Airport Pavement Surface Treatment: A Literature Review

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16. Abstract

The Federal Aviation Administration Airport Technology Research and Development (ATR) Branch conducted a study of airport pavement surface treatments to identify evidence-based best practices and guidance for selecting surface treatments as the appropriate treatment strategy for different airfield pavement locations. The study will be used to further develop airport guidelines for the use of surface treatments. The literature review described in this technical note supports the baseline state of the practice related to the use of surface treatments on airport pavements. It includes an overview of publications on surface treatments used as preventive maintenance, surface treatment selection, effectiveness of surface treatments, and highlights from selected case studies.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ACRONYMS

AC	Advisory Circular
ATR	Airport Technology Research and Development Branch
DoD	Department of Defense
EAC	Equivalent annual cost
ERDC	Engineer Research and Development Center
FAA	Federal Aviation Administration
FOD	Foreign object debris
GA	General aviation
HFST	High-friction surface treatments
L&T	Longitudinal and transverse
M&R	Maintenance and rehabilitation
NASA	National Aeronautics and Space Administration
NAVFAC ESC	Naval Facilities Engineering Systems Command
NTIS	National Technical Information Service
PCI	Pavement condition index
PMP	Pavement management program
SEST	Surface enrichment spray treatment
SLE	Service life extension
TRID	Transportation Research International Documentation

EXECUTIVE SUMMARY

An airport's pavement infrastructure is subject to deterioration from numerous forces. Environmental forces affect the durability of asphalt-surfaced pavements. When the asphalt binder stiffens and becomes brittle, the pavement is more susceptible to surface cracking, weathering, and raveling. Cracks caused by environmental effects can then contribute to accelerated pavement deterioration by allowing moisture to penetrate deeper into the pavement structure and weakening underlying layers. Preventive maintenance is often performed while airfield pavements are in good condition to prevent or slow deterioration from environmental effects. This maintenance can delay the need for costly pavement repairs or reconstruction.

Surface treatments are one type of preventive maintenance used to extend the life of asphalt-surfaced pavements. They are classified into three categories: liquid, liquid and sand mix, and slurry seal or microsurfacing treatments. Surface treatments work by protecting the pavement from environmental effects and fuel spills from airplanes or ground equipment.

The selection of the best treatment for a pavement is affected by many factors. The decision-making for maintenance and rehabilitation (M&R) of airport pavements consists of identifying which pavements should receive M&R treatments and then considering site-specific factors to determine the type of M&R treatment that should be applied. Cost-effectiveness is also considered but does not always determine the final treatment decision. Other factors, such as available funding, restrictions, or constraints in paving operations; required downtime at the airport; general material unit costs; seasonal availability; state obligations in the application of a specific material or treatment; specialized contractor training; and upfront costs may play a more important role in the decision. The Federal Aviation Administration (FAA) lacks clear guidance to airport owners on both selecting treatments to apply and on location on the airfield to apply them. Providing clear guidance on how, when, and where to apply surface treatments would allow airport managers to make informed decisions regarding their pavements.

The impact of surface treatments also needs to be critically considered, including the potential to increase pavement service life and effects on pavement friction characteristics. Factors which impact the effectiveness of a surface treatment include the treatment type, preexisting surface conditions (extent of distress and surface conditions), preexisting structural capacity, site factors (such as traffic and climate), pavement layer types and thickness, and pavement age. Some surface treatments are applied without aggregate or with only a light application of sand. Even treatments with aggregate are likely to have less surface texture than a conventional P-401 asphalt mix pavement. Consequently, the effect of surface treatments on pavement surface friction is a performance metric that needs to be closely monitored as excessive friction loss can increase the risk of loss of control for all vehicles.

The FAA Airport Technology Research and Development Branch (ATR) sponsored a study of airport pavement surface treatments to further develop airport guidelines that identify evidence-based best practices and guidance to select surface treatments as the appropriate treatment strategy for different airfield pavement locations. As part of this study, a literature review was conducted that documents airport experience with surface treatments. It encompasses a selection of documents regarding surface treatments identified by using Google Scholar™, FAA Technical Library databases, and Transportation Research International Documentation (TRID). More than

30 documents were reviewed in depth. This technical note is provided as part of the FAA's study to inform future policy, develop guidelines for airports that identify evidence-based best practices and guidance to select surface treatments, and apply surface treatments on locations on the airfield.

INTRODUCTION

The Federal Aviation Administration (FAA) Airport Technology Research and Development Branch (ATR) sponsored a study of airport pavement surface treatments, to further develop airport guidelines that identify evidence-based best practices and guidance to select surface treatments as the appropriate treatment strategy for different airfield pavement locations. To provide background for this study, a literature review was conducted to document pavement preventive maintenance results related to surface treatment use. Transportation Research International Documentation (TRID) was the primary source for the literature review, and it was supplemented with a Google Scholar™ search. Approximately 150 publications dating from 2010 onward were identified for an abstract-level review. More than 30 items were highly relevant and reviewed in depth. Based on that search, this technical note describes the literature review that documents the baseline state of the practice related to the use of surface treatments as preventive maintenance, discussions on surface treatment selection and the effectiveness of surface treatments, and highlights from selected airport users.

PAVEMENT MAINTENANCE AND SURFACE TREATMENTS

An airport's pavement infrastructure is subject to deterioration from numerous forces, including environmental conditions, traffic loading, designed or built-in defects, and aging (Arabali et al., 2017). Because of the critical role this infrastructure plays and its associated financial investment, it is essential to have a plan to manage and preserve airport assets. Such plans contribute to more efficient and cost-effective operations, thus delaying the need for costly pavement repairs or reconstruction, and, in some cases, preventing pavement abandonment due to lack of resources. However, the increasing cost of pavement maintenance, decreasing budgets, and increasing operations are significant challenges that airport managers face as they strive to maintain their facilities at an appropriate service level.

A survey of public-use airport facilities showed a continued trend of closures over the past four decades, with facilities with runways less than 3,000 feet more likely to close than facilities with longer runways (Thatcher, 2011). The top five cited problems contributing to public-use airport closures were high fuel costs, funding and budget shortfalls, high operating costs, over-regulation, and airspace use. One of the study's main conclusions was that developing a long-term airport preservation strategy, which includes steps to attract more funding and allocate those funds more efficiently, is key to the long-term viability of general aviation (GA) airports.

Preventive maintenance is defined as activities and treatments performed on a pavement while it is still in good condition to prevent or slow pavement deterioration. It has been documented that investing in preventive maintenance early in a pavement's life requires less investment over time to maintain the pavement condition at an adequate level (Rushing et al., 2013).

Providing clear guidance on how, when, and where to perform maintenance would allow airport managers to make informed decisions about the best treatments for their network while also helping to justify maintenance needs at a technical and financial level (Hajek et al., 2011). Appropriate planning for pavement preservation can mitigate pavement deterioration, improve long-term pavement performance, extend service life, and enhance the safety of users (Arabali et al., 2017).

When appropriately designed for expected traffic, pavements are expected to maintain a Pavement Condition Index (PCI) between **GOOD** and **FAIR** for many years. However, if proper maintenance is not administered, a pavement asset can experience rapid deterioration and reach the **POOR** end of the PCI scale sooner than expected. The cost of repairing pavements at the end of their lives to improve pavement condition is substantial in comparison to the more modest investment needed before the onset of rapid deterioration. This principle is illustrated in Figure 1, which presents a typical pavement condition curve over time and highlights the importance of early preservation or preventive maintenance.

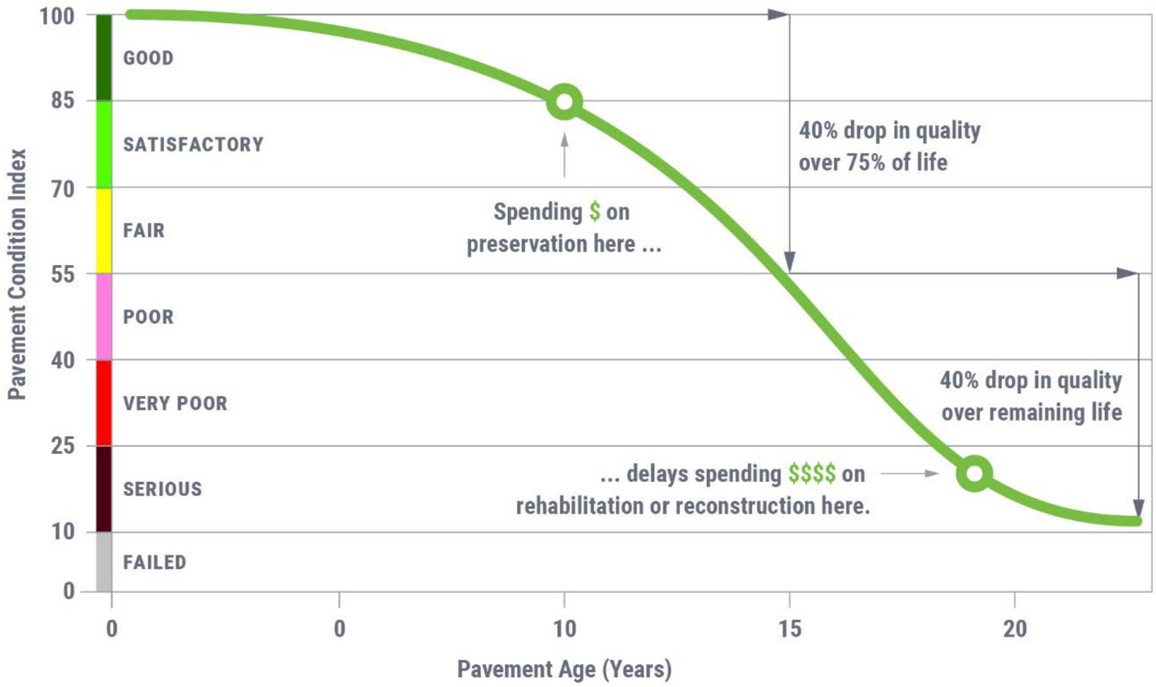

Figure 1. Typical Pavement Deterioration

Using surface treatments in preventive maintenance applications is most effective when the pavement is in **GOOD** to **FAIR** condition. This is because preventive maintenance treatments slow the rate of deterioration rather than restore or repair heavily distressed or structurally compromised areas, as is the focus of more costly maintenance and rehabilitation (M&R) activities. However, GA airport managers often use their scarce resources on the lower end of the life-cycle curve rather than making incremental investments for preservation at the top of the curve (Freeman et al., 2016).

Asphalt-surfaced pavements may benefit from preventive maintenance. Environmental forces reduce the durability of asphalt-surfaced pavements due to oxidation, volatilization, polymerization, and binder absorption; UV radiation; and continued heat exposure. These mechanisms cause the asphalt binder to stiffen and become brittle, which in turn makes asphalt mix pavements more susceptible to surface cracking, weathering, and raveling (Baek et al., 2012). As these mechanisms progress, the ability of asphalt-surfaced pavements to withstand the development of surface cracking is diminished (Al-Qadi et al., 2019). Cracks can then contribute to accelerated pavement deterioration by allowing moisture to penetrate deeper into the pavement structure and affect underlying layers. The pavement surface experiences the brunt of environmental effects, but surface treatments can prevent or delay further deterioration and protect the underlying pavement layers against detrimental environmental effects.

A surface treatment is a special material, or combination of materials, applied to a pavement to improve some aspect of the pavement surface condition (Humphries, 2015). Surface treatments work to address/protect the pavement from past/future environmental effects and fuel spills from airplanes or ground equipment. Due to their comparatively low cost, surface treatments can be a cost-effective way of extending the functional life of asphalt-surfaced pavements (Rushing et al., 2013).

Broadly, surface treatments can be classified into three categories (Brown, 1988; AI, 2008; Godwin, 1975):

- Liquid only—a spray application of soft binder or a rejuvenator directly over the pavement surface. This coating protects weathered surfaces against sunlight radiation, reduces potential raveling by providing a fresh binding agent, and provides some crack filling. Rejuvenators soften the asphalt binder near the surface, slowing down the stiffening and embrittlement of the binder.

- Liquid and sand mixture—a binder or emulsion combined with sand is applied to the surface. Similar to liquid-only treatments, this category protects weathered surfaces and provides some crack filling. The addition of sand reduces loss of surface friction.

- Slurry seal and microsurfacing—a mixture of asphalt emulsion and fine aggregates applied to protect the surface with a durable skid-resistant material. In addition to protecting weathered surfaces, this category of treatments provides some crack sealing, improves surface friction, and (in the case of microsurfacing) can be used to fill small ruts.

SURFACE TREATMENT SELECTION

The selection of the optimal treatment from among various M&R alternatives is a critical decision that may be supported by a life-cycle cost analysis when the least cost over the pavement's life is the selection criterion. Different approaches to analyzing costs can assist decision-makers in selecting optimal treatments in terms of cost-effectiveness, such as equivalent annual cost (EAC), benefit-to-cost ratio, uniform equivalent annual cost, and life-cycle cost analysis (Arabali et al., 2017). Such approaches focus on the costs over a pavement's service life, and the service life of individual treatments, but do not always consider pavement performance.

Airport pavement management programs (PMPs) may also play a role in the treatment selection process. A PMP provides systematic and objective procedures for managing pavement assets, monitoring pavement performance, planning and budgeting M&R activities, and evaluating the cost-effectiveness of past pavement preservation actions (Hein & Aho, 2011). Hein and Aho (2011) described the decision-making for M&R of airport pavements as consisting of two sets of sequential decisions: (1) to identify which pavement sections should receive M&R treatments and

(2) with the use of site-specific engineering considerations, to determine the type of M&R treatment that should be performed on triggered pavement sections. A pavement section is the building block for pavement inventory and the basic unit for pavement management decision-making. The first pavement preservation treatments are typically carried out when the pavement is between 3 and 5 years old and before the distresses progress to the point that more expensive corrective treatments are required (Ali & Mohammadafzali, 2014; Hajj et al., 2011). Hein and Aho (2011) note that pavement performance is affected by the pavement structure, material type, the frequency and type of traffic loads, the environment, and subgrade characteristics including drainage. The uniqueness of these factors means that pavement performance models are not easily transferable from airport to airport. Consequently, airport-specific pavement condition surveys that evaluate the type, severity, and extent of pavement surface distresses are required to customize PMPs by location.

Cost-effectiveness does not always determine the final treatment decision; other factors, such as available funding, restrictions, or constraints in paving operations, required downtime at the airport, general material unit costs, seasonal availability, state obligations in the application of a specific material or treatment, specialized contractor training, and upfront costs may play a more important role in the decision (Arabali et al., 2017). The identification of pavement treatment needs is based on the results of pavement condition surveys, the prediction of future pavement deterioration, and the desired level of service for airfield pavements. Identifying specific pavement conditions and early indicators that trigger the need for preventive maintenance treatments also plays a role in selecting the appropriate M&R treatment (Hein & Aho, 2011).

Arabali et al. (2017) developed airport pavement preservation guidelines considering climate zone and airport category. The guidelines were based on data collected from a survey delivered to 89 practitioners from 36 states in conjunction with engineering judgment. Cases with more than one distress type were considered. The surface treatments included in this study were:

- Rejuvenators
- Fog seals or coal tar seals
- Slurry seals, sand seals, or microsurfacing
- Chip seals or cape seals (chip seal covered by slurry seal or microsurfacing)

According to the investigation by Arabali et al. (2017), rejuvenators, fog seals, and coal tar seals are acceptable for most cases when low- to high-severity weathering is present. These treatments can sometimes be appropriate for low-severity raveling or if low-severity linear cracks are present. It is noted that surface treatments are not intended to address pavement structural distresses; if the pavement exhibits structural deterioration, a separate analysis is needed to determine the right corrective measure. Slurry and sand seals, microsurfacing, chip seals, and cape seals are best suited for cases when low-severity raveling is present. They are also an acceptable treatment for cases when medium-severity raveling is found.

Sometimes two treatments may be applied to a pavement surface in succession. For example, crack sealing, edge repair, or other repair work may be used to prepare a pavement to receive a surface treatment. In such cases, the treatments may be applied days or even months in advance of the surface treatment (Arabali et al., 2017).

EFFECTIVENESS OF SURFACE TREATMENTS

Any treatment used on an airfield pavement should confer a positive benefit in terms of maintaining or improving performance in a cost-effective manner. As such, treatment effectiveness should be an important consideration in the selection of surface treatments. One way to consider the effectiveness of surface treatments is in terms of service life extension (SLE) (Haider et al., 2015). SLE is the increase in pavement service life, in years, due to a treatment application and is given by the difference between pre- and post-treatment remaining service lives. The effectiveness of a surface treatment is affected by the treatment type, preexisting surface conditions (extent of distress and surface conditions), preexisting structural capacity, site factors such as traffic and climate, pavement layer types and thickness, and pavement age.

The study by Haider et al. (2015) is based on roadway treatments including slurry seals and chip seals. In that study, the authors concluded that the effectiveness of surface treatments is directly proportional to the preexisting structural capacity of the pavement. While their study used roadway data for its analysis, it highlights the importance of applying surface treatments while the overall pavement structure is still sound.

An important consideration when using surface treatments is maintaining adequate friction levels. Some surface treatments are applied without aggregate, or with only a light application of sand. Even treatments with aggregate are likely to have less surface texture than a conventional P-401 asphalt mix pavement. Consequently, the effect of surface treatments on pavement surface friction is a performance metric that needs to be closely monitored as excessive friction loss can increase the risk of loss of control for all vehicles.

The FAA Advisory Circular (AC) 150/5320-12D *Measurement and Maintenance of Skid-resistant Airport Pavement Surfaces* (FAA, 2016) details guidance for designing skid-resistant pavements and developing monitoring plans to ensure that the ongoing pavement friction levels are suitable for the level of aircraft operation in the facility. While evaluating pavement friction on airport runways is always required, a survey of airport agencies revealed that at least 8% of them also test friction on taxiways (Hajek et al., 2011). Additionally, some studies have investigated how the application of surface treatments in areas where deicing operations are performed near gate terminals can significantly reduce the friction levels in those areas, highlighting the importance of an adequate treatment selection process depending on pavement use (Korczak et al., 2014).

Doyle et al., (2021) investigated application rates, adhesion properties, surface friction, crack sealing ability, and durability against environmental factors. The authors took particular interest in the effect of oil-contaminated concrete versus clean concrete surfaces on the efficacy of the treatments. The experiment consisted of test strips with each material type applied to deteriorated concrete slabs. Half of the slabs were contaminated with oil, while the other half were clean. Simulated aircraft traffic with high tire pressure was applied with periodic visual observations and surface friction measurements made over 2 years. The surface characteristics were assessed via surface texture analysis and friction measurements. The texture was measured using a laser texture scanner in accordance with ASTM E1845 (ASTM International, 2015) to compute mean profile depth. Friction was measured using a Micro GripTester using the manufacturer's recommended test procedure to obtain the friction coefficient (μ). The study concluded that most products performed well on clean surfaces, but they were less effective when applied on oil-contaminated concrete slabs. This conclusion highlights the importance of taking surface deposits into account when selecting surface treatments because the presence of surface deposits can diminish their effectiveness.

An experiment conducted by the U.S. Army Corps of Engineers, Engineer Research and Development Center (ERDC) focused on field demonstrations of asphalt surface treatments at six locations in various climatic regions of the United States (Rushing, 2012). These demonstrations included test areas for applying 18 different products, all placed on active airfield pavements exhibiting minimal surface distresses such as weathering or longitudinal and transverse (L&T) cracking. A comprehensive evaluation program included annual inspections of the test sites to collect condition and surface property data. This helped to quantify the potential benefits of preventive maintenance on airfield asphalt concrete pavements. The author noted that preventive maintenance techniques had not been commonly used on airfields because of concerns of reduced friction or treatment debonding from the pavement, which can generate foreign object debris (FOD).

This experiment included taxiways and aprons on U.S. Army airfields in three distinct climatic regions in the United States (hot and wet, hot and dry, and cold), with a first phase aimed to test multiple products and a second phase with fewer products over much larger pavement areas. The surface treatments were tested with friction measurements using a Dynamic Friction Tester per ASTM E1911 (ASTM International, 2019) and a GripTester following AC 150/5320-12C (FAA, 2007). For the pavement condition, a scaled map of all existing cracks in the test area pavement was created by documenting crack lengths obtained with a measuring wheel. The pavement surface texture was measured using the National Aeronautics and Space Administration (NASA) grease smear method, in which a known volume of grease is evenly spread onto the pavement surface with a spreader tool to obtain a mean texture depth. This is expected to increase with time due to weathering. In contrast, effective surface treatments will slow the aggregate loss rate associated with pavement aging and the rate at which the non-load associated surface cracks initiate and grow (Rushing, 2012).

After the placement of the liquid-only products, some of the friction values declined significantly and, in almost all cases, below the minimum acceptable value. For slurry-applied products, the surface friction was minimally affected or exceeded the untreated pavement surface. The following are some of the recommendations from the study (Rushing, 2012):

- The use of hand-wand applications is not recommended. An asphalt emulsion distributor or equivalent with a calibrated rate-control system should be used to ensure proper, uniform applications.

- Microsurfacing or slurry seals should include well-screened aggregate to eliminate large stones (larger than the No. 4 sieve), which may drag in the slurry during application.

- The slurry should be compacted with a rubber tire roller when significant aggregate is retained on the No. 8 sieve.

- If aggregates are topically applied, the aggregate should be broadcast from the emulsion distributor to avoid an uneven aggregate distribution and possible pickup on the tires from the secondary vehicle.

The study revealed that surface treatments reduced weathering and could retard top-down surface cracking. Both effects had a positive impact on the PCI of the test sections. However, the surface texture was reduced for most surface treatments, which negatively impacted friction and increased the risk of hydroplaning. The study also recommended that these treatments should not be used in areas where the pavement is experiencing block or reflective cracking since the treatments will not address bottom-up cracking. Surface treatments are not recommended for regions subjected to frequent snow and ice removal operations since the plowing blades will erode and unravel the treatment coating, rendering the treatment ineffective. Finally, areas that experience high-speed aircraft movements should not be subjected to surface treatments due to the reduction friction and increased risk of hydroplaning (Rushing, 2012; Rushing et al., 2013; Rushing et al., 2015).

AIRPORT EXPERIENCE WITH SURFACE TREATMENTS

AUSTRALIA

Most of Australia’s paved airports have used a sprayed seal surfacing (White, 2019), and there is a record of good performance on runways carrying up to Boeing (B)-737-sized aircraft. While past applications of sprayed treatments relied on cutback bitumen, sanded emulsions, and coal tar membranes, the industry has now moved to modified bitumen emulsions and modified polymer membranes. Sprayed seals for airports are designed and constructed differently than for roads. When these airport-specific requirements were not used, significant early-life seal distress resulted in gross wheel path bleeding of the asphalt binder to the pavement surface or excessive aggregate loss from the surface (raveling). These two distresses can be particularly hazardous for aircraft due to FOD production that can damage low-slung jet engines.

White summarized the spray sealing specifications used at Australian airports:

- Larger aggregate sizes, typically 14 mm (0.55 in.) with a 10-mm (0.39-in.) or 7-mm (0.28-in.) surface layer.

- Higher binder application rates. For example, 2.0 L/m^2 (9 gal/yd^2) for a 10-mm (0.39-in.) seal.

- Increased rolling effort, typically one roller hour per 800 L (211 gal) of sprayed binder.

- Steel drum rolling of the surface seal layer to reduce tire wear on landing.

The Australian experience is that well-designed and -constructed sprayed seal runways can provide up to 10 years of service. Weather conditions during construction (recommended during daylight hours of the driest and hottest days) and the delivery of the sprayed seal affect performance. Finally, the author recognized that surface treatments tend to reduce surface texture, which negatively impacts skid resistance. Therefore, it recommended that friction be tested before and after application with a spot tester, such as the British pendulum, and to do a full post-construction friction assessment with a self-wetting device, such as a MUMeter.

TEXAS

Humphries and Lee (2015) examined preferred or successful maintenance practices used in GA airports throughout Arkansas, Louisiana, and Texas, identifying the general cost and documenting how planning and implementation are accomplished.

For this purpose, the authors provided qualitative and quantitative surveys to better understand how GA airports in Arkansas, Louisiana, and Texas conduct maintenance. At the end of the study, based on 60 responding airports, it was determined that slurry seals are the most commonly used surface treatment and have an average rating of 6.18 on a scale from 1 to 7, with 1 defined as not effective and 7 as extremely effective for addressing problems. The best-rated surface treatments were microsurfacing and cape seals, with average ratings of 6.75 and 7, respectively; however, they were not widely used, in large part due to their higher cost. The facility (runway, taxiway, or apron) where the surface treatment was applied was not included on the survey, so application trends cannot be drawn relative to facility use. The findings of this study highlight how treatment selection can be significantly affected by financial constraints.

NETHERLANDS

In the Netherlands, a tar-based surface treatment was used at six airports to assess its anti-skid properties. The researchers explored the thickness of the protective layer and its surface texture properties over 20 years (Xiao et al., 2011). The study found that the thickness of the treatment layers varied from 3 mm to 5 mm, and had a relatively high mean texture depth between 1.3 mm and 1.4 mm. These results indicated that this surface treatment could improve the pavement's friction quality due to an improved macrotexture.

NEW ZEALAND

Nearly 66% of Christchurch Airport's (New Zealand) total asphalt pavement surface does not receive aircraft traffic loading. Therefore, the pavement in this area is only subjected to environmental deterioration, primarily in the form of asphalt oxidation and moisture damage. These can drive an increase in FOD potential over time, requiring the pavement to be resurfaced every 12 to 15 years. That in turn creates a logistical problem for airport operations and a large demand on the airport's pavement maintenance budget.

A case study documented the viability of using a gilsonite-infused asphalt emulsion as a surface enrichment spray treatment (SEST) to waterproof and protect the surface against oxidation (Worthington, 2015). Worthington concluded that using a gilsonite-infused emulsion successfully extended the service life of the treated pavement without requiring as significant a financial investment as a traditional resurfacing. Additionally, the author conducted a life-cycle assessment between the two options, which indicated that this type of surface treatment was a more sustainable alternative to resurfacing. However, the author highlighted a significant loss of surface friction within the first days after the treatment application. This highlights the importance of using surface treatments only in areas where a decrease in friction will not cause an operational hazard.

SEAL COATS IN THE UNITED STATES

Gilsonite-modified seal coats have been widely used in the United States on GA airfield pavements. This petroleum-based rejuvenator is an environmentally friendly product that has been approved by the FAA to be applied on airfields to mitigate pavement raveling (Blanchette, Lee, & Wood, 2020). From 2000 to 2002, the U.S. Army Corps of Engineers, ERDC, evaluated gilsonite-modified sealers as well as a standard asphalt fog seal, a refined coal tar sealer, and an untreated control section. Another investigation was conducted by Naval Facilities Engineering Systems Command (NAVFAC ESC) on six different Department of Defense (DoD) installations in six regional climatic zones throughout the United States. Skid resistance after the application of the treatment was a primary concern of the investigation (Cline, 2021).

The gilsonite-asphalt residues from a P-608 gilsonite-modified seal coat typically penetrate 5 mm or more into the pavement surface. They create a protective layer on the surface containing relatively high amounts of the components that transform most asphalts into high-performance and anti-aging residues, including anti-oxidative polar resins and asphaltenes. These compounds, when blended appropriately into asphalt, impart beneficial and durable anti-aging characteristics (Cline, 2021).

ACs 150/5380-7B and 150/5370-10H (FAA, 2014; FAA, 2018) allow the use of P-608 on all airfield pavements. When applied in a timely manner, asphalt seal coats have been found to effectively extend the time that pavements are in **GOOD** condition, resulting in extended service lives of 15 to 20 years (Cline, 2021).

A review of Colorado airport databases showed the average untreated deterioration rate was 2.4 PCI points per year; while for P-608-treated sections, it was 1.6 points per year, or a 33% reduction. Another dataset corroborated the 33% reduction in deterioration rate with 1.5 PCI points per year for untreated pavements and 1.0 PCI points per year for P-608-treated pavements (Cline, 2021). However, P-608 as a preventive surface treatment has a differential impact on pavements depending on their condition at the time of application. For example, after applying a surface coat, a pavement section with a deterioration rate of 3.7 PCI points per year and a current PCI of less than 60 saw its deterioration rate reduced by 49%. In contrast, a pavement with PCI greater than 90 and a deterioration rate of 2.9 PCI points per year experienced a deterioration rate reduction of 69% per year (Cline, 2021).

A previous review of FAA airports in Colorado, Utah, and Oregon, including Portland International Airport, showed that, regardless of the pavement facility, the use of surface treatments with gilsonite can reduce the deterioration rate of the pavement and extend its useful life (Cline, 2011). One area of concern for such surface coats is curing time, which can impact airport traffic operations (Blanchette et al., 2020).

SUMMARY

This technical note presents a brief overview of literature on surface treatments as preventive maintenance, surface treatment selection, effectiveness of surface treatments, and highlights from selected case studies. Surface treatments play an important role in the preservation of airfield pavements. Performing preventive maintenance early in a pavement's life is crucial to delaying premature pavement deterioration. As the durability of asphalt pavement is affected by the environment, surface treatments are a common approach to protect asphalt against detrimental environmental effects.

Broadly, surface treatments can be classified into three categories: liquid treatments, liquid and sand mix treatments, and slurry seal or microsurface treatments. Environmental forces reduce the durability of asphalt. When the asphalt binder is stiffened and becomes brittle, the pavement is more susceptible to surface cracking, weathering, and raveling. Cracks can then contribute to accelerated pavement deterioration by allowing moisture to penetrate deeper into the pavement structure and affect underlying layers. Surface treatments work to address/protect the pavement from past/future environmental effects and fuel spills from airplanes or ground equipment.

The selection of the best treatment is a critical decision and is impacted by many factors, including the existing pavement distresses, facility use, expected traffic, environment, cost, available funding, material restrictions, constraints in applications operations, and contractor availability.

The impact of surface treatments needs to be critically considered, including the potential to increase pavement service life and effects on pavement friction characteristics. Many surface treatments are likely to have less surface texture than a conventional asphalt mix, which can result in decreased friction values. Consequently, the effect of surface treatments on pavement surface friction is a performance metric that needs to be closely monitored as excessive friction loss can increase the risk of loss of control for all vehicles. However, recent research looking into alternative aggregate sources to produce high-friction surface treatments (HFST) could present a viable option to mitigate friction loss during the service life of surface treatments (Heitzman et al., 2015; Pranav & Tsai, 2021).

More detailed information on surface treatment use and their impacts can be found in some key source documents (e.g., Arabali et al., 2017; Cline, 2011; Hajek et al., 2011; and Rushing et al., 2015).

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