Airfield Failure Mechanisms

Contents

Airfield Pavement Types

Airfield pavements can be collected into two main categories, flexible and rigid.

- Flexible pavements are composed of a granular sub-base overlaid with a bituminous base course, binder course and surface course.
- Rigid Pavements are also underlain with a granular sub-base but the pavement is then constructed of a wet or dry lean mix concrete layer onto which is laid a pavement quality concrete (PQC) slab. This PQC can either be laid with a slipform concrete train as a continuous slab or in individual bays with full depth joints between them. Slipform slabs have a groove formed in the surface, either by placing an insert in the concrete when wet or by sawing the concrete when newly hardened, in order to induce shrinkage cracking to occur in a controlled manner. These are usually formed transversely at regular intervals along the concrete lane to divide it into approximately square bays. They may also be formed longitudinally to subdivide a lane when the bay sizes are considered too large for the thickness of slab.
  Concrete pavement structures are not generally affected by spillage of aviation fuels or oils and do not indent under the high pressure tyres of modern aircraft standing upon them. These properties make concrete paving particularly suitable for use on runway ends, holding points on taxiways, servicing and parking aprons and hangar floors.

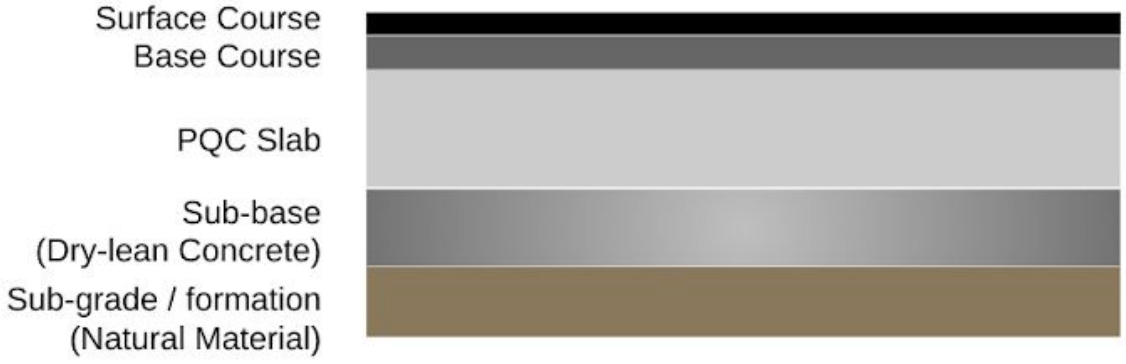
- Composite pavements can be engineered or created by the historic use of a rigid pavement which has later been overlaid with asphalt when the original pavement began to fail. Composite pavements are more prone to reflective cracking than flexible pavements and require extensive ongoing maintenance and eventual resurfacing where this occurs

The performance of all pavements is intrinsically linked to the sub-grade and natural water table levels below the sub-base.

Pavement construction for Flexible Pavements

Pavement Construction for Rigid Pavements

Pavement Construction - Historic Composite Pavements



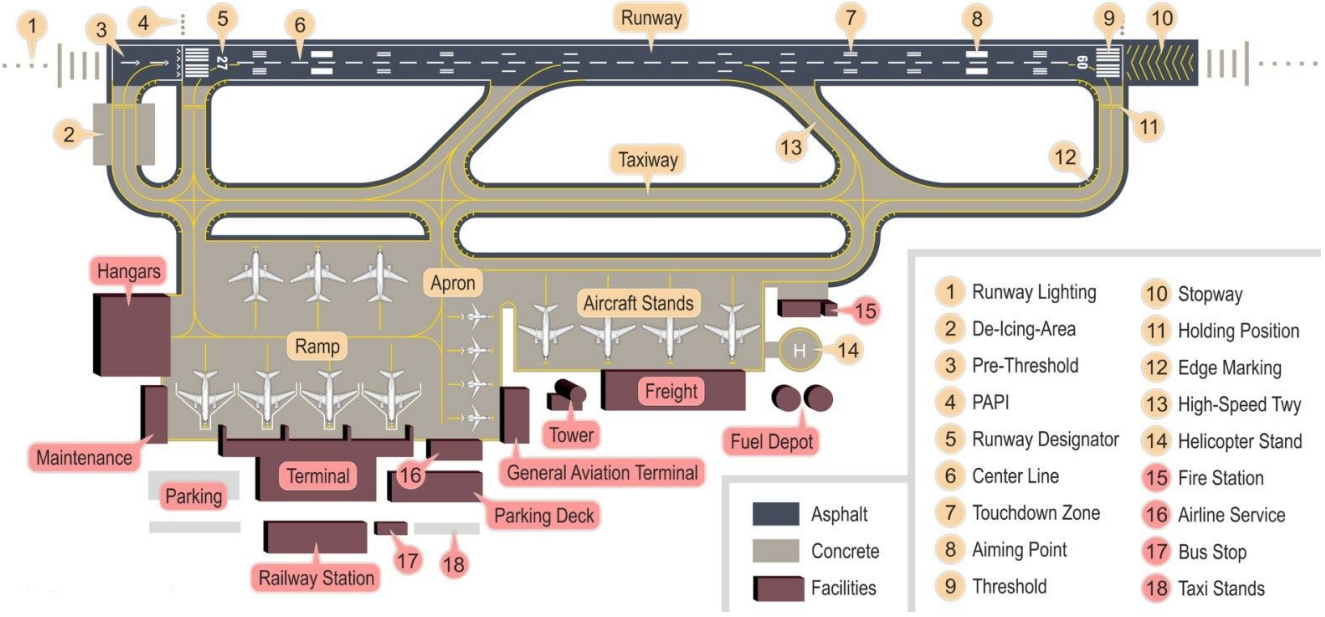
Airfield Pavement Locations

In addition to the differences in overall pavement type the pavement location within the airfield dictates the depth and type of pavement construction. There are four main locations where airfield pavements are utilised:

- Runways
- Taxiways
- Aprons
- Fire Training Areas

Each location requires specific pavement design to deal with different loading and maneuvering conditions.

Typical Airport Layout - Commercial



Runways

The runway pavement is the primary asset of any airfield, in a commercial airfield it represents the main revenue stream for the airport. In a defence airfield it represents a more fundamental operational capacity. Runway pavements are governed by extremely strict geometry, load and friction requirements, the surface of the runway must be maintained in compliance with these requirements to enable an airfield to operate. Failure to comply with these requirements can lead to downgrading of a runway's licence (1[1]) or in extreme cases prohibition against all flights. It is therefore imperative that airports and military bases

[1] Runway licencing governs the size and type of aircraft which can be landed. International Civil Aviation Organisation (ICAO) classifies specific aircraft from Code A to Code F, a Code F aircraft, for example a B747-800 or an Airbus A380 can only land on a Code F runway. A Class E aircraft such as a A340 can land on either a Code E or a Code F runway.

maintain their runway geometry to enable them to optimise the planes which can use the airfield. Runway pavements are designed for the dynamic loads imparted by landing and the friction required to enable the aircraft wheels to brake and accelerate effectively. Friction in runway pavements can be improved by the use of materials with improved macrotexture such as Béton Bitumineux pour chaussées Aéronautiques (BBA) or via the use of transverse grooving of the runway surface.

It is very important that runways are free of FOD which may be thrown up by exhaust efflux, propeller wash or general turbulence possibly to strike aircraft or become ingested into jet engines. Foreign object damage sustained while aircraft are taking off or landing is potentially the most dangerous. This also applies to damage inflicted on aircraft tyres by sharp edges on the pavements. Good rideability is essential on runways as aircraft are moving at their fastest speed on the ground. Good surface water drainage is essential, if aquaplaning is to be avoided this can be improved by the correct geometrical alignment, appropriate drainage and grooving of the runway surface, Skidding resistance has to be good enough to allow aircraft to come to a halt safely within the runway length. However, surface texture provided to achieve good skidding resistance should not be so sharp as to cause excessive tyre wear. The interior length of the runway must be able to withstand the consequences of aircraft tyre bursts.

The ends of the runway have to be resistant to damage by fuel and oil leaks, to indentation by high pressure tyres of standing aircraft and, in a large number of cases, to damage by moderately pro- longed exposure to jet engine exhaust efflux. At some airports a turning area is installed at the end of the runway to enable aircraft to taxi to the end of the runway and turn rountd. These pavements are designed for the turning forces exerted at slow speed by the aircraft, the static load from stationary aircraft and to resist jet exhaust damage.

Taxiways

The geometry of the transition from a Runway to a Taxiway is also part of the criteria for Runway licencing. Large planes require very gradual geometrical transitions to maintain stability and control. This includes the camber of the taxiway and radius of any turns. Taxiway pavements are designed for the turning forces and vertical loads imparted by slow moving aircraft maneuvering to enter or exit the runway. On taxiways, aircraft may be moving in close proximity with one another so that FOD thrown up by jet engine exhaust or propeller wash from one could be hazardous to another. Absence of loose matter on the surface is therefore important. Freedom from sharp edges which might damage tyres is also necessary.

Aircraft are often moving fast enough on taxiways for good rideability to be a requirement. However they are unlikely to be moving fast enough to aquaplane or (in the case of military jets) to sustain engine flame out on hitting ponded rainwater. Surface water drainage is only required to prevent ponds of water which might cause loss of directional control if frozen. The choice of surface material is also less critical on taxiways as the majority of surfacing materials will give adequate skidding resistance for aircraft at taxiing speeds. Excessive texture is better avoided on taxiways in order to limit the tyre wear of aircraft that are turning

sharply. The surfaces on taxiway holding areas must be resistant to damage from fuel and oil leaks and from indentation by the static load of standing aircraft.

Aprons

Airfield Aprons are used for aircraft parking and servicing, either in association with aircraft stands in a commercial airport or for storage or aircraft not in hangers, and also for aircraft refueling, they are referred to as ASP's, Aircraft Servicing Platforms on defence airfields. Aprons are generally areas of high activity for personnel and support vehicles and therefore surface texture must be sufficient to provide grip for all users from aircraft to pedestrians.. As a result of the activities undertaken on them they tend to be subject to fuel spills and are often coated with a fuel resistant resin or similar substance to prevent damage to the underlying pavement. The pavements are generally constructed from Pavement Quality Concrete which is less susceptible to fuel damage and copes well with the static loads imparted by the stationary aircraft. Depressions at the wheel positions of parking slots make it difficult for aircraft to begin moving, the pavement design must therefore accommodate this use without deflection under load. Surface water drainage must be sufficient to prevent ponding since this will be unacceptable for air and service crews and passengers moving to and from parked aircraft as well as being hazardous for aircraft, vehicles and pedestrians if ice forms.

FOD which might be disturbed by jet engine exhaust or propeller wash must therefore be avoided. Sharp edges which might damage aircraft tyres are also an issue. Aircraft are not generally moving fast enough on aprons for rideability to be important. However, vertical steps, for example across joints in concrete, may present a trip hazard for personnel and must therefore be corrected.

Fire Training Areas

Fire training areas are generally located adjacent to the airfield fire station and enable practice of firefighting techniques away from operational areas. The pavement in these locations can be subject to heat and significant quantities of water. Generally these areas are paved with Rigid concrete pavements which are least prone to damage and require least maintenance.

Pavement Classification Numbers

Within the UK there are two main systems of Pavement Classification. The ICAO System uses the PCN/ACN system to designate the load bearing capability of the airport pavement.

- Pavement Classification Number - PCN - A number which expresses the relative load carrying capacity of a pavement in terms of a standard single wheel load
- Aircraft Classification Number - ACN - A number which expresses the relative structural effect on an aircraft on different pavement types for specified standard subgrade strengths in relation to single wheel load. This number is based on the pavement construction and underlying Californian Bearing Ratio (CBR), tyre pressure and gross weight of the aircraft. If the ACN is less than the PCN of the runway the

aircraft can land. The CBR and Pavement construction are published in the Airports Directory maintained by ICAO,

Airport operators specify a PCN level which needs to be exceeded by the airfield pavements constructed and maintained within their airport based on the ACN's of the aircraft which will use their airport. International airports will specify and maintain high PCN levels to maximise the variety of aircraft which can use their airport.

The classification system currently used for UK military airfields is the Load Classification Number - Load Classification Group (LCN - LCG) system.

- Load Classification Number - LCN - each type of aircraft is assigned a number (its LCN) on a scale of 1 to 120 representing its relative damaging effect on pavements, taking into account the weight of the aircraft and the configuration, spacing and tyre pressure of its undercarriage wheels. (An LCN of 120 is the most damaging and LCN 1 the least).
- Load Classification Groups - For the pavements, the values are divided into seven Load Classification Groups (LCG's I to VII, LCG I being the strongest) and pavements are classified as belonging to one or other of these groups according to their load carrying capacity. For each category of LCG there is a specific range of Aircraft LCN's which can use the runway.

LCG	I	II	III	IV	V	VI	VII
LCN	120 - 101	100 - 76	75 - 51	50-31	30 - 16	15 - 11	<10

The LCN-LCG system makes no distinction between the type of runway construction and is therefore less precise than the ICAO - ACN - PCN system

Pavement Failure Mechanisms

Airfield Pavements can fail in a number of ways, these can be categorised as follows:

1. Flexible & Composite Pavements
    a. Aggregate Loss due to Raveling and Weathering
    b. Bleeding
    c. Crocodile Cracking
    d. Flaking
    e. Rutting
    f. Heave or Swell Distress
    g. Shoulder Collapse
    h. Block Cracking
    i. Reflective Cracking (From underlying PQC slabs joints)
    j. Longitudinal & Transverse Cracking (Not Reflective)
    k. Blister
    l. Depressions
    m. Jet Blast Erosion
    n. Oil Spillage
    o. Failure of Patching
    p. Polished Aggregate
    q. Potholes
    r. Shoving
    s. Slippage Cracking
2. Rigid Pavements
    a. Blowup / Buckling
    b. Corner Break
    c. Longitudinal, Transverse, and Diagonal Cracks
    d. Durability Cracking
    e. Cobweb Cracking
    f. Joint Seal Damage
    g. Patch
    h. Popouts / Scabbing
    i. Pumping
    j. Scaling, Map Cracking, and Crazing (Chicken Wire Crazing)
    k. Settlement or Faulting
    l. Shattered Slab/Intersecting Cracks
    m. Shrinkage Cracks
    n. Spalling (Transverse and Longitudinal)
    o. Spalling (Corner)

The specific details of each failure method are provided in the next few pages

Flexible & Composite Pavements

Aggregate Loss due to Raveling and Weathering- Is generally a result of binder hardening (embrittlement) during the lifetime of the pavement. The bituminous binder loses its flexibility and loading to the pavement picks out individual stones which over time reduces the performance of the runway surface. This issue also creates an ongoing Foreign Object Debris (FOD) issue which can have a significant impact on the airfield operations.

Bleeding - Is the process where the bituminous element of the asphalt moves to the surface of the pavement swallowing the surface aggregates and leaving an entirely smooth and often sticky surface with little or no texture. Bleeding significantly reduces the friction performance of the pavement. Bleeding is generally caused by poor material quality with excess tar levels or low air void levels.

Crocodile Cracking - A series of interconnecting cracks caused by fatigue failure of asphalt surfacing under repeated traffic loading. Initiating at the bottom of the asphalt, the cracks propagate to the surface initially as a series of parallel cracks which, after repeated loading, interconnect to form a pattern resembling the skin of a crocodile. Also known as 'alligator' cracking.

Flaking - Partial debonding of thinly layered surfacing so that flakes of it become loose. Most often occurs with slurry seals and marking materials applied to asphalt surfaces.

Rutting - Is the compression of sections of the pavement surface due to excess or repetitive heaving loading on particular areas of the pavement which creates a longitudinal depression in the pavement along the aircraft wheel path. In a similar manner to the compression of the pavement surface on the inside lane of a motorway, the use of a runway by a large number of similar sized aircraft can over time cause compression of the surface in line with the main wheels. Rutting can take two forms, Surface Rutting where only the upper layers of the asphalt pavement are affected or deep structure rutting where the failure exists in the underlying sub-base or sub-grade.

Heave or Swell Distress - Is either the result of the freezing and thawing of water within the underlying sub-grade as a result of fluctuating winter temperatures or it is the result of expansion of adjacent concrete pavement during hot weather

Shoulder Collapse - Code D and E runways require shoulders if their width is less than 60m, all Code F runways require shoulders. The shoulders should be constructed to withstand an aircraft trafficking them in an emergency, however shoulder construction is generally significantly less structurally robust than the main runway. A shoulder collapse can occur under load from an aircraft emergency, resulting in localised collapse of the asphalt pavement used to construct the shoulder.

Block Cracking - Is caused by the formation of interconnected cracks which eventually break the pavement into block sections from a result of asphalt shrinkage and daily temperature cycling. The blocks can vary in size from 250mm to over a metre. This type of failure is common in the countries closer to the equator where there can be large daily fluctuations in temperature.

Reflective Cracking (From underlying PQC slabs joints) - is caused by the movement of the underlying PQC slabs at the joint locations, due to loading or changes in temperature of moisture levels, which causes tension in the asphalt layers of the pavement creating cracks through to the surface of the pavement. Movement of the PQC slabs can be the result of settlement or movement of the underlying sub-grade or failure of the cement-bound sub-base.

Longitudinal & Transverse Cracking (Not Reflective) - Longitudinal cracks can form at poorly constructed paving joints. Asphalt is laid in strips running along the runway. If the pavers do not work in an echelon formation to ensure that the joints between the strips are formed when the asphalt is still hot these joints need to be carefully cut and then treated prior to the next strip being laid. If the treatment of the joint is not correctly applied then the joints can separate over time to create cracks in the pavement. Alternatively these cracks can be caused by shrinkage of the asphalt paving material. Transverse cracks form across the runway at 90° to the centre line. These cracks where they do not coincide with underlying pavement joints can be caused by material shrinkage.

Blister - A circular bulge on the bituminous surface caused by the development of water vapour or other gas pressure within the pavement structure

Depressions - are localised areas of pavement which settle lower than the overall pavement level as a result of either settlement in the sub-grade or errors in laying geometry. Depressions can collect water which does not then run off (Ponding) and creates the potential for hydroplaning.

Jet Blast Erosion - is created when the jet blast burns the bituminous binder creating aggregate loss and debris issues (FOD)

Oil Spillage - because asphalt is made from bituminous binder materials the application of oil can thin these binders causing damage to the surface of the pavement with softening of the binder, loss of aggregates, and dependent on the quantity of oil, erosion of a complete section of pavement surface.

Failure of Patching - Patches to airfield pavements are constructed to address existing damage during short duration closures where resurfacing is not possible. A patch is an area where the original pavement has been removed and replaced with either similar or different material. A patch is considered a defect, no matter how well it performs. Traffic load, material, and poor construction practices can cause patch deterioration and failure.

Polished Aggregate - over time the action of aircraft wheels on the airfield runway can polish the surface of the aggregates where the surface binder has previously been worn away.

Potholes - Cavities more than, 50mm across formed in a blacktop surface by local disintegration.

Shoving - is the displacement of a localised area of asphalt due to heavy braking or turning of an aircraft which drags one layer of asphalt from another.

Slippage Cracking - is often related to shoving and is the crack in the material which occurs when the material moves under horizontal braking or turning load. The crack is typically half moon shaped and is caused by poor quality low strength material or material where the joint between layers has failed to bond to the underlying layer.

Rigid Pavements

Blowup / Buckling- occur in hot weather, usually at transverse cracks or joints that are not sufficiently wide to permit the thermal expansion of the concrete slabs. The expansion of the incompressible materials into the joint space leads to insufficient width. When the expansion of adjacent slabs creates sufficient pressure localised upward movement of the slab edges or spalling occurs in the vicinity of the joint. Blowups can also occur at utility cuts and drainage inlets. Blowups increase FOD potential

Corner Break - is a crack that intersects the joint at a distance less than or equal to one-half of the slab length on both sides, measured from the corner of the slab. Factors causing corner breaks are load repetitions combined with loss of support and curling stresses.

Longitudinal, Transverse, and Diagonal Cracks - divide the slab into two or three pieces and are generally caused by a combination of load repetition, curling stresses, and shrinkage stresses. Low-severity cracks are usually warp- or friction-related and are not considered major structural distresses. Medium- or high-severity cracks are usually working cracks and are considered major structural distresses. In addition cracking can also branch creating a **Bifurcated Crack**

Durability Cracking - is caused by the concrete's inability to withstand environmental factors such as freeze-thaw cycles. It appears as a pattern of cracks running parallel to a joint or a crack. This type of cracking can eventually lead to disintegration of the concrete within 0.5m of the joint or crack. Correctly selected concrete mixes and correct compaction and curing methodology significantly reduce the risk of durability cracking.

Cobweb Cracking - Cracking in a spiders web pattern which progresses from the corners and later the edges of bays, this form of cracking often progresses to spalling

Joint Seal Damage - Joint seal damage is any condition that enables debris (organic or inorganic) to accumulate in the joints or allows a significant amount of water infiltration. Accumulation of incompressible materials prevents the slabs from expanding and can result in buckling, shattering, or spalling. Typical joint seal damage are

- stripping of joint sealant,
- extrusion of joint sealant,
- weed growth,
- hardening of filler,
- loss of bond to the slab edges, and
- lack or absence of sealant in the joint.

Patch - is an area where the original pavement has been removed or replaced by a filler material. Poor construction of the patch, loss of support, heavy load repetitions, moisture, and thermal gradients can all cause damage or failure of patch locations.

Popout / Scabbing - is a small piece of pavement that breaks loose from the surface due to a freeze-thaw action in combination with expansive aggregates. Popouts usually range from approximately 25 - 100mm in diameter and from 10 - 30mm in depth. This type of distress is generally caused by material and environmental factors. Specification of appropriate aggregates can mitigate the risk of popout.

Pumping - Pumping is the ejection of material by water through joints or cracks caused by the deflection of the slab under moving loads. As water is ejected, it carries particles of gravel, sand, clay, or silt from the sub-base and sub-grade, resulting in loss of pavement support. Pumping near joints indicates poor joint sealer and loss of support that will lead to cracking under repeated loads. Pumping can occur at cracks as well as joints.

Scaling, Map Cracking, and Crazing (Chicken wire crazing) - refers to a network of shallow, fine, or hair-like cracks that only affect the upper surface of the concrete. The cracks intersect at angles of 120°. This form of damage is generally caused by over finishing the concrete and may lead to surface scaling. Breakdown of the slab surface occurs to a depth of 5 - 15mm. Deicing salts, improper construction, freeze-thaw cycles, and poor aggregate may also cause scaling cracks

Settlement or Faulting - Difference of elevation at a joint or crack, caused by upheaval, consolidation, or a buildup of loose materials under the trailing slabs, is called settlement or faulting

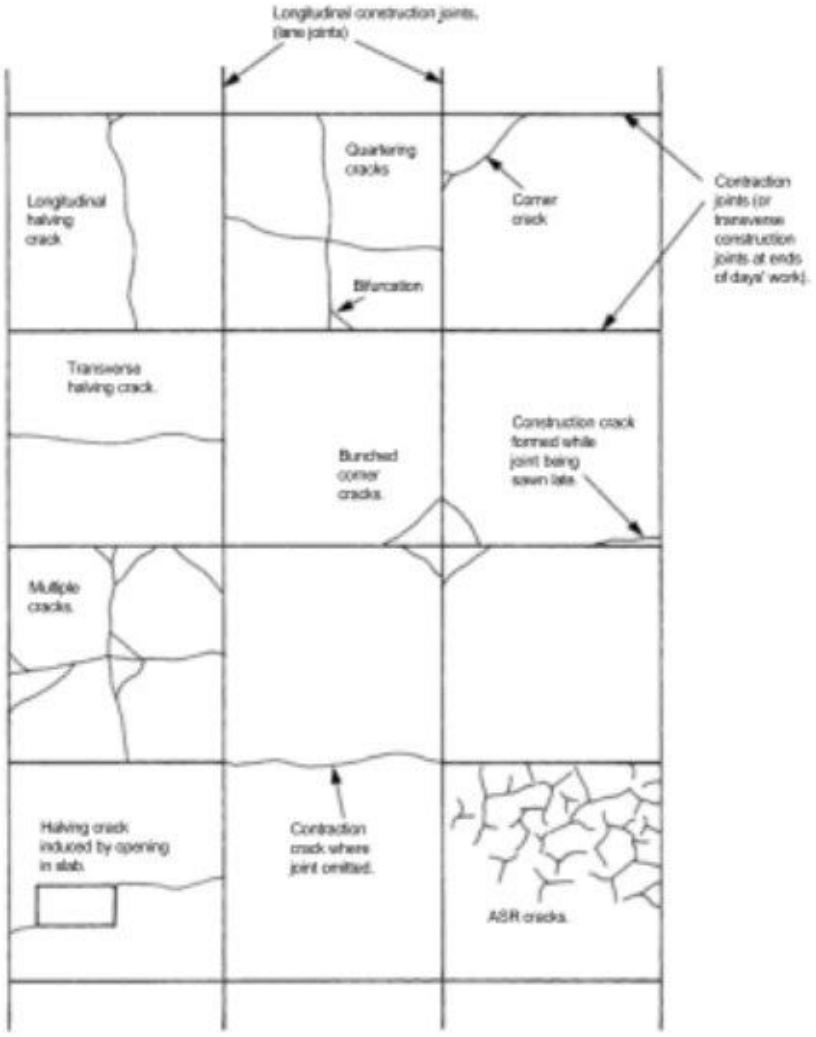
Shattered Slab/Intersecting Cracks - Cracks that break the slab into four or more pieces due to overloading or inadequate support or both are called intersecting cracks, whereas a high-severity level of this distress is referred to as a shattered slab

Shrinkage Cracks - Shrinkage cracks are hairline cracks that are usually relatively short, less than a metre, and do not extend across the entire slab. They are formed during the setting and curing of concrete and usually do not extend through the depth of the slab.

Alternatively the term, shrinkage crack can also be used to describe a load-induced crack that extends only part of the way across a slab.

Spalling (Transverse and Longitudinal) - Joint spalling is the breakdown of slab edges within 0.5 metres of the side of the joint. A joint spall does not extend vertically through the slab but intersects the joint at an angle. Spalling is caused by excessive stresses at the joint or crack caused by infiltration of incompressible materials or traffic loads or weak concrete (resulting from overworking of the mix) at the joints combined with traffic loads

Spalling (Corner) - Corner spalling is the raveling or breakdown of the slab within 0.5m of the corner. A corner spall differs from a corner break in that the spall usually angles across to intersect the joint, while a break extends vertically through the slab.



Failure types in Rigid Pavements

Individual Treatment Options for Pavement Failures

Failure	Traditional Solution	Cost /Unit & Timescale	Alternative Solution	Cost / Unit & Timescale
Flexible & Composite Pavements				
Aggregate Loss due to Raveling and Weathering	• Slurry Sealing • Treatment with PenTack • Plane out & Resurface.		No alternative	N/A
Bleeding	Overlay with Pervious Friction Course or Slurry Seal		No alternative	N/A
Crocodile Cracking	Asphalt Overlay		No alternative	N/A
Flaking	Remove all loose material and reapply thin bond material as required		No alternative	N/A
Rutting	Patch repair for localised areas Strengthen by overlay. Plane out excessive rutting and then overlay.		No alternative	N/A
Heave or Swell Distress	If caused by concrete expansion - install expansion joint. If minor and caused by ground heave - surface reprofiling If major - full depth		Ground heave - stabilisation of underlying material?	TBC

	reconstruction.			
Failure	Traditional Solution	Cost /Unit & Timescale	Alternative Solution	Cost / Unit & Timescale
Shoulder Collapse	Reconstruction of shoulder	Dependent on shoulder construction.	Could the ground adjacent to the runway be stabilised to create a non-bituminous shoulder? Load capacity?	TBC
Block Cracking	Resurfacing		No alternative	N/A
Reflective Cracking (From underlying PQC slabs joints)	Initially - Overbanding Strip repair as the area deteriorates or Recessed SAMI with glass fibre grid reinforcement Finally Runway overlay or full reconstruction	Reflective cracking creates an ongoing maintenance need over years. The initial cost of overbanding is minimal but the impact on the airfield quickly increases	Stabilisation or uplift of underlying slabs	N/A
Longitudinal & Transverse Cracking (Not Reflective)	Initially - Overbanding Strip repair as the area deteriorates or Recessed SAMI with glass fibre grid reinforcement. Resurfacing	Cracking creates an ongoing maintenance need over years. The initial cost of overbanding is minimal but the impact quickly increases	No alternative	N/A
Blister Depressions	No action required		No alternative	N/A
Jet Blast Erosion	Replace section with appropriate PQC pavement		No alternative	N/A
Oil Spillage	Replace section		No alternative	N/A

	of oil affected asphalt			
Failure	Traditional Solution	Cost /Unit & Timescale	Alternative Solution	Cost / Unit & Timescale
Failure of Patching	Break out, cut back and replace with Hot Rolled Asphalt or Marshall Asphalt		No alternative	N/A
Polished Aggregate			No alternative	N/A
Potholes	Patch repair with Hot Rolled Asphalt or Marshall Asphalt		No alternative	N/A
Shoving /Slippage Cracking	Patch repair		No alternative	N/A
Rigid Pavements				
Blowup / Buckling	Bay Replacement	£1500/m2 + Prelims & Risk	No alternative	N/A
Corner Break	Full depth partial bay replacement	£1500/m2 + Prelims & Risk Minimum 2 shifts	Potential to reduce severity of cracking with stabilisation of underlying material	TBC
Longitudinal, Transverse, and Diagonal Cracks	0-3mm No Treatment 3-5mm Overband 5mm and above Clean and widen joint to between 13-20mm and seal with joint compound Multiple cracks	Chase, seal and Overbanding £ /m Bay replacement £1500/m2 + Prelims & Risk	Potential to prevent cracking due to underlying sub-base or subgrade issues with stabilisation.	TBC

	or continued deterioration - Replace Bay			
Failure	Traditional Solution	Cost /Unit & Timescale	Alternative Solution	Cost / Unit & Timescale
Durability Cracking	As Longitudinal, Transverse and Diagonal Cracks	As Longitudinal, Transverse and Diagonal Cracks	No alternative	N/A
Cobweb Cracking	Minor cracking on isolated bays - Instant Bituminous repair material Extensive cracking over multiple bays - Plane out using cold planer and lay back with Hot Rolled Asphalt Total failure - Replace Bay	Dependent on method	No alternative	N/A
Joint Seal Damage	Reseal joint. If spalled use spalling repair methods detailed below	Resealing joint £ /m Minimum visit charge applied - Single shift	No alternative	N/A
Patch Failure	Breakout and replace failed patch	Replacement of Patch £ /m2 Single shift	No alternative	N/A
Popouts / Scabbing	Bonded concrete repair or epoxide resin	Epoxide Resin Repair £ /m2 Single Shift	No alternative	N/A
Pumping	Bay replacement	£1500/m2 + Prelims + Risk 2 Shifts minimum	Stabilise underlying sub-base and sub-grade. Reseal joints to prevent joint damage	TBC

Settlement or Faulting	Bay replacement	£1500/m2 + Prelims + Risk 2 Shifts Minimum	Stabilise or uplift slab	TBC
Failure	Traditional Solution	Cost /Unit & Timescale	Alternative Solution	Cost / Unit & Timescale
Scaling, Map Cracking, and Crazing (Chicken Wire Crazing)	Minor issue - no treatment - monitor for deterioration	Not Applicable	No alternative	N/A
Shattered Slab / Intersecting Cracks	Bay replacement	£1500/m2 + Prelims + Risk 2 Shifts Minimum	Dependent on progress of cracking it may be possible to stabilise the underlying material then repair cracks	TBC
Shrinkage Cracks	If minor - no treatment - monitor If significant - seal cracks	Crack Sealing -	No alternative	N/A
Surface Weathering	Coat surface with Addagrip (Epoxide Resin) or Tar Emulsion Slurry Seal	Addagrip sealant -	No alternative	N/A
Spalling (Transverse, Longitudinal & Corner)	Minor spalls <50mm by joint fill with joint sealant Spalls >50mm Saw cut to define edges. Clear loose material, break out min. 30mm depth and 200mm wide. Bonded concrete or epoxide resin	Dependent on treatment	No alternative	N/A

	repair. Treat crack location with 5mm EVA sheet to prevent joint bonding			

Ancillary Costs of working on Airfields

In addition to the cost of the repairs there are additional costs associated with working on a live airfield or an airfield under possession.

Airside Motor Insurance - Most contracts will require provision of £50m Airside Motor Insurance to cover all vehicles taken airside.

Delay Damages / Liquidated Damages - Late handback of an airside pavement from a possession can be catastrophic for the airport and consequently the charges levied by airport authorities for late hand back of their assets are substantial. At Gatwick late handback costs start at £15k for the first hour and steeply ramp from there with no overall cap on charges, other airports and bases operate at similar or higher charge levels. It is therefore essential that the works are carefully planned and undertaken well within the available window.

Contractor's liability - Most airport related contracts attempt to specify unlimited liability for the contractor. With negotiation this can generally be reduced to the contract value

AirDat driving permits - All operatives driving airside will require an AirDat driving permit or similar. Cost per permit -

GSAT security training - All personnel going airside will require GSAT training. Costs vary but GSATtraining charge £41/ person

Generally Airports expect £10m of Contractor's all risk, Public Liability and Employers Liability insurance insurance together with £10 Professional Indemnity Insurance if any element of design is included.

Safecontractor etc - Most airports require you to be pre-registered with either Safecontractor or Exor or similar. Annual charges vary but Safecontractor charges £249 for their basic package which takes up to 3 months to process. If you need the approval sooner prices increase to £300 or £350

Glossary of Aviation Terminology

Aerodrome - A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft.

AGL - Aeronautical Ground Lighting

AirDat - Airport systems provider used for licencing of contractors and personnel including airside and landside operators licences together with Airside Driving Permits

Aircraft Stand - A designated area on an apron intended to be used for parking an aircraft.

Airside - The secure area not accessible without appropriate passes and permits. This area is a secure controlled space where access is restricted and aircraft operate. Within the UK Airside spaces are fenced with a secure perimeter fence and gates monitored by security personnel.

AOA - Airport Operators Association - Trade association

Apron - A defined area, on a land aerodrome, intended to accommodate aircraft for purposes of loading or unloading passengers, mail or cargo, fuelling, parking or maintenance.

ASP - Aircraft Servicing Platform - Apron area used for servicing aircraft

ATC - Air Traffic Control

BAG - British Aviation Group - Trade Association

CAA - Civil Aviation Authority

CAP - Civil Aviation Publication

CAP 168 - Licencing of Aerodromes - sets out the standards required at UK National licensed aerodromes relating management systems, operational procedures, physical characteristics, assessment and treatment of obstacles, visual aids, rescue and fire-fighting services and medical services.

CBR - California Bearing Ratio

CGA - Cleared and Graded Area (CGA) That part of the Runway Strip cleared of all obstacles except for minor specified items and graded, intended to reduce the risk of damage to an aircraft running off the runway.

Delethalisation - Below ground ramping to buried vertical face of construction designed to reduce risk of damage to aircraft running on cleared and graded area of strip.

Dispersal - Military Aircraft Apron used to disperse parked aircraft around an airfield to reduce the risk of all aircraft being destroyed in an enemy attack

EASA - European Aviation Safety Agency

EMAS - Engineered Materials Arrestor System (Crushable system designed to slow aircraft over-running the end of the runway)

FAA - Federal Aviation Authority - The Aviation Authority of the USA

FOD - Foreign Object Debris

Frangibility - The ability of an object to retain its structural integrity and stiffness up to a

specified maximum load but when subject to a load greater than specified or struck by an aircraft will break, distort or yield presenting minimum hazard to an aircraft.
GAL - Gatwick Airport Ltd
GSAT - General Security Awareness Training
HAL - Heathrow Airport Ltd
Holding bay - A defined area where aircraft can be held or bypassed in order to facilitate the efficient movement of aircraft.
IATA - International Air Transport Association
IATA Code - Three letter identification code for individual airports
ICAO - International Civil Aviation Organisation
ICAO Annex 14 Volume 1 - Aerodrome Design & Operations - Specifies specific design and operational requirements for aerodromes
ILS -Instrument Landing System is a standard system of navigation for aircraft on final approach to an airfield
Landside - All areas of an aerodrome or airport that are outside the airside perimeter fence
LCY - London City Airport (IATA Code)
LDs - Liquidated Damages - Delay damages charged for late handback of possessions or projects.
LDA - Landing Distance Available (Used to calculate Runway Category)
LGW - London Gatwick Airport (IATA Code)
LHR - London Heathrow Airport (IATA Code)
LTN - Luton Airport (IATA Code)
LVP - Low Visibility Procedures - Procedures operated by Airports during Fog and Low cloud situations where surface visibility is reduced to below the level required for CAT 1 operations
MAG - Manchester Airports Group - Operate Manchester, East Midlands and Stansted Airports
Manoeuvring area - That part of an aerodrome provided for the take-off and landing of aircraft and for the movement of aircraft on the surface, excluding the apron and any part of the aerodrome provided for the maintenance of aircraft.
MARS - Multi Aircraft Ramp System - The layout of an apron area whereby a single stand can be used in a number of configurations (for example to park either one wide-bodied aircraft or two narrow-bodied)
MLS - Microwave Landing System - All weather precision guidance system
MTOW - Maximum Take-off weight
NATS - NATS Holdings - Formerly known as the National Air Traffic Services - Main Air Navigation Control provider in the UK
Night Noise Regime - Restrictions on noise levels at airports during night time operations - imposed by Government
Non-instrument runway - A runway intended for the operation of aircraft using visual approach procedures or an instrument approach procedure to a point beyond which the approach may continue in visual meteorological conditions (VMC).
Non-precision approach runway - A runway served by visual aids and a non-visual aid(s) intended for landing operations following an instrument approach operation Type A and a visibility not less than 1000 m.

Obstacle - All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight, or that stand outside those defined surfaces and that have been assessed as being a hazard to air navigation.
Obstacle free zone - A volume of airspace extending upwards and outwards from an inner portion of the Runway Strip to specified upper limits which is kept clear of all obstructions except for minor specified items required for air navigation purposes, of low mass and of a frangible mount.
PAPI - Precision Approach Path Indicator - Electronic guidance system for landing aircraft
PCN - Pavement Classification Number
Precision approach runway - A runway intended for the operation of aircraft using precision instrument approach aids that meet the Facility Performance requirements defined in ICAO annex 10 appropriate to the Category of Operations.
Possession - Closure of the runway and taxiways to aircraft to enable maintenance tasks to be undertaken
NPS - National Policy Statement
OLS - Obstacle Limitation Surface(s) - A number of imaginary surfaces that define volumes of airspace, either within the aerodrome boundary or in the vicinity of the aerodrome, within which the presence of obstacles is either limited or their presence would impact the intended use of the runway and aerodrome(s). For example this restricts the construction of temporary multi-level structures and the use of cranes during aircraft operations
PAX - Passengers
Parallel Taxiway - Taxiway which runs parallel to the main runway and may be used in some circumstances as a secondary runway to enable repairs or maintenance to the main runway.
PSZ - Public Safety Zone - Areas at the ends of some runways where access is restricted to limit injury to members of the public in the event of a crash
RAT - Rapid Access Taxiway - Allows Aircraft to access the runway faster than from a conventional taxiway
Regional Airports - Defined by the Government as: Southampton, Norwich, Southend, Bristol, Cardiff, Bournemouth, Birmingham, East Midlands, Coventry, Manchester, Newcastle, Liverpool, Leeds, Bradford, Durham Tees Valley, Doncaster – Sheffield, Humberside, Blackpool, Glasgow, Edinburgh, Aberdeen, Prestwick, Inverness, Belfast International and Belfast City.
RCA - Regional & City Airports - Owned by the Rigby Group. Owner / Operator of Bournemouth Airport, Coventry Airport, Exeter Airport and Norwich Airport, and holds management contracts for Blackpool International Airport, City of Derry Airport and Solent Airport (formerly Daedalus Airfield).
RESA - Runway End Safety Area - An area defined along the extended runway centreline and adjacent to the end of the runway primarily intended to reduce the risk of damage to an aeroplane undershooting or overrunning the runway. May utilise an aircraft arrestor system such as EMAS
RET - Rapid Exit Taxiway - Allows aircraft to leave the runway faster than from a conventional taxiway

Runway Designators - Runway numbers and letters are determined from the approach direction.
Runway strip - An area of specified dimensions enclosing a runway intended to reduce the risk of damage to an aircraft running off the runway and to protect aircraft flying over it when taking off or landing
SATCO - Senior Air Traffic Control Officer (Defence airfield equivalent of ATC)
SEN - Southend Airport (IATA Code)
Shoulder - An area adjacent to the edge of a paved surface used to provide a transition between the pavement and the adjacent surface for aircraft running off the pavement.
STN - Stansted Airport (IATA Code)
Stopbar - Part of the AGL system Installed at Runway Hold points to prevent aircraft joining the runway until they are authorised to do so
SuDS - Sustainable Drainage Systems - A drain away or storage surface water solution that tries to replicate natural systems that with low environmental impact
SWMP - Site Waste Management Plan (Still a requirement for most airport contracts even if no longer required by statute)
Taxiway strip - An area of specified dimension enclosing a taxiway and intended to protect aircraft operating on the taxiway and to reduce the risk of damage to an aircraft running off the taxiway.
Taxiway holding position - A designated position at which taxying aircraft and vehicles may be required to hold in order to provide adequate clearance from a runway or another taxiway. **Taxiway intersection** - A junction of two or more taxiways.
Threshold - The beginning of that portion of the runway available for landing.