Regional airport pavement challenges and innovations

Greg White
University of the Sunshine Coast

Abstract
The approximately 320 regional, remote and rural airports in Australia generally face a range of pavement-related issues that are different to those faced by airports in capital cities and major centres. More demanding aircraft introduced by airlines often require pavement strengthening, widening and lengthening, with ongoing research aiming to improve the understanding of foamed-based bitumen for this application. Furthermore, airports with sprayed seal surfaces must be aware that different design and construction requirements, compared to those commonly used for road seals, are essential to good airport seal performance. Also related to surface design, it is also important that airports understand that aircraft skid resistance regulations apply to their runways in the same way as they apply to major airports in capital cities. Either 1 mm surface texture, or minimum wet friction levels, or effective sawn grooves (for asphalt only) must be maintained and ongoing compliance must be demonstratable. Finally, when selecting between an asphalt or sprayed seal surface, airports must be aware that asphalt depreciates at around five times the annualised cost of comparable sprayed seals and asphalt is only justified for regional airports requiring pavement shape correction, strengthening or must be resurfaced at night.

Keywords: Regional; Airport; Pavement; Challenges

Introduction
There are around 350 registered, or paved, airports in Australia (CIA 2018) of which it is estimated that around 320 can be categorised as rural, regional or remote (hereafter referred to as regional). The remainder are more substantial, ranging from Sydney, Brisbane and Melbourne down to Mildura, Proserpine and Ayers Rock. The thirty substantial airports are estimated to cater for over 90% of passenger numbers and many are profitable and privately-owned corporations. In contrast, the majority of the regional airports were ‘gifted’ to local government authorities during the Commonwealth Government’s divestment out of airport ownership in the 1990s (Eames 1998). Many of the regional airports are not financially self-sustaining (Wilkie 2018) and face significant pavement-related challenges.
A significant challenge for regional airports stems from their limited access to appropriately skilled technical advisers and the tendency for some runways to be managed by local governments as ‘wide and flat roads’. Furthermore, many of the previous structured initiatives undertaken by the Australian Airports Association (AAA) were focused on the needs of the significant airports and were less relevant to the regional airports. This has changed in recent years, but regional airports still face significant challenges in an environment where resources and professional skills are limited.

This paper summarises pavement-related challenges facing regional airports. The challenges include providing facilities for more demanding aircraft, sprayed seal design and construction, managing aircraft skid resistance and the economics of resurfacing. Initiatives and innovations to address these challenges are also described where appropriate.

More demanding aircraft

Many regional airports were developed for much smaller aircraft than are currently operating passenger services (AAA 2018). The owners and managers of the airports have little control over the introduction and new and more demanding aircraft, which is often determined by politicians and airlines. However, once the introduction of a more demanding aircraft is confirmed, a range of pavement upgrades are often required, including:

- **Efficient strengthening of the pavement.** To meet the demand of heavier aircraft.
- **Expedient expansion.** To meet the needs of wider and faster landing aircraft.
- **Surface geometry.** Which is regulated relative to the size of the aircraft.

A good example is the Dash 8 Q400 (Figure 1). The Q400 is operated by Qantas and, along with the Saab 340 operated by many airlines, is the workhorse of regional airport passenger transportation. An airport previously catering for the smaller Dash 8-100, 200 or 300 series aircraft likely requires strengthening to cater for the Q400. An airport designed for a Saab 340 or smaller regional turboprop is likely to require lengthening, widening and strengthening to cater for the Q400.

Another example is the introduction of jet services into a larger regional airport. Examples include Dubbo (NSW), Weipa (QLD) and Coondewanna (WA). Many of the airports now catering for F100, B717, B737-800 and A320 sized aircraft were originally designed and developed in the 1940s and 1950s to support the war effort and the subsequent cold war era. The main regional passenger aircraft from the 1950s to 1970s was the F27, which was a 19 t turbo-prop, compared to the 46 t F100, 55 t B717, 74 t A320 and 79 t B737, which are all jet aircraft operating into various regional airports.
One challenge for regional airports is upgrading the strength of existing pavements without requiring a continuous runway closure for weeks or months while the work is complete. Simply closing one side of the runway is not operationally possible and closing one half (end) of a runway renders the remaining length too short to continue operations. Similarly, where a widening is required, regulations require no steps or excavations adjacent to runways during aircraft operations. Consequently, expedient construction technologies are required to allow the pavement widening or strengthening to be affected in short night work periods, with the pavement returned to a trafficable and serviceable condition at the end of each work period, including the filling of adjacent excavations back to finished surface level (White 2017).

For regional airport upgrades, foamed bitumen base (FBB) course has been demonstrated to provide a valuable technology for expedient pavement construction or upgrade work (White 2014). FBB is effectively a bitumen stabilised base course that relies on the foaming of hot bitumen (by injection of a stream of cold water) to reduce the viscosity of the bitumen during mixing into the granular base material, as well as during the paving and compaction of the FBB (White 2014).
The properties of FBB that make it suitable for expedient pavement construction and rehabilitation include (White 2018):

- **Shelf-life.** FBB can be produced in the afternoon, stockpiled and then paved and compacted at night. This reduces the risk of a production plant breakdown impacting the return of the pavement to operational status at the end of each work period.

- **Rapid construction.** FBB is able to be paved and unlike hot asphalt, the rate of construction is not limited by the rate of production, due to the longer shelf-life. FBB is also able to be constructed in thick lifts, with up to 250-300 mm recommended, compared to 60-100 mm for hot asphalt.

- **High stiffness.** Within seven days of construction, FBB stiffness is comparable to that of asphalt, cement stabilised base course and exceeds that of FCR, meaning the same structural pavement capacity can be achieved with a significantly reduced pavement thickness.

- **Early trafficability.** As soon as the FBB is compacted, it is essentially trafficable and unlike asphalt, thick layers and courses of FBB do not need to cool down before gaining strength.

- **Moisture resistance.** The foamed bitumen coats the fine aggregate particles, significantly reducing the moisture susceptibility compared to granular materials. This makes FBB well suited to the improvement of existing natural gravel base courses, as well as new crushed rock.

FBB can be produced from new material or from existing pavement materials, whether a crushed rock or a natural uncrushed gravel (Figure 2). It can be produced in-situ, using a specialised pulveriser/stabiliser, or ex-situ, in a pugmil. FBB is similar in composition to asphalt, except that it is produced at ambient temperatures, requires significantly less bituminous binder and does not require granular material fractionation. FBB is often compared to cement stabilised base course material, but at the typically low cement and lime dosage is not susceptible to cracking (White 2018).

![FBB produced with different materials.](image-url)
FBB has been used for different applications at various regional airports, including (White 2018):

- **Gladstone Airport (QLD)**. As part of a bigger upgrade project, a 600 m length of the runway was reconstructed with FBB, produced off the pavement, but using in-situ production methods in 2010.
- **McArthur River Mine (NT)**. The runway, taxiway and apron pavements were rehabilitated using FBB in 2011 to rectify cracking and rutting in the marginal base course.
- **Barimunya Airport (NT)**. The runway was in-situ stabilised by FBB in 2014 to address gross seal flushing and to expediently increase the bearing strength of the pavement.
- **St George Airport (QLD)**. In 2014 the runway strength and moisture resistance were increased by in situ stabilisation of the existing marginal base course.
- **Carnarvon Airport (WA)**. In 2016 the runway was in-situ stabilised with FBB to improve the performance of the marginal gravel base.
- **Whitsunday Coast Airport (QLD)**. In 2017 the runway, taxiway and apron were upgraded by FBB stabilisation of the existing base course material, supplemented by the existing asphalt surface and a fine sandy loam, in an on-site pugmil.
- **Coondewanna Airport (WA)**. The runway was topped up with crushed rock and in-situ stabilised by FBB in 2017 to expediently increase the bearing strength of the pavement.

Research continues to address a number of FBB challenges (White 2018). The aim is to better understand foamed bitumen stabilisation of marginal gravels, comparison of in-situ and pugmill produced FBB, and comparing FBB properties for samples produced and cured in the laboratory to those produced and cured in the field.

### Sprayed sealing design

Many regional airports in Australia have a spray sealed surface on their runway and other aircraft pavements. Although this is surprising to airport managers and engineers from the USA and Europe, Australian airports have supported up to B737 aircraft operations on sprayed seals over marginal gravel pavements for many years (AAA 2017). The challenge for airports is to ensure the sprayed seal is designed and constructed appropriately for use by aircraft. However, in many cases, airport pavements have been sealed like road pavements and subsequent performance under aircraft traffic has been unacceptable (White 2013).

The factors that require particular sprayed sealing solutions for aircraft pavements include:

- Low frequency, typically less than ten per day, of heavy wheel loads, up to 20 t.
- Concentrated traffic with distinct wheel paths 3-5 m each side of the centreline of a typical 30 m or 45 m wide runway.
- Requirement to retain 1 mm surface texture for wet weather skid resistance, as detailed below.
- Fragile aircraft engines requiring the surface to remain free from loose stones throughout its life.
Consequently, aircraft sprayed seals must be designed and constructed differently to road seals, with the main differences being (White 2015):

- Two seal layers in initial seals.
- Larger upper seal layer aggregate sizes, typically 7 mm or 10 mm.
- High binder content, typically:
  - 2.5 L/m² for 14 mm seal layer.
  - 2.0 L/m² for 10 mm seal layer.
  - 1.6 L/m² for 7 mm seal layer.
- Increased rolling effort during construction, around six times more rolling than for roads.
- A sanded-emulsion, or proprietary equivalent, final treatment to ‘lockdown’ the aggregate.
- Steel drum rolling to remove the sharp tops from the aggregate particles for reduced tyre wear on wheel spin-up during aircraft landing.

Well designed and constructed seals provide a durable runway surface free from loose aggregate for up to ten years. Examples are in Figure 3, with and without a sanded-emulsion lockdown treatment. However, airport sprayed seals are often not executed well (Figure 4). This likely reflects some seals being designed like road seals, with inadequate bitumen application, as well as unacceptably low construction rolling (White 2013).

(a) With a sanded emulsion treatment  
(b) Without a sanded emulsion treatment

Figure 3. Typical sound runway seals.
One particular challenge for regional airports is scheduling of sealing works. Airport sealing, like road sealing, is best performed during the hottest dry weather at the particular location. When performed during cooler weather, the aggregate will not fully penetrate into the binder film. However, post-construction traffic will finish the rolling during hot weather. Because the binder content for airport seals is high, filling two-thirds to three-quarters of the aggregate’s least dimension, the capacity to accept additional post-construction binder film penetration is minimal. Consequently, sealing runways outside of the hottest weather increases the risk of flushing. Furthermore, if a seal is performed in cold weather, cutter is necessarily added to keep the binder workable and allow aggregate penetration despite the rapid cooling of the binder film. However, the cutter remains in the binder film and renders the binder soft during subsequent hot weather, often leading to severe flushing during subsequent hot weather trafficking. Many airport pavements have been rendered unserviceable, due to loss of surface texture and bitumen sticking to aircraft tyres, by flushing due to cutter introduced for cold weather sealing (Figure 5).
An airport sprayed seal design method was developed in 2015 (White 2015). The Australian Asphalt Pavement Association and the Australian Airports Association are currently developing a standard airport sealing specification, incorporating a catalogue of standard designs, as well as seal design and construction guidance, and this is expected to be available in late 2018.

Aircraft skid resistance

Pilots can not fly more slowly when landing aircraft during wet weather. Consequently, there is an obligation on all airports, regardless of their size, to provide and maintain a level of skid resistance that allows safe operation of aircraft during wet weather.

The skid resistance requirements are internationally regulated for sealed runways (ICAO 2013) and is reflected in Australian airport safety regulations (CASA 2013), with the overriding intent to:

- Maintain at least 1 mm surface texture. or
- Provide adequate wet friction levels. or
- Groove the surface.

Although each airport is free to select an approach to demonstrating compliant, these requirements apply equally to Dubbo airport as they do to Sydney airport. This presents a challenge to regional airports, some of which still have legacy surfaces from before the time when aircraft skid resistance was regulated in Australia, and many airports do not even realise they are not compliant with current regulations.

In practice for a regional airport with an asphalt surface, the full length (excluding the end nodes) and full width of the runway must either have:

- A surface with texture exceeding 1 mm. New dense graded asphalt generally has a surface texture of 0.4-0.6 mm so will not meet this requirement.
- Runway grooving. Sawn transverse to the runway centreline, nominally 6 mm wide and 6 mm deep and spaced 32 mm apart. Grooving is expensive and hinders subsequent maintenance, as well as introducing the risk of groove closure during hot weather trafficking.
- Periodic friction verification. Must exceed the requirements set by ICAO using an ICAO endorsed self-wetting continuous friction measuring device, such as a Griptester.

An airport with a 7 mm or 10 mm nominal size upper sprayed seal layer will easily achieve 1 mm surface texture as long as the surface is free from aggregate loss and free from flushing. However, as discussed above, runway sealing is also challenging and many airports have failed to maintain 1 mm surface texture in the wheel paths due to flushing. In this case, it is not appropriate to average the flushed and unflushed area surface texture results. Rather, removal of the excess bitumen or resurfacing is required.

In recent years Australia’s airport regulator has become more focussed on aircraft skid resistance and has required regional airports to demonstrate their ongoing compliance on a periodic basis. For a sprayed seal surface, this can readily be achieved by sand patch surface texture testing at intervals
along the runway. Where a runway surface is grooved, visual inspection of the grooves to confirm their freedom from contamination and effective volumes is appropriate. However, where an airport relies on friction testing results for skid resistance compliance, ongoing, periodic testing is required. This can be expensive in remote locations and if often forgotten by airport owners and managers, who often wonder what the appropriate testing frequency should be. Although considered conservative, the USA recommends testing frequencies based on the number of aircraft operations, including (FAA 1997):

- Less than 15 jet landings per day. Annual.
- Greater than 90 jet landings per day. Monthly.

It is unlikely that any Australian regional airport would exceed 15 jet landings per day, meaning annual testing is the maximum rate of testing that would be appropriate for regional airports.

Airports must consider the ongoing compliance, as well as one-off compliance at the time of surface construction or replacement. It is also clear that regional airports must pay attention to aircraft skid resistance so that in the event of an aircraft skidding incident, there is an ability to demonstrate acceptable runway skid resistance has been maintained in accordance with the regulations. Ongoing research aims to provide a better understanding of the evolution of runway skid resistance over the life of a surface and to better correlate surface texture with wet friction. The goal is to simplify and better inform runway skid resistance management.

Resurfacing economics

A typical regional airport has one runway, a single taxiway and a small parking apron. The runway is commonly 1,600-2,000 m in length and 30 m or 45 m wide. Resurfacing regional airports really only has two options:

- **Sprayed seal.** Does not provide strengthening, does not correct shape, but is quick to perform and does not usually impact in-pavement airfield lighting fittings. Seals cannot reliably be constructed at night due to the reliance on ongoing visual assessment of the surface.
- **Asphalt.** Provides shape correction and some strengthening but usually requires grooving for skid resistance and requires a large production plant, which is expensive to mobilise compared to spray sealing equipment. However, asphalt is readily constructed at night with temporary ramps constructed and removed each work period.

Aside from these practical limitations, the main basis for a regional airport to select a sprayed seal or an asphalt surface is economics. Based on typical rates collated over many years, the cost of a typical runway resurfacing in a typically remote location is:

- **Sprayed sealing.** $1 M every 8 to 10 years. A depreciation rate of $110 k/year.
- **Asphalt overlay.** $6 M every 10-12 years. A depreciation rate of $550 k/year.
In many cases, regional airports are not able to fund their resurfacing works, rather relying on State or Commonwealth government grants to fund these critical works. In some cases, airports have upgraded their runway surface from a sprayed seal to asphalt with grant funding. However, they are then obliged to allocate around five times the resurfacing depreciation value to maintain the asphalt surface in the future. This usually does not happen, rendering the airport forever reliant on multi-million-dollar grants to maintain their upgraded pavement surface.

The challenge is to ensure airports understand the greater cost associated with maintaining an asphalt surface, despite only a moderate increase in surface life. For regional airports, asphalt surfacing is only justified where an increase in strength or shape correction is required, where the runway cannot be closed to affect a sprayed seal resurfacing during the day, or where jet aircraft operate on a daily basis. Efforts continue to better educate regional airport managers on the economics of airport pavement resurfacing options.

Summary and Conclusions

Australia’s regional airports face different challenges to the substantial airports in the capital cities and major regional centres. Significant challenges relate to upgrading pavements for more demanding aircraft, appropriate sprayed seal design and construction, managing aircraft skid resistance and the economics of airport pavement resurfacing. Ongoing research and education aim to better inform regional airport managers regarding all these issues.

References


White, G 2013, ‘Challenges for spray sealing of airports’, Airfield Pavement and Lighting Forum, Australian Airports Association, Brisbane, Queensland, Australia, 16-17 April.


White, G 2018, ‘Foamed bitumen base for airport pavements’, 28th ARRB International Conference, Brisbane, Queensland, Australia, 30 April to 2 May.