Slippery when wet

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What aerodrome operators need to know about managing slippery runways.

Graham Bailey

IT'S BEEN raining buckets. You're the pilot of an Airbus A320 accelerating for take-off, but still well short of V_1. Then the nose wheel starts aquaplaning. Control becomes an issue, and you discontinue take-off.

Just such an incident occurred at Melbourne Airport in January 1998. The pilot-in-command discontinued take-off on runway 27, later attempting to take-off from runway 34. The aircraft returned to the terminal after an unrelated problem with the inertial reference systems.

It's often referred to as aquaplaning. Frequently the actual incident turns out to be caused by something different, but still part of what I generally refer to as the "wet, slippery runway" problem.

Slipperiness: Control of an aircraft during ground operations depends on adequate tyre contact and friction between tyre and pavement surface. This interaction is relied on for lateral control and to oppose side forces such as cross wind. Equally significant is the retarding force for braking. In situations where tyre contact or friction are deficient, there is a loss of directional control and braking, generically known as slipperiness.

Three basic modes of slipperiness have been identified: dynamic hydroplaning, viscous hydroplaning and reverted rubber skidding.

Dynamic hydroplaning or aquaplaning: This can occur when an aircraft lands fast enough on a wet runway. Where aircraft speed and water depth are sufficient, inertial effects prevent water escaping from the footprint area, and the tyre is buoyed or held off the pavement by hydrodynamic force.

Viscous hydroplaning: This occurs when a tyre is unable to to puncture the thin residual film left on a pavement in the footprint area. This water lubricates the surface and friction is reduced. The most positive method of preventing this lubrication is to provide a texture to the pavement surface.

Reverted rubber skidding: This is a complex phenomenon which over the years has been the subject of a variety of explanations. Reverted rubber skidding is akin to viscous skidding in that it occurs with a thin film of water and a smooth runway surface. This situation often follows dynamic or viscous hydroplaning where the aircraft wheels are locked. The locked wheels create enough heat to vaporise the underlying water film forming a cushion of steam that eliminates tyre to surface contact.

Once started, reverted rubber skidding will persist down to very low speeds, virtually until the aircraft comes to rest. During the skid, there is no steering capability.

Indications of a reverted rubber skid – albeit after the event – are distinctive white marks on the pavement and a patch of reverted rubber,

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similar to the uncured state, on the tyre.

From the perspective of aerodrome management, it is useful to summarise the following key points:

• The principal dangers to aircraft are greatly increased stopping distance and loss of directional control

• Given sufficient water depth, the critical speed for dynamic hydroplaning increases with the square root of the tyre inflation pressure.

• Nosewheel control can be a consideration at lower speeds, because of their lower tyre inflation pressure.

• Experience suggests dynamic hydroplaning will not occur unless the runway is heavily puddled or flooded. This indicates the importance of runway shape; with crossfall and longitudinal grade such that long drainage paths are avoided. There is also a need for continued surveillance and urgent maintenance, when pavement shape is compromised by depressions or "bird baths".

• The combination of smooth or excessively worn tyres on a smooth surface, has the potential to be lethal in wet conditions. (This is why tyre-wear criteria must be established and monitored in accordance with aircraft maintenance manuals.)

Friction requirements: The International Civil Aviation Organisation (ICAO) recommends that the average surface texture depth of a new surface should be not less than 1.0mm.

Of greater significance is the ICAO Standard which says "measurements of the friction characteristics of a runway surface shall be made periodically with a continuous friction measuring device using self wetting features" .

The standard requires member States to specify two levels:

• A maintenance friction level below which corrective maintenance action should be initiated.

• A minimum friction level below which information that a runway may be slippery when wet, should be made available to pilots.

ICAO now provides guidance information for States to determine friction levels. (Table A-1, Annex 14 Aerodromes). Suggested friction values are tabulated for new runway surfaces, for maintenance planning purposes, and for runway surfaces in use. Values are listed for various alternative friction measuring devices.

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Australia's rules and practices for aerodromes (RPAs) require the aerodrome to "ensure that tests are conducted at a frequency of not less than once a year to determine the friction of runways serving RPT jet aircraft".

These tests refer to surface texture measurement, rather than the continuous friction measuring devices. With the assistance of specialist advice, aerodrome owners can set their own friction values based on the ICAO guidance information, "new construction" datum levels, and the specific conditions at the particular aerodrome. This practice is prudent in cases where rubber build-up is evident, and needs to be monitored.

Australian design standards for licensed aerodromes require paved runways used by regular public transport aircraft to have an average surface texture depth greater than 1.0mm as measured by the grease patch test (in line with the ICAO recommendation). The test is described in the Recommended Practices Aerodromes (RPAs).

Continuous friction measuring devices: Many friction measuring devices have been used. These include the diagonal brake vehicle (DBV), The Swedish Skidometer, the airport surface friction tester (ASFT) the British Mu meter, and the "Griptester" trailer. The Mu meter, a lightweight three-wheeled trailer, has been extensively used in Australia, with some success. These trailers have the necessary mobility to take measurements with a minimal amount of runway down time, and importantly, they provided fast repeatable results.

Runway Treatments: The simplest form of surface treatment is the removal of rubber deposits. This is normally done by specialist contractors, using either chemical or water blast techniques. Mechanical grinding has also been used effectively to remove heavy deposits.

Aerodrome operators should always be vigilant with regard to rubber buildup. In addition to reduced friction, rubber deposits have been known to dislodge under traffic becoming a hazard to aircraft. Such was the case with a Boeing 767 at Melbourne last year.

Grooving is normally the preferred treatment for concrete and bituminous concrete surfaces, for all airport types. Engineers can always "buy an argument" on the specification to be adopted; I favour Transverse grooving with groove size of 6mm x 6mm. The groove spacing has increased over recent years from 32mm to 38mm.

Open graded bituminous concrete is literally porous and is often known as “porous BC”, or “open graded friction course”. The mix properties provide for water dissipation down through the materials rather than sideways, as with grooving. This treatment is suitable over dense surfaces with good shape, effective surface drainage and where shape loss is considered unlikely under forecast traffic operations.

Porous BC is generally more expensive than grooving, and rubber removal is barely feasible from this type of surface. There was a period when porous BC had an advantage over grooving because of a reduced chance of tyre damage. Now improvements in tyre design have substantially reduced this advantage.

Bituminous spray seals with adequate texture are suitable treatments in their own right.

Sealing work is a specialist activity and there needs to be a clear understanding of the required quality of aerodrome work, over and above that normally achieved for roadwork. For instance, loose stones and bitumen flushing are the “order of the day” on our rural roads; something which is unacceptable for a sealed runway pavement. Flushing creates a bitumen rich surface and this reduces friction. Loose stones become lethal missiles to critical aircraft components and surfaces.

Managers of smaller aerodromes should think twice about calling in the local road sealing contractors for aerodrome work. Check for aerodrome knowledge and experience. Seal design, whether single, double or triple, is a case-by-case consideration, taking into account aircraft traffic, climate, and material availability.

Seals are susceptible to damage by high tyre pressure aircraft (and vice versa) and should be used cautiously in such cases. In my view there are no hard and fast rules, however I would recommend using bituminous concrete (rather than sealing) for B737 type aircraft, and above.

MODE	PREREQUISITE
Dynamic hydroplaning	**Flooded runway. High speed.**
Viscous hydroplaning	**Thin water film. Smooth surface. Wheel free to roll.**
Reverted rubber skidding	**Thin water film. Smooth surface. Locked wheel.**

Photos: Boeing image library

Aerodrome management: There are a few important points for aerodrome management worth noting:

• Make sure staff of appropriate responsibility and seniority, are aware of the principles of runway slipperiness, the cause factors and methods for prevention and treatment. Be aware of runway surface condition at all times.

• Information that a runway may be slippery when wet should be made available to pilots.

• A surface-friction inspection and testing schedule and maintenance strategy is recommended along the lines of the ICAO standard, and guidance material. The strategy should be documented as part of the aerodrome manual. While this testing is not mandatory in Australia, it is worthwhile.

• Don’t overlook gravel and natural surfaces. Inspecting officers at smaller aerodromes may wish to consider the use of a medium weight vehicle for assessing whether a surface is suitable for operations, or is so slippery that the strip or runway must be closed in the interest of safety.

A pilot perspective: Runway friction is a significant physical condition affecting aerodrome usability. It follows that pilots should make every effort to understand the principles of runway slipperiness, its causes and options for prevention.

Aircraft operators should talk regularly with aerodrome operators about these matters. Pilots should be watchful for the more cautionary indications such as rubber build up (usually in the threshold areas), bitumen-rich surfaces and abundant freestanding water.

Any water on a runway creates a potential slipperiness situation and should be treated with respect. Cross-wind components add to the threat; holding back water in opposition to the pavement crossfall, at the same time increasing the difficulty of directional control during the ground operation.

In the case of natural surfaces, slipperiness and soft ground is a dangerous combination, particularly when the surface is uneven.

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