SEALED GRANULAR PAVEMENTS FOR LOW VOLUME AIRPORTS

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ABSTRACT

Canadian national standards for airport surfaces define the allowable runway surface types as paved or unpaved. Prior to recent changes implemented because of the work described in this paper, paved runways were defined as asphalt concrete or Portland cement concrete pavements. Saskatchewan Ministry of Highways (MoH) partnered with Transport Canada to create new technical guidance document that allows Canadian airport authorities to utilize thin bituminous surfacing as a recognized surface type for paved runways.

MoH has a long and successful history of using thin bituminous surfaces for low volume roads and airports. These surfaces are comprised of two layers of graded aggregate seal coat placed on granular base course and are locally referred to as sealed granular pavements. Since the runways did not meet the previously governing definitions for paved surfaces, aircraft operators using the runways were required to treat them as gravel surfaces. Taking full advantage of these surfaces has important benefits for the Saskatchewan economy because it has the potential to increase aircraft payload. Recognizing the importance of this work, commercial air carrier Rise Air participated with MoH and Transport Canada in the review of sealed granular runways and their performance.

This paper summarizes the work that was completed to evaluate and confirm the suitability of MoH sealed granular surface runways for classification as paved surfaces. This paper also addresses the key principles of the newly published *Guide to Sealed Granular Airport Pavements in Saskatchewan.* Further, it introduces a new national standard document published by Transport Canada, the Advisory Circular AC 300-*021 Thin Bituminous Surface Runways,* which now allows the use of thin bituminous surfacing as paved runways. Now that they have been implemented, these changes can be taken advantage of to benefit provincial, municipal, and private airport and aerodrome operators across the country, and as a result, the Canadian aviation industry as a whole.

INTRODUCTION

Saskatchewan Ministry of Highways (MoH) owns and operates 17 airports in the northern half of the province that use gravel and flexible pavements to carry aircraft and vehicle loading. Many of these airports are remotely located, with limited site access. As such, when rehabilitating the airport surfaces, a thin bituminous surface comprised of two layers of graded aggregate seal coat, can usually be constructed on top of the prepared granular base course at a comparatively lower cost than the traditional Hot Mix Asphalt (HMA) surface. Locally referred to as sealed granular pavements, these structures can be more readily repaired and maintained by MoH crews when surface irregularities develop due to settlement, frost heave, or moisture related failures. MoH has successfully been operating eight airports with sealed granular runway surfaces for more than 20 years. Figure 1 shows examples of aircraft using sealed granular surfaces on Saskatchewan airports.

Figure 1 – Aircraft Using Sealed Granular Surface Aprons on Saskatchewan Airports

Prior to the work described in this paper, sealed granular surfaces did not fit into the "paved" category within Transport Canada definitions. As a result, aviation services operators using the runways were required to apply operational rules and aircraft performance criteria for gravel surface runways, despite a long history of good performance comparable to paved surfaces. Aircraft need to be specially equipped to land on gravel runways, to protect from damage by loose rock and soil particles. In addition, there are aircraft performance restrictions for gravel runways that account for impacts of loose gravel during landing and takeoff. These restrictions mean the carriers need to reduce their operating weight by as much as 15% when compared to paved surfaces.

The weight reductions for gravel runways limit the economies of scale that could be achieved if operators were able to fully take advantage of the sealed granular pavement surface type. Most businesses and residents in northern Saskatchewan rely on air carriers, and for some, it is the only way to access medical and other important services, and to remain connected to the rest of the province. To illustrate the magnitude of the potential impact, passengers traveling from Saskatoon to Wollaston Lake pay similar or higher costs as a return flight to Paris, France.

The gravel classification also impacts fleet management for companies providing air services in Saskatchewan. Innovative technologies cannot be implemented as newer, larger aircraft that are not gravel certified cannot be deployed for scheduled flights to gravel surface airports.
In MoH's history, sealed granular pavements have provided a sound, water-resistant, dust-free, and reasonably durable riding surface under low traffic volume in both roadway and airport applications. MoH successfully operates over 5,700 km of sealed granular highways. Due to different national regulations governing their operation, charter flight operators have been able to use the sealed granular runways and treat them as paved. For more than 20 years, MoH Airport Operations staff have observed many different aircraft, including private corporate jets, successfully using these surfaces as pavement. Pilots consistently provide feedback that these runways are not like gravel, and they feel safe treating them as paved. Historical evidence indicates the sealed granular runways behave like paved runways when used by small to medium sized aircraft typical of northern Saskatchewan.

MoH reached out to Transport Canada and was successful in engaging the national government in a joint multi-year effort to review and potentially revise the existing standards. Northern Saskatchewan commercial air services provider, Rise Air, was included as part of the project team to contribute important operational insights and experience in the review of sealed granular runway performance. The project involved collaboration between MoH operations staff and engineers, Transport Canada's aerodrome standards and flight performance staff, and Rise Air's management and flight operations staff.

BACKGROUND

Saskatchewan Highways' Experience

Sealed granular pavements have been used extensively on Saskatchewan's lower volume highways for several decades. Highways with an average annual daily traffic (AADT) of less than 1,200 vehicles per day and truck traffic less than 70 trucks per day are constructed as sealed granular pavements. These flexible pavements provide adequate load-carrying performance for low volume roads, and a dust free surface with less expensive material inputs than an asphalt concrete pavement.

Flexible pavements rely on multiple pavement structural layers that work as a system to carry loading. The thickness of the layers and their material properties are engineered to dissipate the load stresses and strains and protect the existing soil subgrade from excessive deformation under load. The structural layers nearest the surface of the road carry the most loading, and therefore must be designed to withstand higher stresses and strains than subsequent lower layers. Sealed granular pavements typically consist of three layers constructed over subgrade embankment: subbase course, granular base course, and graded aggregate seal coat. Figure 2 illustrates these pavement layers in cross section.

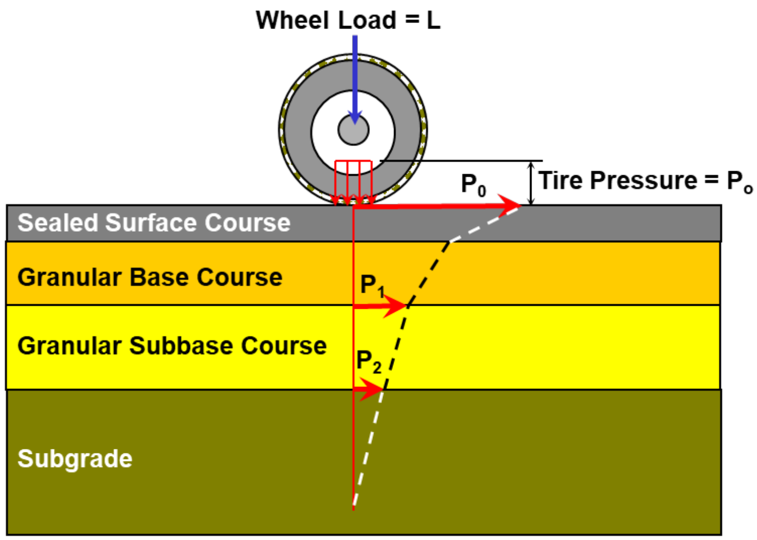

Figure 2 – Sealed Granular Pavement Layers

The subbase layer is a porous, sandy layer that allows moisture to drain and pore pressures within the pavement structure to dissipate. The subbase layer enhances the bearing strength of the road and reduces potential for frost heave. The granular base course layer is the primary load-carrying layer. The base course is typically an unbound, densely graded, engineered material containing a blend of crushed aggregate and natural sands. Thickness of the granular layers is determined based on the subgrade soil strength, frost susceptibility, and the anticipated design aircraft loading. Typical structures consist 150 to 400 mm of of granular subbase overlaid by 150 to 250 mm of granular base course. The final layer is the graded aggregate seal coat surface. This layer consists of two separate applications of asphalt cement emulsion embedded with graded aggregate. This is often referred to as a double seal coat because there are two successive applications of emulsion and aggregate. While the seal coat provides a dust-free, waterproof surface layer, it does not directly add to the bearing strength of the pavement structure.

When designed and constructed according to MoH standards, sealed granular pavements have provided adequate long-term performance as evidenced through distress monitoring, reasonable maintenance costs, and acceptable timing for rehabilitation or upgrades (15 years or more). Where site access is limited, a sealed granular surface offers an alternative to asphalt concrete, providing a dust-free surface that is less expensive to construct, and more readily maintained and repaired by local MoH crews. An added advantage of a sealed granular surface over HMA surfaces is the seal coat’s membrane-like mechanical properties, which allow it to withstand some moderate distortion in the underlying layers, with less potential for surface cracking. The seal coat layer can also effectively self-heal hairline and some minor cracks in warm temperatures.

Transport Canada Airport Surface Types

Transport Canada's TP 312 *Aerodrome Standards and Recommended Practices* [1] recognizes two categories of runway surface type: paved, and unpaved. Paved runways are defined as "a surface of asphaltic concrete (flexible) or Portland cement concrete (rigid)." Pavement surfaces which do not meet the definition of paved are considered as unpaved surfaces. Transport Canada publishes Advisory Circulars (AC) which provide interpretation of the regulations and standards and provide functional guidance on means of compliance. Unpaved surfaces also include Surface Treated Runways. AC 300-004 – *Unpaved Runway Surfaces* [2] defines a Surface Treated Runway as "a gravel pavement structure covered with a thin layer of asphalt stabilized material to prevent the penetration of water and facilitate drainage."

Aircraft performance is affected by the runway surface type. Typically, take-off and landing performance data are determined by the manufacturer and certified by the regulator. The data is compiled into performance charts in the aircraft flight manual specific to each type of aircraft. Flight crews calculate the required runway length to land or take-off using the performance charts considering factors such as wind, temperature, altitude, surface type, and gross weight. The calculation determines the runway length required to safely conduct the operation. If the runway length available is inadequate, then it is necessary to adjust the inputs until the length requirements fall within the facility's available runway length. Typically, this results in a reduction in the aircraft gross weight (i.e. payload). Gravel runways are subject to an approximate 15% performance reduction, meaning the runway length required to operate with a given payload is 15% longer than the same operation on a paved surface.

For example, if the gross weight of an aircraft is 20,000 lbs., an aircraft may need 4,000 ft of take-off run available on a paved surface. The same aircraft on a gravel runway might require 4,600 ft of runway. If the runway is only 4,000 ft long, then flight crews must reduce their gross weight. It is possible for some aircraft operations on gravel runways to occur at 50% payload compared to operations on paved runways of the same length.

A further complication specific to gravel runway operations is the need for special equipment packages on the aircraft to protect against foreign object debris (FOD) damage. A limited number of aircraft are available with such equipment. This equipment may include special engine cowlings to redirect wash, and guards on the landing gear to prevent debris from being directed upwards. The requirement of this special equipment can further complicate the ability to deliver payload to many of the remote communities relying on these facilities.

Scan of Practice

Transport Canada operates 13 remote airports, and there are more than 100 other remote northern airports across Canada [3]. These are in most cases funded and operated by the Provincial and Territorial highway departments. In addition to Saskatchewan, the provincial transportation agencies responsible for several remote northern airports include those from Québec, Ontario, and Manitoba. The Ministère des Transports du Québec (MTQ) is responsible for northern airports in Nunavik in the north of Québec [4], all of which have gravel surfaces.

The Ontario Ministry of Transportation is responsible for 29 remote airports in northern Ontario [5], all of them with gravel surfaces. Manitoba Infrastructure is responsible for 22 remote northern airports [6], and all the airports also have gravel surfaces. Overall Canada ranks 5th in the world for the number of unpaved runways, behind the United States, Brazil, Mexico and Argentina, with just under 1,000 airports with unpaved runways [7]. When interviewed, the agency representatives revealed that they struggle with keeping dust under control despite the use of various dust suppressants, and struggle with the overall cost and challenges of providing crushed gravel and maintaining the gravel surfaces [7].

An international scan of practice completed for this project demonstrated that chip seal surfaces are successfully being used in other countries for low volume, light to medium aircraft, and can even handle loading from larger aircraft. This information is summarized below and supports the assertion that MoH sealed granular pavements can be used as airport surfaces for northern airports:

The U.S. Federal Aviation Administration (FAA) permits the use of chip seal coat for use on general aviation airports serving small airplanes (< 5,670 kgs) [8]. Discussions with the International Civil Aviation Organization (ICAO) representatives for South America, and the Chilean Ministerio de Obras Publicas Dirección de Aeropuertos, indicated that there are at least 15 airports in the country where the pavement surface type is reported as "asphalt surface treatment" [9]. These include 8 airports in the Aysén Region for which the pavement surface is DTS – Doble Tratamiento Superficial (Double Surface Treatment). The first DTS runway was placed in 1996 at Melinka Airport, Chile, which receives about 6,000 annual aircraft operations (2018). The maintenance for the runway has been a fog seal every three years and in 2011 a slurry seal was place on the surface of the DTS. The maximum take-off weight of the aircraft using these facilities is 5,700 kg. The Dirección de Aeropuertos has developed material and construction specifications for the use of surface treatments for aircraft operations.

Australia is one of the highest users of sprayed seals for airport pavements [10]. In Australia, sprayed seals are the most common rural and remote airfield surfacing material, and they have been used for more than 10 years [11]. They are recommended for aircraft up to Bombardier Q-400, but Boeing 737-800 aircraft also operate on sprayed sealed runways on a daily basis in Australia. The seals are specifically designed for airport pavements. The seals include a higher binder content to reduce Foreign Object Damage (FOD) generation, have aggregate sizes between 7 and 14 mm, stiffer binders and utilize pneumatic tire/steel drum rolling. The compaction is intended to push the aggregates into the bituminous binder film to "seat" the aggregate and to reduce aircraft tire wear during operations.

The Boeing company has published "Runway Pavement Surface Type Descriptions" in response to airline requests [12]. This document defines a Seal Coat as: a "*type of runway that is usually an unpaved (gravel) runway, the surface of which has been treated with a spray sealant (usually asphaltic or resinous) to create a well-textured, waterproof surface that typically has a total thickness of less than one to two centimeters. Such surfaces generally do not stand up well to* *high tire pressures or high wheel loads, but if the surface is unbroken, the runway is considered paved (or hard surfaced)*".

BAE Systems (BAE) has published guidance for remote runway operations for BAe 146 and Avro RJ aircraft [13]. This guidance includes the definition of a paved runway as: "*a sealed hard surface such as tarmacadam or concrete and is capable of supporting the operational weight of an aircraft for the intended period of use*". BAE defines Tarmacadam Pavement as: *"uniformly sized stones rolled or compacted in-place, and usually sealed by an asphalt treatment that penetrates into the uppermost portion of the surface or coated with tar or bitumen. Usually, such surfaces are thin by typical airport standards, in the order of 2 to 5 cm thick."* This would indicate that a seal coat surfaced granular pavement would qualify to be considered a hard surface pavement.

RUNWAY PERFORMANCE REVIEW

The project team identified runway surface friction testing and bearing strength testing as necessary data to understand the performance of sealed granular runways, and to be able to draw comparisons to other runway surface types. In-person inspections were also considered an important part of the project: to provide an opportunity to visually assess the surface, interview local operations staff and pilots, and to experience takeoff and landing on these runways. The following sections summarize these three phases of the performance review.

Friction Testing

From past testing regimes, MoH had observed that sealed granular highway pavements have had similar or higher friction coefficients than asphalt concrete pavements. It was important to re-affirm with current data that sealed granular pavements have comparable or better friction coefficients than paved surface runways. Friction testing was performed on select runways in June and July of 2021 by an engineering consultant. Three runways were tested at the following locations: Buffalo Narrows, with an HMA asphalt concrete surface; La Loche, a sealed granular pavement; and Ile-a-la-Crosse, a sealed granular pavement.

Figure 3 – Surface Friction Testing at Ile-a-la Crosse Airport

Testing was completed in accordance with the equipment and methods indicated in Transport Canada's guidance documents, Advisory Circular 302-017 [14]. A self-wetting, continuous friction tester was used. The friction results of the three runways tested in 2021 are summarized in Table 1 below, as well as the test results of the Prince Albert asphalt concrete runway tested in 2018. As a reference value, Transport Canada indicates that corrective maintenance must be taken when a runway's average coefficient of friction is less than 50.

Table 1 – Summary of Friction Measurements Using Continuous Surface Friction Tester

Site Surface Type	**Runway Left and Right Offsets From Centreline (m)**	**Average Runway Friction Index**	**Age of Surface At Time of Testing (years)**
Buffalo Narrows Asphalt Concrete	3	92	6
	6	88	
Prince Albert (tested in 2018) Asphalt Concrete	3	82	6
Ile-a-la-Crosse Thin Bituminous Surface	0	96	4
	1.5	97	
	3	91	
	6	92	
	10	69	
La Loche Thin Bituminous Surface	0	80	10
	1.5	81	
	3	80	
	6	85	
	10	82	

From Table 1, it is evident that the surface friction of all runway surfaces was well above the required maintenance levels. The friction test reports noted in all cases that there was no significant rubber contamination on any of the runway surfaces. Comparing the two runways that are closest in age but having different surface types (Buffalo Narrows and Ile-a-la-Crosse), friction measurements were found to be similar. Although the current data set is limited, this supports the assertion that sealed granular pavements have similar coefficients of friction to asphalt concrete pavements. In addition, Table 1 shows that the friction decreases with the age of the surface, as would be expected from the effects of traffic and maintenance operations on the surface.

The measurements for the Ile-a-la-Crosse runway at 10 m offsets from centreline showed a decrease in the Average Runway Friction Index by approximately 20 points from the rest of the runway. This decrease was most likely due to loose material on the surface at the edges of the runway, as noted in the friction testing report.

Bearing Strength Testing

The bearing strength of the pavement structure is an important characteristic of the runway. A pavement with appropriate bearing strength can support repeated air traffic loading without causing structural failure of the pavement and creating safety concerns.

As a measure of pavement bearing strength, an estimate of the California Bearing Ratio (CBR) was determined for four sealed granular airport pavements as part of a routine testing regime. The estimated CBR was measured using a Boeing high load penetrometer, a recognized test method for estimating in-place CBR. Table 2 summarizes the results of the penetrometer testing.

Table 2 – Summary of Estimated CBR Using Boeing High Load Penetrometer

Site Pavement Type	**Estimated CBR**	**Test Date**
Ile-a-la-Crosse Sealed Granular Pavement	36.6	June 16, 2020
Wollaston Lake Sealed Granular Pavement	41.1	June 21, 2021
Stony Rapids Sealed Granular Pavement	> 55	June 22, 2021
La Loche Sealed Granular Pavement	46.3	June 22, 2021

Since the seal coat layer is not a load bearing layer, and the penetrometer is pushed to a depth of 100 mm, the estimated CBR is a measure of the granular base course strength. The estimated CBR values in Table 2 are in line with typical values required for low volume gravel runways. . Further to this, according to Figure 1 in AC 300-004, Transport Canada would allow the runways to operate without tire pressure restrictions [2]. It should be noted that the CBR of > 55 for Stony Rapids indicates that the CBR exceeded the maximum at which the penetrometer could provide an accurate measurement.

Runway Inspections

The project team performed surface inspections at five northern Saskatchewan airports on June 16, 2021. The main purpose of the inspections was to observe first-hand the characteristics and performance of the sealed granular surfaces. The site inspections also provided opportunity to see typical maintenance issues and repairs encountered for surfaces of different ages. Airports with sealed granular pavements included in the inspections were Wollaston Lake, Stony Rapids, le-a-la-Crosse and Fon-du-Lac. At the time of the inspections the Fond-du-Lac airport was undergoing a rehabilitation treatment consisting of adding granular base course and installing a double seal coat surface. The Buffalo Narrows airport, which has an HMA surface, was also visited to compare its characteristics to the sealed granular surfaced airports on the tour.

As shown in the example photo from Wollaston Lake Airport in Figure 3, the runways were well-maintained, clean, free of loose rocks and soil, had asphalt sealant applied to surface cracks, and showed visible rubber tire skid marks, indicating that the seal coat surface is relatively hard and is similar to HMA.

Figure 4 – Surface Inspection of Wollaston Lake Airport Runway June 2021

The project team was able to observe three sealed granular pavement runways being used by different aircraft for landing and takeoff, and personally experience the landing and takeoff performance of a Beechcraft 1900D aircraft on all runways visited. The team was also able to observe the Wollaston Lake Airport's sealed granular surface runway in wet conditions, during a period of rain. The overall conclusions from the trip were very positive, having observed evidence of similar performance as that of HMA paved runways. There was no visible surface deformation, no identified issues with FOD generation, and it was difficult to tell the difference visually, or otherwise, between the double seal coat and an HMA surface.

STANDARDS DEVELOPMENT

Saskatchewan Guide to Sealed Granular Airport Pavements

As part of the work on this project, MoH published a document in 2021 titled *Guide to Sealed Granular Airport Pavements in Saskatchewan* [15]. This guide documents practices in the design, construction, and maintenance of sealed granular airport pavements. The following sections provide an overview of MoH practice.

Design

MoH airport flexible pavement structures are designed using the latest Public Works and Government Services airport pavement design methods. The design process for both new construction and rehabilitation of existing airport structures must consider the subgrade soils and the granular structure. The process relies on characterizing the subgrade soil bearing strength and ensuring that the granular structure is strong enough to carry the anticipated loading from the design aircraft in the varying seasonal conditions and local climate. Detailed design procedures are described in Public Works Canada pavement design manuals [16, 17]. MoH sealed granular pavements rely on granular materials for load bearing capacity therefore the “granular equivalency method” of pavement design is used. The subgrade bearing strength is used in combination with the standard aircraft gear loading to determine the pavement structural thickness requirements. The individual pavement layers are then determined by multiplying the thickness of the layer by its granular equivalency to determine the required thickness of the pavement. The minimum thickness for frost protection is a function of the average annual air freezing index in °C-days. The final depth of flexible pavement structure is the greater of the calculated equivalent granular thickness or the frost protection thickness requirement.

Construction

Employing best practices for airport pavement construction is important in creating a durable structure. The construction of sealed granular airport pavements relies on the same principles and techniques as roadway construction of flexible pavements, and only the northern airport-specific issues are highlighted here.

Typically, a completed granular base course layer is protected from moisture infiltration by applying an asphalt prime coat, and application of the two seal coat layers follows shortly after. Asphalt emulsion-stabilized base course may be a consideration for facilities where air traffic is to be maintained during construction or where the seal cannot be constructed in reasonable time after base course construction. The asphalt emulsion-stabilized base course layer can be opened to traffic soon after construction and will have increased stability and improved resistance to moisture infiltration.

Figure 5 – Granular Base Course Construction Stony Rapids Airport 2014

MoH has had positive experience with paver-laying the granular base course instead of using the more traditional end-dump truck and grader-spreading operation. Placing the granular base course with a paver allows good control of the surface cross slope. Achieving the final design grade must be done with the surface of the granular base course since the seal coat layers do not correct any variations in the underlying surface.

Figure 6 illustrates a newly completed seal coat on an airport runway. Traffic and temperature conditions play an important role in the early performance of the seal coat. The construction of a seal coat surface for an operational low volume airport in northern Saskatchewan may involve practices that are different than typical highway seal coat applications. Seal coats require several weeks of warm, dry weather to fully cure. This is a challenge for any seal coating operation, and even more so in northern climates, where the warm weather window is very short. To help facilitate bonding and curing, and to mitigate the impacts of the weather, compaction effort is increased; sweeping is delayed; and seal coat application is completed as early in the construction season as possible. Delaying sweeping will allow the asphalt emulsion to further set and begin curing, and to better retain aggregate. For airports, the first seal aggregate is left on the surface and the runway is managed as a gravel surface. Sweeping occurs just prior to the application of the second seal.

Figure 6 – Newly Completed Seal Coat on a Runway

While highway traffic can often assist in embedding the aggregate rocks in the seal coat, this is not the case for low volume airport applications. It is essential that the compaction effort is maximized during construction, and as a result, it is reasonable to expect an increased compaction effort when compared to traditional highway seal coating operations. To offer additional protection to the surface, the final seal coat is left un-swept for as long as possible. For late season seal coat applications, the period of time left un-swept will usually extend over the following winter season. The additional time before sweeping allows the asphalt emulsion more time to cure and increases aggregate retention. The loose aggregate cover also acts as a temporary wearing surface, preventing aggregate loss from air traffic movement and winter plowing operations. While curing takes place and loose aggregate remains on the surface, the runway is operated as a gravel surface until it has received its final sweep, which typically occurs after the second seal has over-wintered one season. In comparison, sweeping of new seal coat on highways begins soon after compaction to prevent damage to vehicles caused by loose stones.

Maintenance

Maintenance of sealed granular pavements for airports is similar to that of roadways. Routine maintenance is intended to delay or prevent surface distresses so that the pavement substructure is protected, and more costly repairs can be avoided. Pavement surface maintenance activities include crack filling/sealing, hand patching, spot sealing, and failure repairs.

Crack filling/sealing is best performed in the spring when cracks are the widest, and as early as possible to minimize water infiltration into the pavement. Figure 7 illustrates MoH crews applying cold-pour rubberized crack sealant emulsion to treat surface cracks. Since the seal coat layer is thin, routing the crack and filling with a hot rubberized sealant is not a suitable repair. The cold-pour sealant has the advantage of curing quickly so that any disruption to air traffic is minimized. Crack filling may also be done using seal coat asphalt emulsion such as HF-150 or 250S, followed by blotter sand to prevent tracking of the material as it cures.

Figure 7 – Crack Sealing Using Rubberized Crack Sealant

For minor surface defects or small areas of shear failure, hand patching with cold mix asphalt is used. For surface defects over larger areas, spot sealing may be a more appropriate repair measure. As seen in Figure 8, spot sealing uses the same materials and equipment as the initial seal coat construction. When deeper failure repairs are warranted, the work may include removal and replacement of granular base materials, and a spot seal over the repaired area.

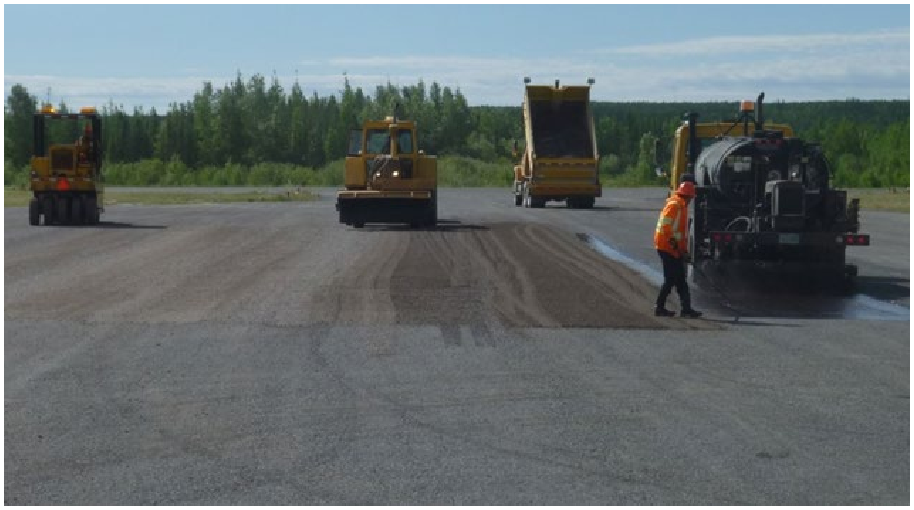

Figure 8 – Maintenance Crews Spot Sealing the Runway

Transport Canada Advisory Circular

Following the agency scan and performance review of MoH's facilities, Transport Canada recognized the need for a separate and distinct pavement surface type for Canadian airports and aerodromes using thin bituminous surfaces. The existing definition of Surface Treated Runway broadly grouped a wide range of different surfaces. In December of 2013, the Transportation Association of Canada (TAC) published the *Pavement Asset Design and Management Guide* [which acknowledged the broad class of surface treatments. TAC groups these different treatments into three main structural categories: Class 1, Class 2, and Class 3.

Recognizing the need to define new surface type, Transport Canada developed Advisory Circular AC 300-021 – *Thin Bituminous Surface Runways* [19]. The AC defines a Thin Bituminous Surface (TBS) runway as a separate and distinct surface type from other Surface Treated Runways. AC 300-021 specifies TBS runways as those runways with a TAC Class 3 pavement structure. Class 3 TBS have staged construction, comprised of full depth base and sub-base layers with a thin bituminous surface (rather than a traditional hot-mix asphalt). While the surface does not add bearing capacity to the structure, it imparts several benefits compared to gravel surfaces including improved surface drainage, reduced surface water infiltration, reduced rolling resistance, and a bound surface which greatly reduces the potential for FOD on the runway. Class 1 and Class 2 treatments remain as Surface Treated Runways as defined in AC 300-004 – *Unpaved Runway Surfaces*.

AC 300-021 specifically acknowledges an acceptable TBS pavement. A TBS consists of a double-sealed granular surface treatment like that which has been operated by MoH over the past 20 years, as described earlier in this paper. The AC specifies criteria which must be met upon construction of a new TBS pavement, or conversion of an existing gravel runway to TBS. A runway will be considered as unpaved until the newly built TBS has undergone a period of at least one seasonal spring thaw and the moisture content of the underlying granular structure has stabilized. Subsequently, the runway surface must be thoroughly swept to ensure any loose granular material has been removed. Finally, the operator must inspect and ensure the surface has fully cured.

The standards related to runway pavements are performance based, rather than prescriptive standards. Different standards are applicable depending if the runway surface is paved, or unpaved. For paved surfaces, there are no mix design requirements or minimum strength requirements. Rather, aerodrome operators are required to report a Pavement Classification Number (PCN) for paved surfaces, while unpaved surfaces may report the California Bearing Ratio (CBR). AC 300-021 specifies that aerodromes should report the pavement bearing strength as a PCN, in keeping with other paved surfaces. However, the operator may choose to also publish CBR values. Like gravel pavements, the TBS pavement derives its structural performance from the base and subbase layers. As such, publication of CBR values may still be of use to flight crews in determining whether any tire pressure restrictions specific to their aircraft are applicable.

With respect to pavement markings, standards are specific both to the runway surface type as well as the level of service. The concept of the Aircraft Group Number (AGN) is used to provide a simple method of interrelating the numerous technical specifications concerning aerodromes and the critical aircraft. AC 300-021 specifies that the pavement should be considered as a paved surface with respect to markings as specified in TP 312. In practice, this means that the TBS pavement will require markings corresponding to the AGN.

CONCLUDING REMARKS

The work that was completed by the project team confirmed the suitability of MoH sealed granular surface runways for classification as paved surfaces. MoH ihas now completed the process of reclassifying its sealed granular pavement runways as “paved”, and the aviation industry has implemented changes to their operations to maximize the benefits of the new surface type.

The newly implemented Canadian national standards that now include thin bituminous surfaces as paved surface types are providing important benefits for the Saskatchewan economy by removing landing and takeoff performance penalties for the aircraft using these runways.

To ensure continued safety and integrity of low volume airport operations, agencies and airport operators considering using thin bituminous surfaces must do so only with sufficient due diligence. Applicable standards and best practices for design, construction, maintenance, and operations of these runways must be followed.

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