACTED AIRFIELD OPERATIONS		
A	Almost Certain	Airfield operations are impacted or potentially impacted continuously
B	Likely	Airfield operations are impacted or potentially impacted monthly to several times per year
C	Possible	Airfield operations are impacted or potentially impacted once every year or two
D	Unlikely	Airfield operations are impacted or potentially impacted once over an extended timeframe (e.g. two (2) to five (5) years)
E	Rare	Airfield operations are impacted or potentially impacted only in exceptional circumstances (e.g. five (5) plus year event)

⇩

Step 3

RISK MATRIX		CONSEQUENCE				
		1. Catastrophic	2. Major	3. Moderate	4. Minor	5. Insignificant
LIKELIHOOD	A. Almost Certain	Extreme	Extreme	High	Medium	Low
	B. Likely	Extreme	High	High	Medium	Low
	C. Possible	Extreme	High	Medium	Medium	Low
	D. Unlikely	High	High	Medium	Low	Low
	E. Rare	High	Medium	Medium	Low	Low

Step 4

For details on the APCRS refer to Section 8.

ASSESSMENT		RECOMMENDATION	
Assessment Method 1 – Risk Matrix	Assessment Method 2 – Defect Level	Urgency of Repair	Action
Extreme	APMM severity level 'high' (APCRS 1 to 2)	Immediate	Immediate regional repair required (or DNAP repair if current project delivery on-site). Consider closing pavement to aircraft until repairs complete.
High	APMM severity level 'medium' with likely FOD from defect (APCRS 3 to 4)	Immediate to three (3) months	Urgent regional repair (or DNAP repair if current project delivery on-site). Minimise trafficking and risk manage any use of pavement by aircraft until repairs complete.
Medium	APMM severity level 'medium' with unlikely FOD from defect (APCRS 5 to 7)	Less than two (2) years	Repair during next DNAP works package (generally delivered within 12 to 24 months)
Low	APMM severity level 'low' (APCRS 8 to 10)	Greater than two (2) years	Forecast into 10 year DNAP works program. Consider regular local monitoring and conduct technical re-evaluation during next biennial pavement inspection.

9.3 Airfield Pavement Inspection Reports

Refer to Appendix C for details on the Defence Airfield Pavement Inspection Report process.

9.4 Airfield Surface Texture Depth

9.4.1 Surface Texture Depth Requirements

Adequate surface texture depth (both macro texture and micro texture) is required on airfield pavements

The macro texture is normally achieved by grooving the surface (in the case of asphalt pavements), brooming (or brushing) or grooving the surface (in the case of concrete). The micro texture is normally achieved through specification of an asphalt mix with a specific grading and maximum aggregate size with requirements on the type, strength and shape of the aggregates (and in some specifications, including a limit on Polished Stone Value (PSV) – typically a minimum of 52). The macro and micro texture of an asphalt and concrete surfaces can wear with aircraft traffic and climatic and environmental effects.

CASA MoS 139 (2012) Chapter 6.2.9.1 requires that "the surface of a bitumen seal, asphalt or concrete runway must not have irregularities that would result in the loss of frictional characteristics or otherwise adversely affect the take-off or landing of an aircraft).

Similar to ICAO standards, CASA MoS 139 (2012) recommends a minimum average surface texture depth of the runway to be 1.00mm (Chapter 6.2.9.1A) and that minimum runway slopes are recommended to prevent the accumulation of water (Chapter 6.2.8).

The texture depth of an airfield pavement surface is typically measured using the sand patch test as described in Section 9.4.2 below.

9.4.2 Sand Patch Test

Sand patching testing is undertaken to determine the texture depth of a pavement surface in accordance with Austroads AG:PT/T250 (or to BS598 Part 105).

The surface texture of a pavement or runway is important for the safety aspect of the running surface. A good surface texture is necessary at high vehicle speeds to facilitate rapid drainage of water from the surface and to utilize the tyre tread rubber to absorb some of the kinetic energy of the vehicle.

Sand Patch Test

Typical texture depths measured by the sand patch method for AC14 airfield mixes varies from 0.4 to 0.6mm and for AC20 airfield mixes these are typically higher. Grooved asphalt texture depths are typically in excess of 1mm (ie meeting the requirements of CASA MoS139 Chapter 6.2.9).

Spray/Chip sealed surfaces typically have texture depths in excess of 1mm.

Slurry sealed surfaces typically have texture depths in excess of 1mm.

Concrete surfaces are typically have texture depths between 0.7 and 1.5mm.

9.5 British Pendulum Swing Test

The resistance of wet pavement surfaces to skidding can be checked by means of a Portable Skid-resistance Tester (Portable Pendulum Tester). This apparatus was developed at the UK Road Research Laboratory is used to measure the frictional resistance between a rubber slider (mounted on the end of a pendulum arm) and the road surface. This method provides a measure of frictional property, microtexture of surfaces, either in the filed or in the laboratory. The quantity measured with the portable tester has been termed "skid-resistance" and this correlates with the performance of a vehicle with patterned types braking with locked wheels on a wet road at 50 km/h.

The test is undertaken to AS/NZS 4663 (2004) (both BS7976 and NSW RTA Test Method T130.2) to measure the British Pendulum Number (BPN) (and in turn, an approximate Coefficient of Friction).

Since 2011, Defence having been using the British Pendulum Swing Test to measure the relative BPN before and after application of PME surface treatments on a number of runways and taxiways.

British Pendulum Swing Test

10. Flexible Pavement Repairs

10.1 Introduction

Flexible pavements typically have a functional life in the order of 12 to 15 years between major maintenance treatments, the actual interval depends largely on the environmental conditions, with bituminous surfaced pavements ageing faster in hot climates.

In between the cyclic resurfacings, repairs will be required to rectify defects observed during pavement inspections. It is likely that some form of mid-life surface treatment with a PME application will be required.

Operational considerations are a primary factor in the decision to carry out repairs or maintenance works of any kind, but the interval between major maintenance events is usually extended if defects are promptly repaired.

In deciding whether to repair defects at any particular time, it is necessary to consider:

(a) The cause extent and severity of the defects;

(b) The location of the defect;

(c) Whether the defect represents an operational hazard or a potential operational hazard;

(d) Airfield operational issues (particularly if closures are involved);

(e) The observed rate of development of the defect; and

(f) The age of the pavement and the period until the next programmed maintenance.

In many circumstances, the early treatment of a minor defect may save costs in subsequent remedial treatment.

Load associated pavement distress (e.g. rutting, pumping, potholes etc), whether localised or widespread, indicate a pavement weakness. Surface distress (e.g. fretting, spalling, surface erosion, stripping of seal aggregate, faulting, etc) is usually an immediate operational concern compared to load associated distress which occurs over time. Cracking which can be either load associated or surface distress, will invariably increase the exposure of the subgrade and pavement layers to moisture and may eventually affect pavement strength, hence why even if not an immediate operational concern, it still needs to be addressed in a timely manner

10.2 Cracks

10.2.1 Objective

The objective of repairing cracks is to:

- Prevent the propagation and/or widening of cracks and spalling and subsequent development of FOD risk;
- Prevent the propagation and/or widening of cracks, potentially leading to structural degradation of the pavement; and
- Prevent the ingress of moisture, potentially leading to saturation of the base course and softening of the underlying layers and/or subgrade.

Repair Methods

Cracks in flexible pavements should be sealed with either hot bitumen (i.e. rubberised or PMB) applied on or into the crack. The surface of the bitumen sealant may require a light covering of sand to prevent adhesion to aircraft or vehicle tyres.

The procedure to be used for crack sealing will vary depending on the extent of cracking (length) and size (width) of the cracks, ease of access to the pavement area, the time available, availability of skilled personnel, and the availability of sealants.

Before filling and sealing cracks, all foreign matter such as grass or weeds, loose stones or spalls and soil should be removed. A weed eradication program should be undertaken as required (but not less than annually) on all pavement areas to reduce/eliminate infestations. If possible, a water based chemical should be used as a petroleum/solvent based herbicide may cause bonding problems between the crack sealant and the existing pavement or promote surface deterioration if incorrectly applied. Weed eradication should precede the crack repairs by at least three (3) weeks.

Rubberised bitumen bandage (RBB) treatments should not be used on pavements to be used for helicopter run-on landing training. This is due to the potential for the repair to be damaged by skids and for the material to become loose and constitute a FOD problem. The use of rubberised bitumen bandage may also cause differential friction on the skids which is potentially a safety hazard.

Additionally, consideration needs to be given to the appropriateness of using rubberised bitumen bandage treatments in runway TDZs, because the bandaging may be damaged by the rubber removal process. There have been cases in which the bandaging material has become loose and has created a FOD problem. There have been some reported incidents of RBB remaining tacky for some hours after application and potentially being prone to either aircraft tyre imprints and in extreme cases aircraft tyre pick up.

Refer to Section 13 for a list of airfield pavement maintenance products.

10.2.2 Low Severity Cracks

Description

Low severity cracks are cracks of hairline width or barely visible (typically less than1mm wide) with or without associated spalling, but little or no potential for dislodgement of particles (typically with a spall width less than 25mm).

Example of Low Severity Cracking

Treatment

No repair is required. The crack should be monitored for lengthening and/or widening and/or spalling at the next pavement inspection.

10.2.3 Medium Severity Cracks

Description

Medium severity cracks are cracks of a width clearly indicating the potential for further movement (typically 1mm to 5mm wide) and/or spalling with a potential for material to become dislodged after further trafficking and create a FOD problem (typically spall width 25mm to 50mm).

Treatment – Rubberised Bitumen Banding (RBB)

Before commencing, the crack should be visually inspected and both ends located. All loose particles should be removed from within the crack, the surface should be dried, cleaned, and made free of contaminants such as oils, dust, loose or unbound pavement material, old sealant or any other material which may adversely affect the bonding of new sealant or the performance of the repair, prior to conducting the repair.

Specialist sub-contractors usually carry out these applications due to the need to use customised equipment. Prior to the application of the approved over banding material, the crack should be filled with dry sand to 10mm below the surface of the pavement. The surface of the prepared pavement should be primed 25mm to 50mm either side of the crack/spalls using approved material (usually required by the repair material manufacturer's instructions). The approved repair material should be applied to the pavement surface at a constant width (ensuring crack/spalls are covered to a total width of 25mm to 50mm) and thickness (1mm to 3mm) along the length of the crack, ensuring all affected areas of the crack (including spalls) are covered by the repair material. Care should be taken to ensure that no material is splashed onto the adjacent pavement.

Rubberised bitumen (hot) could be used to seal fine cracks in joints (the paving lane joints in asphalt) or reflected slab joints, in which case a narrow (50mm to 75mm) wide bandage should be applied. It is difficult to apply a bead of sealant effectively to fine cracks.

The freshly placed repair material should be covered with clean washed sand, stone dust, hydrated lime, Portland cement or any other approved material to ensure that the repair material is tack free (hours to days) and will not be picked up by aircraft tyres.

After completion of the over banding, the works site must be thoroughly cleaned, and all slurry, dust, particles, excavated pavement material, tools and excess repair material must be collected and removed.

10.2.4 High Severity Cracks

Description

High severity cracks are cracks of a width likely to allow water penetration (typically greater than 5mm wide) and/or spalling with a high potential for material to become dislodged after further trafficking and create a FOD problem (typically with a spall width greater than 50mm).

Example of High Severity Cracking

Treatment - Rubberised Bitumen Banding (RBB)

Before commencing treatment, the crack should be visually inspected and both ends located. All loose particles should be removed from within the crack. The surface should be dry and clean, and free of contaminants such as oils, dust, loose or unbound pavement material, old sealant or any other material which may adversely affect the bonding of new sealant or the performance of the repair. The cracks ideally should be dried with a hot air lance.

Wide cracks can be those that have not been sealed for some time, shrinkage and reflection cracks (usually occur in dry weather) and slippage cracks. All of these types of cracks can have curled edges which should only be sealed with rubberised bitumen after rolling to flatten the curled edge as this process usually breaks the edge, and thorough cleaning. This is necessary to encapsulate any broken, yet stable fragments/spalls.

To ensure that no voids exist in the crack, it may be necessary to choke the crack with dry sand or a bead or rope like plug of repair material (to approximately 10mm below the surface) prior to the application of the rubberised bitumen bandage.

The surface of the prepared pavement should be primed 25mm to 50mm either side of the crack/spalls using approved material if required by the repair material manufacturer's instructions. The approved repair material should be applied to the pavement surface at a constant width (ensuring crack/spalls are covered to a minimum 15mm to 25mm either side of the crack) and thickness (1mm to 3mm) along the length of the crack, ensuring all affected areas of the crack (including spalls) are covered by the repair material. Care should be taken to ensure that no material is splashed onto the adjacent pavement.

Rubberised bitumen bandage treatments should be wide enough to cover edge spalling and any secondary cracks, but should not generally be more than 75mm wide. Care should be taken to neatly apply the rubberised bitumen bandage and achieve consistent thickness (2mm to 3mm) – the use of a "shoe" to help control placement should be encouraged.

Examples of Poor Rubberised Bitumen Banding

10.2.5 Slippage Cracks

Description

Slippage cracks are half-moon or crescent shaped cracks, commonly associated with the slippage and deformation of the wearing course under horizontal wheel loads (braking and/or turning of aircraft). Cracks occur in a closely spaced parallel group, confined within the slipped asphalt layer.

Treatment

Immediate treatment of slippage cracks is desirable to avoid spalling and a potential FOD problem. Since slippage cracking nearly always occurs in the surface layer of multiple layers of asphalt, it is unlikely that water ingress will significantly affect the pavement strength. Water entering the slippage cracks acts as a lubricant at the interface and aids in the de-bonding process.

Cutback bitumen should not be used to seal slippage cracks (even temporarily) as it will also act as a lubricant and promote further de-bonding. If the slippage cracking cannot be repaired by patching within a short time (days), the cracks may be sealed temporarily using bitumen emulsion and sand (apply the sand in the cracks prior to the sealant) as described above in Section 10.2.3. While this type of repair is only temporary, it can effectively prevent further slippage and spalling for some time (months) before patching is required. However, the temporary repair should be monitored regularly.

Patching of the slipped area of surfacing using hot asphalt is the only permanent repair that is appropriate. Rigorous attention to the patching technique is necessary (i.e. thorough cleaning and texturing of the underlying asphalt surface/slippage plane) and adequate tack coating to prevent a recurrence of the distress.

The slipped area of asphalt should be excavated using a jack hammer taking care to ensure that the full extent of the de-bonded layer is removed, as de-bonding can extend a significant distance beyond the area of visible cracking. The interface should be thoroughly cleaned and scabbled with a spade bit on the jack hammer to produce an irregular pattern of indentations approximately 10mm deep. Tack coat should be applied to the prepared area using neat bitumen emulsion so as to just fully coat the surface and edges of the excavation. Depending on the proposed thickness of asphalt to be placed, timber guides should be placed of appropriate thickness on the existing asphalt to allow for the compaction surcharge and screed off.

Hot asphalt should then be placed by hand (or paver) to match the level of the timber guides or the surrounding pavement surface (as appropriate). The asphalt should then be thoroughly compacted. If the asphalt is placed by hand, a timber straightedge should be used to screed the loose asphalt prior to compaction to avoid building a hump. The asphalt patch may require the edges to be sealed with RBB to ensure waterproofing. If the surface of the asphalt patch is open or coarse it should be treated with an application of PME.

10.2.6 Reflection Cracks

Description

Reflection cracks are caused by movement at joints or cracks in the underlying concrete slab, cement stabilised layer or previous asphalt surface.

Examples of Severe Reflection Cracking in Asphalt Pavements

Treatment

Reflection cracks in asphalt overlays on concrete pavements are common and the most difficult type of reflection crack to treat. However, reflection cracks also occur from significant cracking (usually wide and often on construction joints) in underlying asphalt surfaces. It is not possible to entirely prevent reflection cracking, but various techniques can be used to retard the inevitable appearance of the cracks in the surface of the pavement.

Thick layers of asphalt have been shown to be the most effective means of retarding the reflection of underlying slab joints and cracks. The common rule-of-thumb for reflective cracks propagating through asphalt of "one inch thickness per year" generally only applies to thicker overlays (about 100mm to 150mm) and thicknesses of 50mm or less can be expected to exhibit reflection of the underlying cracks within about a year.

Due to restraints on the practical thickness of overlays because of abutting pavements, surface gradients, drainage structures, buildings, cost etc, other methods of retarding reflection cracks have been developed:

- Rubberised Bitumen
  Polymer Modified Bitumen (PMB) containing an SBS (Styrene-Butadiene-Styrene) type polymer can be used as the binder in the asphalt overlay to provide it with some elasticity, normally not present in conventional asphalt.

- Membrane Interlayers
  Rubberised/PMB membranes such as a SAMI applied as a sprayed seal between the old pavement and the overlay can be effective if the whole pavement area is treated. The interlayer provides a slip layer that distributes the stresses from the cracks/joints.

- Geofabrics
  These are essentially a reservoir for bitumen and permit a higher application of membrane interlay without bleeding.

- Reinforcing Grids
  Grids consist of polymer (or glass fibre) materials in the form of moulded or woven meshes, and can be stiff or flexible, installed either loose or tensioned. The purpose of the grid is to act in a similar manner to reinforcing steel in concrete, and they predominantly hold the reflected cracks together.

- Strip Treatments
  These are basically either membranes, fabrics or grids (usually self-adhesive) applied as a strip along the cracks/joints in a band approximately 300mm wide. They are less effective than the overall treatment because the stresses from the cracks are transferred to the edges of the strips and often two reflection cracks occur instead of one. Rubberised bitumen over banding is also a strip treatment.

Differential vertical movement in the underlying slabs will generate reflection cracks very rapidly under traffic loadings and none of the above mentioned treatments will be effective. To prevent vertical movement 'rocking' of slabs it will be necessary to either stabilise the support to the slab by injecting a cementitious grout through holes drilled in the slabs, or breaking the slabs up into smaller pieces so they are all fully in contact with the base course.

Elastic joint filler in concrete pavement joints, particularly if wide, will usually result in an instant reflection of the joint under compaction rolling of the asphalt. It will be necessary to remove such jointing material before overlaying. Hemp rope may be inserted in wide joints to provide a firm filler and prevent asphalt entering the joint. The rope should be twisted (to tighten) and stretched when installing to enable easy insertion. Narrow joints do not require filling.

When deciding on a means of retarding reflection cracking it is essential to examine the relative costs of the various treatments and their probable success together with the additional difficulties in application. Further guidance can be found in AAFT P0504 "Techniques for Mitigation of Reflective Cracks" and UK Defence Estates Design and Maintenance Guide 33 "Reflection cracking on airfields – a design guide for assessment, treatment selection and future minimisation".

10.3 Surface Defects

10.3.1 Objective

The objective of repairing surface defects is to:

- Prevent further deterioration of surface defects and subsequent development of FOD;
- Prevent further deterioration of surface defects, potentially leading to structural degradation of the pavement; and
- Prevent the ingress of moisture, potentially leading to saturation of the base course and softening of the underlying layers and/or subgrade.

10.3.2 Repair Methods

Refer to Section 13 for a list of airfield pavement maintenance products.

10.3.2.1 Surface Holding Treatments

A surface holding treatment is a light application of a bituminous material to the wearing course of a pavement for the purpose of retarding erosion of the surface. Erosion is the loss of the surface (top/wearing) layer of aggregate by environmental degradation, embrittlement of the binder, traffic abrasion and/or jet engine efflux. Both asphalt and sprayed seal surfaces may be treated. However, it is of paramount importance to apply these treatments in a timely manner otherwise the optimum performance/benefit will not be obtained.

Visual inspection of the surface of the asphalt is required to assess the texture depth, loss of fine aggregate matrix supporting the coarse aggregate, any loss of coarse aggregate, age hardening of the binder, onset of (fine) age cracking, etc. A simple assessment of texture depth can be made using the sand patch test and a measure of friction can be made using the portable British Pendulum TRL Swing Test apparatus (as noted in Section 9.5). If the holding treatment is applied too early, only a small quantity of residual binder can be incorporated into the surface and the cost-benefit of the treatment will be minimal. On the other hand, if the surface has deteriorated excessively and/or is too old, the treatment may wear/weather off prematurely and will not be cost effective. For optimum results, it is essential to apply a holding treatment when only some of the surface matrix of binder and fine aggregate has been lost, but preferably no coarse aggregate, and before the binder hardens to the stage where age cracking has commenced. The age of the asphalt when these conditions exist will vary depending on the climate, the quality of the initial construction (e.g. compaction, occurrence of segregation), type and quality of bitumen (including method of manufacture), frequency of traffic, frequency of rubber/paint removal, etc.

Surface holding treatments should only be used as an interim measure when operational, budgetary or strategic development considerations preclude a full asphalt overlay.

The light application rate that is generally necessary to allow aircraft to traffic the surface within a minimal period does not allow bitumen to significantly penetrate the existing surface. Accordingly, whilst the surface may be rejuvenated by this light application, the remainder of the depth of the asphalt surface continues to age and become brittle. If left for too long, the embrittled asphalt does not form a suitable substrate for any subsequent resurfacing. In most circumstances, an asphalt surface should be overlaid or removed and replaced within a period of 12 to 15 years.

In general, a surface holding treatment will typically last for about three (3) to five (5) years. A surface holding treatment should be typically applied when the asphalt surface is between five (5) to 8 (eight) years old. Hence, after an interval of five (5) to eight (8) years, if the asphalt surface is exhibiting signs of ageing, the application of a surface holding treatment should be considered.

Multiple applications of surface holding treatments are not deemed appropriate due to the adverse effect this has on surface texture and because depth of penetration is reduced on subsequent applications.

Surface holding treatments are difficult to apply on grooved surfaces because at high application rates, the grooves tend to fill. Any application on grooved surfaces should be trialled, with multiple passes at low rates, and/or brooming (parallel to the grooves) considered.

Sprayed seals commonly suffer from insufficient binder application initially, but insufficient pneumatic tyred rolling at construction and/or over spreading of cover aggregate can result in continual shedding of stone or loss of the entire surface layer. It is very difficult to construct a sprayed seal without some loose aggregate occurring. Sometimes a bitumen emulsion and sand seal is applied at the time of initial construction when it is essential to ensure that no loose aggregate occurs. When a bitumen emulsion and sand seal is applied to a sprayed seal initially or shortly (within five (5) years) after construction, a significant improvement in the life of the seal can be achieved by almost full retention of the cover aggregate.

Holding treatments consist of SESTs, Polymer Modified Emulsion (PME) and Bitumen Emulsion/Sand Seals. Slurry seals are not suitable for airfield pavements as discussed in Section 10.3.2.4 (though they are commonly used on military airfields in Europe – refer to UK Defence Estates Airfield Specification 045). Normally PMEs or SESTs are more applicable to asphalt than sprayed seals and the bitumen emulsion and sand seal is commonly used on sprayed seals. Sometimes a SEST using bitumen emulsion can be appropriate for a sprayed seal (usually un-trafficked or very lightly trafficked) but cutback bitumen is seldom used since the cutter is likely to soften the binder excessively and cause loss of cover aggregate. Bitumen emulsion/sand seals should only be applied to asphalt that has a very coarse texture (usually losing coarse aggregate).

In recent years, the use of PMEs have been favoured over SESTs. This has been due to OHS issues associated with Coal Tar SESTs and also OHS issues around the use of powerful solvents (such as Shell A1 solvent) in cut back SESTs. These powerful solvents often have dangerously low flash points and are governed by strict legislation regarding their storage and handling. SESTs cut back with kerosene can have excessive curing times (often in excess of seven (7) days) meaning they are often impractical for operational aircraft pavements. These issues have led to the development of various emulsion based materials that are being increasingly used in SEST style rejuvenate applications.

Larger sized asphalt mixes can usually accept more residual binder than finer mixes due to a greater surface texture depth.

Example of PME Surface Treatment (Before and After)


PME Application to Chip Seal Surface (Mount Bundey - August 2012) - Aged Asphalt - Pavement Treated with PME

10.3.2.2 Rehabilitation Using a Bitumen Emulsion and Sand Seal

Bitumen emulsions and sand seals are usually applied to spray sealed surfaces that have a deficiency in the original binder application rate or to severely segregated asphalt surfaces. The current trend is towards using proprietary PME products as opposed to emulsions and sand seals. PMEs are essentially a bitumen emulsion with particular mater suspended within the emulsion (i.e. sand particles and fine filler particles) combined with other additives to aid adhesion and longevity.

Bitumen emulsion and sand seal treatments will choke the existing (coarse) surface texture, if applied correctly, and, unlike a slurry seal, will not delaminate. The treatment can be applied to new or old sprayed seals or asphalt.

An outline of the procedure for applying a bitumen emulsion and sand seal is provided below. However, it is stressed that the procedure is **not** suitable for use as a specification. Technical specifications for bitumen emulsion and sand sealing should be prepared by engineers having specialist experience in this type of work.

Initially the pavement should be swept to remove loose aggregate and to wash off any fuel or oil contamination. The full area of the seal should be rolled using a static steel drum roller (approximately 6 tonnes mass) to apply two complete coverages, one in each direction (i.e. longitudinally and transversely). Bitumen emulsion should then be sprayed onto the pavement when it is at or above a temperature of 15°C. The bitumen emulsion may be diluted with up to 20 parts of water. Rapid setting cationic bitumen emulsion is preferred but medium setting cationic and slow setting anionic emulsions have also been successfully used.

Once the bitumen emulsion has started to break (i.e. to turn black on the tops of the stones), clean dry sand should be spread at a rate sufficient to completely cover the bitumen emulsion to a depth of at least 5mm (i.e. such that there is a generous excess). This rate will be approximately 200 m^2 per m^3. The bitumen emulsion should not penetrate the sand.

Immediately following application of the sand, it should be dragged with a dragging mat to even the spread. A drag broom should **not** be used as the bristles may disturb the bitumen emulsion.

Six (6) coverages of a pneumatic tyred roller (loaded to 1 tonne per wheel at 700 kPa tyre pressure) should be applied to incorporate the sand.

Any excess sand should be removed by sweeping when the bitumen emulsion has fully broken, but preferably after curing for approximately 24 hours.

10.3.2.3 Rehabilitation Using SEST (including Rejuvenation) and PMEs

Surface Enrichment Sprayed Treatment (SEST) of airfield pavements surfaced with Dense Graded Asphalt using cutback bitumen has been successfully used in Australia since the mid-1970s as a low cost holding treatment to extend the life of the asphalt (i.e. to defer the inevitable, but more expensive, resurfacing). On some occasions, sprayed seal surfaces have also been successfully treated but this is not common. Cutback bitumen containing nominally 100 parts of Class 320 bitumen and 100 parts of power kerosene, Avtur or similar cutter is preferred. However, mineral turpentine has been used as the cutter instead of kerosene when it was required to reduce the curing time of the SEST.

The low viscosity of the cutback bitumen and the high cutter content (50%) permit the SEST to be readily drawn into the air permeable voids in the asphalt surface (approximately 5mm to 10 mm). Since kerosene is a medium curing cutter, some days are required for all of the cutter to evaporate, although in warm to hot and/or windy weather the exposed surface of the SEST usually becomes substantially cured within 24 hours or less. In cooler climates, the curing period can be significantly longer and the surface is subject to damage from rain resulting in run off (and potentially causing environmental issues).

It is essential to closely inspect the pavement area to be treated prior to undertaking a SEST. An initial general application rate can be selected based on the average surface texture depth of the asphalt. Trials at varying application rates applied to typical areas of the pavement surface must be carried out to refine the application rate prior to full scale application of the SEST.

Application rates for SEST can be as low as 0.15 litres/m^2 of residual bitumen, or up to 0.5 litres/m^2 of residual bitumen on untrafficked areas. Normal application rates vary between 0.25 to 0.35 litres/m^2 of residual bitumen.

The texture depth of the asphalt is not substantially reduced by application of a SEST (provided that sand is not applied). On runways it is desirable to maintain an average texture depth of at least 1mm (using the sand patch test) to ensure good frictional characteristics. In some instances it has been found that SESTs can be slippery for a period of time after application.

A SEST is generally not suitable for open graded asphalt (porous friction courses (PFC)) or grooved dense graded asphalt, but in some instances these pavement surfaces have been treated by this technique with some success.

Cutback bitumen is not considered to rejuvenate (i.e. reinstate the original properties of) the bitumen. It is a preservation type of treatment. Techniques for rejuvenation of aged asphalt surfaces have been available in Australia since the mid-1990s using a Coal Tar Rejuvenator. This material is a miscible mixture of coal tar and tar oils (approximately 40%, although variable within the range 30 to 60%) in highly volatile petroleum solvents (similar to white spirit). The tar constituents cannot dissolve in the solvent because they have a different molecular structure and are dispersed therein in a similar manner to bitumen in an emulsion (water based).

Polymer Modified Emulsion (PME) surface treatments (such as Liquid Road, Jet Black, Carbonyte etc) are more commonly being used on airfields and a number of proprietary products are available. They are typically applied at application rates of 1 to 1.25 litres/m^2.

PMEs are a particularly practical form of rejuvenation treatment as they are water based and cure in a matter of hours making them ideal for aircraft pavements where windows for access are short. Defence have undertaken trial applications of PME used as an “early intervention” on the northern section of Runway 03-21 at HMAS Albatross, to help quantify the benefit of applying PMEs relatively early in the pavement life. Recently large scale applications of PME have been undertaken at RAAF Learmonth and RAAF Base East Sale and before and after testing (a combination of friction (Griptester), British Pendulum Swing, texture depth and permeability) has been undertaken.

RAAF Base Learmonth – Before and After PME Surface Treatment in November 2011

The PME must be applied to a clean and dry surface and all rubber deposits removed. On large projects, the use of specialist spray trucks is recommended. Trials are required to determine the application rate for each asphalt surface and the rate will depend on the texture of the surface. Some very coarse areas may require a pre-treatment of PME.

PME Application at RAAF Base Edinburgh in 2012

A simple assessment of texture depth can be made using the sand patch test and a measure of friction can be made using the portable British Pendulum TRL swing test apparatus (refer to Section 9.5). The tests should be made before and application of the PME surface treatment.

Coal Tar Rejuvenators are normally applied at a rate slightly less than that for cutback bitumen but the residual coal tar application is substantially less (about 50%) due to the higher solvent content. It is understood that the solvent in the Coal Tar Rejuvenator behaves in a similar manner to the kerosene in a cutback bitumen SEST, carrying the coal tar into the surface voids of the asphalt and softening the aged bitumen. The residual coal tar and tar oils are believed to combine with some of the bitumen providing an improvement in physical properties. The solvent rapidly evaporates, particularly under warm/hot conditions, and the treatment is usually dry and tack-free in four (4) to six (6) hours.

Due to the rapid drying of Coal Tar Rejuvenators this material is suitable for grooved dense graded asphalt and open-graded asphalt surfacing. However, only a few such applications have been undertaken in Australia to date.

Coal tar is classified as a carcinogenic material. State OH & S legislation applies to the use of the material and contractors must demonstrate full compliance with all legislated requirements when Coal Tar Rejuvenators are specified. In addition, the future recycling of asphalt that has been treated with Coal Tar Rejuvenators may also present OH&S concerns with respect to fuming during heating, and some organisations have banned its use on their pavements for this reason. Defence revised its ban on coal tar products in 2008 in light of new application techniques and improved OH&S controls, and will now allow their use on ADF airfields when applied by competent contractors under appropriate supervision.

SESTs and rejuvenation treatments are specialised types of maintenance and are required to be designed, documented and supervised by experienced personnel. If the type of treatment or the application rate is inappropriate for the particular pavement, or the strict construction procedures are not followed, serious operational problems can result (e.g. low surface friction, contamination of aircraft components). Consequently, the application of these maintenance treatments to runways should be supervised directly only by suitably experienced airfield pavement engineers.

10.3.2.4 Rehabilitation Using a Slurry Seal

Slurry seals generally comprise a mixture of well graded crushed aggregate (normally 5mm to 10mm), filler, emulsified bitumen and water. Slurry seals are generally applied to a pavement as a surface treatment.

Slurry seals are generally unsuitable for use on airfield pavements due to their tendency to delaminate with the resultant FOD potential. In addition, slurry seals contain a high air void content and very thin bitumen film thicknesses which lead to problems with durability, cracking and rapid erosion/abrasion.

It is considered to be more cost effective and more appropriate operationally and technically, to use a PME instead of a slurry seal.

Slurry seals are more suited to road pavements where frequent trafficking can maintain the flexibility and integrity of the treatment.

10.4 Deformation

10.4.1 Objective

The objective of repairing deformations is to:

- Prevent further deterioration of surface deformation and subsequent development of FOD;
- Prevent further deterioration of surface deformation, potentially leading to structural degradation of the pavement; and
- Prevent the ingress of moisture, potentially leading to saturation of the base course and softening of the underlying layers and/or subgrade.

Examples of Deformation in an Aircraft Wheel Path

10.4.2 Repair Methods

Refer to Section 13 for a list of airfield pavement maintenance products.

10.4.2.1 Rehabilitation Using Asphalt Patching

This repair technique covers the replacement of the pavement base course (or part thereof) and surfacing layer (either asphalt or sprayed seal). It is not applicable to the rectification of surface depressions ('birdbaths'), which is covered in the following section.

Distressed portions of asphalt or spray seal surfaced pavements may be repaired using hot or cold mixed asphalt depending on the size of the area to be treated. Hot mix asphalt repairs can be constructed by hand or machine placement. Hand placing should be confined to using 10mm size mixes (or smaller) but machine placing may use up to 14mm size mixes. Larger size mixes should not be used, particularly in the surface layer, although if the patch is deep (greater than 200mm), a 20mm size mix may be appropriate. Cold mix patching should generally only be used for small patches/repairs as a temporary measure in the absence of available hot mix. Most small repairs can be satisfactorily and economically carried out using specially formulated proprietary premixes.

Patches should always be constructed such that the finished surface is slightly proud of the surrounding pavement and tapered to match the existing surface at the edges of the patch to prevent water accumulating on or at the edges of the patch.

The area to be repaired should be excavated using either a cold planing/milling/profling machine or jack hammer and excavator/hand tools. Diamond saw cutting should not be used as the cutting slurry generated is difficult to remove from surfaces. All faces should be cut square (approximately 100mm beyond the extent of the distressed area) ensuring that the area removed fully encompasses all of the distressed pavement. The excavation should be thoroughly cleaned of all loose particles including edges and corners, but care must be exercised not to damage, break or under-cut the surfacing layer at the edge of the excavation. Old surfacing material is usually hard and brittle and is damaged easily, particularly by rollers during compaction of the asphalt. A timber mat should be used on the existing pavement surface at the entry/exit locations to protect the edge of the excavation.

Thin patches (i.e. replacement of asphalt surfacing and/or part of the base course not exceeding 50mm in depth) should be constructed typically using 10mm size asphalt. Depths in excess of 50mm should be constructed using 14mm size asphalt. However, if these particular size mixes are not readily available the nearest larger or smaller size can be used. When using 14mm size mixes or larger, special attention must be given to raking segregated coarse aggregate particles off the surface prior to compaction.

If the underlying surface of the patch area is asphalt or other bound material, the surface and the edges should be tack coated using neat bitumen emulsion to just fully coat the surfaces. Any pools of tack coat that may accumulate in the corners or depressions must be swept out. Unbound surfaces (e.g. fine crushed rock) should not be tack coated or a prime coat applied unless the patching material can be spread by hand to fully cover the tack coated or primed surface to prevent pick-up on tyres and roller drums. Tack coats and prime coats must be permitted to break/cure fully before spreading the patching material. If this is likely to cause unacceptable delays in re-opening the pavement to aircraft, then only the edges of the surfacing layer at the edges of the patch should be tack coated.

The patching material should be spread by machine or hand providing sufficient allowance for compaction. Hand placed patches will require a greater allowance for compaction than those placed by machine. A timber screed should be used to even the hand placed patch and check the compaction allowance prior to compaction. Compaction should be carried out using a steel drum vibrating roller and pneumatic tyred roller. If these rollers are not available vibrating plates, hand operated rollers or static rollers may be suitable, but the highest density achievable should be obtained. If the compacted surface or edges of the patch are open textured or porous after compaction is completed, these areas (or the entire surface of the patch) should be sealed using bitumen emulsion and sand as previously described.

Deep patches (greater than 100mm) should be constructed in two approximately equal layers, although if a patch is large and riding quality is important, two layers should be used for depths greater than 80mm. When compacting the lower layer, the edges and corners must be compacted using a vibrating plate or preferably a mechanical rammer. If this equipment is not available, compaction of areas inaccessible by rollers must be carried out by hand. The lower layer should be allowed to cool to ambient temperature before placing the surfacing course. The surface should not be flooded with water to cool it more rapidly as the water will enter the pavement and may lead to further distress.

Rubberised bitumen bandaging of the edges of patches may be necessary if the repair is not carried out with sufficient care to avoid an open textured joint or a rough edge that can permit water to enter the pavement. This material requires specialised equipment for application that may not be readily available. Alternatively, multiple applications of bitumen emulsion and sand (or fine aggregate) may be used. Cutback bitumen should not be used as it will penetrate deep into the joint and flux (soften) the bitumen in the asphalt possibly leading to subsequent softening and disintegration. Rubber bitumen bandaging in wheel path areas of the pavement can result in pick-up of the material on aircraft tyres during hot weather, even if the bandage is sanded. It is strongly recommended that all bandage treatments in trafficked locations be primed prior to application of the rubberised bitumen. Proprietary primes are available otherwise bitumen emulsion should be used.

Cold mix patching should only be carried out using specially formulated proprietary premix asphalt. Three materials that are known to be suitable for use on airfield pavements are Perma-Patch, Repairoad, and EzyStreet. These premixes are a 7mm nominal size graded aggregate mixed with a specially formulated modified bitumen based binder containing hardeners. These premixes have been used successfully at a number of airports in Australia for small repairs (some up to one square metre or more) and in both concrete and asphalt surfaced pavements. Similar procedures apply to repairs using cold premix as detailed above for hot asphalt, but it is essential to thoroughly compact these materials to fully activate the hardeners incorporated therein. If compaction is inadequate, the repair will remain soft and may be dislodged or picked-up by aircraft tyres. Very small repairs can be compacted using a rubber mallet, otherwise use a vibrating roller or plate, or mechanical rammer.

Areas of asphalt patching with a coarse or open appearance should be treated with an application of PME.

10.4.2.2 Rehabilitation of Shallow Depressions

This repair technique is recommended for the rectification of shallow surface depressions in spray seal surfaced pavements.

Rectification of shallow surface depressions can be effected by either ‘skin’ patching with hot asphalt or a proprietary premix and over sealing with bitumen emulsion and sand, or applying multiple layers of bitumen emulsion and aggregate/sand. Repairs of this type require special care to ensure that the treatment does not delaminate from the existing pavement surface or fret or bleed so as to create an operational hazard.

(a) Method 1 – Skin Patching

The area to be repaired should be determined by pulling a stringline across the surface at a number of locations and marking the points at which the surface of the pavement deviates from the stringline and marking the area with spray paint. Alternatively, the pavements may be inspected immediately after rain and the areas (perimeter) in which water is ponding should be located and marked. The depressed area should be swept to remove sediment, dust, dirt, loose aggregate, etc. A tack coat of neat bitumen emulsion should be applied to fully coat the sealed surface uniformly. The tack coat should be allowed to break completely prior to spreading the premix asphalt. It should be screeded to an even shape parallel with the plane of the surface using a length of timber. A compaction allowance should be based on the deepest part of the patch. The premix asphalt should be compacted using a vibrating (or flat non-vibrating) steel drum roller, vibrating plate, mechanical rammer, etc. taking care not to crush the aggregate particles excessively. Some crushing of the aggregate will inevitably occur at the edges of the repair.

Following completion of compaction, an excess of dry medium or fine grained sand should be applied to the surface of the patch and broomed with a heavy bristled broom into the surface voids. After a period of working the sand over the surface and into the voids, any excess sand and any waste/dislodged premix should be broomed off the patch and removed from the pavement surface. A neat bitumen emulsion should be applied to the sanded repair and worked into the surface using a squeegee. The repair should be finished by a light application of fine dry sand to prevent pick-up.

(b) Method 2 – Multiple Seal Coats

The areas to be treated should be prepared as detailed for Method 1 - Skin Patching. Neat bitumen emulsion should be applied at a rate of approximately 1 litre/m^2 and such that run-off does not occur. The aggregate should then be applied immediately and in excess. 10mm size aggregate should be used unless the depressions are very shallow, in which case it is questionable whether repair is warranted. A hand broom should be used to evenly distribute the aggregate. When the bitumen emulsion has broken, excess aggregate should be removed by sweeping and the surface rolled with 2 or 3 passes of a flat (static) steel roller. A second (lighter) application of bitumen emulsion (approximately 0.5 litres/ m^2) should then be applied followed by 5mm size aggregate (or coarse sand), spread using a hand broom. The surface should then be swept off and rolled after the emulsion has broken. The 5mm size coat should be repeated as required until the patch is tightly interlocked and stable. However, multiple coats should not be applied to the extent that the repair is proud of the plane of the pavement surface. The final coat may consist of a light application of bitumen emulsion covered with sand or just sand. The sand should be worked into the surface of the repair with a soft hand broom to avoid dislodging the aggregate. The coats subsequent to the first (10mm size coat) should overlap the edges of the previous coat by approximately 100mm or more. A light application of fine dry sand should be spread over the repair to prevent pick-up on aircraft tyres.

In all applications of the bitumen emulsion, careful judgement is required to ensure that just sufficient emulsion is applied to hold the aggregate without running off the surface and/or creating a fatty patch. This is not difficult with the first application but the second and subsequent applications can be more difficult to judge because the emulsion is retained in the interstices of the aggregate. The final appearance of the repair should indicate plenty of texture from the 10mm size aggregate with the voids choked with the finer aggregate and sand.

10.5 Maintenance of Unsealed Pavements

10.5.1 Requirements

CASA MoS 139 Chapter 13.1.7.2 notes that the surface of the unsealed runway must not have irregularities, which would adversely affect the take-off and landing of an aircraft. An empirical test for runway riding quality is to drive a stiffly sprung vehicle such as a medium size utility or un-laden truck along the runway at not less than 65 kph. If the ride is uncomfortable, then the surface needs to be graded and levelled.

CASA MoS 139 Chapter 10.15.5.1 also notes that the surface of natural and gravel surface runways and runway strips must be maintained to the physical standards outlined in Chapter 13 of CASA MoS 139 and further notes that a rough surface, in combination with a soft, wet surface, is particularly hazardous for aircraft operations.

10.5.2 Causes of Deterioration

The primary causes of deterioration of aggregate surfaced pavements requiring frequent maintenance are the environment and aircraft traffic. Rain or water flow will wash fines from the aggregate surface and reduce cohesion, while aircraft traffic action causes displacement of surface materials.


10.5.3 Maintenance of Unsealed Pavements

Maintenance should be undertaken at least every six (6) months and more frequently if required. The frequency of maintenance is likely to be high for the first few years of use but will decrease over time to a constant value. The majority of the maintenance will consist of watering and rolling with a Pneumatic Tyred Roller (PTR) to reduce stone loss and maintain surface integrity; periodic grading to remove ruts and potholes caused by the environment and aircraft traffic and to replace lost surface fines.

During the lifetime of the pavement, the surface layer may have to be re-sheeted consisting of scarifying the surface, wetting, applying a 50mm layer of new aggregate (with an element of plastic fines) and re-compacting to the specified density.

A dust palliative can be used to prevent particles from an aggregate surface becoming airborne as a result of wind or aircraft traffic. Where dust palliatives are considered for trafficked airfield areas, they must be able to withstand the abrasion of the wheels. An important factor limiting the applicability of the dust palliative in traffic areas is the extent of surface rutting or abrasion that will occur under traffic. Some palliatives will tolerate deformations better than others, but normally ruts in excess of 10mm to 15mm will result in the virtual destruction of any thin layer or shallow-depth penetration dust palliative treatment. A number of materials for dust control are available and further details are contained in TM 5-830-3 and Section 13.

US Department of Defense UFC 3-26002 (June 2001) and TM5-822-12 provides some further guidance on the design and maintenance of unsealed aggregate surfaced pavements.

10.6 Miscellaneous Pavement Maintenance Treatments

10.6.1 Maintenance Rolling of Bituminous Pavements

Only sprayed seal pavements can be effectively improved by maintenance rolling.

Bitumen is a natural organically derived flexible adhesive which deteriorates (hardens, shrinks, cracks and loses its flexibility) over time due to the effects of air, ultraviolet light and moisture. This age deterioration is often observed to be more severe in infrequently trafficked areas of pavement compared to adjacent more heavily trafficked areas.

The rate at which the bitumen deteriorates (particularly its loss of flexibility) can be reduced, and the flexibility even restored to some extent, by rolling the pavement regularly using pneumatic tyred rollers. Such rolling is most effective when the pavement temperature is high and early in the life of the seal before embrittlement.

The reasons for this are:

- Bitumen softens when subjected to kneading in a similar way that semi-hardened putty can be made pliable by reworking it between the fingers;

- Fine cracks in the bituminous seal can often be 'healed' if the materials on each side of the crack are pressed ('welded') back together during hot-weather rolling; and
- The adhesive bond between bitumen and stone can be improved or re-established if the stones are pressed ('worked') into the bitumen binder by rolling when the bitumen is softened by the hot weather.

However, despite the obvious benefits to be gained, maintenance by rolling is now rarely carried out unless rollers and suitable operators are available on the airport (i.e. airport owned) at a low cost.

10.6.2 Storage of Bituminous Materials

Drummed bitumen emulsion will settle and it should be stored such that it can be mixed at regular intervals (approximately once per month) by rolling the drums on the ground. The drums should not be stacked or stored on end. Storage should ensure the older stocks are used first.

Where various types of bitumen emulsion are stored (for example, slow setting, rapid setting, cationic or anionic) it is essential that each be clearly identified and separated.

Bitumen emulsions should be used as soon as possible after manufacture. Three (3) months is considered the maximum safe shelf life. Drums of bitumen emulsion should be thoroughly mixed by rolling prior to use.

Cutback bitumen must be stored in accordance with all relevant local, state and national OH&S and environmental regulations. If cutback bitumen is allowed to be stored in drums, all necessary precautions should be taken to ensure that the drums do not settle, and as a minimum precaution against the outbreak of fire, the stockpiles should be on level ground to reduce the risk of burning liquid flowing toward other flammable items. This risk can be further reduced by constructing an earth bund around the stockpiles or alternatively a wide shallow earth drain.

11. Concrete Pavement Repairs

11.1 Introduction

Concrete pavements normally have a functional life in the order of 40 years after which time, removal and replacement may be required. Concrete gradually deteriorates with age, exhibiting progressive cracking and spalling and sometimes other problems such as faulting.

In order to preserve the potential long life of concrete pavements it is necessary to diligently undertake maintenance to manage the structural integrity and to retain the functionality of the pavement.

Operational considerations are a primary factor in the decision to carry out repairs or maintenance works of any kind, but the interval between major maintenance events is usually extended if defects are promptly repaired.

In deciding whether to repair defects at any particular time, it is necessary to consider:

(a) The extent and severity of the defects;

(b) The location of the defect;

(c) Whether the defect represents an operational hazard;

(d) Airfield operational issues (particularly if closures are involved);

(e) The observed rate of development of the defect; and

(f) The age of the pavement and the period until the next programmed maintenance.

In many circumstances, the early treatment of a minor defect may save costs in subsequent remedial treatment.

Load associated pavement distress, whether localised or widespread, (e.g. rutting, pumping, structural cracking of concrete, etc) indicates a pavement weakness. Surface distress is usually an operational concern (e.g. fretting, spalling, surface erosion, stripping of seal aggregate, faulting, etc). Cracking will invariably increase the exposure of the subgrade and pavement layers to moisture and may eventually affect pavement strength.

Refer to Section 13 for a list of airfield pavement maintenance products.

11.2 Cracks

11.2.1 Objective

The objective of repairing cracks is to:

(a) Prevent the propagation and/or widening of cracks and spalling and subsequent development of FOD;

(b) Prevent the propagation and/or widening of cracks, potentially leading to structural degradation of the pavement; and

(c) Prevent the ingress of moisture, potentially leading to saturation of the base course and softening of the underlying layers and/or subgrade.

Examples of Cracked Concrete Pavements and Repaired Pavement Requiring Repair

11.2.2 Criteria for Repair

Cracks exhibiting no evidence of significant spalling should be monitored regularly. These cracks are not "working" cracks and can remain dormant for the life of the pavement or may slowly become active as the crack progresses to the full depth and/or width of the slab. Small chips are usually picked up by routine pavement sweeping/aircraft operations and it is not usual for significant amounts of loose material to be present. If isolated cracks become clogged with debris, they should be cleaned by blowing out with high pressure compressed air.

Cracks should only be sealed when they start to spall significantly and routine sweeping/monitoring is not able to ensure that loose particles will not occur. When cracks begin to spall, some large spalls may occur and repair using a suitable material may be required in addition to sealing of the crack.

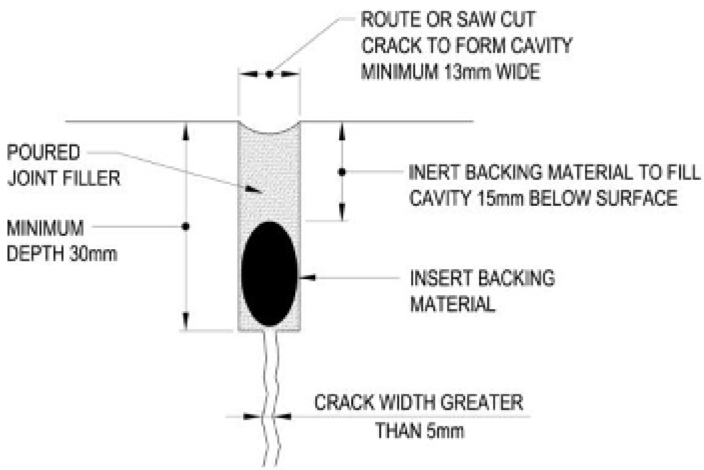
In almost every case it is more economical to repair the cracks in a slab than to replace the slab. Where access to pavements is severely restricted or limited (e.g. runways), it is essential to ensure that crack repairs are durable and in such instances only the best available materials should be used. Often, repairs on pavements with limited access are subject to tight time restraints and are carried out at night. It is better to spend extra time to repair smaller portions of the defect progressively in each work period to ensure permanency than to attempt larger scale repairs that may be subject to doubtful quality and performance.

11.2.3 Repair Methods

The preferred method for repairing cracks wider than 5mm is to rout them to form a reservoir and then seal the cavity with a flexible joint sealant as shown in Figure 11-1.

Figure 11-1

Typical Crack Repair Method



The method is as follows:

(a) Each crack should be visually inspected and both ends of the crack located.

(b) Cracks must be routed out (using a 'soft' router that will not result in shattering of the adjacent concrete) or saw cut in short straight lengths to match the alignment of the crack. The resulting recess is to be a minimum of 13mm wide by 30mm deep. In routing or cutting the cracks to the minimum depth required, it is essential that the sides of the recess are vertical and the edges are not spalled.

(c) All foreign and loose particles (including cutting residue), must be cleaned from the crack recess with high pressure air immediately prior to filling. The air nozzle should be held parallel to the crack, at a 45 degree angle to the surface, and traversed along the crack.

(d) If there are any spalls adjacent to the crack that are greater than 40 mm wide, they must be repaired in accordance with Section 11.4.3.

(e) A soft inert filler (e.g. rubber or soft plastic tube, or closed cell foamed plastic rod) should be inserted into the cleaned recess, and must be pushed down into the recess to a depth approximately equivalent to the width of the recess, but the manufacturer's recommendations should be followed.

(f) An inspection of the prepared recess should be carried out immediately prior to installing the sealant to ensure that it is clean and dry.

(g) Where recommended, a primer should be applied to the sides of the recess using a pressure sprayer or by brushing.

(h) The installation of the poured joint sealant should be in accordance with the manufacturer's recommendations. A nozzle or spout that fits into the recess so that the sealant fills the groove in one pass from the bottom upwards should be used. This will prevent formation of air bubbles beneath the joint material that can weaken the seal. Silicone and single component polyurethane sealants are supplied in cartridges for use in an applicator "gun".

(i) The filled recess must be immediately 'tooled' to form the surface recess.

(j) At the completion of sealing, the pavement surface must be cleaned of all loose particles.

(k) The sealed crack should be protected from traffic for a minimum of 24 hours or as required by the manufacturer's recommendations.

Example of Crack Repaired with Rout and Seal

11.3 Joint Sealing

11.3.1 Objective

The objective of resealing joints in concrete pavements is to:

(a) Restrict water ingress (although effective waterproofing over time has rarely been achieved in practice);

(b) Prevent pumping (the loss of fine material from the underlying base in suspension under the action of traffic); and

(c) Prevent stones and other hard objects lodging in the joints and causing spalling and 'pavement growth' as the joints try to close up in hot weather.

Contemporary airfield pavement construction is moving towards thicker pavements and open joints. Joint sealing is undertaken only when justified in specific circumstances. Airfield pavements in Australia are typically 350mm to 450 mm thick (with some up to 500mm) compared to 230mm to 250mm for highways, and undergo less thermal movement because the lower part of the slab remains cool. This means that when stones and foreign objects are trapped in joints, spalling is less likely to occur.

By eliminating joint sealants, joints need only be 3mm to 5mm wide. This compares to the 10mm to 25mm required for sealed joints to allow the sealant material to function properly. Narrow joints do not harbour large loose stones and foreign objects, reducing the possibility of spalling and FOD. Long term maintenance and FOD problems associated with failed sealant material are also eliminated.

11.3.2 Criteria for Repair

Joint sealing is recommended in the following circumstances:

(a) Where open joints are detrimental to safe aircraft operations, particularly jet aircraft operations;

(b) To reduce the incidence of additional spalling and to hold in particles which become loose from the side of the existing joint (also applies to cracks);

(c) In joints used for electrical cabling, in order to hold the cable in place;

(d) In locations where sweeping is not conducted regularly enough to ensure that the joints remain free from debris; and

(e) In pedestrian areas where justified for safety reasons.

11.3.3 Repair Methods

The repair technique should be selected taking into account:

(a) Extent of repair work required;

(b) Performance of existing joint sealants;

(c) Extent of joint preparation required;

(d) Ease of application of joint sealant;

(e) Cost;

(f) Compatibility of sealant with existing jointing material in cavity;

(g) Required resistance to fuel spills and jet efflux;

(h) Time available to carry out the repair;

(i) Weather conditions; and

(j) Required degree of water proofing.

Where extensive joint repairs are required a testing program for selection of a suitable jointing material is recommended. The testing program should involve the following:

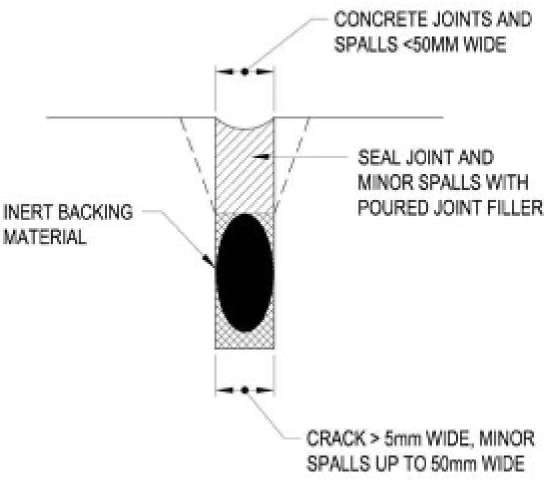
- Taking samples of the proposed jointing material for laboratory testing of the materials key properties. It has been found that the material properties of commercially available joint sealing materials can vary significantly from batch to batch; and
- Conducting field trials to evaluate the proposed installation procedures. Properties to be evaluated include pot-life, time to reach a tack-free condition, joint cleaning requirements, dimensional ratio comparing depth to width, and evidence of bubbling. Accurate records should be kept of trials and results summarised in a report. The field trials will indicate the suitability of the poured jointing material. Trials should be continued until a suitable material is found after which actual joint sealing can proceed.

Flexible joint sealants applied during the colder months will have a better chance of long term survival. This is due to the joints being at their maximum width at cold temperatures.

Joints are to be cleaned and filled as shown in Figure 11-2, and as detailed below.

Figure 11-2

Typical Poured Joint Resealing Method



(a) If the material to be used to fill the cavity is not compatible with the existing joint sealant, the latter should be removed from the joint adjacent to the spall and for a further 25mm either side of the spall.

(b) Where an existing preformed jointing material has been used, it is generally able to remain. The work will be facilitated if it is undertaken during the coldest part of the day when the contraction of the slabs is at its greatest. Should further cleaning of the joint be required a router or saw should be used, slightly increasing the existing groove width.

(c) The cavity formed, or the cavity already occurring should be thoroughly cleaned with high pressure compressed air or other means as necessary to remove all loose particles and to expose a clean face of concrete within the cavity.

(d) Adhesion failure is the most common cause of sealant failure and is usually caused by poor cleaning of the concrete surfaces. Oil, bitumen, mud or other deleterious substances often coat the sides of the cavity and these may prevent bonding of the material to be used in filling the cavity. If high pressure compressed air will not remove contaminants and leave a clean concrete face, sandblasting, steam cleaning or scabbling must be used to clean the cavity. In adopting any of these treatments, due care is to be taken to not damage or cause expansion to the adjacent preformed joint material, and should any damage be incurred, the section of damaged material should be removed and replaced. The minimum length of section which must be removed, regardless of the length of the damaged material, is 300mm.

(e) Where the depth of the cavity extends below the depth recommended by the manufacturer, an inert backing material is used to prevent the joint sealant from being lost down the joint.

(f) Where the joint sealant manufacturer recommends the use of a primer, the joints should be primed with a spray gun operated by compressed air which sprays the primer through suitably designed nozzles onto the sides of the joint.

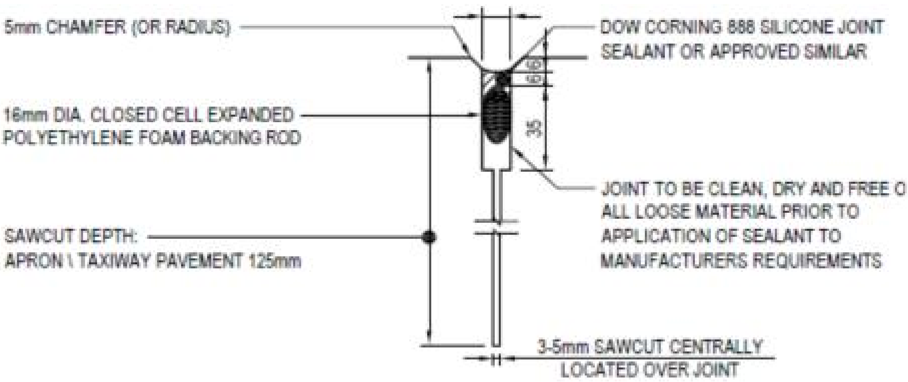
(g) Care must be taken to not overfill the cavity, and it is preferable to leave the level of the sealant in the cavity slightly below the surface level. The repaired areas should be protected from any form of trafficking for up to 24 hours.

(h) The installation of the sealant must be in accordance with the manufacturer's recommendations. The application device should have a nozzle or spout so that the material fills the groove in one pass from the bottom up. This prevents formation of air bubbles beneath the joint material which weakens the seal. Cork is not recommended as a joint filler in new construction. For maintenance purposes cork is sometimes used where there is a very wet climate, which will ensure that the cork does not dry out. Care must be taken to protect the cork from moisture (including humid air) prior to installation.

Concrete joint chamfering before sealing is becoming a more common practice on airfields in Australia with recent examples including RAAF Base Edinburgh Transport Apron and various airfield projects at Melbourne Airport. The purpose of the chamfering is to reduce in service damage of the joint edge and reduce the potential for spalling and FOD. A typical detail of the chamfering is shown below in Figure 11-3.

Figure 11-3

Detail of Chamfered Joint



As an alternative to joint resealing, over banding may be appropriate where a large number of joints are to be repaired and especially where an excessive amount of minor spalling is associated with the joints and where the joints or cracks are too narrow to be filled without first widening. Section 11.4.3 provides details of repair techniques.


Example of Good Joint Sealant


Example of Poor Joint Sealant

11.4 Spalling

11.4.1 Objective

The objective of repairing spalling adjacent to joints and cracks in concrete pavements is to:

(a) Prevent the possibility of loose particles emanating from the spalling becoming ingested in jet engines or causing propeller or aircraft skin damage; and

(b) Prevent the entry of aggregate particles and similar foreign materials into joints that may lead to subsequent spalling problems.

11.4.2 Criteria for Repair

Often the removal of loose fragments of concrete is all that is warranted, and not restoration of the edge of the slab. This is conditional upon the resulting gaps and/or surface irregularities not affecting the riding quality of the pavement to an unacceptable degree, nor causing damage to small or high pressure aircraft tyres using the pavement. However, in many cases the spalled area contains fractured concrete around the edges that is not immediately obvious. When the loose or partially loose fragments are removed, traffic and thermal movements will rapidly loosen and dislodge further spalls in these fractured areas. Consequently, it may be prudent to repair spalled areas that otherwise appear innocuous.

In practice it is often difficult to decide whether potential spalls should be prised loose or left in place. Because of the cost and difficulties (primarily time and access) in making permanent repairs to spalled areas, the voids resulting from spalling should generally be left unrepaired if the unevenness of the pavement surface can be tolerated from an operational viewpoint.

Rigid patching materials commonly de-bond from the concrete due to the shrinkage they undergo while curing, or because their thermal expansion characteristics differ from that of the parent concrete. They then also become a spall and are equally a danger to aircraft.

Alternative flexible patching materials such as hot mix asphalt; rubberised poured sealants and instant bituminous repair materials (e.g. Perma-Patch) are often effective, but are subject to attack by spilt fuels, particularly on aprons. More recently, semi rigid epoxies with sand (SRE(S)) have been increasingly (and successfully) used where bitumen-based patching is unsuitable, but they are expensive and should be used judiciously.

Repairs not carried out correctly can fail, and then act as an additional source of loose, hard fragments (i.e. spalls) that can damage aircraft.

The recommended method for repair of spalls in concrete pavements is dependent on the size of the spall as detailed in Table 11-1.

Table 11-1

Recommended Spall Repair Treatments

Size (Width) of Spall	Spall Repair Treatment
Less than 10mm adjacent to joint or crack.	Do nothing except remove loose spall fragments.
10mm to 50mm adjacent to joint or crack (minor spalls).	Fill the joint or crack (routed as necessary) with an adhesive joint sealant material which will hold spalls in place if and when they re-occur, or allowing them to be detected and removed.
10mm to 50mm at locations other than adjacent to joints and cracks, i.e. surface spalls (minor spalls).	Remove spall and fill the recess with a suitable repair material (see Section 11.4.3).
Greater than 50mm (major spalls).	Cut out the spall, forming a squared area with vertical sides and uniform depth, and backfill with a suitable repair material (see Section 11.4.3).
Individual slabs or pavements with excessive spalling (usually associated with significant cracking).	It is preferable to replace the damaged slabs but pavement closures may not be acceptable to permit this type of repair (unless Rapid Set Cement (RSC) Concrete is used). Patching repair may be the only practical option. Overlaying the pavement with asphalt is only practical if the extent of the damage warrants such treatment and if level considerations and functional requirements permit.

11.4.3 Repair Methods

The cost of repairing spalls is generally very high and can consume a large part of a maintenance budget, perhaps without gaining a significant benefit, and at the expense of doing other less expensive repairs that may be more cost effective.

Consequently, only three material types have been recommended for use in concrete spall (and joint) repairs:

- Conventional hot asphalt;
- Proprietary instant bituminous premix; and
- Semi-Rigid Epoxy (with Sand) (SRE(S)).

Each of these materials is considered to be suitable for permanent repairs, but selection of any one type will be project specific.

Proprietary rigid patching/repair materials have generally not performed well on airfield pavements with the exception of rigid epoxies in some locations, but the development of semi-rigid epoxy has now superseded the rigid epoxies. Other rigid cementitious materials are not recommended because their failure rate is generally high.

The following sections detail the procedures for repairing spalls of various types.

11.4.3.1 Spalls Adjacent to Joints

(a) Spalls less than 10mm wide adjacent to existing joints

Normally no repairs are required to such spalls other than blowing out the joint to remove any spall fragments or loose debris using high pressure compressed air. It is also necessary to clean up the loose particles blown out of the joint using a vacuum sweeper.

(b) Spalls between 10mm and 50mm wide adjacent to existing joints (Minor Spalls)

The joint should be cleaned of all loose particles using high pressure compressed air and then the joint (and adjacent spall recesses) at that location should be sealed with a suitable joint sealant such as:

- Hot poured rubberised bitumen (PMB);
- Pavement grade silicone sealant;
- Single component polyurethane joint sealant;
- Thioflex 600 (two (2) component polysulphide joint sealant); or
- Dow Corning 888 silicone joint sealant.

The above listed joint sealants have been, and are currently being used successfully at Australian airports. These sealants have generally shown good performance if installed correctly. Thioflex 600 has a long history of successful service under a variety of operating and climatic conditions in all areas of Australia, particularly at ADF Airfields. A significant disadvantage is that being a two component sealant, the pot-life is short and priming is mandatory. Therefore, there is more opportunity for poor workmanship. The silicone sealants have a low modulus (soft) and do not resist fuel spills well. The single component polyurethane sealant is a relatively new product but, like the silicon, is simple to install.

Other joint sealants may be available or may become available in the future and they should be carefully assessed prior to being used. There is no Australian Standard for joint sealants for use in pavements. The following US and British specifications apply to the above listed joint sealants:

- Two Component Polysulphide (do not use where fuel spills may occur) : US Federal Specification SS-S-200E
- Silicone: No known Standard.
- Single Component Polyurethane: There is a British Standard for Cold Applied Joint Sealant Systems (BS5212: Part 1: 1990), but it does not specifically cover single component sealants and it is not known whether Single Component Polyurethanes comply.
- Rubberised Bitumen: A British Standard exists (BS 2499) and this should be used if required, in preference to the US (ASTM) standards.

The most common failure in joint sealants is usually not within the sealant itself but as a result of the installation procedure. The most common defect is de-bonding due to “poor” cleaning of the joint faces.

All joint sealants must be installed strictly in accordance with the manufacturer’s instructions.

Generally, the following requirements apply to the installation of joint sealants:

- For hot poured rubberised bitumen, the joint faces must be clean and primed.
- For other proprietary sealants, the joint faces must be clean and a prime may also be required.

- All proprietary sealants require that a backer rod be installed at a specified depth and the sealant bead must be applied to a minimum thickness and the surface recessed a specified minimum depth below the pavement surface.
- The specific requirements for each sealant type recommended by the manufacturer will include minimum/maximum joint widths and minimum/maximum sealant thicknesses. These requirements must be strictly followed.

(c) Spalls greater than 50mm wide (Major Spalls)

The repair must be made by forming rectangular recessed patches covering the full area of the spall damage. The damaged concrete is removed to a uniform depth and replaced with a suitable repair material.

The exact thickness and size of the patch depends on the particular distress. Guidance on the size of the patch required is provided below.

As a general rule, spall repairs, using any material, should not be carried across joints. Repairs across construction and contraction joints should be saw cut on the line of the joint to prevent cracking, and possibly spalling of the repair material. If a spall repair is required to span an expansion or isolation joint, the joint must be reinstated within the repair, including the sealant.

Suitable materials for patching include:

- Hot mixed asphalt (bituminous concrete);
- Instant bituminous premix; or
- Semi-rigid epoxy (SRE (S)) is a proprietary material only available from one source in Sydney. The two components of the material require careful mixing, the addition of dry sand (filler) and warm (rather than cold) conditions for curing. Sand is typically heated to reduce the curing time.

Other repair materials (e.g. proprietary mortars, rigid epoxy cements, Portland cement concrete, etc), many of which have previously been used on airfield pavements are now not recommended for repairing spalls. While rigid epoxies have generally performed exceptionally well in the past in some locations, the development of a semi-rigid epoxy has superseded the rigid types and this is now the preferred material. Proprietary mortars have demonstrated generally poor performance, primarily due to shrinkage and de-bonding, and these materials are no longer recommended.

Portland cement concrete similar to that of which the pavement is constructed is a most suitable repair material but it requires a significant curing period and in most cases this is not practical. Also, the preparation work required to achieve a satisfactory bond to the parent concrete and the high standard of workmanship necessary precludes this material from being a practical option for spall repair.

Both hot mixed asphalt and instant premixes are suitable spall repair materials, although they may require replacing and/or rejuvenating because the bituminous binder hardens with age and the surface erodes through weathering. These materials are the most economical for spall repairs, but they are not normally suitable for use on aprons due to their susceptibility to damage by fuel spills. The use of hot mixed asphalt is only practical if a large number of spalls are to be repaired at any one time, or the repairs are extensive. Instant premix is a more economical and amenable material for general spall repairs and is easier to use. However, there is only one suitable (locally manufactured) product currently available at a reasonable price, Perma-Patch. Other instant premixes are available (e.g. Instant Bitumen, Samifilla) but these materials have generally not shown as good performance as Perma-Patch.

(d) Procedure

(i) Excavation/Preparation of Spall Site

The general procedure for preparing a spalled area for repair is to:

- Mark off the area to be repaired using straight lines between the corners;
- Make a normal-to-the-surface cut along the marked boundary;
- Remove all concrete from within the cut perimeter to a near uniform depth;
- Sound the remaining concrete within the repair area for weaknesses and perform any further removal as needed; and
- Clean all surfaces within the repair area.

The marked area should have 90-degree corners with the sides parallel or normal to the direction of the reinforcement (if any). The marked boundaries for the repair area should be a minimum of 50mm outside the perimeter of the spall. For a single spall at a pavement joint, the repair area will vary depending on the repair material to be used, however generally it should be a minimum of 100mm wide (measured normal to the joint) and 200mm long (measured along the joint). If a number of spalls are closely located to each other, these spalls should be included in a single area marked for repair.

A normal-to-the-surface cut along the marked boundary should be made with a diamond blade saw. However, when sawing is not practical, the normal edge can be made with a suitable sized jack-hammer. The depth of cut should be a minimum of 25mm, except for spalls at pavement joints, where a minimum 50mm deep cut is recommended. In situations where the diamond saw could cut into the reinforcing steel due to inadequate concrete cover, the boundary edge should be formed by means of jack-hammers. A pachometer can be used to estimate the depth of cover.

The existing concrete should be removed to produce a near uniform depth for the repair area. For all spalls it is recommended that the depth of repair be a minimum of 50mm. Otherwise the depth should be at the deepest level of the spall. A full-depth repair (i.e. partial slab replacement) must be used when dowel bars are encountered or when the spall depth is greater than one-third of the thickness of pavement (refer to Section 11.7).

Mechanical milling is only applicable where the top surface of the concrete is to be removed over large areas. Care must be taken to avoid contact with the reinforcing steel as both the reinforcing and the cutting drum could be damaged. The front and back edges of removal will be rounded and the other two sides could possibly be chipped and ragged. These edges will require recutting with either a diamond saw or a suitable jack-hammer.

Hydro-demolition (water jet blasting) is also applicable for large areas of spall repair where the reinforcing steel could be exposed and reused in the repair. Waterborne fines deposited on newly exposed concrete and reinforcing surfaces during removal should be removed by low-pressure water blasting before deposits dry. Chipped and ragged edges along the removal boundary should be cut to form a normal-to-the-surface boundary.

After removal, exposed surfaces should be visually inspected and sounded for weaknesses and delaminations. If such weaknesses are found, additional removal will be required.

(ii) Repair with Instant (Cold) Bituminous Premixes

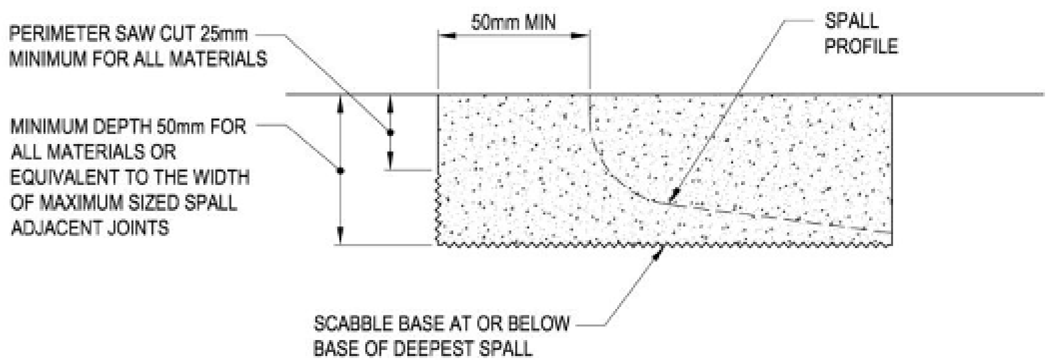
These are cold asphalt-like premixed materials that consist of a small sized, uniformly graded aggregate mixed with a modified bituminous binder. The binder rapidly hardens when exposed to air or is compacted (due to incorporation of pressure sensitive hardeners). The material is generally not compatible with most jointing materials and repairs cannot be finished to form a free standing edge.

Due to the small (approximately 7mm) maximum size of these premixes, they should generally not be used for repairs greater than about $1m^2$.

Details of instant (cold) bituminous premixes are contained in Section 13.

Figure 11-4

Repair with Instant Bituminous Premix



The procedure for installing the instant bituminous premix is as follows:

(a) Remove loose spalls and adjacent jointing material (if any) from cavity;

(b) Prepare the surface of the spall cavity as detailed in Section 11.4.3.1 (d) (i);

(c) Reduce the level of the spalled area by use of hand tools, scabbler or cold planer to a roughly horizontal surface at generally the same level as the deepest level of the spall or saw cuts whichever is the lower, but not less than 50mm;

(d) Blow the repair clean of dust debris and standing water using oil-free compressed air;

(e) Tack coat or prime the repair surfaces with bitumen emulsion and allow to break;

(f) Place premix asphalt into the cavity and screed to a thickness sufficient to allow for compaction. Compact the premix by hammering using a suitable mechanical rammer or a rubber mallet, adding small amounts of additional material as required to deficient areas before full compaction is applied. Do not over compact the premix to the extent that the aggregate particles are crushed. Use of a vibrating plate compactor is generally not as effective as hammering because it may not fully activate the hardener;

(g) Finish the repair flush with, or not more than 5mm above, the surrounding concrete and remove all laminations overlapping thereon;

(h) Apply a light coating of medium to fine dry sand to the surface of the repair, working it into the surface voids with a soft broom; and

(i) Apply a PME treatment to the surface.

(iii) Repair with Hot Asphalt

The use of hot asphalt is recommended for repair of individual spalled areas greater than 1m^2, or multiple spall sites, or deep spalls (greater than 50mm), but only if such material is readily and economically available. If this is not the case, the premix materials should be used, but particular attention must be given to adequately compacting the material in deep repairs.

The procedure for installing the hot asphalt is as follows:

(a) Remove loose spalls and adjacent jointing material (if any) from cavity;

(b) Prepare the surface of the spall cavity as detailed in Section 11.4.3.1 (d) (i);

(c) Reduce the level of the spalled area by use of hand tools, scabbler or cold planer to a roughly horizontal surface at generally the same level as the deepest level of the spall or saw cuts whichever is the lower, but not less than 50mm;

(d) Blow the repair clean of dust debris and standing water using oil-free compressed air;

(e) Tack coat or prime the repair surfaces with bitumen emulsion and allow to break (ie: is sticky underfoot and has gone from brown to black in appearance);

(f) Place hot asphalt into the cavity and screed to a thickness sufficient to allow for compaction. Compact the hot asphalt by rolling with a suitably sized roller (roller size depends on layer thickness and area of patch). Compaction plant is required to achieve 98% relative compaction;

(g) Finish the repair flush with, or not more than 5mm above, the surrounding concrete and remove all laminations overlapping thereon; and

(h) Apply a PME treatment to the surface. Consider applying RBB to the perimeter of the patch.

Examples of asphalt patches constructed in concrete pavements are shown in the photographs below.

Examples of Hot Asphalt Joint and Corner Spall Repairs in Concrete Pavements

(iv) Repair with Semi-Rigid Epoxy with Sand (SRE(S))

This material is supplied by Recycled Rubber Technologies Pty Ltd in pre-packaged two component lots suitable for mixing 20 litres of the material. Strict adherence to the manufacturer's instructions is required to ensure a satisfactory repair. Meticulous preparation of the surface for repair is essential. The material is flexible and can span construction and contraction joints and cracks. It **must not** be used to span expansion and isolation joints without reinstatement of the joint recess and the joint sealant. Small repairs spanning slab joints are likely to de-bond on one of the vertical faces parallel to the joint during cold weather due to excessive tensile stresses. The material is not prone to spalling and adhesion to the other surfaces of the repair will normally prevent the SRE(S) from being dislodged. To prevent de-bonding, it is recommended that the joint be reinstated with a saw cut through the full depth of the repair, along the line of the joint. No joint filler/sealer is required.

The procedure for installing the SRE(S) is as follows:

(a) Remove loose spalls and adjacent jointing material (if any) from cavity;

(b) Prepare the surface of the spall cavity as detailed in Section 11.4.3.1 (d) (i);

(c) Reduce the level of the spalled area by use of hand tools, scabbler or cold planer to a roughly horizontal surface at generally the same level as the deepest level of the spall or saw cut whichever is the lower, but not less than 50mm;

(d) Blow the repair clean of dust debris and standing water using oil-free compressed air; and

(e) Install the SRE(S) strictly in accordance with the manufacturer's instructions.

SRE(S) Repairs in Concrete Pavements

Examples of Semi Rigid Epoxy (SRE(S)) Repairs in Concrete Pavements

Example of Failed SRE Repair (where the material was too thin)

(v) Repair with Portland Cement Concrete

This material is not normally suitable or practical for spall repairs in operational airfield pavements due to the time required for curing.

(vi) Repair with Special Concretes

The use of special rapid setting and/or high early strength cements are also not appropriate for spall repairs due to the significant differences in shrinkage characteristics between the repair material and the parent concrete, and the need for elaborate preparation and bonding techniques.

Polymer concretes (e.g. Methacrylates) generally perform much better than the cementitious types, but they contain chemicals that are an OH&S concern. Strict adherence to OH&S procedures is required if these products are to be used.

The Rapid Set Cement (RSC) Concrete (Volumetrics Concrete) can achieve a flexural strength of over 3.5MPa at four (4) hours and has been trialled (typically single slab replacements) at both Sydney and Melbourne Airports in recent years with some success. It is a relatively expensive product and its use should be carefully considered.

Example of "Good" Concrete Repair

Example of "Poor" Concrete Repair

11.4.3.2 Spalls Adjacent to Cracks

Cracks that exhibit spalling may be "working" (i.e. the crack extends to the full depth of the slab) or "cyclical" (i.e. the crack is as a result of thermal movement occurring in the top portion of the slab). Such spalling should be monitored and the cause of the spalling determined, including the rate of spall generation. A decision can then be made whether to just clean the crack or repair it.

(a) Cracks less than 3mm wide with associated spalls (less than 10mm)

Normally the spalls and the crack will not require repair (subject to no significant working of the crack) and blowing out of spall fragments and other loose particles with high pressure compressed air is all that is required. The dislodged particles must be cleaned from the pavement surface with a vacuum sweeper.

(b) Cracks greater than 3mm wide with minor spalls (between 5mm and 50mm wide)

These cracks are most likely to be "working" and they will normally require repair. However, the cracks should be monitored as suggested above to verify the behaviour of the distress before deciding on the type and extent of repair required.

The crack and associated spalling should be routed to a minimum width and depth of 15mm and either a polysulphide or polyurethane sealant should be installed. Rubberised bitumen bandage (RBB) could also be used if available, but the installation of this material requires specialised heating equipment that is not always readily available and it may not be economical to use this material. Also, bitumen based and silicon sealants are not suitable on apron areas where fuel/oil contamination may occur.

The availability (access) of the pavement area and curing time for the sealant should be considered when selecting a sealant for the particular repair.

The sealant must be installed in accordance with the manufacturer's instructions and the routed recess must be cleaned, and primed as recommended by the manufacturer.

The sealant should be installed nominally 3mm below the pavement surface (i.e. recessed). The absolute minimum recessing is 1mm.

(c) Cracks (any width) associated with major spalls

If the crack is less than 3mm width and/or is not working, it normally will not require sealing. If the crack exceeds 3mm width and is "working" it should be routed and sealed as detailed above in Section 11.4.3.2 (b).

The associated major spalls should be repaired using instant premix or SRE(S) (see Sections 11.4.3.1 (d) (ii) and 11.4.3.1 (d) (iii), respectively). Hot mixed asphalt is generally not appropriate unless the size and/or extent of the repairs warrants the purchase of such a large volume of material (minimum 1 tonne). However, the cost of the materials is usually not significant in the overall cost of the repair.

(d) Procedure

The repair procedure is generally the same as for major spalls as detailed in Section 11.4.3.1 (c), but noting the following:

- Premix or hot asphalt repair materials will invariably develop reflective cracking along the line of the existing crack and spalling will eventually occur. To minimise the potential for this occurring, a former strip should be inserted within the repair along the general line of the crack (e.g. plastic strip).
- Large SRE(S) repairs will effectively span cracks, but smaller repairs should be saw cut along the line of the crack to prevent de-bonding.

11.4.3.3 Isolated Spalls (Spalls not associated with joints or cracks)

This type of spalling is mainly related to "poor" quality concrete, the expansion of weathered particles of coarse aggregate or the inclusion of foreign material in the pavement surface (e.g. wood, construction debris, etc). The repair techniques described below apply to isolated spalls. Where significant extensive spalling exists on the pavement surface the slab should be replaced.

(a) Spalls less than 50mm diameter

No action is to be taken except for normal pavement sweeping, unless the spall could pose a FOD hazard.

(b) Spalls greater than 50mm diameter

No action is to be taken unless the spall:

- Is prone to accumulate debris which could pose a FOD hazard;
- Affects the pavement rideability; or
- Exposes steel reinforcement.

If repair is required, the procedure described for the repair of spalls in Section 11.4.3.1 (c) should be followed.

11.5 Slab Grouting

When there is loss of level in a concrete slab, or faulting at joints or cracks resulting from loss of support, filling of cavities by grout injection through drilled holes (slab-jacking) may be warranted. The objective is for the grout to fill all of the voids thereby restoring uniform support.

The grout is pumped under pressure through holes drilled in the slab, thus creating an upward pressure on the underside of the slab in the area around each hole. The upward pressure decreases as the distance away from the hole increases. This is due to the viscosity of the grout and the skin friction created by the flow of the grout. Based on this principle, it is possible to raise one corner of a slab without raising the whole slab.

Stiff grouts do not flow as easily as more fluid grouts and may form an undesirable cone or pyramid under the slab, leaving unfilled cavities and the potential for uneven bearing support and consequent cracking.

Grouting under concrete slabs requires competent and experienced personnel. One of the key factors in successful slab grouting is the spacing and location of the holes, and this may vary depending on the defect being rectified. Generally, holes should not be located less than 300mm or more than 450mm from a transverse joint, nor more than about 2m centres so that not more than about 2.5m^2 to 3m^2 of slab is raised by pumping in any one hole. Additional holes may be required if the slabs are cracked.

A variety of grout mixes have been successfully used. They generally consist of fine sand and Portland cement with water added to produce the required consistency. Additives that increase flowability may also be used in the mix.

Prior to commencing work, some method of controlling the amount the slab is to be raised should be determined. This may be by straightedge, stringline or level.

Pumping is undertaken in successive holes (in sequence depending on the defect being rectified) until the grout shows in successive holes, indicating that the underlying void has been filled.

Proprietary products (such as Uretek, a synthetic resin) are available for slab grouting, together with experienced contractors.

Ground penetrating radar has been successfully used to detect voids under concrete pavements (refer to Section 7.10).

11.6 Surface Defects

Minor surface defects should be repaired using similar materials and techniques that are used for spall repairs (ie SRE(S), RBB etc).

For larger areas, the area should be squared up to form a rectangular cavity of constant depth prior to the application of the repair material.

11.7 Concrete Slab Removal and Replacement

When warranted due to the extent or severity of the defects within a slab, either all or part of the slab should be replaced over its full depth.

11.7.1 Full Concrete Slab Replacement

The existing concrete should be removed as carefully as possible so as to minimize the damage to the adjacent slabs and the underlying base course. In particular, removal of the existing concrete adjacent to the existing joints on all four sides should be undertaken with care so as not to damage the load transfer devices. Initially, full or partial depth saw cuts should be made across the slab and into the corners, but without extending into the adjacent slabs. The existing concrete should then be carefully broken out and removed to the top of the base course. If necessary any damaged base course material should be replaced and any prime coat, primer seal or separation layer reinstated. If the existing base course material is significantly disturbed and is unable to be re-compacted, lean mix concrete should be placed prior to reconstructing the concrete slab.

An assessment will have to be made of the suitability of the existing load transfer devices for retention.

In longitudinal joints, the load transfer devices will normally comprise of dowels or keys. If these are undamaged they should be retained. If they are damaged, advice should be sought from an experienced airfield pavement engineer as to how load transfer should be provided for the new replacement slab.

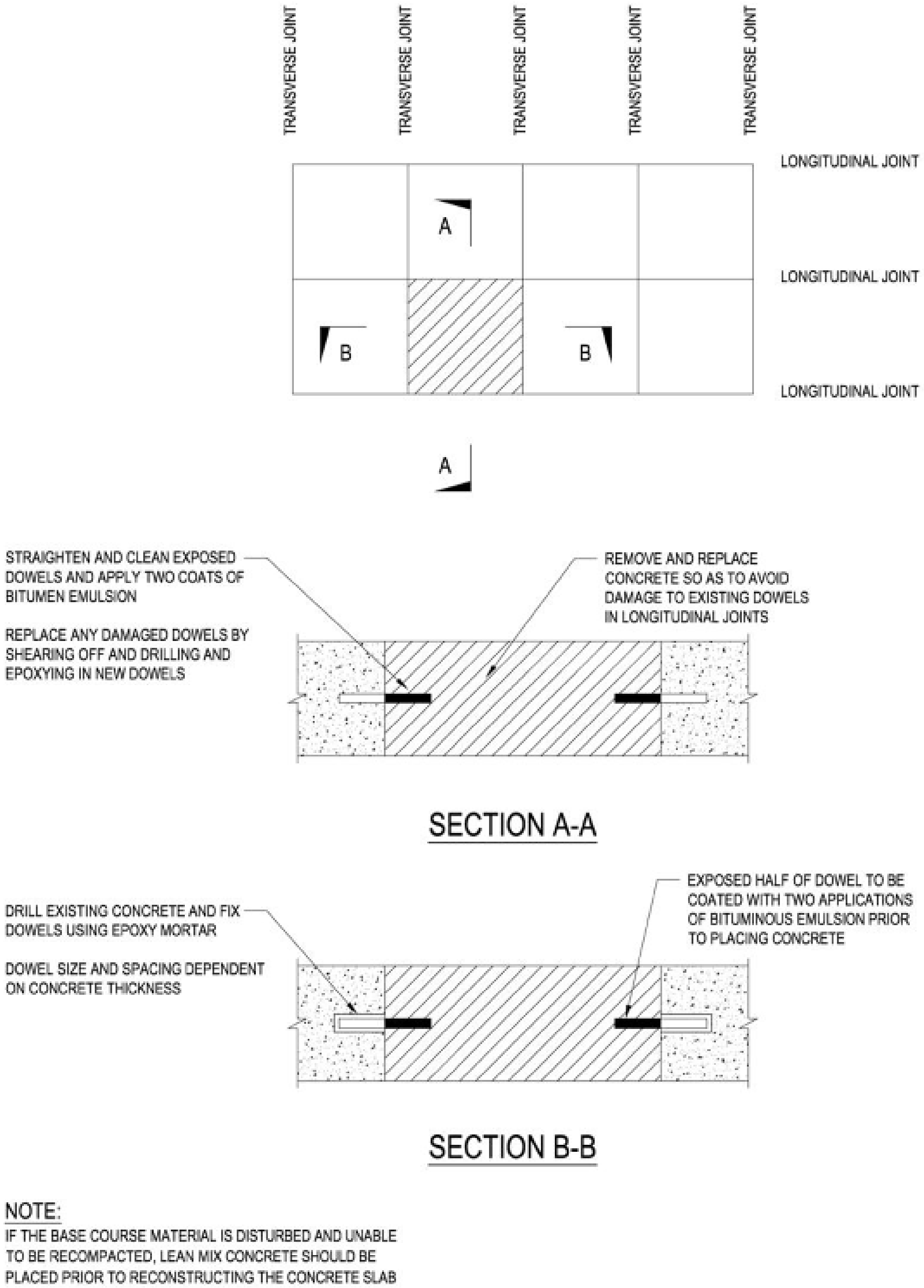
In transverse joints, the load transfer will normally be provided by aggregate interlock in sawn contraction joints. It is not practical to maintain aggregate interlock when the replacement slab is constructed, so all sawn contraction joints should be replaced with dowelled construction joints. Holes of appropriate diameter should be drilled in the existing joints at the required centres so that dowels can be fixed in place using epoxy. Advice should be sought from an experienced airfield pavement engineer as to dowel sizes and spacing – guidance is provided in US FAA AC150/5320-6E.

Since it is intended that all joints at the edges of a full slab will allow movement (primarily shrinkage, but also subsequent expansion and contraction due to temperature variations), the dowels should be installed parallel to the surface of the base course and parallel to the sides of the slab, and all exposed dowels should be coated with two (2) coats of bitumen emulsion.

Pavement strength concrete (minimum 40MPa compressive strength) of 50mm slump should then be placed, spread, screeded, compacted, finished and textured to match existing levels at the boundaries of the slab. Recesses for joint sealing should be sawn after the concrete has been cured for a minimum period of seven (7) hours.

Figure 11-5

Full Concrete Slab Replacement



11.7.2 Partial Concrete Slab Replacement

Partial concrete slab replacement should be undertaken as for full depth slab replacement but with the following changes.

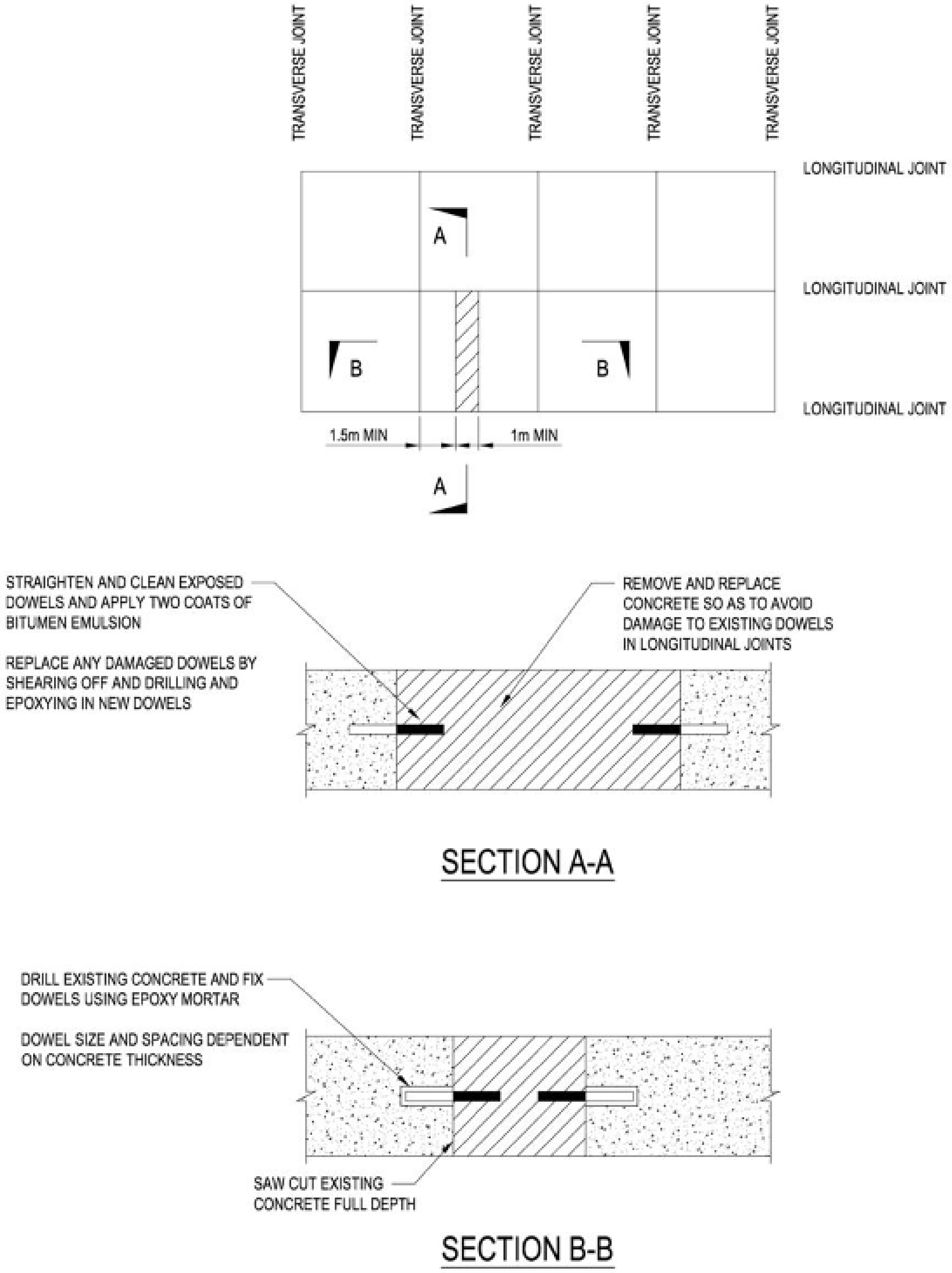
The boundaries of the area to be replaced should be marked out to form a rectangle, and a vertical saw cut should be made through the full depth of the slab around the perimeter of the repair. The minimum plan dimension of the repair should be 1m to allow the installation of dowels.

Unlike full slab replacement, the intent of partial depth replacement is to make the repair integral with the remainder of the slab unless one or more boundaries are at the edge of the existing slab. All new joints that are remote from the existing slab edges should be made so as not to allow movement, and accordingly, the dowels should be placed without coating.

Where the ratio of the length of the repair to the width of the repair exceeds 1.25:1, a layer of SL102 mesh reinforcement should be installed in the top of the partial slab repair with a cover of 50mm.

Figure 11-6

Partial Concrete Slab Replacement



12. Interlocking Concrete Block Pavement Repairs

12.1 Introduction

If an Interlocking Concrete Block Pavement (ICBP) has been designed and constructed correctly, it will usually not require any significant maintenance or repair during the life of the pavement.

Replacement of paving units is usually very difficult due to the 'lock-up' that is developed in the block layer during construction and subsequent trafficking, and individual blocks are impossible to remove without disrupting or damaging adjacent blocks. Only large areas of severely distressed interlocking concrete block paving should be removed and replaced. Individual cracked blocks should be jointed (as detailed in Section 12.2), and spalled blocks should be patched with a suitable epoxy or special premixed asphalt as appropriate.

The reinstatement of joint filling sand is the most common type of maintenance that is required in well-constructed ICBP, and this should be carried out regularly (approximately every two (2) years). However, if a cutback bitumen sealant is used, erosion of the jointing sand should not occur for at least five (5) years, and then only to a very limited extent.

Refer to Section 13 for a list of airfield pavement maintenance products.

12.2 Broken Pavers

Paving blocks containing cracking without spalling may be rectified by converting the cracks into joints. This is carried out by inserting a steel wedge into the crack and opening it to approximately 2mm in width. The wedge should be removed and the edges of the crack chamfered by grinding similar to the moulded chamfers on the block edges. The opened cracks should be filled with fine dry sand or stabilised sand.

Where spalling has occurred, the blocks should be replaced. The blocks will usually need to be broken up into smaller fragments to facilitate removal. The bedding sand should be replaced to level using a scratch template riding on the surface of adjacent in-situ blocks, and then the new blocks installed. Since it is likely that the sizes of the replacement blocks will be slightly different from those removed, it may be necessary to cut blocks to suit. The replaced blocks should be bedded down using a medium sized vibrating plate and the jointing sand should be replaced with new sand complying with the particle size distribution specified in Section 12.5 and then sealed. Alternatively, a proprietary stabilised sand or liquid sealant may be used.

If the pavement has been overloaded to the extent that the blocks have rotated, cracked and or spalled, the affected areas should be replaced as described above.

For cracks that have occurred due to concentrated loading, the solution is to replace the blocks. However, if it is a widespread problem or continues to be a problem then consideration should be given to replacing the affected area with concrete pavement.

12.3 Lipping

Where lipping has occurred, the affected blocks should be removed, the bedding sand re-levelled and the blocks replaced. Individual blocks may need to be broken up into fragments to facilitate removal. The bedding sand should be replaced to level using a scratch template riding on the surface of adjacent in-situ blocks, and then the new blocks installed. Since it is likely that the sizes of the replacement blocks will be slightly different from those removed, it may be necessary to cut blocks to suit. The replaced blocks should be bedded down using a medium sized vibrating plate and the jointing sand should be replaced with new sand complying with the particle size distribution specified in Section 12.5 and then sealed. Alternatively, a proprietary stabilised sand or liquid sealant may be used.

12.4 Loss of Edge Restraint

The integrity of the edge restraint should be restored by removal and replacement (with a reinforced concrete edge restraint) or if the spalling is minor, repair by patching with a suitable epoxy (concrete) or special premixed asphalt.

12.5 Loss of Joint Filling Sand

Sand Replacement

Sand for filling the joints between interlocking concrete block paving units should be natural quartz sand having a particle size distribution complying with the limits given in Table 12-1. The joint filling sand should also be non-plastic, and free from all clay, dirt, organic and other deleterious matter.

Table 12-1

Particle Size Distribution for Joint Filling Sand

AS Sieve Size	Percentage Passing AS Sieve (by Mass)
2.36mm	100
1.18mm	95-100
0.600 mm	55-100
0.300 mm	15-50
0.150 mm	0-15
0.075 mm	0-3

Joints should be refilled by brooming the jointing sand over the pavers while simultaneously vibrating the surface of the interlocking concrete block paving using medium sized vibrating plates. This process is repeated until all the joints are filled with sand. Excess sand is then swept off the surface of the interlocking concrete block pavers and the surface is sealed to prevent further loss of jointing sand.

Alternatively, proprietary stabilised sands such as ‘SuperSand’, ‘Pave-Lok’ or ‘Gap Sand’ may be used.

Suitable sealants that have been used are “Pavseel” (a proprietary liquid PVC supplied from the UK that is applied by spraying) or cutback bitumen (50:50 Class 170 bitumen and power kerosene) that is poured onto the pavement surface and worked along the joints using squeegees. The cutback bitumen will temporarily stain the interlocking concrete block surface brown for approximately three (3) to six (6) months after which time the original block colour will return. The jointing sand will remain black. Cutback bitumen has been found to be a significantly more durable and cost effective sealant than any other proprietary sealant or stabilised sand. Resiblok 22 has also been used on airfields with success (Christchurch International Airport in New Zealand).

Drainage

Unless specific provision is made in the design of the interlocking concrete block paving, runoff water will generally not percolate into and through the block joints. Consequently, normal provisions should be made in the design of the pavement for collection and disposal of storm water.

Rainfall and surface runoff on interlocking concrete block paving does not significantly erode stabilised jointing sand and has little or no effect on sealed jointing sand, particularly if the sealant is cutback bitumen.

Bedding sand is not affected by rainfall and/or water that may percolate into the pavement through the block joints, unless the jointing sand is inferior (i.e. contains clay or degrades in service such as to generate excessive fines). If the bedding sand does not comply with the strict quality requirements normally specified for the use in airfield pavements, pumping may occur under traffic and both the jointing sand and the bedding sand will be lost. The paving units will become loose and localised depressions will usually develop in the wheel paths (known as 'elephant foot prints'). Consequently, if the bedding sand is inferior, the ICBP should be removed and reconstructed using a suitable high quality bedding sand.

12.6 Surface Depressions

Where the subsidence causes water ponding, the blocks should be removed, the shape of the base corrected and the blocks re-laid. The pavement shape should not be improved solely by the addition of bedding sand as this will result in differential compaction and/or settlement. Instead, the bedding sand should be removed, the base course shape corrected with lean mix concrete, the bedding sand replaced to constant depth, and the blocks then re-laid.

The jointing sand should be spread and worked into the joints, followed by vibrating the surface of the interlocking concrete block paving using medium sized vibrating plates to seat the pavers in the bedding sand and to lock up the joints. The surface should then be sealed (refer to Section 12.5). Any damaged blocks should be replaced.

If the bedding sand has pumped, then the blocks should be removed, and the designed outlet point for the bedding sand drainage located and checked to ensure that it is operating correctly or repaired as necessary. The bedding sand should be replaced, the blocks re-laid, the joints filled and the surface sealed.

If the bedding sand has migrated, then it must be determined how and where the sand is moving (usually a large crack in the cement stabilised base). The escape path should be sealed with a proprietary bitumen based sealer or overlaid with geotextile, before replacing the bedding sand and pavers.

Expansive Soils

The design and construction of interlocking concrete block paving at sites which have expansive subgrade soils should conform to the usual requirements for flexible type pavements under these conditions. Appropriate subsoil drainage should be provided. If an interlocking concrete block pavement exhibits distress that is the result of subsoil drainage not having been provided it may be practical to install such drainage at the edges of the pavement. However, each particular case should be assessed individually to determine the most appropriate repair.

13. Pavement Maintenance Products

13.1 Introduction

In this section, a range of products and suppliers are presented for use during maintenance works. The list is for guidance only and is not exhaustive and other products and suppliers may exist which may be equally suitable for certain applications.

The following applications are addressed:

- Fuel Resistant Surfaces/Membranes (FRM)
- Rejuvenating Agents and Polymer Modified Emulsion (PME) surface treatments
- Rubber Removal Chemicals
- Line Marking Paint Strippers
- Line Marking Paints
- Rubberised Bitumen Sealants
- Over-banding Crack Sealing Systems
- Silicon Based Sealants
- Polymer Based Sealants
- Instant Bituminous Repair Materials
- Proprietary Patching Mortars
- Epoxy Concrete including SRE(S)
- Portland Cement Concrete
- AGL Slot Sealants
- ICBP Joint Filling Sand Sealants
- Rapid Set Cement (RSC) Concrete

For each application, the following information is provided:

- Product Name
- Product Description
- Comments
- Supplier

At the end of the section, a list of current known suppliers is provided. For each supplier, the following information is listed in tabular form:

- Supplier Name and Address
- Telephone/Fax Numbers
- Website/e-mail

During maintenance planning, and prior to ordering materials, reference to product suppliers is recommended to check the following items:

- Availability of products;
- Lead time for ordering materials;
- Cost of materials;
- Name of specialist contractors;
- Suitability of intended application; and
- Site specific constraints.

The comments provided in this section are based on the experience of a number pavement engineers, and are provided for guidance purposes.

It should be noted that products and suppliers are subject to change, and that product improvements occur over time. It is recommended that product suppliers be contacted during the planning phase for maintenance work to obtain the most current product information.

13.2 Fuel Resistant Surfaces/Membranes

Note: Some fuel resistant surfaces/membranes contain coal tar, which has been reported as being carcinogenic in some circumstances. OH&S procedures should be strictly observed for these products.

Defence revised its ban on coal tar products in 2008 in light of new application techniques and improved OH&S controls, and will now allow their use on ADF airfields when applied by competent contractors under appropriate supervision.

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
Pavron	Fuel and oil resistant coal tar emulsion.	Used at RAAF Bases Richmond, Perth and Cairns Airports. OH&S procedures should be strictly observed	Swepdri International
Bitulastic Roadseal	Coal tar rejuvenator; miscible mixture of coal tar in petroleum spirit.	Has been used as a fuel resistant treatment at some airports, including some ADF Airfields. Specialised equipment and contractor required for application. OH&S procedures should be strictly observed.	Bituminous Products Pty Ltd
Mexphalte Fuelsafe	Polymer Modified Binder bitumen (EVA/EMA type) used in asphalt.	A trial of this binder was constructed at Sydney Airport in 2000 and RAAF Base Amberley 2003 and RAAF Base East Sale 2007.	Shell Australia
Coal Tar Pavement Sealer	Coal tar based emulsion fuel resistant membrane.	Has been used at a number of airports in Australia (Mt Isa, Brisbane, Adelaide, Coolangatta, Gladstone, Cairns) and in PNG, Indonesia and Pacific Islands. Also used at RAAF Bases Darwin, Tindal, and at Woomera Airfield. Formally Superseal. OH&S procedures should be strictly observed.	Australian Pavement Maintenance Services (APMS)
Sealmaster Coal Tar Sealer	Coal Tar Emulsion Sealer	Used at RAAF Base Pearce in September 2011	Sealmaster
Viroseal AB	Water based aliphatic urethane acrylic sealant.	Has been used at RAAF Bases Williamtown, Amberley, Darwin and Townsville and AAC Oakey and Woomera Airfield. Also used at Coolangatta Airport. Can be slippery when wet.	Slip Resistant Surfaces Pty Ltd

13.3 Rejuvenating Agents and PMEs

Note: Some rejuvenating agents contain coal tar, which has been reported as being carcinogenic in some circumstances. OH&S procedures should be strictly observed for these products.

Defence revised its ban on coal tar products in 2008 in light of new application techniques and improved OH&S controls, and will now allow their use on ADF airfields when applied by competent contractors under appropriate supervision.

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
AsPen AC – Pavement Rejuvenator	Clay filled bitumen emulsion, surface rejuvenator.	Used on some aprons at Sydney Airport. Used at Luscombe Airfield in 2012. Cures rapidly (approx one (1) hour).	Australian Pavement Maintenance Services (APMS)
Carbonyte	PME	Used at RAAF Base Edinburgh	SAMI Bitumen Technologies Pty Ltd
Liquid Road	Mineral and fibre reinforced asphalt emulsion blended with polymers and surfactants.	Generally requires specialised equipment for application. Used at numerous Defence airfields around Australia.	Australian Pavement Maintenance Services (APMS)
Jet Black	PME	Used at RAAF Base East Sale and Edinburgh, Mount Bundey Airfield and Woomera Aerodrome.	Fulton Hogan
Reclamite "A" (for use on asphalt) or "S" (for use on sprayed seals).	Cationic emulsion containing petroleum resins and selected petroleum fractions.	Claimed to restore flexibility and ductility to old brittle pavements, seal the surface against intrusion of air and water, delay ravelling and stripping of aggregate. More expensive than cutback or emulsion treatments. Trialled at Melbourne Airport in 1970's and Cairns Airport in early 1990's. If proposed for use on airfield pavements sufficient curing time must be allowed, as it requires a longer time to cure than most alternatives. Trials should be carried out to assess curing.	SAMI Bitumen Technologies Pty Ltd
Bitulastic Roadseal	Rejuvenation fuel sealer. Miscible mixture of coal tar in petroleum spirit.	Has been used at most airports, including some RAAF Bases. Specialised equipment and contractor required for application. OH&S procedures should be strictly observed.	Bituminous Products Pty Ltd

13.4 Rubber Removal Chemicals

NOTE: Most rubber removal chemicals contain strong alkali and OH&S procedures should be strictly observed.

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
Avion 50	"Environmental friendly" chemical	Used at Sydney Airport	Chemtek www.avion50.com
Aerokleen Runway Rubber Remover and Cleaner (ARRRC)	Sodium hydroxide solution, 5 to 10% w/w.	Designed for the removal of all rubber tyre residues from airport runways, taxiways and apron constructed of concrete and asphalt.	CKS Hydro Services Pty Ltd
AeroGreen 4035 Runway Rubber Remover	100% readily bio-degrable product (Ethylene Glycol N Butyl Ether)	Trialled at Sydney Airport	Hi-Lite Solutions www.hi-litesolutions.com
CH-R48T Runway Rubber Remover	Liquid detergent for rubber removal from runways.	Used at RAAF Base Richmond.	Callington Haven Pty Ltd

13.5 Line Marking Paint Strippers

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
CH8880 Paint Stripper	Phenolic paint stripper.	Removes paint from concrete and metal surfaces. Requires 30 minutes reaction time. Wash off with water in accordance with local EPA regulations. Current airport environmental requirements may require collection of all wash water and disposal off site.	Callington Haven Pty Ltd

13.6 Line Marking Paints

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
Airpave	Synthetic latex emulsion based pavement marking paint.	Formulated to erode at a controlled rate to provide maximum visibility. Exclusively manufactured for use on airfield pavements. Used on many airports around Australia and commonly used on Australian Defence Airfields.	Wattyl Pty Ltd
523-57300 Roadmaster WB2	Water based road marking paint.	Application with airless spraying equipment, without thinner, recommended. Not suitable for application by brushing.	Dulux Australia
OMNIGRIP EP 176 Part A and 175 Part B	Thermoplastic road marking material with frictional characteristics.	Manufactured in UK and marketed in Australia by Boral. Supplier can also apply. Generally used on roads around Australia	Omnicrete Pty Ltd
Rapid Dry Supreme Road Marking Paint	Water based road marking paint.	Can be used on runways where paint build-up is unacceptable. Recommend to dilute with 50% water to further reduce build-up.	Bristol
Stamark Polymer Pavement Marking Tape	Reflective line marking tape that may be used for temporary markings and removed.	No known use in Australia. Used for temporarily marking an apron for a different aircraft type such as a visiting SQN.	3M Australia Pty Ltd
Streamline	Water based (acrylic) road marking paint.	Has been used on runways (as an alternative to latex emulsion based paint) where paint build-up is unacceptable.	Wattyl Pty Ltd
Top Dek Runway Marking Paint	Water based co-polymer line marking paint	Has been used at RAAF Bases Pearce, Gin Gin and Learmonth	Paint Industries Pty Ltd

13.7 Rubberised Bitumen Sealants

Rubberised bitumen bandage sealants are available as either cold (emulsion) or hot poured proprietary PMBs.

The cold poured emulsions are generally only suitable for cracks/joints up to 5mm wide. The hot poured sealants may be used for sealing cracks or joints up to 50mm wide and should be applied at 185°C /195°C using specialised equipment.

Rubberised bitumen sealants generally have a low tolerance to fuel and oil contamination and should not be used on aprons. The materials are relatively inexpensive compared to alternate sealants.

It is important that cracks and joints are adequately cleaned and prepared prior to filling.

Some rubberised bitumen sealants require priming of the cracks and joints, especially on concrete pavements. This can be difficult when treating narrow cracks or joints.

When used in wide joints the sealant should be recessed approximately 5mm below the pavement surface.

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
Bitulastic Standardflex	Hot poured bitumen rubber joint sealing compound.	Suitable for joints and cracks 10mm to 40mm wide. Primer required. Not fuel resistant. Trials carried out at Sydney Airport in 1991.	Bituminous Products Pty Ltd
Pourable Crack Sealant	Cold poured crack sealant.	No known use on airfield pavements in Australia.	Australian Pavement Maintenance Services (APMS)
Samifilla HM	Hot applied bituminous based PMB joint sealer.	Preferred crack repair material at Melbourne Airport. Suitable for cracks up to 50mm wide. Usually trafficable after cooling but blinding with dry cement may be required in hot weather. Requires specialised heater applicator. Primer (SamiPrime) should be used when sealant is applied to concrete pavements.	SAMI Bitumen Technologies Pty Ltd
Swepco Heavy Duty Asphalt Paving Sealer	Black bituminous sealing compound.	Apply directly from tube. For cracks up to 6mm wide and/or deep. Supersedes Joint Seal "H" and Swepco Crack Filler.	Swepdri International
Maxiseal Crack Sealant	Hot bituminous material containing granulated (recycled) rubber. May be blinded (finished) with grit.	Widely used, including Sydney, Melbourne and Adelaide Airports. Relatively inexpensive. Can be too soft in hot weather for pedestrian traffic and may adhere to aircraft tyres. Should be blinded with sand to prevent immediate pick-up on tyres.	Road Maintenance Pty Ltd

13.8 Over Banding Crack Sealing Systems

Over banding crack sealing systems are generally hot applied rubberised bitumen bandage (RBB).

Over banding crack sealing systems fill and seal joints, cracks and spalls up to 50mm wide and have been used successfully at a variety of sites including where considerable seasonal moisture movement occurs.

Generally over banding crack sealing systems have low tolerance to fuel and oil spills and are not suitable for aprons.

Some over banding crack sealing systems require specialist equipment for application.

The application of an overly thick band should be avoided as it may inhibit surface drainage. It is possible to recess most products, but this is generally not necessary.

Some over banding crack sealing systems may be trafficked 20 minutes after application is completed.

When over banding crack sealing systems are applied to cracks prior to asphalt resurfacing, the treatment should be ideally be undertaken at least three (3) months prior to any asphalt resurfacing work.

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
CrackMaster Supreme	Hot pour crack sealant. Similar to other over banding treatments.	No known use on airfield pavements in Australia.	Australian Pavement Maintenance Services (APMS)
Bituthene Liquid Mastic Membrane	Hot applied rubberised bitumen.	Suitable for cracks and joints up to 20 mm wide. Immediately trafficable. Used at Essendon Airport and RAAF Base Pearce.	Grace Australia Pty
Supersealing	Hot applied rubberised bitumen sealant	Used on a number of Defence airfields	Supersealing
Maxiseal Crack Sealant	Hot bituminous material containing granulated (recycled) rubber. May be blinded (finished) with grit.	Widely used, including Sydney, Melbourne and Adelaide Airports. Relatively inexpensive. Can be too soft in hot weather for pedestrian traffic and may adhere to aircraft tyres. Should be blinded with sand to prevent immediate pick-up on tyres.	Road Maintenance Pty Ltd
Polyflex II	Hot applied rubberised bitumen.	Used on a number of New Zealand airfields	Crafco

13.9 Silicone Based Sealants

Silicone based sealants are generally suitable for joints and cracks/spalls in concrete from 6mm up to 25mm wide.

Some silicone based sealants can tolerate fuel spills and oil contamination; however, the product may swell and should therefore be recessed.

It is important that all joints and cracks/spalls are adequately cleaned of all oil and grease prior to sealing. This should be done by diamond sawing or sand blasting joint faces.

Compatibility of the sealant with the parent material must be established prior to application.

It should be noted that some single component silicon based sealants cure by contact with moisture in the air.

Generally silicone based sealants are applied directly using an applicator gun.

Generally silicone based sealants do not require the surface to be primed prior to application.

Some silicone based sealants may be trafficked 30 minutes after application is completed.

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
Parchem Emer-Seal		Has been used at Melbourne Airport in 2011	Parchem
888 Silicone Joint Sealant	One part, cold applied silicone crack and joint filler/sealant.	DO NOT install in wet or damp concrete or during inclement weather. Recess sealant below pavement surface. No primer required. Cures within approximately 10 minutes. Used at Sydney and Melbourne Airports and numerous Australian Defence airfields.	Dow Corning Australia Pty Ltd
890SL	Silicone based joint sealant	Used to seal AGL chases at Adelaide Airport (2010/2011)	Dow Corning Australia Pty Ltd
Emer-Seal Roadseal	Silicone based joint sealant.	One part, non -ag silicone rubber joint sealant for roads, runways, car parks and pavements.	Parchem Construction Products Pty Ltd

13.10 Polymer Based Sealants

Polymer based sealants are generally suitable for joints from 3mm up to 50mm wide and generally have excellent adhesion properties.

Polymer based sealants are generally not suitable for use on asphalt or bituminous surfaces.

Some polymer based sealants may not be suitable for applications where movement occurs (eg expansion joints).

It should be noted that a bond breaker or backer rod is required on lower face of construction and contraction joints.

Generally polymer based sealants are two (2) component products and thorough mixing is required.

Generally polymer based sealants should be recessed a minimum of 3mm below the pavement surface.

Some polymer based sealants can tolerate fuel spills and oil contamination.

It is important that all joints are adequately cleaned of all oil and grease prior to sealing. This should be done by diamond sawing or sand blasting joint faces.

Generally polymer based sealants require the surface to be primed prior to application.

Generally polymer based sealants may require up to 12 hours curing time after application is completed.

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
Concrete Protector and Restorer	Two (2) part methacrylate polymer.	Penetrates surface and fills cracks. Used overseas but limited use in Australia. Methacrylate materials may be hazardous to health and strict compliance with OH&S requirements is recommended.	3M Australia Pty Ltd
Megaprene40	Polyurethane elastomeric fuel resistant two part sealant.	For damp surfaces a primer must be used. Initial cure six hours with full cure in seven days. Suitable for concrete surfaces only and joint widths of 12mm to 30mm.	Vivacity Engineering Pty Ltd
Nitoseal 280	Two (2) component epoxy-urethane joint sealant.	Good resistance to fuels and other hydrocarbons. Limited use on airfield pavements in Australia.	Parchem Construction Products Pty Ltd
Seal-N-Flex FC	Single component polyurethane joint sealer for concrete pavements.	Used at Sydney Airport.	Bostik Australia Pty Ltd
Everek SRE/B	A semi rigid epoxy sealant containing crumbed (recycled) rubber.	The material is a two (2) component cold poured and cures faster in warm weather than cold. Suitable for concrete slab joints. Trials currently in progress to evaluate use in sealing ground lighting cable slots and cracks in asphalt.	Recycled Rubber Technologies Pty Ltd
Sikaflex-PRO or 11FC	Single component polyurethane joint sealant.	Reacts with silicone sealants. No known use in airfield pavements in Australia.	Sika Australia Pty. Ltd
Sikaflex-TANK	Cold applied two part polyurethane and coal tar based joint sealant.	Maximum joint width 35mm. Oil and fuel resistant. Only known use at RAAF Base Pearce. Critical to mix thoroughly before applying.	Sika Australia Pty. Ltd
Fosroc Thioflex 600 (Pourable and Gungrade)	Two component cold applied pourable polysulphide elastomeric sealant (similar to Nitoseal 280).	High resistance to ageing 10 years plus Similar cost to silicone. Used on many RAAF Bases (particularly W.). Correct tools must be used for installation. Priming essential. Critical to mix thoroughly before applying or material doesn't set or sets too hard.	Parchem Construction Products Pty Ltd

13.11 Instant Bituminous Repair Materials

The distinguishing characteristic of this group of products is that, unlike conventional cold mixes, they do not rely on evaporation of water or solvents to harden. Therefore they can be placed in greater thicknesses than cold mix and will harden under moist conditions.

Generally instant bituminous repair materials have a low tolerance to fuel spills and oil contamination.

Instant bituminous repair materials in a free standing edge will generally not support traffic.

Most instant bituminous repair materials are not compatible with polyurethane or silicone joint sealants.

Instant bituminous repair materials generally require minimal surface preparation or priming prior to application and some may be applied in wet conditions.

Instant bituminous repair materials generally require no pre-mixing and are placed cold.

Generally instant bituminous repair materials may be trafficked immediately after application is completed.

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
EzyStreet	Proprietary pre mix cold mix asphalt for patching	Propriety product supplied by numerous agencies	Fulton Hogan
Pavefix	Bitumen, selected 5mm aggregates and resins.	Cold applied. Can be applied in wet conditions. Minimal shrinkage. Widely used in Australia.	SAMI Bitumen Technologies Pty Ltd
Perma Patch	Asphalt, chemical additives, pressure sensitive plastics and special (limestone) aggregates.	Similar to Pavefix, but has more graded aggregate so produces a less porous patch. Used at Sydney, Melbourne, Ayers Rock Airports and RAAF Base Scherger.	Pioneer Road Services Pty Ltd (now Fulton Hogan)
Quickfix	Epoxy bitumen binder, selected aggregates, additives, resins and adhesives.	Cold applied in wet or dry conditions. Priming recommended.	Instant Bitumen Pty Ltd

13.12 Proprietary Patching Mortars (Grout)

Most proprietary patching mortars can tolerate fuel spills and chemical contamination.

Generally proprietary patching mortars require the surface temperature of adjacent concrete to be between 4°C and 35°C.

It is important that the repair surfaces be adequately clean, sound and dry prior to application. This should be done by saw cutting a regular shape with squared edges.

It should be noted that with some proprietary patching mortars it is possible to include aggregate in the mortar to improve strength characteristics and/or increase bulk.

Some proprietary patching mortars may be trafficked 10 minutes after application is completed.

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
Fosroc Paveroc	Blend of cements, graded aggregates special sealers and chemical additives.	Designed for large repairs. Rapid strength gain with initial cure in 12 hours. Allow 24 hours before trafficking by aircraft. Suitable for 12 to 50 mm spalls.	Parchem Construction Products Pty Ltd

13.13 Epoxy Concrete

Most epoxy concrete can tolerate fuel spills and chemical contamination.

Generally epoxy concrete requires the surface temperature of adjacent concrete to be between10°C and 30°C.

Meticulous repair surface preparation is required for most epoxy concrete products. It is important that the repair surfaces be adequately clean, sound and dry prior to application.

Generally epoxy concrete requires the surface to be primed prior to application.

The larger the patch, the greater the induced interface stresses. Therefore, more success has been achieved when using epoxies to repair small spalls.

The cost of epoxy concrete is generally high and combined with the requirement for demanding repair surface preparation, these are probably the least cost effective.

Some epoxy concrete products may be trafficked 10 minutes after application is completed.

There are numerous 'rigid' types of epoxies available for concrete repairs.

Generally there has been fairly poor success over the years with conventional rigid epoxies. This is mainly because rigid epoxies have no flexibility and usually have coefficients of thermal expansion different from the parent concrete. Temperature changes cause high stresses at the interface between the epoxy patch and the concrete. These stresses often lead to de-bonding.

However 'flexible' or 'semi-rigid' epoxies have been used extensively at Sydney and Melbourne Airports with some success.

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
E300 Hardener	Rigid epoxy binder to be incorporated with aggregates to form mortar.	For concrete repairs. Fuel resistant.	Hychem International P/L
PF3 Hardener	Epoxy adhesive and grout (rigid).	For minor concrete repairs.	Hychem International P/L
Fosroc Nitomortar 908	Silica aggregates bonded with epoxy resin – rigid epoxy compound.	Cures under damp conditions. Primer required. Early strength. 3 times harder than concrete.	Parchem Construction Products Pty Ltd
Epoxy Repair Cement	Rigid epoxy compound.		Selleys Pty Ltd
Everek Semi-Rigid Epoxy (SRE(S)).	Contains rubber and is flexible. Can be used in repairs spanning joints and cracks without reflection or de-bonding.	Used extensively at Sydney and Melbourne Airport. No failures have been observed in more than five (5) years of use at Sydney Airport. Used on a number of Australian Defence airfields in recent years with a good track record when installed by specialist contractors.	Recycled Rubber Technologies Pty Ltd

13.14 Portland Cement Concrete

Portland Cement Concrete (PCC) can generally tolerate fuel spills and oil contamination.

Generally PCC is compatible with all types of joint filling materials.

It is important that the repair surfaces be adequately clean, sound and dry prior to application. This should be done by saw cutting a regular shape with squared edges.

It should be noted that PCC all abutting surfaces to be sound, clean and dry.

PCC repairs typically need to be isolated from traffic for up to seven (7) days.

PCC can be used to repair spalls in concrete pavements (as full depth repairs) but the preparation of the surfaces against which the repair is to be made **must** be carried out properly and an epoxy bonding agent **must** be used. Even then, due to the shrinkage of the concrete used for patching, there is a high likelihood that the patch will de-bond from the parent concrete. Also, despite the best efforts to use concrete with similar characteristics to the parent concrete, the thermal expansion characteristics are likely to be significantly different. Therefore, temperature changes induce stresses at the patch interfaces which often lead to de-bonding.

As a general rule, PCC is not preferred as a repair material, except for partial (or full) concrete slab replacement.

When the repair involves a full depth replacement of part of a slab the use of Portland cement concrete becomes more attractive as the repair can be connected to the parent slab using dowel bars instead of epoxy. The larger the repair, the greater the likelihood of success.

It is recommended that partial slab replacements be designed and supervised by specialist pavement engineers.

The following aspects **must** be considered:

- Assessment of the extent of unsound concrete by sounding techniques;
- Design and installation of suitable dowel bars;
- Suitable concrete mix design; and
- Adequate curing.

13.15 Rapid Set Cement Concrete

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
Rapid Set Cement Concrete	Special low shrink cement (CTS) to achieve high early strengths	For concrete slab replacements – trialled at Sydney and Melbourne Airports between 2009 and 2012.	Volumetric Concrete Australia Pty Ltd

13.16 AGL Slot Sealants

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
890SL	Silicone based self-levelling sealant	Used at Adelaide Airport in 2010/2011	Dow Corning

13.17 ICBP Joint Sealants

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
Resiblok 22	A pre-polymer urethane jointing sand stabiliser	Assists retention of jointing sand. Widely used in Europe	www.resiblock.com
Pave-Lok	Bonding jointing sand	Available in Aus through Boral	Boral
SuperSand	Stabilised jointing sand	Not widely distributed in Australia	Alliancegator.com
Gap Sand	Stabilised sand		Cementaustralia.com

13.18 Un-Sealed Pavement Dust Suppressant

PRODUCT NAME	PRODUCT DESCRIPTION	COMMENTS	SUPPLIER
PTac	Dust Supressant	Use not known	SAMI

13.19 Supplier's Contact Details

SUPPLIER	ADDRESS	PHONE	FAX	WEB SITE
3M Australia Pty Ltd	A/1 Rivett Road, North Ryde NSW 2113	136 136	1300 363 329	www.3m.com.au
Atherton Chemicals Pty Limited	47 Industrial Park Drive, Lilydale VIC 3140	(03) 9739 4311	(03) 9739 4355	www.athertonchemicals.com.au
Australian Pavement Maintenance Systems	15-27 Armstrong Street (PO Box 1867), Tamworth NSW 2340	1800 241 665	(02) 6760 7399	www.apmsystems.com.au
Bituminous Products Pty Ltd	33 Violet Street Revesby NSW 2212	(02) 9772 4433	(02) 9792 1016	www.bituminous.com.au
Boral Asphalt	Seven Hills Building E, 22 Powers Rd 2147	(02) 8801 2000	(02) 8801 2011	www.boral.com.au
Boral Asphalt (Crack Sealing)	PO Box 63 Toongabbie NSW 2146	(02) 8801 2094	(02) 8801 2090	www.boral.com.au
Bostik Australia Pty Ltd	21 Tattersall Road, King Park, NSW 2148	1300 364 710	1300 725 852	www.bostik.com.au
Callington Haven Pty Ltd	30 South Street, Rydalmere NSW 2116 P.O Box 144 Rydalmere NSW Aus 1701	(02) 9898 2788	(02) 9684 4215	www.callingtonhaven.com
CKS Hydro Services	17/514 Botany Road, Alexandria NSW 2014	1888 338 0816	-	www.cksrubberremover.com
Dow Corning Australia Pty Ltd	3 Innovation Road North Ryde, NSW, 2113	1300 360 732	1300 650 785	www.dowcorning.com
Dulux Australia	1 Gow St Padstow NSW 2211	(02) 9794 9777	1800 800 864	www.dulux.com.au
Ecolab Pty Ltd	6 Hudson Avenue, Castle Hill, NSW 2154	(02) 9680 5444	(02) 9680 1643	www.ecolab.com
Epirez Construction Products Pty Ltd	100 Hassall Street, Wetherill Park NSW 2164	1800 063 511	1800 803 596	www.epirez.com.au
Grace Australia Pty	40 Sealon Drive, Epping VIC 3076	(03) 8401 6349	(03) 8401 6301	www.au.graceconstuction.com
Hychem International Pty Ltd	1/30 Bluett Drive, Smeaton Grange NSW 2567	(02) 9548 2186	(02) 9520 2522	www.hychem.com.au admin@hychem.com.au

SUPPLIER	ADDRESS	PHONE	FAX	WEB SITE
Instant Bitumen	www.instantbitumen.com.au	1300 137 731	(08) 8359 4011	www.instantbitumen.com.au
Fulton Hogan	115-119 Churchill Rd Nth, Dry Creek	(08) 83494455		www.fultonhogan.com
Omnicrete Pty Ltd	P.O Box 79 Eltham VIC 3095	1300 851 523	1300 556 160	www.omnicrete.com.au
Paint Industries Pty Ltd	61 Lionel St, Naval Base WA 6165	(08) 9437 1488	(08) 9410 2395	www.paintwa.com.au michael@paintwa.com.au
Parchem Construction Products Pty Ltd	64 Elizabeth Street , NSW	(02) 8781 2000		www.parchem.com.au
Recycled Rubber Technologies Pty Ltd – CTI Consultants Pty Ltd	4 Rothwell Avenue, Concord NSW 2138	(02) 9736 3911	(02) 9736 3287	www.cticonsultants.com.au
Road Maintenance Pty Ltd	14-16 Elliott Road, Dandenong, VIC, 3175	(03) 9794 6454	(03) 9794 6878	www.roadmaintenance.com.au
SAMI Bitumen Technologies Pty Ltd	12 Grand Ave PO Box 163 Granville NSW 2142	(02) 9638 0150	(02) 9638 4983	www.samibitumen.com.au
Sealmaster	See APMS Systems			
Sellys Pty Ltd	1 Gow Street, Padstow NSW 2211	1300 55 205	1300 555 305	www.selleys.com.au
Sika Australia Pty Ltd	55 Elizabeth Street, NSW	(02) 9725 1145	(02) 9725 2605	www.sika.com.au
Shell Australia	PO Box 872K Melbourne 3000	(03) 8823 4444	(03) 8823 4800	www.shell.com.au
Slip Resistant Surfaces Pty Ltd	C/58 Stanley Street, Peakhurst NSW 2210 PO Box 374 Riverwood NSW	(02) 9534 4579	(02) 9534 5855	www.slipresistant.com.au
Supersealing	3/1 James Street, Bayswater, VIC 3153	(03) 9720 1255	(03) 9720 3855	www.supersealing.com.au
Swepdri International	3 Watson Road Padstow NSW 2211 Sydney Australia	(02) 9771 0011	(02) 9771 0111	www.swepdri.com.au
Taubmans	9 Birmingham Avenue Villawood NSW 2163	131 686	1800 676 746	www.taubmans.com.au

SUPPLIER	ADDRESS	PHONE	FAX	WEB SITE
Volumetrics Concrete Australia Pty Ltd	19-21 Cann Street, Guildford, NSW 2161	(02) 9632 1900	02 9892 1825	www.volumetric.com.au
Vivacity Engineering	3 Sefton Rd Thornleigh NSW 2120	(02) 9875 3044	(02) 9875 3665	www.megapoxy.com info@megapoxy.com
Wattyl	Level 4, 2 Burbank Place, Norwest Business Park, Baulkham Hills NSW 2153	(02) 9981 3333	(02) 9831 3344	www.wattyl.com.au wattyl@wattyl.com.au

Australian Government
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Reference Material

Austroads
Pavement Technology Series
Pavement Rehabilitation
A Guide to the Design and Rehabilitation Treatments for Road Pavements

Austroads
Technical Report AP-T41/06
Specification Framework for Polymer Modified and Multigrade Bitumens - 2006

Civil Aviation Safety Authority (CASA)
Manual of Standards Part 139 – Aerodromes
Version 1.10: May 2012

Department of Defence
Australian Defence Force Publication
Joint Services Works and Administration
ADFP 602 - Aerodrome Design Criteria
To be superseded by the Defence Aerodrome Design Manual - due for release in 2013.

Department of Defence
ADF Friction Policy Manual
Version 1.2: May 2011
To be updated in 2012.

International Civil Aviation Organisation (ICAO)
International Standards and Recommended Practices for Civil Aerodromes
Annex 14 to the Convention on International Civil Aviation (ICAO Annex 14)
Volume I – Aerodrome Design and Operations
Fifth Edition, July 2009

US Transportation Research Board - Airport Cooperative Research Program
ACRP Synthesis 22
Common Airport Pavement Maintenance Practices – 2011

ASTM
ASTM D 5340 Standard Test Method for Airport Pavement Condition Index Surveys

US FAA
AC150/5320-17 Airfield Pavement Surface Evaluation and Rating Manuals (PASER)

AC150/5380-6B Guidelines and Procedures for Maintenance of Airport Pavements

AC150/5320-6E Airport Pavement Design and Evaluation

Biennial Pavement Inspection Process

AIRFIELD PAVEMENT AUDITS AND ROUTINE INSPECTIONS

BIENNIAL PAVEMENT INSPECTION PROCESS

1. In order to determine the airfield pavement maintenance requirements for the immediate and long term future, Defence employs specialist airfield pavement consultants to supplement the skills provided by regional Defence Support Group (DSG) staff and Royal Australian Air Force (RAAF) Airfield Engineers (AFENG). The program is run by DSG Infrastructure Division (ID) Capital Facilities and Infrastructure (CFI) National Airfields Projects (NAP) in conjunction with the Directorate of Estate Engineering Policy (DEEP) Civil Engineering Section (CES) and involves a specialist airfield pavement consultant, alongside base and DEEP staff inspecting Australian Defence Force (ADF) airfield pavements for signs of ageing, wear and damage. These inspections not only report on the condition of the airfield pavements but they make recommendations on the type and extent of repair and maintenance works that are required on the subject pavement in order to maximise its serviceable life.

2. The Pavement Inspection Report (PIR) is the medium used to record the inspection findings and proposed maintenance and deliberately does not attempt to provide a specification for each maintenance recommendation. Minor maintenance work can be performed using the techniques and products recommended in Chapter 13 of the Airfield Pavement Maintenance Manual (APMM, 20012). Larger and more significant maintenance works, which require a separate design and specification to be developed, are included in the Defence 10 year program for delivery by NAP and their airfield pavement consultants.

3. These inspections of the pavement condition usually take between one and two days per airfield and involve recording and describing the following.

a. pavement structural condition:

(1) structural distress indications; and

(2) stepping, faulting.

b. pavement operational adequacy:

(1) pavement shape and ride-ability issues;

(a) assessment of longitudinal shape (usually confirmed by driving vehicle at 100kph along runway and 40kph along taxiways); and

(b) assessment of transverse shape (quantified using string line and digital spirit level).

(2) surface integrity/condition (extent of cracking and FOD potential), including surface texture (roughness and frictional characteristics – friction testing is conducted separately);

(3) approach conditions;

(4) condition of RESA, stopways and clearways; and

(5) condition of stabilised, graded and vegetated horizontal areas of flight strip.

c. pavement maintenance requirements:

(1) pavement defects (cracking, aggregate loss, joints, deformations, etc.);

(2) condition of concrete slabs (degree of cracking);

(3) condition of joints in asphalt surfacing and concrete pavements; and

(4) presence of weeds growing through cracks.

d. pavement markings;

e. assessment of drainage adequacy;

f. condition of ancillary equipment:

(1) Movement Area Guidance Signs (MAGS), including Distance to Run Markers (DTRM) and Hook Cable Markers (HCM);

(2) interface of cable arresters with pavement;

(3) integrity of secondary Aeronautical Ground Lighting (ALG) cables cut into pavement surface;

(4) aircraft tie-down points; and

(5) physical condition of earthing points (electrical resistance checks are conducted by others).

g. policy compliance (e.g. ADFP 602 or equivalent, ICAO, MOS 139);

h. detailed photographic record:

(1) photographs of typical defects found;

(2) photographs of specific defects found; and

(3) photographs of typical condition(s).

4. In most cases, immediately following the inspection, DEEP-CES personnel and their specialist pavement consultants debrief the regional personnel responsible for maintenance and the Senior Air Traffic Control Officer (SATCO) on any issues that require immediate attention to maintain aircraft operational safety. The debrief also provides these personnel with an overall indication of the pavement's condition and some insight into how the pavement has performed since the last inspection.

5. Upon completion of the inspections a PIR is produced. At the front of the report is an executive summary of the pavement's condition and immediately following is a list of works that are recommended to be undertaken immediately, in the next two years and in the next 10 years. Each of these recommended works items is presented with an indicative cost. The inspection report will also include a 'supplement' / update of previous reports with respect to the significant maintenance performed since the last inspection.

6. Upon receipt of the PIR the regional DSG office are responsible for undertaking those work that are recommended for immediate attention. Directorate of NAP prepares funding bids to adequately resource the annual and Defence 10 year maintenance program and undertakes works recommended for the budget year (and beyond).

7. Some of Defence's airfields (e.g. Darwin and Townsville) are *joint-user* airfields and are partly funded by the civilian lessee operator. In order to ensure the lessees are financing their use of the airfield facilities, *Joint-User Deeds* (JUD) have been developed between Defence and these non-Defence users of the airfield. Defence and the lessee are jointly responsible for the maintenance of the Joint User Areas (JUA) with cost sharing arrangements determined by the formulae or mathematical models within the JUD. Defence manages the land within the JUA as part of the deed; however in order to avoid disagreement with respect to the extent and cost of maintenance works required to be undertaken at a *joint-user* airfield, it is standard practice to invite joint-user representatives to participate in the biennial inspection process. This participation often includes: providing a representative on the inspection party itself, working with Defence to agree on the products to be used in the repair process and, more importantly, the timeframes in which the works can be undertaken.

PAVEMENT INSPECTION REPORT TASKS & INDICATIVE TIMEFRAMES

Activity	**Timing**
Inspection programme established through Defence Airfields Maintenance Program	12 weeks prior
Initial contact with Base prior to inspection	4 weeks prior
Program finalised with Base	2 weeks prior
PAVEMENT INSPECTION ON-SITE	
Draft (Microsoft Word Document) report submitted to DEEP	4 weeks after
Draft comments (using Word Track Changes) returned from DEEP	6 weeks after
Final report (MS Word & Adobe Acrobat *.PDF) submitted to DEEP	8 weeks after
DEEP release to Defence Stakeholders	10 weeks after

Deliverables:

- 1 electronic (PDF) copy to DNAP
- 1 electronic (PDF) copy to Air Base Executive Officer/Base Services Manager (or equivalent)
- 1 hard copy to DEEP
- 1 hard copy to Joint User Representative (if required)
- 1 electronic (PDF) file to Infrastructure Division Web Content Manager for upload on the Defence Estate Quality Management System (DEQMS).
- All electronic files archived in DRMS (actioned by NAP)

PAVEMENT INSEPCTION REPORTS – GENERAL NOTES

1. Each PIR is to be supplied in the following format:

   a. Draft Copy

      (1) Electronic PDF File or Word Document soft copy

   b. Final Hard Copy

      (1) Joint User airfields: Two (2) bound colour copies

      (2) All other airfields: One (1) bound colour copies

   c. Final Electronic Copies:

      (1) PDF copy of full report (including all annexes embedded in this copy) suitable for upload to the Defence DEQMS website

         (a) 5MB for internal e-mail (5MB);

         (b) 1.5MB for outgoing e-mails crossing the Defence Gateway

         (c) Email messages that exceed the size limits or that contain certain types of attachments (in particular graphics, movie or sound formats) will be automatically captured, held and the originator informed.

         (d) The sender receives an email (Outgoing Email Limit Notification) that provides the details of the outgoing message, a unique message identifier and a time stamp. The originator then confirms that the transmission is both an appropriate use of limited Defence resources and work-related before it is released.

         (e) Blocked emails are stored for a maximum of five working days. If no request is received, the email is automatically deleted.

         (f) **Incoming email size limits.** Emails sent from outside into the Defence Restricted Network (DRN) domain are subjected to the same constraints as for outgoing emails. Originators of incoming emails that exceed the size limit or attachment policy are also sent an email (Defence Email Limit Notification) to inform them of Defence policy and procedures to enable any work-related emails to be released.

      (2) Word copy of the Executive Summary (as an individual file)[1].

[1] Summary provided to the Air Base Executive Officer (E) or his representative (e.g. Base Airfield Engineering Officer, BAEO) to brief the member/s on the condition of airfield pavements at the base.

2. Airfield data (except pavement profiles) contained in Airfield Pavement Strength Evaluation Manual (APSEM) is to be validated during the inspection. A copy of current data can be provided by DEEP-CES upon request.

3. All Defence owned and/or maintained pavements are to be inspected throughout the inspection.

4. Specialist airfield pavement consultants will generally be engaged in packages grouped by location. Significant works are to be timed such that major works are grouped into the same year. For example, if a runway overlay is required in Darwin in 2023 and taxiway overlay is due in Tindal in 2024, these works should be programmed for the same year to avoid mobilisation of asphalt crews and plants one year apart.

5. Costs estimates are to be reported in $AUS dollar values for the year of works, and are to be accurate to +/- 20% for works in the next two years.

6. Treatments, specific locations and the cost basis (quantity and unit price) are to be detailed in the description field of recommended works. For example:

7.

Item	Location	Description/Method	Quantity	Budget Estimate
1	RWY 09/27	RBB longitudinal joints on outer construction joints of full runway	6000 m	$12,500
2				
			TOTAL	

8. Regions will be requested to provide escorts or Works Safety Officers (WSO) for airside access. There may be a requirement for both Defence personnel and Consultant Engineers to undertake site specific airside access training depending on individual Base requirements.

9. To avoid ambiguity between timings specified by different Consultants, the following terminology is to be used to describe work urgency/priority:

a. Immediate repair

b. Regional maintenance

c. DNAP maintenance

d. Forecasted maintenance

e. Monitor

10. The work urgency/priority is further defined in the table below:

Urgency of repair	Potential Risk	Terminology to be used in PIR	Agency/program for repair	Impact of no corrective action
Immediate	Very High	Immediate repair	Regional repair works (General Estate Works)	Very high risk to operations/capability/safety. Extreme cases may cause aircraft damage or pavement closure.
< 6 months	High	Regional maintenance	Regional repair works (General Estate Works or Project depending on scope)	Significant/High risk to operations/capability/safety, with potential for defect to deteriorate at short notice to become an immediate repair.
< 2 years	Medium	DNAP maintenance	Next DNAP maintenance project at Base	Moderate. Likely further deterioration, cost to repair at a later date likely to be higher for delayed repair, some risk to operations/capability/safety
> 2 years	Low	Forecasted maintenance	Later DNAP maintenance project	Minor. Possible non-critical deterioration
Monitor	Very Low	Monitor	Monitor through biennial pavement inspections	Negligible

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TEMPLATE FOR DEFENCE PAVEMENT INSPECTION REPORT (PIR)

Title Page

The title page is to clearly identify the airfield name, month of inspection (not the month the report is submitted) and the company undertaking the inspection.

Document Control & Copyright Page

Consultants engaged through the Defence Infrastructure Panel are to use the following disclaimer for Copyright:

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The Defence Infrastructure Panel (DIP) reference for intellectual property warranties is at Clause 5.4 in Volume 2 of the Standing Offer Agreement.

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1. Executive Summary

A brief summary of the results of the pavement inspection including specific mention of the following:

1.1 The overall condition of the airfield pavements and significant maintenance since the last report;

1.2 All concerns identified by stakeholders and recommended action;

1.3 Issues arising from the inspection (include any significant non-conformances or safety issues identified during the inspection);

1.4 Urgent works to be undertaken by the base;

1.5 A summary of the maintenance requirements to be delivered by Directorate National Airfields Projects (DNAP) for the next two years, including the total dollar amounts for each year.

2. Introduction

2.1 Introduction

As part of the 20XX-YY National Airfields FACOPS Project Programme, [Company Name] were appointed by the Department of Defence (Defence) in [DATE] to undertake airfield inspections and detailed scoping of short term airfield pavement maintenance requirements at 25 air bases throughout Australia.

This Report provides details of the visual airfield pavement inspection undertaken [Company] in [date] and provides recommendations for future airfield pavement maintenance works.

2.2 Purpose and Structure of Report

The purpose of this Pavement Inspection Report (PIR) is to:

- Identify any airfield pavements which require urgent/immediate maintenance repairs or treatments.
- Comment on the current visual condition of the airfield pavement surfaces observed at the time of the inspection.
- Provide a photographic record of the airfield pavement surfaces observed at the time of the inspection.
- Provide recommendations of the airfield pavement works to be included in the 20XX-YY National Airfields FACOPS Projects Programme of Works.

Provide recommendations of airfields pavement works, both maintenance and capital, to be budgeted for over the next ten years.

3. Recommended maintenance works

Maintenance work is to be broken into the following five sections:

3.1 Works undertaken since last inspection (detail major capital works and the previous PIR recommendations):

WORKS UNDERTAKEN SINCE LAST INSPECTION				
Item	**Location**	**Description**	**Cost estimate**	**Complete Y/N**
1				
2				

3.2 Urgent works to be undertaken by Base/Region. Include enough detail to enable regional Defence personnel to undertake the work without further technical assistance (expand in main body of report as required):

Item	**Location**	**Description/Method**	**Quantity**	**Budget Estimate**
1				
2				
			TOTAL	

3.3 Recommended works for 20AA (next calendar year):

RECOMMENDED WORKS 20AA				
Description	**Cost estimate**	**Description/Method**	**Quantity**	**Budget Estimate**
1				
2				
			TOTAL	

3.4 Recommended works for 20BB (calendar year after):

RECOMMENDED WORKS 20BB				
Description	**Cost estimate**	**Description/Method**	**Quantity**	**Budget Estimate**
1				
2				
			TOTAL	

3.5 Recommended works for 20CC to 20DD (out to 10 years):

RECOMMENDED WORKS 20CC TO 20DD				
Description	**Cost estimate**	**Description/Method**	**Quantity**	**Budget Estimate**
1				
2				
			TOTAL	

3.6 Airfield Pavement Condition Rating

Chapter 8 of the Airfield Pavement Maintenance Manual (APMM) details a simple airfield pavement condition rating system which has been developed to determine the relative condition of each pavement area at each airfield to assist in the determination of timing and prioritisation of airfield pavement maintenance works. It is intended that a pavement condition rating is obtained biennially with each pavement inspection.

The airfield pavement condition rating system consists of ten (10) ratings from 10 ("Very Good") through to 5 ("Fair") to 1 ("Failed").

Table xx (and Drawing No **** at Annex D) provides details of relative condition rating of the airfield pavement areas at RAAF **** in DATE****.

TABLE 2.4– AIRFIELD PAVEMENT CONDITION RATING – RAAF Base ****	
Location	**Condition Rating at DATE **** **
Runway XXX	Rating 1-10
Runway YYY	5
Taxiway A	5
Taxiway B	5
Taxiway C	5
Apron AAA	4
Apron BBB	5
Apron CCC	5
All Pavements	**5**

4. Inspection Details

4.1 Date of Inspection
The airfield pavement inspection was undertaken by [company] in the company of Defence personnel on [date].

4.2 Date of Last Inspections
The previous airfield pavement inspection was undertaken by [company] on [date].

4.3 Inspection Personnel
Inspection personnel included the following:
[DEEP staff]
[Consultant staff]
[Local Base staff]
Additional personnel present at the time of the inspections included the following:
[WSO/others]

Prior to undertaking the airfield pavement inspection a general and safety briefing was held with the WSO and local DSG staff.

4.4 Weather Conditions
Weather conditions at the time of the inspection were as follows:
[Date day 1] – [note temp, weather and pavement conditions].
[Date day 2] – [note temp, weather and pavement conditions].

4.5 Stakeholder Meeting Summary
A Stakeholder Meeting was held on [date] at [location] with the following personnel being present:
[list attendees]

The main points noted regarding the condition for [airfield] included the following:

[list key outcomes from meeting and any user concerns relating to the airfield pavement condition]

4.6 Aircraft Movements
The principal aircraft types operating at [airfield name] include:
[list aircraft movements]

[note if a significant change in aircraft movements is anticipated].

4.7 Runway Friction
[note if airfield is included in Defence friction testing program and any relevant friction data that is available].

5. **Airfield Pavement Inspection Methodology**

5.1 Airfield Pavement Inspection Methodology
[Note consultant methodology for undertaking inspection]

5.2 Limitations
[Note any limitations to methodology or observations from inspection].

6. Runways

6.1 Main runway XX/YY

6.1.1 Description
6.1.2 Pavement composition
6.1.3 Observations
[Runway Thresholds, Main pavement area, RESA's, shoulders, Operational Readiness Platforms (ORP)]
6.1.4 Recommended maintenance for following year

6.2 Runway PP/QQ (Include each cross and parallel runway separate)

6.2.1 Titles as per main runway.

6.3 Grass Runway RR/SS

7. Taxiways

7.1 Taxiway A
7.1.1 Description
7.1.2 Pavement composition
7.1.3 Observations
[Main pavement area, shoulders]
7.1.4 Recommended maintenance for following year

7.2 Taxiway B (and so on in alphabetical order)

8. Aprons

8.1 Air movements apron
7.1.1 Description
7.1.2 Pavement composition

7.1.3 Observations
[Main pavement area, shoulders]
7.1.4 Recommended maintenance for following year

8.2 Flight line aprons
8.3 Main aprons
8.4 RSAF aprons
8.5 Ordnance Loading Aprons (OLA), in numerical order
8.6 Engine run up apron
8.7 Aircraft wash apron
8.8 Civilian aircraft aprons

9. Miscellaneous

9.1 Pavement markings

9.1.1 Runways
9.1.2 Taxiways
9.1.3 Parking Aprons
9.1.4 Other

9.2 Aircraft tie-down points (visual inspection only)

9.3 Aircraft earthing points (visual inspection only)

9.4 Surface texture including roughness and frictional characteristics (TBA – visual only, sand or grease patch tests??)

9.5 Pavement shape and rideability

9.6 Drainage

10.6.1 Pavement surface drainage
10.6.2 Overall airfield drainage

9.7 AGL pavement issues

Although not the focus of a pavement inspection, items such as excessive cracked lenses or other abnormalities are to be reported

10. General Airfield Information

10.1 Weather and Climate

The climate and rainfall data for [airfield name] is shown in Figures 10.1 and 10.2 below.

[insert climate and weather data for airfield]

10.2 Validation of APSEM data)

10.2.1 Pavement dimensions (runway widths, taxiway widths and apron dimensions) are to be verified. A measuring wheel is to be used for all reported dimensions, pacing is not permitted.

10.2.2 Pavement types (rigid, flexible, block) are to be verified and new pavements are to be identified.

10.2.3 Pavement history is to be updated.

ANNEXES

Note: There is no requirement to include the ERSA extract as an annex to the PIR.

A. Abbreviations

B. Glossary of terms

C. Airfield Pavement Layout Drawing

Must be labelled to show all areas of the airfield referenced in the PIR (including sealed runways, grass runways, taxiways, aprons, OLA, ORPs, helipads, etc…).

D. Airfield Pavement Repair Maps

Colour coded maps showing pavement areas requiring repairs are to be provided. Multiple maps may be required depending on the complexity of the pavement types, number of repair types required and overall degradation of the pavement.

Map 1 (Area wide maintenance plan): Includes items such as AC overlay, SEST, concrete joint repairs, rubber removal, etc… as required. Legend will list the maintenance task and the map will colour code where this maintenance is required.

Map 2 (Severity based maintenance plan): Legend to align with level of risk in paragraph 9 (p.A-7).

E. Photographic Record

Photos should be landscape (where appropriate) and sized two photos per page. Each photo is to have a chronological photo number and title describing where the photo was taken, in which direction (if relevant) and any special features to note.

Photos are to follow the order that they are referenced in the PIR.

Photos should be relevant and represent typical conditions, typical defects and specific defects identified during the inspection. Avoid repeating photos of typical defects. As a rough guide, the number of photos that should be included in a PIR is:

Major ADF airfield with significant works required: 150
Major ADF airfield: 100
Other ADF airfield with significant works required: 100
Other ADF airfield: 50-75
[These numbers are not fixed and may be adjusted up or down depending on the complexity of the airfield and the condition of the pavements.]

F. Maintenance and CAPEX forecast 2013-22

This forecasts the major maintenance work items required at the airfield as well as the required timing of capital works (such as pavement overlays and apron reconstructions). Budget estimates are to be provided so the works can be programmed into the National Airfield Projects forward works plan.

G. Update of previous inspection report

Essentially a ‘supplement’ to the previous reports to capture what significant maintenance (if any) has been performed since the last inspection. This may be included where bases are inspected annually as part of the maintenance program, and a formal PIR is only completed every second year.