Contractors' Perspectives on Airfield and Highway Hot Mix Asphalt Pavement Projects

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Abstract

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Asphalt pavement covers most highways and airfields in the United States. While paving primarily occurs on highways, airfield projects carry greater risks for contractors and involve different management styles, construction execution methods, and project specifications. Failure to consider and quantify project differences may cause delays and financial repercussions. Therefore, this research answers the question, "From a paving contractor's perspective, what are the differences between airfield and highway paving projects within the State of Washington?" Following a review of specifications and best practices guides, interviews with three Washington asphalt contractors yielded comparisons of project experiences with the Washington State Department of Transportation (WSDOT), the Federal Aviation Administration (FAA), and the

Department of Defense (DoD). Research results may benefit general audiences and, more specifically, United States Air Force (USAF) pavement engineers. Sharing contractors' perspectives about asphalt paving enlightens government representatives about project partners' issues and encourages communication and awareness.

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Chapter 1. INTRODUCTION

Asphalt pavements cover most public roadways and airfields in the United States (U.S.), including 94% of the nation's nearly 4.2 million centerline miles of public roadways and upwards of 90% of the Federal Aviation Administration's (FAA's) runway surfaces within the National Plan of Integrated Airport Systems (Asphalt Institute, 2019; FHWA, 2019; NAPA, 2020). While airfield paving evolved from lessons learned from highway work, airfields and their pavement systems have unique issues and attributes. Airfield owners and users understand that pavement repairs are necessary for the safety of aircraft and personnel, but construction closures impact revenues and airport access. Though both project types involve similar materials and equipment, airfield paving often demands high-quality construction within shorter project schedules.

Several best practices manuals and specifications for airfield paving exist and serve as technical guides for pavement design and construction. However, few discuss paving operations and issues from contractors' perspectives. Contractors typically bear greater financial and administrative burdens during airfield projects, and they must ensure the constructed pavement meets the FAA's and the Department of Defense's (DoD's) more restrictive specifications. These projects need more personnel, equipment, and administrative support to complete due to shorter project timelines and greater financial risks. The majority of published asphalt paving literature relates to highway construction; of those resources about airfield paving (like the Airfield Asphalt Pavement Technology Program (AAPTP), as referenced in Table 11), they tend to focus on projects' technical aspects. While government entities rely on contractors' expertise to execute projects, little published work discusses contractors' perspectives on hot mix asphalt

(HMA) paving, and few available resources document how airfield paving impacts contractors' operations as compared to their typical projects: asphalt roadway paving. This thesis asked several key asphalt paving contractors in Washington State (all with experience in airfield and highway paving) to articulate their experiences and perspectives on how these projects differ. Sharing contractors' perspectives can foster improved owner-contractor relations by creating awareness and understanding of contractors' concerns and business practices while helping owners better anticipate potential project issues.

1.1 Background

HMA describes a construction material made of asphalt cement and aggregate mixed at elevated temperatures in an asphalt plant (USACE, 2013). Asphalt pavement is a sustainable, crucial material to our national infrastructure and economy. With nearly $84 billion in funding and grants spent annually to maintain roadway and airfield pavements, asphalt paving spurs job creation and economic activity (NAPA, 2020). Within Washington State, asphalt surfaces over 97% of roadways and bridges, with a replacement value exceeding $9 billion (Asphalt Institute, 2019; WSDOT, 2019). While highway paving got its start in Washington at the turn of the 20th Century, airfield paving did not take off in the U.S. until 1928 (Wells, 2000). At that time, highway paving specifications served as the basis for airfield work, but operators soon realized these pavement systems face different demands. Highway pavements see higher vehicle load volumes, with maximum tractor-trailer weights capped at 80,000 pounds (FHWA, 2015). This weight pales in comparison to large aircraft like the Boeing 747, which can weigh nearly one million pounds at maximum take-off weight (MTOW), with tire pressures exceeding 150 psi (Boeing, 2010; FAA, 2019). Therefore, the FAA and the DoD produce airfield pavement specifications to better serve and protect aviators and their planes from pavement damage while sustaining elevated pavement performance.

Several published construction best practices resources aide owners and their representatives with highway and airfield projects. These guides are informative and discuss key issues experienced in both highway and airfield paving. They also identify airfield specifications as more stringent, both in site management criteria and specification tolerances. However, these guides do not include comprehensive perspectives from asphalt paving contractors about their approaches to executing paving projects or issues they encounter during these projects. Understanding contractors' perspectives and their approaches to paving are essential for owners and their representatives to anticipate project concerns and issues while fostering strong partnerships between government agencies and the contractors.

1.2 Problem Statement

Owners and contractors alike know airfield and highway paving projects differ despite using similar materials. Several publications produced by organizations like the National Center of Asphalt Technology (NCAT) and the U.S. Army Corps of Engineers (USACE) outline pavement design and construction methods for both airfield and highway paving; however, these documents primarily focus on paving projects and operations from an owners' perspective while disregarding issues faced by the contractors. Therefore, to capture part of this missing perspective, interviewed Washington State paving contractors discussed their project experiences and enabled a side-by-side comparison of airfield and highway projects. Their insights identified concerns, risks, and planning approaches that contractors implement when tackling these projects, as well as sharable lessons for the paving industry.

1.3 Research Objectives

The research objective is to answer the following question: From a paving contractor's perspective, what are the differences between airfield and highway paving projects within the State of Washington? To answer this question, research and literature reviews focused on the following areas before interviewing available contractors.

- What are the owners' current paving project expectations and specifications?
- What differences exist between airfield paving specifications provided by the FAA or the DoD and highway paving specifications provided by WSDOT?
- What existing publications discuss best construction practices for each respective project type, and from whose perspective (e.g., owner/owner's representatives, contractors) are they presented?

This thesis assumes a baseline knowledge of pavements, thereby enabling the document to focus on contractors' perspectives on topics like contracting and project management, construction practices and management, and pavement materials and mix design. This document avoids describing best construction practices for asphalt paving projects; rather, Section 3.4 lists published sources describing these processes. This document will also not delve into pavement systems design (beyond that of the final surface course) or pavement maintenance and rehabilitation practices.

1.4 Methods

This research has three main tasks. First, the literature review included researching previously published work on HMA design and construction on both highway and airfield paving. Questions generated from the literature review were categorized into three topics: contracting and project management, construction practices and management, and pavement materials and mix design. Next, in-person interviews with three experienced Washington asphalt paving contractors garnered perspectives and experiences about highway and airfield paving. This document concludes with results and recommendations from the research, with interview questions and summaries included as appendices.

1.5 Thesis Format and Overview

Within this thesis exists the following sections:

- **Chapter 1:** Overview of subject background, the scope of the selected research topic, and research methods.
- **Chapter 2:** Summarizes research methods used during interview questionnaire development and subsequent contractor interviews.
- **Chapter 3:** Contains relevant literature review, including airfield history and present role of the FAA, discussions about ownership and use of highway and airfield asphalt in Washington, an introduction to HMA contracting and project management, construction practices and management, and pavement materials and mix design, and finally, additional resources about paving methods and construction site requirements.
- **Chapter 4:** Presents data collected during interviews, with conclusions and applications related to the three subject areas: contracting and project management, construction practices and management, and pavement materials and mix design.
- **Chapter 5:** Provides conclusions and recommendations related to the research.

Chapter 2. RESEARCH METHODS

This chapter describes the research methods used to develop this thesis. The methodology includes research of currently available pavement construction resources, interview questionnaire development, contractor identification and selection, interview processes, and data collection and summary. Chapter 5 discusses the application of findings and possible areas of additional research.

2.1 Research Intent

This research intends to answer the question, "From a paving contractor's perspective, what are the differences between airfield and highway paving projects within the State of Washington?" Despite using similar materials and construction methods, highway and airfield paving differ in various ways, including in project planning and management, construction management and quality control, and surface course mix design. Several sources describe best industry practices for both highway and airfield paving, but these sources describe pavement construction issues from academic or owner perspectives. They typically do not discuss issues facing contractors throughout paving projects, particularly during airfield projects which normally have shorter project schedules and higher risks. Engaging paving organizations about issues faced not only during construction, but also during project management and mix design processes, helps owners anticipate potential issues while establishing strong partnerships with parties involved in these projects.

2.2 Literature Review and Interview Questionnaire Development

The literature review, comprised of WSDOT, FAA, and DoD HMA specifications, existing academic literature, and published industry materials, provided a foundation from which interview questions were developed. The review summarized paving processes involved in these projects while highlighting their similarities and differences; it did not include an exhaustive review of both highway and airfield asphalt paving history and design processes. This background knowledge was the premise for the development of interview questions and led to the questions being divided into three core topics, as noted in Table 1.

Table 1: Contractor Interview Question Categories and Subcategories

Contracting and Project Management	Construction Practices and Management	Pavement Materials and Mix Design
• Risk • Contracts and Contract Claims • Compensation/Pay Factors • Personnel and Training	• Construction Site Management • Foreign Object Debris (FOD) Mitigation • Paving Operations • Night Paving Operations • Mat Density and Longitudinal Joints • Weather Concerns	• Nominal Max Aggregate Size (NMAS) • Voids in Mineral Aggregate (VMA) • Asphalt Content and Binder Type • Reclaimed Asphalt Pavement (RAP) Use • Perpetual Pavement/Long Lasting Pavement

The selected question categories reflect different construction project phases. Contracting and project management relates to initial project planning, bidding and contract development, and financial and personnel management. Construction practices and management pertains to on-site supervision, coordination of paving operations, and site concerns. Finally, pavement materials and mix design describe aspects of HMA material sourcing and performance. Because extensive literature exists about mix design processes, the interviews instead focused on the first two question categories, with pavement mix design placed at the end of the interview.

The structured interviews provided time for contractors to respond to thirty-eight prepared questions (Appendix A), and the interviews were conversational. Questions covered various aspects of asphalt paving, and the conversational-style interviews allowed contractors to not only respond to the prepared questions but to also discuss other related pavement topics. This environment encouraged contractors to share their experiences and discuss elements of airfield and highway asphalt paving beyond the selected interview topics.

2.3 Contractor Selection and Experience

Interviewee selection relied on suggestions from the Washington Asphalt Pavement Association's (WAPA's) technical director. Ultimately, three Washington-based asphalt contractors were selected, each with experience working in different regions of Washington on both WSDOT and FAA/DoD paving projects. Contractors 1 and 2 work in Western and Central Washington, while Contractor 3 primarily works in Central and Eastern Washington. This distinction about regional project experience is critical to note due to differences in climate and traffic density across Washington State.

2.4 Interview Process

First, researchers contacted potential interviewees via email to gauge interest in participating in this research and meeting availability. While the initial email informed interviewees of the three question categories, no questions were provided before the scheduled interviews to encourage candid responses. In-person, conversational interviews with contractors lasted approximately three hours, and interviewees received summaries of their interview responses to review for accuracy before publication of this thesis. Appendices B-D include the three interview summaries.

2.5 Presentation of Research Results and Discussion

The order of interview questions and data presented in this document mirrors the order in which interviewees responded to posed questions. To provide context and enhance the clarity of contractor responses, a short specification review may be included to highlight differences between various owning agencies' guidance. In the case that reviewed specifications are identical (as may be the case with FAA and DoD guidance), the document notes these similarities. The results represent the majority opinion, with identified minority opinions or comments. Following a review of all category subtopics, a short conclusion presents key take-aways from each category.

Chapter 3. LITERATURE REVIEW

This chapter summarizes the literature reviewed when developing the interview questions contained in Appendix A. This chapter will briefly describe the development of the airport system in the U.S., followed by the use of asphalt on highways and airfields in Washington State. Next, the similarities and differences between highway and airfield paving will be discussed in terms of contracting and project management, construction practices and management, and pavement materials and mix designs. The author assumes readers have a basic knowledge of asphalt pavement design and construction processes. If the reader requires additional asphalt pavement information, Section 3.4 lists paving specifications and recommended references, with a short glossary of terms contained in Appendix E. The chapter frames the results and discussions contained in subsequent chapters; it is not intended to be an exhaustive review of asphalt pavement design, construction practices, or agency specifications.

3.1 AIRFIELD PAVING AND THE FEDERAL AVIATION ADMINISTRATION

Aviation's growth in popularity since the Wright Brothers' first flight in 1903 spurred advances in aviation technology and supporting infrastructure (Wells, 2000). When the first paved airfields appeared, paving contractors used early highway paving specifications as guidelines. In 1928, Ford Terminal in Dearborn, Michigan, poured the first concrete runway at a U.S. airport (Wells, 2000). Meanwhile, the U.S. military paved its first runways at Barksdale Air Force Base (AFB), Louisiana, Selfridge AFB, Michigan, and Mitchell Field, Wisconsin, in the mid-1930s (Hartzer, 2014). However, the first use of flexible pavements on airfields showed that demands on airfield pavements were different than those on highways. Higher aircraft loads and tire pressures resulted in pavement shoving and rutting, making surfaces unsuitable for aircraft operations (FAA, 2019). Also, practitioners noticed in the 1940s that factors like underlying geology, climatic effects, and load repetitions also impacted pavement quality (Wells, 2000). These findings spurred organizations responsible for airfield pavements to develop specialized design and construction criteria.

While the paving industry adjusted construction practices to meet airfield operational requirements, the federal government established safety regulations and monitored operations, maintenance, and construction of the U.S.'s budding airport system. President Franklin D. Roosevelt approved the Civil Aeronautics Act of 1938, which established the Civil Aeronautics Administration as the forerunner to today's Federal Aviation Administration (FAA) (Wells, 2000). Following the end of World War II, the military released hundreds of surplus military airfields to small communities to aid them socially and economically. Interest in aviation rapidly blossomed, as did "the desire to establish and maintain an extensive system of well-equipped airports serving all classes of civil aviation" (Wells, 2000). Post-World War II expansion bolstered the development and accessibility of aviation.

Currently, the U.S. leads the world in the number of airfields, paved or unpaved. In 2018, the U.S. had over 13,117 airports, which is nearly three times more than the next closest nation, Brazil (CIA, 2013). With a large civil aviation system in need of maintenance and standardization, the FAA strives "to work with State and local units of government, as well as other stakeholders, to ensure effective planning of a safe and efficient system of airports to support the needs of the civil aviation industry" (FAA, 2018d). In 1982, the federal government established the Airport Improvement Program (AIP) via the approval of the Airport and Airway Improvement Act (FAA, 2017). The AIP is an airport capital improvement program which today supports the development and planning of nearly 3,300 airports currently included in the National Plan of Integrated Airport Systems (NPIAS) (FAA, 2018d). Funding comes from taxes and fees collected from airport users, such as taxes on fuel and airline tickets, and AIP grants support four airport project types: noise compatibility programs, airport development, airport planning, and capacity enhancement and preservation (Wells, 2000). Figure 1 outlines eligible construction projects, including airfield pavement construction. Upon accepting AIP funding, airports agree to comply with published FAA design standards to the extent practical. This agreement establishes continuity across the U.S. civil aviation enterprise. Meanwhile, the DoD maintains its pavement specifications under the Unified Facilities Criteria (USACE, 2001).

Eligible Projects	Ineligible Projects
Runway construction/rehabilitation	Maintenance equipment and vehicles
Taxiway construction/rehabilitation	Office and office equipment
Apron construction/rehabilitation	Fuel farms*
Airfield lighting	Landscaping
Airfield signage	Artworks
Airfield drainage	Aircraft hangars*
Land acquisition	Industrial park development
Weather observation stations (AWOS)	Marketing plans
NAVAIDs such as REILs and PAPIs	Training
Planning studies	Improvements for commercial enterprises
Environmental studies	Maintenance or repairs of buildings
Safety area improvements	
Airport layout plans (ALPs)	
Access roads only located on airport property	
Removing, lowering, moving, marking, and lighting hazards	
Glycol Recovery Trucks/Glycol Vacuum Trucks** **(11/29/2007)**	

*May be conditionally eligible at non-primary airports. Contact your local Airport District or Regional Office for more information.

**To be eligible, the vehicles must be owned and operated by the Airport and meet the Buy American Preference specified in the AIP grant. Contact your local Airport District or Regional Office for more information.

Figure 1: Projects Eligible for Funding under the FAA's Airport Improvement Program (FAA, 2017)

3.2 Development of Washington's Paved Highway and Airport Systems

This section describes asphalt ownership and uses in Washington State across these transportation platforms.

3.2.1 Ownership and Use of Highway Asphalt in Washington State

Highway networks have connected the state since the establishment of the first State Historical Road in 1852 (WSDOT, n.d.). In 1905, the Washington Highway Department, the forerunner to WSDOT, was created, and by 1912, Washington had its first roadway surfaced with an asphaltic wearing course (WSDOT, n.d.). The roadway system in Washington today contains state highways and city/county roads, as well as roadways within the National Highway

System (NHS) and the Interstate System (WSDOT, 2019). Roadway pavement management primarily falls to three agencies: the state, cities, and counties. Figure 2 identifies lane miles affiliated with each jurisdiction.

2018 Miles and Daily Vehicle Miles Traveled (DVMT) Information

Jurisdiction	Centerline Miles		Lane Miles		Daily Vehicle Miles Traveled (1,000's)	Annual Vehicle Miles Traveled (Millions)	Percent of VMT
State Total [1] (Interstate)	7,051.52 (763.66)	8.7% (0.9%)	18,699 (4,044)	11.1% (2.4%)	96,920 (47,744)	35,376 (17,427)	56.7% (27.9%)
City	17,179.99	21.3%	35,976	21.4%	44,639	16,293	26.1%
County	39,232.46	48.6%	78,720	46.9%	26,855	9,802	15.7%
Other [2]	17,188.90	21.3%	34,390	20.5%	2,454	896	1.4%
Total	**80,652.87**	**100%**	**167,784**	**100%**	**170,868**	**62,367**	**100%**

[1]Interstate figures are also included in the State total. [2]Other Jurisdictions include State Dept. of Natural Resources, State Parks, Other State, Port Districts, Indian, U.S. Forest, and National Parks.

State Highway Mileage data is from State Highway Log; other data is from HPMS reporting

Figure 2: Roadway Mileage across Jurisdictions in Washington in 2018 (WSDOT, 2018a)

The state transportation agency, WSDOT, maintains and manages nearly 18,700 roadway lane miles valued at over $19 billion (WSDOT, 2019). While this mileage accounts only for 11% of the state's total lane mile inventory, state-managed roadways support more than half of the vehicle miles traveled annually within the state.

Across Washington's pavement inventory, flexible pavements like HMA and Bituminous Surface Treatment (BST, or chip seal) outnumber other materials. Overall, HMA covers 49% of the state's lane miles (Figure 3); assuming all vehicle lanes are 12 feet wide, WSDOT maintains nearly 581 million square feet (SF) of HMA (WSDOT, 2018b).

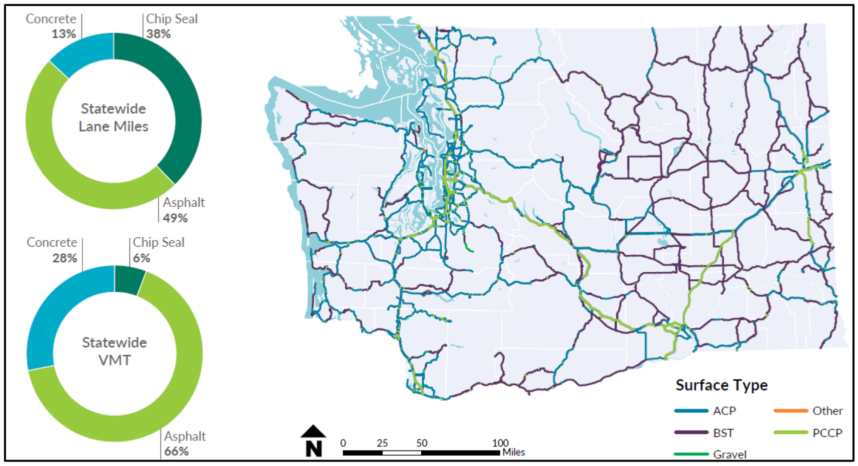


Figure 3: Washington's Pavement Material Use in 2019 (WSDOT, 2019)

Periodic monitoring of pavement conditions allows WSDOT to track pavement degradation and assess long-range, cost-effective repair options. As is the case for several government agencies, available funding for paving projects cannot pay for all requirements. Between 2024 and 2028, Washington's pavement needs will total $1.5 billion (WSDOT, 2019). However, WSDOT estimates the planned spending during that same period will be $1.0 billion (WSDOT, 2019). Therefore, to be good stewards of public funding while maintaining first-rate roadways, WSDOT relies on quality paving materials and repair schedules to optimize scarce financial resources.

When selecting a pavement type, WSDOT uses a three-step process: an analysis of pavement design, an examination of life-cycle costs, and an assessment of project details. Regardless of pavement type, WSDOT roadway designs follow a 50-year design life (WSDOT, 2010). First, pavement design analysis involves reviewing project aspects including climate, drainage, types of traffic, material availability, and construction considerations. Next, a life-cycle cost analysis determines the most cost-efficient paving option based on either "the lowest net present value or annualized cost over a given analysis period" (WSDOT, 2010). Costs incurred over the analysis period include maintenance, rehabilitation, construction, and impacts to travelers. Finally, project-specific details must support the selection of one pavement type over another. For WSDOT, flexible pavements are essential to their pavement maintenance approach. When properly timed, periodic pavement resurfacing restores HMA and BST (like those in Figure 4). If maintenance and rehabilitation occur in concert with proper monitoring, WSDOT anticipates these flexible pavements will not need complete reconstruction.

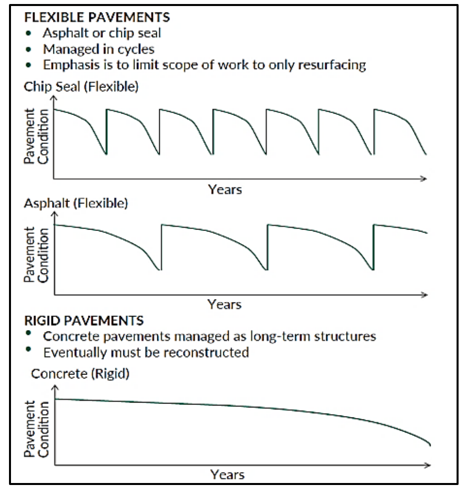


Figure 4: Comparison of Flexible and Rigid Pavement Conditions over Useful Life (WSDOT, 2019)

3.2.2 Ownership and Use of Airfield Asphalt in Washington State

Though they utilize similar materials, HMA pavement management and ownership differ at Washington's airports. Five types of public or government organizations may be involved with the administration and operation of U.S. airports. Airports can be municipally-operated, operated under an airport or port authority, or run by a state or federal government (Wells, 2000). Washington State has 138 public-use airports, 80% of which are publicly-owned (WSDOT, 2011). Only 64 Washington airports are listed on the 2019-2023 NPIAS and eligible for federal funding (FAA, 2018b). Figure 5 identifies these airports with red and blue markers. The yellow Xs identify primary military airfields, which receive federal funding for pavement construction, maintenance, and repair.

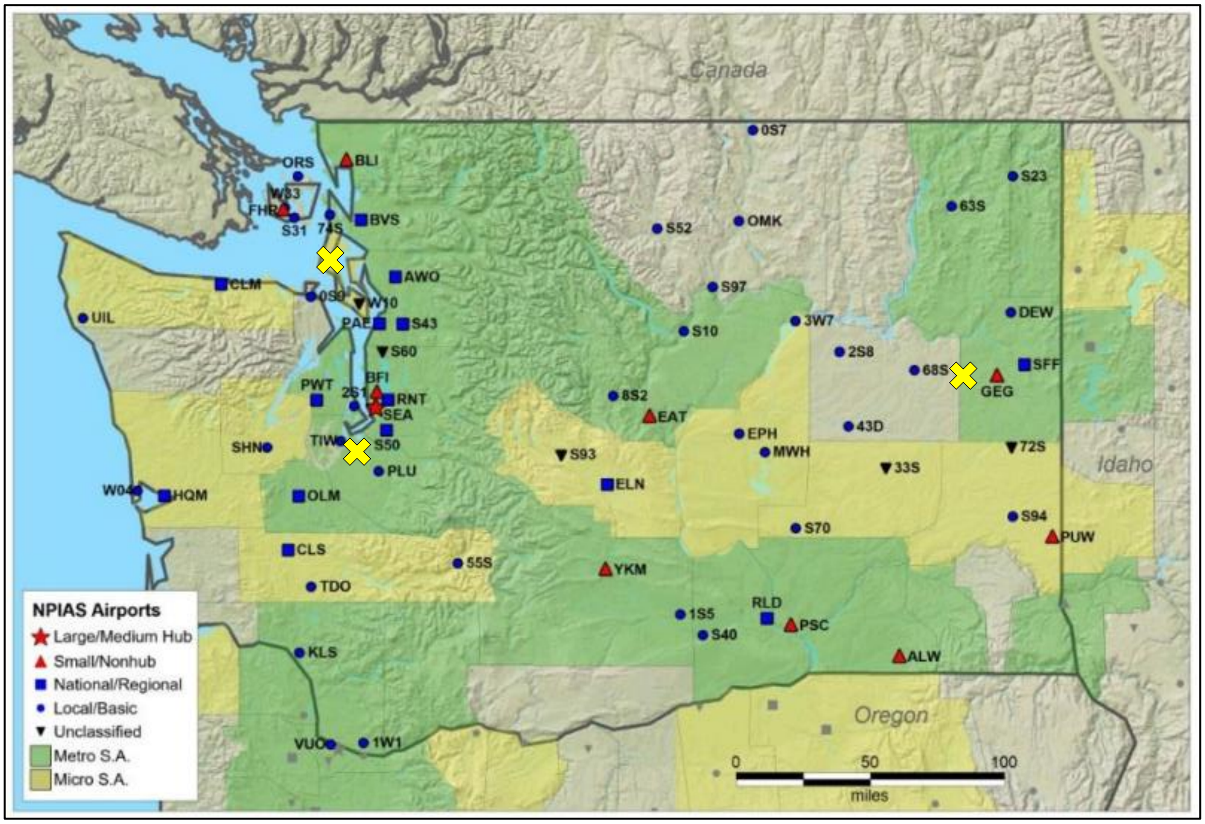


Figure 5: NPIAS and Military Airports within the State of Washington (FAA, 2018c)

In total across its NPIAS airports, Washington contains almost 143.9 million square feet (SF) of airfield pavement across four pavement sections: runways, taxiways, aprons/helipads, and T-hangars (as noted in Table 2).

Table 2: Total Area (in Square Footage) of Airfield Pavements at Washington's NPIAS Airfields, based on Airfield Use and Pavement Section (WSDOT Aviation, 2018)

Airport Uses	**Pavement Section Area (SF)**			
	Runways	*Taxiways*	*Aprons/Helipads*	*T-Hangars*
General Aviation	21,862,733	16,939,140	20,238,007	707,373
Primary	19,062,946	20,887,388	25,857,629	808,392
Reliever	3,946,302	4,729,947	6,012,002	763,051
Commercial	1,296,554	758,292	928,721	22,428
TOTAL (SF):	**143,889,184**			

Appendix E contains definitions of identified airport uses.

The FAA endeavors to maintain quality pavements within the civil aviation system by keeping at least 93% of its NPIAS runway pavements in excellent, good, or fair condition; in Fiscal Year 2017, 97.8 % of NPIAS runways met this standard (FAA, 2018d). Preventative maintenance (PM) and rehabilitation projects protect pavements and aircraft from dangers posed by deterioration. The latest NPIAS Report recommends airport pavement PM every four to seven years, with significant rehabilitation every 15 to 25 years (FAA, 2018d). Because contractors experience different concerns for roadway and airfield pavements, they must be aware of these variations before bidding for these respective projects.

3.3 Comparisons of Highway and Airfield Asphalt Paving Processes

This section compares basic highway and airfield HMA paving concepts in topic areas such as contracting and project management, construction practices and management, and pavement materials and mix design. While this section summarizes typical project similarities and differences, it is not an exhaustive review. If readers desire more information, Section 3.4 contains current agency specifications and additional HMA publications.

Airfield paving projects rarely occur for contractors in comparison to HMA roadway projects. From a financial perspective, all levels of government within the U.S. spend nearly $80 billion annually on capital improvements to roads, highways, and bridges; in that same time, only approximately $4 billion is spent on NPIAS airfields in the U.S. under the AIP (NAPA, 2020). This difference in spending could be because airfield pavements are a small percentage of the total pavements in the U.S. In Washington alone, WSDOT noted that in 2018, the state had nearly 168,000 lane miles of paved roadways (**Error! Reference source not found.**; W SDOT, 2018a). Assuming each lane's width is 12 feet (typical width for Washington highways), the state has nearly 10.6 billion square feet of rigid and flexible roadway pavements (WSDOT, 2017). Yet, the state only has 144 million square feet of airfield pavements (rigid and flexible) across its NPIAS airports (as noted in Table 2). Therefore, airfield pavements are approximately 1% of Washington's total pavement inventory, and flexible airfield pavements are an even smaller percentage. Contractors are comfortable with roadway HMA paving due to its prevalence, but when approaching airfield paving projects, they must consider additional details and specifications during bidding and throughout the project.

3.3.1 Contracting and Project Management

In this document, questions within the contracting and project management section relate to project processes and bidding considerations; project planning and management practices; administrative burdens; project risk; contracts and contract claims; compensation and pay factors; project execution strategies; and personnel and training. While these elements play a critical role during the bidding and planning phases of a project, they continue to impact contractors' construction operations. While few available resources discuss contractors' perspectives on contracting and project management (and instead focus on pavement design and construction), reviewed literature noted several differences between typical airfield and highway HMA projects, as noted in Table 3.

Table 3: Typical Differences between Highway and Airfield HMA Projects in Contracting and Project Management (Brown, et al., 2008; FAA, 2018a; USACE, 2017; WSDOT, 2020)

Criteria	Highway	Airfield
Parties involved in Project Coordination	Owner Project Inspections/Engineers Testing Laboratories Contractors/Subcontractors	Owner/Owner Representative Project Inspections/Engineers Testing Laboratories Airport Operations/Management Contractors/Subcontractors
Contract Conflict Resolution	Contractors coordinate with DOT personnel	Contractors coordinate with construction managers (CMs) who are the owner's representatives
Types of Specifications Used	Quality Assurance/Quality Control (QA/QC)	QA/QC - More QC submittals required
Use of Pay Factors	Yes - Contractors can be paid up to 105% of pay lot price	Yes - Contractors can earn pay factors but cannot be paid more than the contract price
Site Access/Security	Easy access Limited security	Training required for site access More security and inspections

While this table is not all-inclusive, it covers key topics that were later discussed with the interviewed contractors.

Public agencies want cost-effective, quality pavements, regardless of pavement type or use. To achieve these ends, owners changed their specifications from methods-based to quality assurance (QA) specifications. The QA system divides project quality verification into two categories: QA conducted by CMs/owners' representatives and quality control (QC) conducted by contractors. These parties monitor pavement attributes like asphalt content, density, and gradation while assessing quality based on the percentage of the pavement lot within specified limits (LaVassar, Mahoney, & Willoughby, 2009). Under a QA/QC system, owners and contractors have vested interests in producing quality pavements because both parties retaining risk in project outcomes. While owners relinquish some project control, contractors have the autonomy to develop innovative and efficient HMA designs. As state and federal agencies lose experienced pavement experts, this risk-sharing specification method benefits contractors by encouraging them to use their pavement expertise while simultaneously freeing owners from being the sole pavement quality authority (Brown, et al., 2008).

Before paving, CMs and contractors gather at a preconstruction meeting to review project specifics and establish working relationships. While owners or CMs host the meeting, the goal is to share unique project aspects with contractors like site safety, security, project schedule, and site operations (Brown, et al., 2008). Contractors also present contractor quality-control plans (CQCPs), and for airfield work, review requirements for control strip construction. Federal and state transportation agencies require contractors to provide CQCPs outlining their methods of meeting paving specifications. Under the FAA's CQCP, contractors must test at least "asphalt content, aggregate gradation, temperatures, aggregate moisture, field compaction, and surface smoothness" for QC (FAA, 2018a). Besides these tests, the DoD also specifies testing for laboratory air voids, mix stability and flow, grade, and asphalt mixture moisture content (Table 4; USACE, 2017).

Table 4: Quality Control Testing Requirements for Department of Defense Airfield Paving Projects (USACE, 2017)

Pavement Characteristic	Minimum Number of Tests Required per Lot
Mix Temperature	4
Laboratory VMA Value	4
Asphalt Content	2
Aggregate Gradation	2
Aggregate Moisture	1
Mixture Moisture Content	1
Field Density	Test as necessary to ensure compliance with specifications
Smoothness and Grade	Test as necessary to ensure compliance with specifications

While the DoD requires verification of more pavement characteristics, the number of tests required is the same for common FAA and DoD quality criteria. By sharing responsibility for pavement quality, contractors become intimately involved in pavement mix design and understand the repercussions of altering certain pavement characteristics.

Also, an agency's CQCP may include provisions related to QC monitoring. Typically, if owners request QC documentation, they request control charts because these charts offer visual depictions of collected pavement compliance data (USACE, 2013). While contractors in Washington normally used control charts for internal monitoring of WSDOT work, both the FAA and the DoD require contractors to submit control charts as part of the QA/QC specification arrangements (FAA, 2018a; USACE, 2017). Beyond monitoring pavement production issues, control charts may help contractors decrease mix variability and inspection frequency, provide permanent records for pavement quality and acceptance, and show a baseline from which mix alterations can be compared (USACE, 2013). Control charts monitor contractors' internal operations while communicating concerns about mix quality and consistency with owners.

3.3.2 Construction Practices and Management

Resources related to best construction practices and management dominate available airfield and highway paving literature. In this document, questions about construction practices and management relate to paving productivity; plant/aggregate setups; foreign object debris (FOD) mitigation methods; pavement placement; night paving operations and impacts; longitudinal joint and mat in-place density and quality; site management; and weather concerns. Quality construction extends pavement life and durability, reduces permeability, and lowers risks for additional compaction under applied traffic (Brown, et al., 2008). Though the equipment and materials used are similar, the reviewed literature outlined several differences between typical airfield and highway HMA construction projects (Table 5).

Table 5: Typical Differences between Highway and Airfield HMA Projects in Construction Practices and Management (Brown, et al., 2008; FAA, 2018a; USACE, 2017; WSDOT, 2020)

Criteria	Highway	Airfield
Plant/Aggregate Setups	Similar Set-Up for Highway and Airfields	Similar Set-Up for Highway and Airfields
Mandatory Control Strip/Test Section Construction	No mandatory test section - Required for High Reclaimed Asphalt Pavement (RAP) mixes - Contractor's option for low-RAP mixes	Yes, mandatory control strip
Foreign Object Debris (FOD) Mitigation	Low Emphasis	High Emphasis
Pavement Acceptance Testing Criteria	Statistical Evaluation using - Nuclear Density Gauge - Cores	Statistical Evaluation using - Cores
Surface Smoothness	Tested	Tested Daily
Surface Grade	Monitored - Different from airfields	Monitored

This table highlights topics discussed during contractor interviews; it is not an all-inclusive list of construction differences.

Once CMs accept the project's CQCP and rolling plans, contractors must demonstrate they can meet airfield paving criteria (via the control strip) before receiving the authorization for full pavement production (FAA, 2018a; USACE, 2017). Under WSDOT specifications, control strips (called "test sections") are mandatory for high-RAP mix designs (defined as having more than 20% of total HMA weight of RAP), but paving test sections is the contractors' option for low-RAP mixes (WSDOT, 2020). For the FAA, a control strip consists of one half of a sublot or at least 250 tons of HMA, whichever is greater (FAA, 2018a). If the CM accepts the control strip, the contractor can move to full production. However, if the strip does not comply with specified requirements, contractors must remove and replace the noncompliant pavement at no cost to the owner (FAA, 2018a; USACE, 2017). Therefore, control strips can become costly for contractors, both in lost time and materials.

A key element to pavement construction is meeting in-place density specifications, particularly on airfields. Increased rutting is proportional to tire pressure increases, and because aircraft have typically higher tire pressures than passenger vehicles or trucks, higher compaction is a must on airfield pavements (Mallick & El-Korchi, 2013). To monitor in-place pavement densities, contractors and CMs use nuclear and non-nuclear gages for testing on both highway and airfield projects; these testing methods provide quick density measures and may help contractors adjust compactive efforts during paving operations. However, these methods are insufficient for pavement acceptance on FAA and DoD projects. Rather, airfield paving acceptance requires core samples. Cores more accurately determine pavement density, but they are destructive testing methods that require pavement repairs afterward (Brown, et al., 2008). Also, testing results from cores take longer than in-field testing methods. With upwards of ten core samples taken per paving day, this testing method requires more repair work with slower results (Brown, et al., 2008). Due to the criticality of airfield pavement quality, though, owners desire the most accurate density measures available.

With compaction, pavement gains strength, but density is typically easier to achieve in an HMA mat than at its edges. Contractors struggle to achieve quality joints, particularly on airfield projects. Joints are the weakest part of a pavement system and are susceptible to loading and environmental damage (Mallick, Kandhal, Ahlrich, & Parker, 2007). Longitudinal joints are joints parallel to paving operations, and they are known to be key causes of airfield pavement distresses. While longitudinal joints are on both highway and airfield pavements, airfield projects are often wider and have more longitudinal joints that highways (Mallick, Kandhal, Ahlrich, & Parker, 2007). These joints bear intense aircraft loads, particularly in areas of channelized traffic, and joint failure results in maintenance problems while exposing aircraft to dangerous foreign object debris (FOD). Therefore, the FAA and DoD place additional scrutiny on longitudinal joint quality (including more in-place density testing) to ensure pavement longevity and airfield safety. However, deteriorating joints may be unavoidable because longitudinal joint cracking is associated with thermal effects rather than loading (Mallick, Kandhal, Ahlrich, & Parker, 2007). Pavements in colder climates are at greater risk, meaning HMA pavements in Washington may experience more joint damage due to environmental impacts than in other locations. Joints are problematic on all paving projects, but they severely impact airfields due to the concentration of longitudinal joints and FOD risks.

Higher in-place density leads to better pavement performance and longevity. However, meeting compaction in the field can be time-consuming, both in personnel and equipment (Howell, 2019). Field compaction may take 30 minutes to achieve after a paver places HMA; in the meantime, the HMA is cooling, which negatively impacts compaction effectiveness (USACE, 2013). While 0.375-inch nominal maximum aggregate size (NMAS) HMA mixes are easier to compact, several variables contribute to meeting compaction in the field (Howell, 2019). Ambient temperatures, roller equipment and patterns, and compaction of underlying pavement layers all play a role in pavement quality (USACE, 2013). Achieving adequate compaction, both in the laboratory and in the field, is critical to pavement performance and contractor payment. Due to in-place density and longitudinal joint quality for airfield paving, these projects require skilled, experienced contractors to meet specifications and paving production within tight project schedules.

Pavement grade and smoothness are unique acceptance criteria that differentiate airfield and highway paving. Table 6 lists these criteria from the respective agency specifications.

Table 6: Agency Smoothness and Grade Specification Comparisons (FAA, 2018a; USACE, 2017; WSDOT, 2020)

Agency	Smoothness Specification	Grade Specification
DoD	Based on Profileograph Testing - Only for final wearing surfaces Surface cannot deviate more than 4 inches per mile	Completed within 5 days of placement of a specific lot. Testing conducted at 25-foot intervals. - Deviation may not exceed 0.36 inches (runways) or 0.6 inches (taxiways) from approved plan grade.
FAA	Testing conducted with - Rolling inclinometer, - 12-foot straightedge, or - External reference device which simulates the straightedge. Surface cannot deviate more than 0.25 inches within 12 feet parallel to centerline	Completed daily. Grade must at least be evaluated before and after first lift placement, and after surface lift placement. - Grade deviation may not exceed 0.5 inches vertically and 1.2 inches laterally from the approved plan grade.
WSDOT	Based on the International Roughness Index (IRI) - Used for concrete roadways Surface cannot vary by more than 0.125 inches over 10-foot straightedge, parallel to centerline; 0.25 inches over 10-foot straightedge transverse.	No asphalt grade specifications similar to FAA/DoD specs; WSDOT requires pavers to have automatic screed controls to maintain transverse slope and grade (WSDOT, 2020). Specs state that "when concrete pavement is to be placed on HMA, the surface tolerance of the HMA shall be such that no surface elevation lies above the Plan grade minus the specified Plan depth of concrete pavement" (WSDOT, 2020)

Evaluating smoothness and grade reduces the risks of ponding on the pavement while providing a smooth ride to vehicles or aircraft. Testing smoothness and grade are required for FAA and DoD projects, but WSDOT monitors pavement smoothness without specific grade tolerances for asphalt pavements.

3.3.3 *Pavement Materials and Mix Design*

Several available resources also describe the HMA mix design process and how to improve pavement performance by adjusting various mix characteristics. In this document, questions about pavement materials and mix design pertain to mix design development and verification; mix design methods (gyratory compactor versus Marshall); nominal max aggregate size (NMAS); voids in mineral aggregate (VMA); asphalt content and binder type; use of reclaimed asphalt pavement (RAP); and the emphasis of perpetual pavements and long-lasting pavement. Table 7 notes areas of major differences identified from the reviewed literature.

Table 7: Typical Differences between Highway and Airfield HMA Projects in Pavement Materials and Mix Design (Brown, et al., 2008; FAA, 2018a; USACE, 2017; WSDOT, 2020)

Criteria	Highway	Airfield
Mix Design Verification Process	Two-Step Approval Process	Two-Step Approval Process
Primary Mix Design	Gyratory Compactor/Superpave	Marshall Mix Design
NMAS Used	0.375-inch NMAS 0.5-inch NMAS	Typically 0.5-inch NMAS
VMA Percentages	Mix Dependent	Mix Dependent
Asphalt Content and Binder Type	Mix Dependent	Mix Dependent
RAP Allowed in Surface Course	Yes High-RAP: RAP > 20% total weight Low-RAP: $0 \leq$ RAP $\leq 20\%$	No

This table includes typical differences noted between these project types and is not all-inclusive.

While this document does not elaborate on flexible pavement design, these systems work to reduce the stress transferred to the subsoil under applied loads (USACE, 2001). Unlike rigid pavement systems that use the Portland cement concrete as a structural element, flexible pavements use the HMA layer solely as a wearing surface. Besides this structural difference, Table 8 shows variances between airfield and high-volume highway design parameters.

Table 8: Comparison of High-Volume Highway and Airfield Design Parameters (Boeing, 2010; FAA, 2019; FHWA, 2015; Mallick, Kandhal, Ahlrich, & Parker, 2007; USACE, 2001; WSDOT, 2018b)

Design Characteristic	High-Volume Highway	Airfield
Load Repetition	High	Low
Maximum Vehicle Load	Truck Trailer: 80,000 pounds	747-400ER: 910,000 pounds (MTOW)
Applied Tire Pressure	Passenger Vehicle: 35-45 psi Truck Trailer: 85-110 psi	150-255 psi
Approximate HMA Pavement Thickness	6 - 13 inches	4 - ~24 inches

Possible airfield uses of flexible pavements include the interiors of runways (also known as keels), secondary taxiways, overruns, shoulders, and areas not explicitly requiring rigid pavements (USACE, 2001). Areas subjected to jet blast, fuel spills, or parked aircraft are unsuitable for flexible pavements. While HMA on highways and airfields use similar materials and design processes, certain aspects and parameters of airfield pavements make them unique.

However, despite structural design differences, the reviewed literature noted airfield and highway mix designs are similar. HMA contains two basic materials, but economics, durability, and load resistance help determine the optimal aggregate-to-asphalt ratio for long-lasting HMA. Careful control of asphalt content determines pavement performance due to its correlation to a mix's volumetrics (Brown, et al., 2008). Low asphalt content results in durability issues, while high asphalt content reduces air voids and results in rutting. Therefore, contractors must measure a mix's asphalt content multiple times a day for QC. Also, because asphalt binder is susceptible to temperature, proper binder selection ensures pavements will perform well in their intended environments. Asphalt binder classification follows the performance-grade (PG) binder system, which identifies temperature ranges between which pavement is expected to perform (Roberts, 1996). For Washington State, the base PGs for Eastern and Western Washington are 64-28 and 58-22, respectively (WSDOT, 2010). Though the average HMA mix consists of 5% to 6%

asphalt, ensuring the proper binder is selected with the right asphalt content aids pavement workability and durability (USACE, 2013).

The other primary HMA element, aggregate, resists deformation from applied loads. Aggregate shape and gradation impact HMA's performance, and proper monitoring and control ensures quality pavement consistently arrives at the construction site (USACE, 2001). Aggregate gradation divides HMA into three basic types: open-graded, gap-graded, and dense-graded (USACE, 2013). Most U.S. HMA pavements are dense-graded, so this paper will focus on this type. Further, dense-graded HMA has three sub-classifications based on the mix's NMAS: conventional, sand asphalt, and large-stone. WSDOT and the FAA/DoD use HMA mixes meeting the first two classifications. A conventional HMA's NMAS is 0.5-inch to 0.75-inch, while a sand asphalt's NMAS is less than 0.375-inch (USACE, 2013). Figure 6 highlights the differences between these gradations.

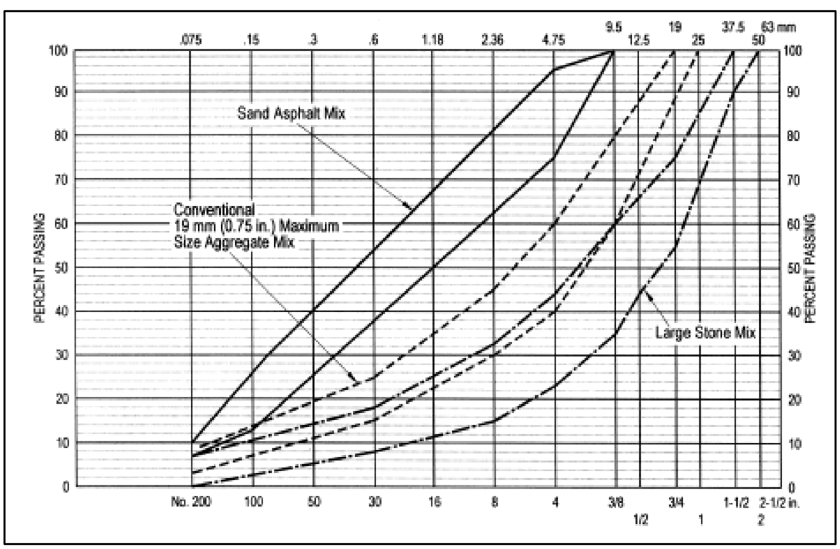


Figure 6: Dense-Graded Aggregate Gradations (USACE, 2013)

Sand asphalt HMA mixes typically contain more asphalt binder and have higher VMA percentages (USACE, 2013). For most HMA surface courses, VMA values range from 12% to 16%, but variations may cause pavements to either suffer from stability issues (higher VMAs) or decreased durability (lower VMAs) (Roberts, 1996). Contractors may desire lower VMA values to save money on asphalt binder, but pavement uses and performance requirements determine HMA specifications.

While FAA and DoD prescriptive mix designs require HMAs with 0.5-inch NMAS, 0.375-inch NMAS mixes are gaining popularity within WSDOT. Between 2007 and 2019, the number of WSDOT contracts with 0.375-inch NMAS mix increased because these mixes may "improve pavement service life by reducing fatigue cracking, raveling, oxidation/premature aging, and permeability" (Howell, 2019). Yet, Howell identified minimal differences between 0.375-inch and 0.5-inch NMAS mixes beyond different construction costs, as noted in Table 9.

Table 9: Comparison of 0.375-inch and 0.5-inch NMAS Mix Performance within WSDOT (Howell, 2019)

Asphalt Pavement Aspect	0.375-inch vs. 0.5-inch NMAS Comparison
Cost of Construction	Cost greater than 0.5-inch NMAS
Asphalt Content	Slightly higher asphalt content than 0.5-inch NMAS
Density	Slightly lower field density vs. 0.5-inch NMAS
Pavement Condition and Distresses	Pavement Performance is similar over time - *Cracking Performance:* 0.375-inch NMAS performed similarly to 0.5-inch NMAS - *Rutting Performance:* 0.375-inch NMAS performed similarly to 0.5-inch NMAS

Surveys and interviews with Washington pavement contractors attribute this price increase to higher aggregate crushing costs and asphalt contents (Howell, 2019). While contractors work within prescriptive mixes for FAA and DoD work, WSDOT relies on contractors' expertise to meet outlined design requirements.

Regardless of project location, two mix design methodologies dominate HMA paving: the Marshall Method and the Superior Performing Pavement (Superpave) Method (also known as gyratory compactor method). Developed in the 1930s, the Marshall Method has historically been used for airfield pavement design (Mallick & El-Korchi, 2013). Superpave gained popularity within the highway paving community in 2000, but acceptance of this method by the FAA and DoD for airfield pavements has been slow. In July 2014, the FAA added the gyratory method to both P-401 and P-403 sections, and the most recent Unified Facilities Guide Specifications (UFGS) includes gyratory design specifications (FAA, 2018a; USACE, 2017). To comply with the FAA's goal of "considering the prevalent [design] method in use in the local project area," more airfield pavement projects are anticipated to adopt Superpave methodologies (FAA, 2018a). Overall, these design methods follow similar processes and differ only in the method of determining optimum asphalt content during laboratory compaction testing (Brown, et al., 2008). FAA and DoD pavements traditionally follow Marshall design methods, but processes may change due to the wide use of Superpave methods in highway paving.

Due to the criticality of compaction on HMA quality, producing necessary densities in a lab before placing HMA in the field helps contractors determine rolling patterns used during construction (USACE, 2013). In Marshall mix design, a manual or automated compaction hammer produces mix densities representative of those anticipated from repeat traffic loading in the field. In the Superpave method, the gyratory compactor subjects samples to a specified number of gyrations (N_{design}); this number is based on the project location's climate and traffic (USACE, 2013). In the FAA and DoD specifications, the number of Marshall blows is commensurate with the N_{design} gyration count (FAA, 2018a; USACE, 2017). However, while the goal of lab compaction is to replicate in-field placement conditions, results in the lab do not always reflect what may happen in the field. In the lab, HMA mixes are compacted against solid surfaces, but in the field, project locations have variable base stiffnesses and soil types (USACE. 2013). Differences between lab and field conditions may cause significant changes to compaction results. Laboratory testing is vital in determining the compactive effort required to meet paving requirements in the field, but lab testing could yield inaccurate results.

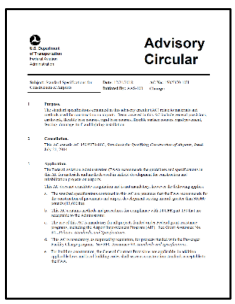
A project mix design may also include reclaimed asphalt pavement (RAP). According to the National Asphalt Paving Association (NAPA), RAP usage exceeded 82.2 million tons in 2018, with the average mixture RAP content being 21.1% total weight of HMA (Williams, Willis, & Ross, 2019). Under WSDOT specifications, mix designs can contain up to 20% RAP before falling under high-RAP mix criteria (WSDOT, 2020). Contractors often choose to stay below 20% RAP to avoid complying with additional specifications, and Howell found minimal benefits exist in using high-RAP pavements (Howell, 2019). While WSDOT widely uses RAP, RAP usage in airfields pavements is rare. In the 1980s, the U.S. Air Force (USAF) experimented with airfield HMA RAP content and monitored pavement performance in the late 1990s (Shoenberger & Demoss, 2005). The evaluated airfield HMA mixes contained between 35% and 60% RAP and were placed at four military installations across the globe supporting various aircraft. In all cases, pavement recycling occurred in a closed-loop system (i.e., new pavement included pavement milled from the site). Though the RAP mixes contained excess asphalt cement (which increases susceptibility to load-related distresses), they only experienced durability or climatic distresses; these results caused the research team to propose that airfield pavement designs focus on durability rather than load capacity (Shoenberger & Demoss, 2005). While the researchers admitted that "a wide range of factors combine[d] to limit the effectiveness of this RAC [recycled asphalt concrete] performance evaluation," they determined that HMA pavements containing RAP were feasible, economical solutions for the USAF (Shoenberger & Demoss, 2005). However, despite publications supporting the use of RAP pavements on airfields, both FAA and DoD specifications continue to limit its use, particularly in surface course mixes.

Beyond slight variations in tolerances, few differences exist between highway and airfield HMA mix design specifications. Contractors combined asphalt and aggregate in different ratios to result in mix designs capable of meeting outlined requirements. However, one of the greatest design differences between airfield and highway pavements is the design methodology. FAA and DoD pavement designs have historically followed Marshall mix design principles and have only recently added gyratory compaction methods to their specifications. Contractors must be aware of what mix design method to follow for airfield projects if it differs from highway HMA processes.

3.4 Agency Hot Mix Asphalt Specifications and Additional Resources

WSDOT, the FAA, and the DoD all publish pavement design specifications suited to meet the demands placed on their pavements. While WSDOT updates its specifications every two years, updates to FAA and DoD specifications are not as regular. Table 10 lists current construction specifications from agencies involved in the design, construction, and rehabilitation of highway and airfield pavements in Washington.

Table 10: Federal and State Agencies' Pavement Design and Construction Specifications (FAA, 2018a; USACE, 2001; USACE, 2017; WSDOT, 2020)

Agency	Specification Cover	Specifications and Regulations	Asphalt Paving Section
DoD		Unified Facilities Criteria (UFC) Unified Facilities Guide Specifications (UFGS)	UFC 3-260-02 *Pavement Design for Airfields* UFGS 32 12 15.13 *Asphalt Paving for Airfields*
FAA		Advisory Circular (AC) No. 150/5370-10	Item P-401, *Asphalt Mix Pavement* Item P-403, *Asphalt Mix Pavement Base/Leveling/Surface Course*
WSDOT		Standard Specifications for Road, Bridge, and Municipal Construction	Division 5, *Surface Treatments and Pavements* Section 5-04, *Hot Mix Asphalt*

All specifications are available online via publicly accessible websites.

Several quality resources discussing HMA pavement design and construction best practices exist for highway and airfield paving. Table 11 highlights these additional publications.

Table 11: Additional Asphalt Paving Resources (Brown, et al., 2008; Roberts, 1996; Scott, 1999; TSC, 2013; USACE, 2013; USACE, 2014)

Topic Area	Source	Description of Topics
Airfield Pavement Construction and Inspection	*Airfield Asphalt Pavement Construction Best Practices Manual* National Center for Asphalt Technology	Technical resource for government representatives or contracted organizations "to ensure that high-quality HMA is constructed" (Brown, et al., 2008). Topics include - Mixture quality management - Best construction practices - QA/QC
Airfield Construction Safety	*Safety and Health Requirements Manual, Section 32: Airfield and Aircraft Operations* U.S. Army Corps of Engineers	Regulations discussing construction site safety and requirements, including vehicle marking and construction phasing plan requirements (USACE, 2014).
Asphalt Materials, Design, and Construction	*Hot Mix Asphalt Materials, Mixture Design, and Construction* National Center for Asphalt Technology	Guide providing general asphalt technology descriptions and information. Topics include - Asphalt materials and properties - Construction methods and equipment - Admixtures and additives
Highway Pavement Construction	*Hot-Mix Asphalt Paving Handbook* U.S. Army Corps of Engineers AC 150/5370-14A, Appendix 1	Resource presents "the state of the art of asphalt paving" to field technicians (both pavement contractors and overseeing agency personnel - Asphalt plant operations - Paving surface preparation and construction processes - Construction site issues

While these publications describe requirements and best practices for highway and airfield paving, few consider contractors' points of view on these projects. Chapters 4 and 5 will highlight research results and discussions captured from conducted contractor interviews. Understanding all perspectives on airfield and highway paving projects establishes a dialogue between owners and contractors about project concerns and how HMA products can be improved.

Chapter 4. RESULTS AND DISCUSSION

This chapter discusses contractors' responses to structured interview questions developed from the reviewed literature, agency specifications, and other resources. Topics include contracting and project management, construction practices and management, and pavement materials and mix design. Appendix A lists the prepared questions, while Appendices B-D contain summaries of contractor interviews.

The presented data follows the order in which contractors answered posed questions. Unless otherwise stated, data in the following sections state majority opinions. Minority opinions are identified, if presented. If required, specifications comparisons may accompany the data presentation to provide subject clarity or context. Following a review of all category subtopics, a short conclusion presents key take-aways from each question category.

4.1 Contracting and Project Management

The following section includes contractor responses and discussions on general questions, as well as four topic areas related to contracting and project management: risk, contracts and contract claims, compensation and pay factors, and personnel and training.

4.1.1 *General Questions*

How does your organization decide what projects to bid on? Are the criteria the same for highway and airfield projects?

The three contractors agreed that the heightened financial risk and additional administrative burden posed by airfield paving projects impact bidding approaches. Before bidding for projects, contractors must ask at least three questions about their company's readiness:

- How much work do contractors have when bidding for the new project (i.e., how busy are they)?
- How much work have contractors already committed to during this project's anticipated paving schedule?
- What risks (financial or otherwise) does this new project involve?

Even if a company is capable of taking on the burden of an airfield project, competition may be limited to larger paving organizations due to owners requiring contractor prequalifications. Prequalification requirements, according to one interviewee, could include contractors' recent experience (e.g., within the last 5 years) with similarly-sized projects or the ability to bringing qualified, experienced personnel from other locations on-staff to serve as project liaisons with owners and their CMs. One interviewee stated that for a King County International Airport/Boeing Field paving project, 80% of paving contractors in Washington State were unable to compete for the project because of the prequalification requirements. Large paving firms may be able to source expertise, paving crews, and required equipment that smaller organizations may struggle to supply.

Depending on the project size, airfield paving projects can pose a large financial risk, including an elevated risk of liquidated damages (LDs). LDs for the FAA "reflect a reasonable estimate of the actual costs which will be incurred by the Owner and users of the airport" if construction is delayed (FAA, 2018a); they not only apply during paving operations, but also during final closeout and maintenance periods. All interviewed contractors considered FAA specifications more restrictive, and with airfield projects typically having shorter contract paving windows, LDs may be more difficult to avoid. Table 12 provides examples of LDs mentioned in the interviews and during the literature review. If needed, Appendix E contains airport definitions.

Table 12: Airfield Paving Projects Liquidated Damages Examples (Jung, 2018)

Project Location	Size of Airport	LDs during Project ($/day)	LDs during Close-Out ($/15 min)
Metropolitan Oakland International *Oakland, CA*	Medium Hub	$10,000	$7,500
King County International/Boeing Field *Seattle, WA*	Non-Hub	$360,000	Not Specified during Interview
Pullman/Moscow Regional *Pullman, WA*	Non-Hub	Not Specified	$8,000

Besides evaluating paving capacity and financial risks, interviewed contractors mentioned other considerations when bidding for airfield projects include

- Unfamiliarity with FAA and DoD project specifications and site requirements
- Material/aggregate sourcing, if mix requires 100% fractured faces
- Contract length and paving schedule intensity
- Time of year paving must be completed
- Paving crew and equipment mobilization
- Night paving operations (schedule dependent)
- Additional airfield-specific requirements

Responses to these concerns can influence contractors' bidding approaches and paving operation plans.

What differences are there in managing airfield vs highway projects?

Despite contractors viewing airfield specifications as more restrictive, two of the three contractors agreed that minimal differences exist between managing highway and airfield projects. Both project types require similar equipment, construction methods, and paving materials, despite airfields requiring higher compaction and more equipment/personnel to complete. Yet, while these projects have similarities, most interviewed contractors feel more pressure to perform on airfield projects. According to one contractor, companies mobilize experienced "elite paving crews" for these projects, and management is more involved. One interviewee said that "as a QC manager, I have to be on every airport [paving project]. I don't have to be on all the WSDOT jobs… On the airport, I must be there physically." Paving company management may supervise 24-hour paving operations, too, so ensuring senior company members are available for different shifts becomes a planning factor. Besides adjusting internal management practices, working with different project partners can frustrated contractors. Contractors are familiar with WSDOT project personnel; however, airport paving projects combine "unique set[s] of [third-party] construction managers, owners, and third-party testing." Owner's CMs may have little airfield paving project experience due to the rarity of these projects, which frustrates contractors and can negatively impact high tempo paving operations by causing communication delays with owners. Overall, airfield projects tax paving organizations due in part to the posed financial risks, restrictive specifications, shorter paving windows, and strict contract adherence attitudes from owners.

How does your organization prepare to execute an airfield paving project, and is this process different than what you do prior to a highway paving project? Preparations could include hiring additional personnel, etc.

Contractors prioritize airfield projects higher than highway projects, due in part to financial risks, restrictive specifications, and manpower and equipment requirements. Multiple paving crews (typically two to three) may mobilize for an airfield paving project; if the project demands 24-hour paving operations, more crews are required to meet paving project requirements. Paving crews mobilized from different regions can struggle with communication breakdown between teams. One contractor noted experiencing communication miscues between paving teams on an airfield project; in his case, teams did not designate one person to alert the asphalt plant about production "cut off" at the end of the day. Another contractor said project prioritization can be difficult to communicate to the Department of Transportation (DOT) personnel, particularly if their projects are prioritized below an airfield project. DOT personnel may be frustrated when familiar regional paving crews mobilize for an airfield project instead of DOT work, but issues subside after the few days on the job. Also, emphasis on securing equipment and materials (like proper rollers or reliable asphalt plants) eases project preparation and management concerns. Having several experienced paving crews committed to completing one project severely impacts a company's ability to commit to other work. To compensate for productivity impacts, contractors must include additional crew mobilization fees and airfield-specific line items to bids.

How much administrative burden do airfield projects have compared to highway projects? Burdens could include security clearances, coordination with airfield operations, etc.

All contractors agreed that airfield projects carry greater administrative burdens than highway projects. The FAA requires more detailed submittals often earlier in the project than WSDOT does, with P-401 mix designs (i.e., FAA specifications for airfield flexible pavement surface courses) being submitted at least 30 days before paving. During paving operations, daily documentation and control charts of quality and testing measures must be submitted to the project's CM for FAA and DoD work; these documents are only used for internal monitoring by contractors for WSDOT projects. Besides additional quality control submittals, coordination with airfield operations and compliance with security protocol builds strong relationships with project owners and keeps projects running smoothly. Paving personnel, including truck drivers, may need security clearances before stepping onto an airfield construction site. Access to the project site is limited to those with the required security training, and additional measures (like truck screenings) may be required if paving occurs on a military installation. One contractor mentioned that traffic control plans are vital on an airfield project, and heeding guidance from airfield operations saves relationships between owners and contractors. For trucks entering the project site, precautions may be taken to inform drivers of driving routes and proper airfield crossing procedures.

4.1.2 *Risk*

What risks do you consider when bidding airfield projects versus highway projects? As a contractor, what is the #1 risk associated with highway projects? Airfield projects?

Contractors provided an extensive list of risks to consider when bidding for an airfield paving project, including

- Project schedule
- Liquidated damages
- Capital risks
- Limitations to additional project bidding/existing project commitments
- Control strip placement and verification
- Density specification compliance
- Mix design types (Marshall vs. gyratory)
- Mix testing
- Surface grade

When asked about their number one risks associated with highway and airfield projects, contractors had various answers (Table 13).

Table 13: Contractor Responses to Associated Asphalt Paving Risks

Contractor	Highway Paving	Airfield Paving
Contractor 1	Jobsite Safety	Time Delays and LDs
Contractor 2	Achieving Compaction	Pay Lot Size
Contractor 3	HMA Testing	Compaction

Two contractors identified compaction and HMA testing as critical elements to their WSDOT bids. Compaction is becoming a larger risk for WSDOT work since the organization established a minimum surface lift thickness in their 2018 specifications (Howell, 2019); with thinner lifts, pavement becomes more difficult to compact, particularly during night paving operations when ambient temperatures cool pavement faster and reduce the effectiveness of roller operations. Plus, WSDOT's mix verification process frustrates contractors because of testing staff's inexperience and general unawareness of repercussions (financial or otherwise) faced by contractors for failed tests. Contractors could offset higher project risks by increasing their bids to compensate for testing variability and the threat of exceeding contractual days (possibly due to mix design approval delays). From these interviews, it appears that issues with inaccurate HMA testing and results have been a problem between WSDOT and contractors for years, with contractors now pushing for solutions. Inaccurate testing impacts contractors' product development and bottom lines, and finding a solution to these issues will keep projects within contractual days while restoring faith between WSDOT and contractors.

While the DoD- and FAA-required control strip was not identified as a top risk, each interviewee noted it is one of the greatest obstacles in an airfield project. The control strip consumes both crew time and materials, and if not completed to specification, it could mean financial losses for a contractor. One contractor noted that on a recent project, his company was required to complete four control strips before receiving the authorization for full production;

these failures were due to over-compaction. To avoid removing new HMA at their expense, contractors seek to place control strips at locations needing repaving (like a service road). However, paving locations away from the airfield may have a different pavement structure, thereby impacting pavement laydown and performance. Control strips are one of the many required risks contractors take to prove they can meet FAA and DoD construction standards.

4.1.3 *Contracts and Contract Claims*

For contract claims, are there differences between claims for airfield projects and claims for highway projects? If so, why?

All contractors agreed that contract claims are easier to resolve with WSDOT than with the FAA or DoD. Thanks to working relationships established between DOT personnel and contractors over several projects, WSDOT is viewed as being more willing to negotiate contract claims. To be good stewards of public funds, WSDOT would rather negotiate claims, typically on force-account ("the objective… is to reimburse the Contractor for all costs associated with the Work, including costs of labor, small tools, supplies, equipment, specialized services, materials, applicable taxes and overhead and to include a profit commensurate with those costs" (WSDOT, 2020)). In regards to FAA and DoD projects, two contractors said claim resolution is more difficult when working with a third-party CM. When claims arise during an FAA project, they "are almost an impossibility" to secure, said one contractor. Contractors do not negotiate with owners directly, and most times, contractors must remove and replace the noncompliant airfield pavement anyway. Airfield owners and their representatives strictly enforce specification compliance and project schedules, often because of the financial impacts bore by airlines using the airfield and to avoid additional closures to repair subpar pavements.

Is there a difference in compensation between federal and state paving jobs? If so, what is the range (in percent) of compensation differences?

Compensation varies between FAA, DoD, and WSDOT projects. On WSDOT projects, contractors can earn up to 105% of the pay lot value (via pay factors) if the product exceeds requested pavement placement criteria. The interviewed contractors feel confident that they can achieve bonuses on WSDOT work but do not necessarily assume they will be earned. Bonus pay is just that - a bonus. In contrast, while the FAA does have pay factors built into their projects, those pay factors are only used to balance out pay factors below 100%. Because no additional pay can be made through pay factors for airfield projects, contractors must plan for their compensation during bidding. One contractor said that for airfield projects, his company plans for the worst and may increase bids due to high-risk line items (e.g., preparing two or three control strips). Another contractor echoed this bidding tactic, which seeks to offset financial risks posed by more restrictive airfield paving requirements and project schedules. He noted that airfield projects typically have higher markups, with the average margin difference between highway and airfield projects being approximately 5%. Highway project margins are between 8% and 10%, while airfield projects may be between 10% and 15%. Anticipating additional costs during bidding protects contractors from potential financial risks.

What organization typically provides the best project specifications, and what makes this organization stand out?

This question intended to identify aspects of specifications that contractors deem valuable or useful. Because all specifications have good and bad aspects, all interviewees agreed that as long as contractors take the time to thoroughly review the provided specifications, they are not confusing or tricky. Each outlined his definition of what constitutes the “best” specifications:

Contractor 1:	Familiarity with specifications versus specification tolerances
Contractor 2:	Easiest to understand and meet
Contractor 3:	Familiar, similar specifications versus setting clear project expectations and with tough specifications

Overall, contractors appreciate the familiarity of WSDOT specifications; there is comfort in knowing the design guidance and project owners well (Table 14). FAA and DoD projects typically have more restrictive specifications with shorter project timelines, and contractors have less ability to negotiate with owners. Also, large airfield paving projects comprise a large percentage of a contractor's annual work. Therefore, it is in the contractor's interest to meet these expectations.

Table 14: Benefits and Drawbacks to Various Pavement Specifications

WSDOT Specifications		**DoD/FAA Specifications**	
Benefits	*Drawbacks*	*Benefits*	*Drawbacks*
Clear specifications Contractors are familiar with the specifications and regional DOT personnel Negotiation possible between DOT and contractors	Tight monitoring of certain mix design specifications (i.e., VMA percentage) restricts contractors' mix design optimization abilities Shared contractor-WSDOT mix design process, particularly as related to mix verification results	Clear, thorough specification Tighter, tougher specification upheld by the owner; sets and keeps a high-performance bar Risk relationship clearly defined	Less familiarity with DoD/FAA specifications due to rarity of airfield projects Strict specification enforcement increases the risk of contractor-funded removal of noncompliant pavement

One contractor noted that city and county pavement specifications are the best due to their straightforwardness and simplified mix design process. Mix designs from several years ago may still be acceptable for some municipal projects, which saves contractors from spending time and effort on new mix designs when older designs are sufficient. He also praised specifications from the Federal Highway Administration (FHWA).

4.1.4 *Compensation/Pay Factors*

4.1.4.1: Definitions and Specifications

Table 15 outlines the pay factors among the specified organizations.

Table 15: Agency Pay Factors (FAA, 2018a; USACE, 2017; WSDOT, 2020)

WSDOT Specifications	FAA Specifications	DoD Specifications
Maximum Composite Pay Factors (CPF) Payment: 105% for HMA mixture <u>Composite Pay Factors (CPF)</u> - Gradation for Specified Sieves (varying factors) - Asphalt Binder - VMA - V_a	Maximum Payment: 100% pay for lot Pay Factor of upwards of 106%, but can only be used to offset values below 100% <u>Pay Factors/Pay Adjustments</u> - In-Place Density for Mat - In-Place Density for Joints (weighted pay factor) - Air Voids in Lab Samples - Smoothness - Grade	Maximum Payment: 100% pay for lot Pay factors are up to 100%. <u>Pay Factors/Pay Adjustments</u> - In-Place Density for Mat - In-Place Density for Joints (weighted pay factor) - Air Voids in Lab Samples - Smoothness - Grade

Pay factors are used differently between airfield and highway projects. Highway pay factors are used as incentives to elevate contractor performance to increase placed pavement life, whereas airfield pay factors encourage contractors to meet more restrictive specifications within project time limits.

4.1.4.2: Contractor Responses

Do you encounter pay factors for both airfield and highway projects? If so, are the pay factors used on highway or airfield projects preferred, and why?

Do the pay factors adequately compensate contractors for the work needed to meet or exceed project requirements?

Pay factors are used on various paving jobs, including those for municipalities, but they are used differently as motivators for contractors. For WSDOT projects, contractors may earn up to 105% of the pay lot price. This approach assumes contractors will view additional pay as "an incentive to produce superior quality material" (WSDOT, 2020). In contrast, the FAA and DoD use their pay factors to offset substandard lots that do not meet 100% pay. For example, if one pay lot earns a 104% while another earns 96%, contractors may add the additional 4% to the subpar lot; yet, at the end of the project, contractors may only collect 100% of the pay lot price. In this case, pay factors motivate contractors to continue meeting high pavement quality standards.

All contractors agreed that the specified pay factors are just if they are offered to all contractors and can be bid accordingly. However, because no additional money is earned on airfield projects (especially considering the financial risk incurred by contractors for these projects), WSDOT pay factors are preferred over FAA or DoD pay factors. In the case of these latter projects, contractors must attempt to compensate for the lack of bonus pay. Contractors are confident in their abilities to earn bonus pay on highway projects, so this additional revenue does not need to be included in a highway project bid like it is in an airfield project bid. Ultimately, the increased risk incurred on airfield projects with no additional pay factors shrinks the pool of contractors willing or able to take on these projects.

4.1.5 *Personnel and Training*

How many crew members do you typically plan to mobilize for a large highway paving job? Is this number similar to what you plan for on an airfield job?

Most contractors said airfield paving requires more mobilized crews (Table 16), but they all agreed that the size and pace of the project schedule will dictate crew requirements.

Table 16: Crews Required for Highway and Airfield Projects

Contractor	**Number of Crews Required for Paving**	
	Highway	*Airfield*
Contractor 1	1 For full closure project: 2-3	2-3 - 2 for mainline paving - 1 for fillets/aprons
Contractor 2	1-2	2 + 2-4 extra personnel - Extras support rolling and cold joint efforts
Contractor 3	1-2	1-2

Because airfield projects often require the mobilization of additional crews because of expedited project schedules, one interviewee claimed that contractors typically pay more in overtime during airfield projects; this issue commonly impacts Western Washington contractors who are subjected to more inclement weather delays. Contractors, therefore, must request overtime work and double-time for weekend work with union crews.

How are security clearance concerns addressed for airfield paving projects?

What trainings do your crews complete when working on a highway paving project? Are additional trainings required prior to working on an airfield paving project? If so, what are these additional trainings?

Security is a major emphasis when working on airfield projects. Unanimously, contractors view obtaining security clearances for airfield projects as a time-consuming task. While security requirements vary based on project location, contractors commented that all personnel, including truck drivers, are typically required to attend a “badge training” course for larger airfield paving projects. Because it may be difficult to schedule a second training once the project is underway, several contractors suggested bringing additional personnel into the badge training to serve as backfills, if necessary. The course is offered by FAA personnel and discusses various aspects of airfield paving, including cut-back joints and foreign object debris (FOD) mitigation. The all-day course is required, regardless of airport size or employee airfield paving experience. Additional security measures, such as truck labeling or gate inspections, may also be required, depending on the project location. One contractor claimed security measures at large airports, like Seattle-Tacoma International Airport and Portland International Airport, are more stringent and require additional training and background checks. Meanwhile, for projects at smaller airports like at King County International/Boeing Field, security measures may not be as extensive. Also, projects on military installations may require additional truck screenings before the vehicle enters the base; this inspection time is taken into consideration during project bidding and scheduling. Security, if not planned for, can be costly both in time and money for contractors.

Besides the FAA-required course, contractors note that minimal additional training is required for project site access. Two contractors have hosted job site safety training, and one mentioned that his company teaches classes about compaction and project requirements. Overall, the goal of the required FAA training is to ensure contractors and their employees are amply aware of airfield project requirements and how they differ from highway projects.

4.1.6 *Conclusions*

Key concepts derived from the interviewed contractors about contracting and project management are

- While airfield projects have more restrictive specifications, contractors view them as fair, albeit more demanding.

- Airfield projects pose greater financial risks to contractors and require additional personnel, equipment, and administrative efforts to complete over shorter contractual periods.
- Contractors are more involved with quality control during airfield projects than for highway projects, resulting in additional documentation and QC monitoring.
- Team dynamics while working with inexperienced third-party CMs frustrate contractors. A perceived link exists between CM inexperience and communication delays with project owners.
- Contractors assume the worst will happen during airfield projects in hopes of offsetting potential financial losses, like paving additional control sections or earning lower pay factors.
- Security clearances and crew training is more time consuming for airfield projects than highway projects. Abiding by airfield protocol and specifications can ease tensions between contractors and owners.

4.2 CONSTRUCTION PRACTICES AND MANAGEMENT

The following sections cover topic areas related to construction practices and management: construction site management, foreign object debris (FOD) mitigation, paving operations, night paving operations, mat and longitudinal joint density, and weather concerns.

4.2.1 *Construction Site Management*

How does your paving productivity compare between airfield and highway projects? On average, what is your production rate for airfield paving, and what impacts this rate?

In terms of productivity, all contractors agreed that airfield paving is more productive on average than highway paving. Highway paving is hindered by traffic, and often contractors are required to pave at night to mitigate disruptions to the traveling public. Night crews may only be able to produce 175-200 tons of HMA per hour; one contractor commented that his company may only be able to run their asphalt plant for four hours at night before halting operations ahead of morning rush-hour. Coordinating with traffic severely impacts contractors' highway paving productivity, but for airfield paving, the opposite is often true. Contractors may have multiple crews paving the same airfield section, which translates to wider paving lanes and fewer cold joints (if paving in echelon, like in Figure 7). Paving productivity could be nearly 250 tons per hour. At King County International/Boeing Field, one contractor's company paved 280 tons per hour during a 19-day full closure, with over 106,000 tons of HMA laid for the project. Another contractor echoed these high productivity values, stating that his company paved approximately 4,000 tons of asphalt daily while paving at

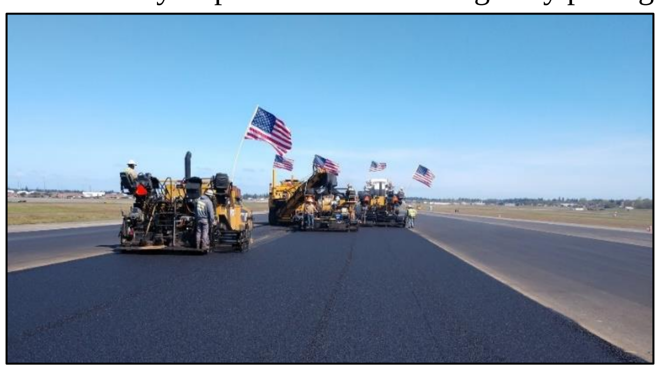


Figure 7: Echelon Paving on Joint Base Lewis-McChord, Washington. Photo courtesy of the USAF.

Portland International Airport. However, while airports can yield higher productivity values, contractors must be aware of their pay lot size. For the FAA, “a standard lot will be equal to one day’s production divided into approximately equal sublots of between 400 to 600 tons;” the DoD’s pay lot is typically 2,000 tons of HMA (FAA, 2018a; USACE, 2017). If contractors pave more than their anticipated daily production, a new battery of compliance tests like those highlighted in Section 3.3.1 will be required for this new pay lot, thereby costing contractors additional time and effort for testing.

Typically, are different plant and aggregate storage setups required for airfield jobs as compared to highway paving jobs?

All contractors stated that the same plant and aggregate storage setups are used across project types. For airfield projects, having additional crushed aggregate piles on hand helps the paving operations move ahead steadily, but otherwise, operations remain the same. One project requirement unique to airfields is that owners may specify that contractors have two asphalt plants available to support operations. One contractor mentioned that large organizations have the advantage when it comes to bidding additional plants; another contractor agreed and mentioned that his company has plants near every airfield in Western Washington, thereby giving them an operational advantage.

4.2.2 *Foreign Object Debris (FOD) Mitigation*

What FOD mitigation measures does your organization implement for an airfield paving job, but not for a highway job? For both airfield and highway projects, how is FOD prevention priced?

All contractors agreed that FOD mitigation is a high-emphasis item on FAA and DoD projects. While FOD also impacts highway projects, airfield paving project managers notoriously critique project site cleanliness, despite airfields having far less FOD than highways. According to the interviewees, contractors must be more meticulous about sweeping and managing garbage at the site (Table 17).

Table 17: Foreign Object Debris (FOD) Mitigation Pricing Methods

Contractor	FOD Mitigation Pricing Methods
Contractor 1	Two full-time sweepers and FOD patrol crew (appx. 2 hours of work) required. - Ensuring adequate FOD mitigation is included as a line-item is critical for bidding and project planning.
Contractor 2	Company subcontracts additional work (for example, sweeping) to continue focusing on paving specialty
Contractor 3	Same FOD mitigation for both projects - Airfields swept more frequently.

One contractor commented that one of the greatest FOD threats to an airfield project is employees on-site, particularly truck drivers. This contractor's organization requests that drivers dispose of trash from their cabs before traveling to the project site to avoid introducing additional FOD.

Depending on the project owner, FOD mitigation may go beyond sweeping and trash collecting. One contractor mentioned that during a project at Renton Airport, the owner requested special airfield striping paint with a lower concentration of reflective glass beads. The owner requested this change because aircraft parts had previously been damaged by loose glass beads. This request resulted in a reflectivity specialist being brought to the project for consultation. Again, large paving companies with access to additional consultants may have an advantage in large paving projects over smaller companies.

4.2.3 *Paving Operations*

4.2.3.1: Definitions and Specifications

A material transfer vehicle (MTV), also known as a material transfer device (MTD), is a machine used to hold HMA and sustain paving operations once the paver hopper runs out of material and until trucks return with additional material (Mallick & El-Korchi, 2013). MTVs also keep the HMA warm and reduce aggregate segregation by mixing the HMA for uniformity. An example of an MTV is shown in Figure 8, and Table 18 outlines the required uses of MTVs on various paving projects.

Figure 8: Material Transfer Vehicle in Use during Runway Paving at Joint Base Lewis-McChord, Washington. Photo courtesy of the USAF.

Table 18: Use of Material Transfer Vehicles (MTVs) in HMA Paving (FAA, 2018a; USACE, 2017; WSDOT 2020)

WSDOT Specifications	FAA Specification	DoD Specifications
MTVs are required to be used for paving the top 0.3 feet of HMA in traffic lanes. MTV is optional for irregularly shaped paved areas or pavement areas accepted only by Visual Evaluation	MTV must be used for taxiway and runway construction for aircraft weighing more than 100,000 lbs; use for shoulder construction optional. *Recommended for all pavement systems, if they will not be damaged by MTV's weight.	MTV must be used for taxiway and runway construction; use for shoulder construction optional.

While regulations are similar across pavement project types, contractors need to be aware of projects requiring MTVs.

4.2.3.2: Contractor Responses

Please describe typical placement operations for both airfield and highway projects.

a. ***In airfield projects, how often (as a percent) is an MTV used to aid placement?***
b. ***In highway projects, how often (as a percent) is an MTV used to aid placement?***

All interviewed contractors support the use of MTVs across all project types; in fact, they rely on this equipment 100% of the time for mainline paving. The use of MTVs is deemed necessary for contractors to boost production and improve paving quality. From one contractor, "We love to have the Shuttle Buggy [a prominent MTV brand] out there [on the project] … it's a benefit to us." However, MTV effectiveness depends on the size and location of the paving site. For smaller projects in tight quarters, MTV use may not be as efficient or as helpful compared to other projects. Also, purchasing an MTV may be a barrier to entry for smaller paving companies; according to one contractor, having easy access to this technology is an advantage to his company when bidding large paving projects.

4.2.4 *Night Paving Operations*

How often is night paving needed for an airfield project? How does this rate compare to a highway project? Please provide your answer in percentage of projects.

How does night paving impact productivity and paving quality, regardless of project type? Are there any additional safety concerns to be considered during night paving operations on an airfield paving project?

Because the interviewed contractors have experience working in different areas of Washington and the Pacific Northwest, their answers varied on how essential night paving was to their operations. Overall, the view was that in high-traffic zones, night paving has become a necessity, particularly in Western Washington. Contractor 3, who works in Eastern Washington, noted that his company sees less night paving due to overall lower traffic volumes in the region compared to Western Washington; therefore, day paving can occur without major impacts to traffic. Contractor responses are included in Table 19.

Table 19: Percentage of Paving Projects Requiring Night Paving Operations

Contractor	**Paving Projects Requiring Night Paving (%)**	
	Highway	*Airfield*
Contractor 1	70-80%	50% - If 24-hour paving schedule
Contractor 2	>50%	Rarely Done
Contractor 3	<50% - Exception: high-volume traffic areas	Rarely Done - Only experienced on one project

However, most contractors note that night paving is not typically required for airfield paving unless the project has a severely condensed schedule. Two contractors admitted that airfield night paving is rare, whereas the other contractor had experienced several projects requiring night operations.

While they strive to keep paving quality consistent, all contractors admitted having concerns and issues when paving after sundown. Two contractors commented that night paving can severely impact production. Due to limited nighttime paving windows, more starts-and-stops are experienced with night paving. Contractors are also forced to limit their asphalt plant operation times and may only lay between 1,000 and 1,200 tons per day. This value is half of the production typically seen during day operations. One contractor also noted that it may be more difficult to achieve compaction at night due to poor visibility for roller teams and to ambient temperatures cooling asphalt lifts quickly, thereby reducing roller effectiveness.

Comparatively, night paving on airfields is safer than on highways. Though airfields may have aircraft landing during paving projects, flights are scheduled in advance and allow paving crews time to move off the airfield. Therefore, the majority of contractors agree that night paving on airfields is easier due to scheduled, predictable traffic. Besides impacts on productivity, paving at night poses additional risks to crew members and pavement quality. Visual QC measures become more difficult, particularly with poor lighting, and most contractors agreed that more caution must be taken around paving machines and reversing trucks. Night paving is particularly dangerous on highway projects due to high-speed traffic. Contractors are concerned about adequate signage and lighting to make drivers aware of paving operations, but changes in traffic patterns may confuse motorists. Also, drunk drivers always pose a threat.

4.2.5 *Mat Density and Longitudinal Joints*

4.2.5.1: Definitions and Specifications

The minimum mat and joint density specifications are outlined in Table 20.

Table 20: Minimum Allowable Federal and State Density Specifications (FAA, 2018a; USACE, 2017; WSDOT, 2020)

WSDOT Specification	FAA Specification	DoD Specification
Mat Density: 92.0% TMD Joint Density: Not Specified	Mat Density: 92.8% TMD Joint Density: 90.5% TMD	Mat Density: 92.0% TMD Joint Density: 90.5% TMD

The UFGS 31 12 15.13 also identifies maximum mat densities. The maximum allowable mat density for DoD work is 97.0% TMD (USACE, 2017).

4.2.5.2: Contractor Responses

What are typical mat and longitudinal joint densities (% of theoretical) for both airfield and highway projects? What are the major issues for achieving sufficient densities for airfield and highway projects?

Pavement lift thickness and ambient temperatures impact highway pavement densities. Typical highway pavement lifts are 1.8 inches thick, as compared to airfield pavement lifts which are approximately 2.5 inches thick, according to one contractor. Thinner lifts cool quicker, thereby reducing the time rollers have to compact the mix, but one contractor commented that as long as the pavement system's base course is adequately compacted, it provides the proper platform on which surface layer HMA densities can be met. While the contractors agreed on issues impacting highway pavement quality, opinions diverged for airfield paving. One contractor commented that upper compaction limits for FAA projects have been major issues for his organization, particularly when compacting projects with 50-gyration mixes. Another commented that ensuring joint quality was his company's greatest issue; airfield joints must be cut back if paving cannot be done in echelon, and care must be taken during joint cutting to avoid causing additional pavement damage. After cutting back the pavement joint, longitudinal joint density will be more reflective of the mat density. Therefore, equivalent coverage should be given to both the joint and the mat.

What do you use to verify mat and joint densities for these projects?

The use of nuclear density gauges in Washington for QA is unique; for density measurements, almost the same number of agencies use nuclear density gauges as use cores (Lundy, 2001). Therefore, perspectives from Washington contractors on HMA density testing using cores may differ from the opinions of contractors from other states. The interviewed contractors in this research all use nuclear density gauges to verify mat and joint densities on both project types in Washington. However, the FAA and DoD projects also require cores to be taken along longitudinal joints and randomly in the HMA mat due to potential variability of in-field nuclear density testing. Core density testing is the most accurate and reliable method for determining HMA density, but one contractor viewed this testing method as short-sighted for several reasons:

- Owner's CMs typically are not staffed sufficiently to keep pace with the production of paving contractors, which causes testing to lag behind operations.
- Core sample results take up to 24-hours to receive, which is slower than results from either nuclear or non-nuclear gauges.
- Cores provide a small-scope view of asphalt paving quality, whereas implementing both nuclear and non-nuclear testing allows for more testing across the project.
- While valuable for validating nuclear gauge results, cores add a level of complexity to projects, especially those involving several organizations.
- Damage caused during the coring process impacts pavement quality near joints.

For projects on military installations, one contractor commented that his organization no longer uses their nuclear density gauges on projects due to base officials requiring additional screening. Instead, they contract with a private testing company that has base clearance for nuclear gauge testing.

How do you measure the quality of longitudinal joints on an airfield project? How do these processes differ from your methods used on highway projects?

Because WSDOT does not require significant QC for longitudinal joints on highway projects, joint density is not an emphasis item for the organization. WSDOT uses a sloping step joint in their projects, and their roadways are superelevated. For successful joints on WSDOT work, having skilled roller operators to contain the joint while rolling is critical. According to one contractor, highway paving typically does not have a confining edge, and the HMA tends to spread if unconstrained. Airfields, on the other hand, are relatively flat with cut cold joints. Longitudinal joint quality is a major issue for airfield paving primarily due to the FOD risk posed by joint raveling, and their construction requires more effort from contractors to meet density requirements relative to highway projects. If possible, contractors prefer to pave in echelon, which yields higher joint quality without requiring the joint to be cut back. However, most projects require contractors to cut the joints, including on the control strip. Before joints can be cut, internal pavement temperatures must be below 135 degrees Fahrenheit, which can "easily [be] three hours of downtime," said one contractor. After joint cutting, contractors tack the joints and use confining edges from neighboring paving lanes to aid compaction.

4.2.6 *Weather Concerns*

What weather-related paving differences have you noticed for airfield and highway projects in Eastern Washington vs. Western Washington?

Washington State contains two major climate zones, roughly divided by the Cascade Mountain Range. Eastern Washington's climate is a mixture of marine and continental characteristics, whereas Western Washington has a marine-type climate (Table 21, NOAA, n.d.).

Table 21: Weather-Related Paving Issues in Eastern and Western Washington (NOAA, n.d.; NOAA, 2018a; NOAA, 2018b)

Eastern Washington	Western Washington

- Minimal moisture-related weather delays
- High ambient temperatures during peak paving season; cools off significantly during fall
- Monthly Average Max/Min Temperatures (°F)
  o April: 57.2/36.8
  o July: 83.3/56.3
  o October: 58.0/37.2
- Days with Sunshine (%)
  o Summer: 80-85%
  o Winter: 20-30%
	- Several moisture-related weather delays; rainy season Oct-Mar
	- Lower average temperatures throughout paving season, but tends to have higher temperatures later in the year
	- Monthly Average Max/Min Temperatures (°F)
	  o April: 58.5/42.2
	  o July: 75.8/55.6
	  o October: 59.7/45.8
	- Days with Sunshine (%)
	  o Summer: 60%
	  o Winter: 25%

Due to significant weather changes starting in the fall, WSDOT limits paving between 1 October to 31 March, unless the project engineer explicitly concurs with paving later in the season (WSDOT, 2020). Both WSDOT and the FAA/DoD specify minimum surface temperature requirements for the placement of asphalt surface courses (Table 22).

Table 22: Minimum Surface Temperature Requirements for Surface Course Paving (FAA, 2018a; USACE, 2017; WSDOT, 2020)

Mat Thickness (inches)	WSDOT Specifications (°F)	FAA/DoD Specifications (°F)
3 or greater	35	40
1.2-2.4	45	45
Less than 1.2	55	45

Each Washington region brings a host of different climate impacts to paving operations. One contractor noted issues with late-season paving requests in Western Washington because the average temperatures in the fall are near both WSDOT and the FAA/DoD's specified minimum surface temperatures.

Typically, weather delays on FAA and DoD projects concern contractors due to tight project timelines. One contractor commented that there is no schedule allowance for non-working days on FAA or DoD projects. Therefore, contractors may decide to spend additional money to pave aggressively at night during the project to avoid delays and liquidated damages. However, while WSDOT, FAA, and DoD specifications state that "asphalt shall not be placed upon a wet surface" (FAA, 2018a; USACE, 2017; WSDOT, 2020), FAA and DoD officials are more involved in determining if weather conditions are conducive to paving. The FAA is warry of conducting paving operations at any sign of inclement weather; these actions differ significantly from WSDOT's operations, according to the interviewed contractors. For WSDOT projects, contractors are responsible for determining if weather conditions are suitable for paving. Therefore, weather days on FAA projects are far easier to negotiate due to owner involvement in weather-related pavement placement delays.

4.2.7 *Conclusions*

Key concepts derived from the interviewed contractors related to construction practices and management are listed below.

- Productivity is higher on airfield paving projects, which aids contractors in avoiding delays and liquidated damages while under shortened project schedules.
- FOD and site management are more critical for airfield projects than highway paving projects.
- MTVs aid pavement placement, regardless of project type, and acquiring this equipment may give large paving contractors an advantage over the competition (assuming that the project is large enough to warrant MTV use).

- FAA and DoD’s density verification processes with cores, while thorough, may not provide the widest view of pavement quality. Using nuclear and nonnuclear options may provide a fuller view of overall pavement quality.
- Airfield joints, while having higher density requirements, are more of a reflection on mat quality because of the joint cut-back requirement. However, the process of cutting back the joint may cause pavement damage and other construction concerns.
- The FAA is more concerned about weather conditions during paving than WSDOT, which makes negotiating weather delays simpler for contractors.

4.3 Pavement Materials and Mix Design

The following sections will discuss general questions, as well as five topic areas related to pavement materials and mix design: nominal max aggregate size (NMAS), voids in mineral aggregate (VMA), asphalt content and binder type, reclaimed asphalt pavement (RAP) use, and perpetual pavement/long-lasting pavements.

4.3.1 *General Questions*

Who typically performs mix designs for highway and airfield projects: owners or contractors? How satisfactory is the interaction between contractor and owner in regards to the mix design process? If not satisfactory, how can it be improved?

In both projects, mix design is a two-step process, with mix designs submitted by contractors and approved on behalf of the owner following performance verification by a laboratory (Figure 9).

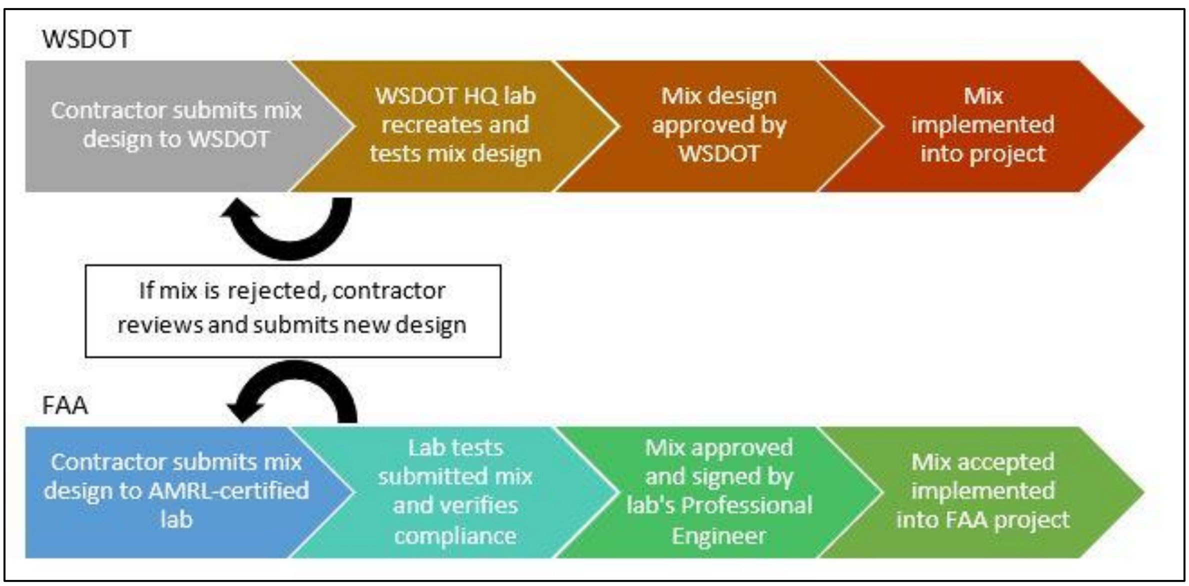


Figure 9: Mix Design Approval Process for WSDOT and FAA Paving Projects

For WSDOT work, mix design verification is conducted internally at WSDOT, with each design verification costing contractors $10,000. For FAA work, an AMRL-certified (AASHTO

Materials Reference Laboratory) laboratory must verify the mix design. Because most paving companies do not have these certifications, they often seek a third-party lab for mix designs. Several laboratories within Washington have these credentials, and if possible, one contractor said his company likes to work with the same accredited lab selected for the owner's QA mix design acceptance testing. In Central/Eastern Washington, two labs currently have the proper certification, but as the FAA transitions to more gyratory mix designs (perhaps to meet its goal of using a local area's prevalent design method), it becomes more difficult to find labs capable of conducting the necessary tests (FAA, 2018a).

Though WSDOT and the FAA have similar two-step mix design approval processes, their interactions with contractors are different. Overall, interactions with the owner during FAA projects is limited, but contractors believe interactions during the mix design phase are satisfactory. The FAA mix design is a prescriptive mix; assuming the mix meets outlined requirements, the owner and their CMs have no issues. Once the mix is approved, the contractor maintains the risk of demonstrating compliance with in-placement pavement specifications. Noncompliant material is subsequently removed at no cost to the owner. Clear expectations are set by the owner, and contractors understand the requirements placed on them going into paving operations. Within WSDOT, however, contractors have become accustomed to what one contractor called a "hand-holding system." WSDOT and contractors share risk during the mix design process, but due to recent issues with mix verification testing, the relationship between WSDOT and contractors has soured. Each mix design costs contractors $10,000 to verify; if a mix fails a test, not only do contractors risk being penalized for a failure (both financially and in lost contractual days), but they also must redesign the mix, resubmit, and pay an additional $10,000 for WSDOT testing. Several contractors voiced frustration with this process, and one called into question why WSDOT continues conducting pavement testing internally rather than going to more of an FAA-style system. To some, WSDOT's current testing system harms the paving process more than helping.

Are gyratory compactor/volumetric mix designs required for both airfield and highway projects?

Superpave gyratory designs are the only mixes authorized for WSDOT work. However, for the FAA and DoD, either Marshall or Superpave gyratory mixes can be specified. According to interviewed contractors, airfield paving projects have been relatively slow to adopt gyratory designs.

4.3.2 *Nominal Max Aggregate Size (NMAS)*

Do you prefer either 0.375-inch or 0.5-inch NMAS mixes? Please identify a preferred NMAS for both airfield and highway projects.

For highways, most contractors prefer 0.375-inch NMAS mix because it is easier to pave, has a higher binder content, and is less permeable. However, one contractor cautioned that one NMAS does not necessarily work in all scenarios. He claimed that 0.375-inch NMAS mixes should not be used on mountain passes or interstates because they do not contain enough aggregate to support applied loads, thereby becoming susceptible to rutting. In his mind, 0.5-inch NMAS mixes may be more resilient to high amounts of loading. But according to another contractor, 0.5-inch NMAS mixes have lower binder contents, are more difficult to compact, and may have a greater risk of aggregate segregation. Therefore, disagreement exists regarding the best NMAS mixes for various paving projects.

For the majority of contractors, FAA paving projects require a 0.5-inch NMAS in its prescriptive mix design process. However, one contractor noted that significant changes were recently made to the FAA's gradation percentages, making the mix specifications in the recent AC 150/5370-10 harder to meet, in his opinion. Table 23 shows the surface course gradations published in 2014 as compared to 2018's values.

Table 23: FAA AC 150/5370-10 Gradation Requirements Comparison (FAA, 2014; FAA, 2018a)

Sieve Size	Percentage by Weight Passing Sieves (2014)	Percentage by Weight Passing Sieves (2018)
	Gradation 2	*Gradation 2*
1 inch	--	--
¾ inch	100	100
½ inch	79-99	90-100
3/8 inch	68-88	72-88
No. 4	48-68	53-73
No. 8	33-53	38-60
No. 16	20-40	26-48
No. 30	14-30	18-38
No. 50	9-21	11-27
No. 100	6-16	6-18
No. 200	3-6	3-6
Asphalt Content		
Stone or gravel	5.0-7.5	5.0-7.5
Slag	6.5-9.5	6.5-9.5

While asphalt content values stayed the same for both specifications, it appears that the ranges for gradations between the No. 4 and the No. 50 sieves increased, potentially allowing more sand into an asphalt mixture.

4.3.3 *Voids in Mineral Aggregate (VMA)*

4.3.3.1: Definitions and Specifications

Minimum VMA values required for WSDOT, FAA, and DoD mix specifications are in Table 24.

Table 24: Agency Minimum Voids in Mineral Aggregate (VMA) Values (FAA, 2018a; USACE, 2017; WSDOT, 2020)

WSDOT Specification	FAA Specification	DoD Specification
0.375-inch NMAS: 15% 0.5-inch NMAS: 14% - Section 9-03.8(2), *HMA Test Requirements*	0.5-inch NMAS: 15% - P-401 Table 2, *Gradation 2*	0.5-inch NMAS: 14% - Section 2.5.1, Table 7, *Gradation 2*

As noted in the table above, FAA and DoD specifications do not provide VMA requirements for 0.375-inch NMAS mixes because an associated prescriptive HMA surface course design for 0.375-inch NMAS mixes is not included in either specification.

4.3.3.2: Contractor Responses

Do specified ranges of VMA for airfield and highway projects cause issues for your organization?

All contractors agree that the specified ranges of VMA on airfield and highway projects are not currently an issue for their organizations. However, two contractors noted that if WSDOT continues to reduce their VMA specification without other mix adjustments, pavement quality may suffer.

4.3.4 *Asphalt Content and Binder Type*

What are typical asphalt contents for airfield and highway projects, respectively?

What typical binder types and binder additives are used on airfield and highway paving projects? If your answer varies by state, please identify the state you're referencing.

Contractor responses related to asphalt binder percentages and types are included in Table 25.

Table 25: Contractors' Responses for Asphalt Content and Binder/Additive Usage

Contractors	Asphalt Content		Binder/Additives	
	Highway	*Airfield*	*Highway*	*Airfield*
Contractor 1	0.5-inch NMAS 5.2-5.3% 0.375-inch NMAS 5.8-6.1%	0.5-inch NMAS 5.5-5.6%	Western WA PG 58H-22[6] Eastern WA PG 64H-28	PG 58V-22
Contractor 2	0.5-inch NMAS 5.1%[1] 6.1%[2]	0.5-inch NMAS 6.3%-6.6%[4]	Western WA PG 64-22	PG 64-22
Contractor 3	0.5-inch NMAS 5.4%[3]	0.5-inch NMAS 5.8%[5]	Eastern WA PG 64H/V/S	PG 70-28, 70% elastic recovery

[1] 100-gyration mix design
[2] 75-gyration mix design
[3] Contains 4% air voids (V_a)
[4] Airfields typically have 0.2-0.5% greater asphalt content
[5] Contains 3% air voids (V_a)
[6] V is used on interstate pavements

As noted from the table, Contractor 2 responded that his mixes contained more asphalt than the other two interviewed contractors. Upon being asked about this deviation, he mentioned that these ranges were in part due to differing aggregate specific gravities from various aggregate sources. For his lower binder HMA mixes, the Theoretical Maximum Density (TMD) of the mix was 167 pounds per cubic foot (lbs/ft^3), whereas the higher binder content mix was 153 lbs/ft^3 TMD. He also stated that FAA and DoD pavements typically contain between 0.2% and 0.5% more binder due to their higher VMA requirements.

4.3.5 *Reclaimed Asphalt Pavement (RAP) Use*

4.3.5.1: Definitions and Specifications

The specified percentage of RAP by total weight of HMA from each agency specification is included in Table 26.

Table 26: Reclaimed Asphalt Pavement (RAP) Mix Design Content (FAA, 2018a; USACE, 2017; WSDOT, 2020)

WSDOT Specification	FAA Specification	DoD Specification
Low-RAP: $0 \leq \text{RAP\%} \leq 20$ High-RAP: $20 \leq \text{RAP\%} \leq 40$[1] [1]If no binder contributed by recycled asphalt shingles (RAS) - Section 5-04.2(1), *Mix Designs Containing RAP and/or RAS*	No RAP for surface courses, unless used on the shoulders. - P-401, 401-3.4 *Reclaimed Asphalt Pavement (RAP)*	No RAP for surface courses, unless used on the shoulders. - 2.6 *Recycled Asphalt Pavement*

Despite the USAF previously testing RAP-containing pavements on airfields, RAP still is not allowed in surface courses on either FAA or DoD pavements except for shoulders.

4.3.5.2: Contractor Responses

What is the average percentage of RAP allowed on airfield and highway projects?

Are there limitations on which HMA layers can contain RAP? If limitations exist, why does the owner limit RAP usage, in your opinion?

Interviewed contractors commented that HMA mixes for highways, on average, use 20% RAP. One contractor mentioned a Western Washington asphalt plant produces high-RAP pavement, so highway pavements in Western Washington may have an average RAP content closer to 22%. For airfield paving, RAP has only recently been added to the specifications. The DoD added RAP content in its 2014 specifications (NIBS, 2019), but no RAP is allowed in surface courses. The FAA allows RAP only in P-403 base layers, and from one contractor's experience, P-403 specifications are rare. RAP usage in airfield pavements is still limited unless it is used as a base layer material.

4.3.6 *Perpetual Pavement/Long Lasting Pavements*

4.3.6.1: Definitions and Specifications

Perpetual pavements are engineered asphalt pavements capable of resisting normal distresses while lasting for longer periods (Mallick & El-Korchi, 2013). Typically, perpetual pavements are designed so that distresses only impact the top wearing course. This design method eases repair requirements and is a more economical method of paving because it only requires the replacement of the top wearing course.

4.3.6.2: Contractor Responses

Have your paving practices, regardless of project type, changed with the trend of placing long-lasting pavements?

Do you foresee long-lasting pavements increasing the HMA thickness on airfield or highway pavements?

For this section, contractors seemed unable to meaningfully answer these questions, and they had minimal comments on how the long-lasting pavement discussion will impact FAA or DoD pavement thicknesses. From the contractors' perspective, owners emphasize the use of perpetual pavements, but until changes are made to agency specifications, contractors can only provide quality pavements following provided guidance. According to one contractor, WSDOT has continued to tighten the VMA specification and increase compaction standards since 2016 with the intent of making their pavements more resistant to wear. However, all interviewed contractors agreed that these changes alone are not enough to develop long-lasting pavements. Contractors' abilities to develop more innovative, long-lasting pavement solutions are limited by current specifications, and these limitations have strained the WSDOT-contractor partnership. In the words of one contractor, asphalt paving organizations are providing the best products they can within the specifications provided, but WSDOT could have better projects if it solicited feedback and worked with contractors on developing ideas about perpetual pavements. Yet, contractors understand that for many municipalities, the idea of thicker, longer-lasting pavement is not feasible at this time due to budget constraints; instead, owners are placing thinner, cheaper asphalt lifts which ultimately fail ahead of strategic maintenance timelines. Yet, according to one contractor, the majority of pavement in Washington fails from top-down cracking rather than bottom-up cracking (if the pavement fails at all). Therefore, only the surface HMA courses are replaced instead of replacing the entire pavement system, which is good news for owners.

4.3.7 *Conclusions*

Key concepts derived from the interviewed contractors related to pavement materials and mix designs are listed below.

- Perpetual pavements are not an emphasis item for paving contractors. However, contractors are open to partnering with WSDOT to discuss ways of reaching perpetual pavement goals.
- The current WSDOT mix design system is unsatisfactory to contractors and draws criticism regarding its usefulness in current practice. A move to a third-party mix verification process may be desirable to contractors.
- The selection of the optimum mix NMAS causes debate amongst contractors despite WSDOT's move to more 0.375-inch NMAS mixes.

Following the conclusion of these interviews, applications of the results were considered. Chapter 5 contains summaries, conclusions, and possible applications of this research.

Chapter 5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents conclusions from the conducted research and outlines possible applications of the results. Ultimately, the goal of this thesis was to highlight contractors' approaches to highway and airfield asphalt paving projects and to make owners and their representatives aware of considerations and calculated risks faced by paving companies. The researcher used conversational-style interviews to collect contractors' perspectives on topics related to contracting and project management, construction practices and management, and pavement materials and mix design. Appendices B-D contain interview summaries. Contractors prioritize airfield paving projects higher than their typical highway projects, and they implement multiple sets of crews and equipment to complete these projects. If further research is conducted related to this topic, Section 5.2 outlines possible topics.

5.1 Research Summary

Overall, interviewed contractors believe airfield paving projects are more demanding (on personnel, equipment, and administrative efforts), and most differences between these two paving projects exist in elements of contracting and project management. This conclusion counters the usual topics seen in existing paving sources, which emphasize differences in the technical aspects of paving and mix design differences. More restrictive construction specifications, greater liquidated damage risks, and coordination with unique owners and CM teams on airfield projects require contractors to navigate team dynamics along with unfamiliar requirements. Benefits, like securing higher profits or boosting company reputations, entice paving organizations, but these benefits balance against greater financial risks and demands on personnel and equipment. Contractors cannot earn bonus pay for airfield projects, and claims on these contracts are difficult to achieve. Plus, airfield work brings higher manpower costs, including mobilization and overtime requests. Security protocols and site management requirements demand attention, and airfield projects limit contractors' abilities to take on additional paving work. According to the interviewed contractors, airfield project management demands more attention and effort from contractors than the management of a WSDOT highway project.

Beyond contracting and project management, fewer differences exist in construction practices and pavement mix design. FAA and DoD guidance requires the placement of a control strip where contractors demonstrate their abilities to meet owners' stringent specifications and QC measures. Contractors participate in QC testing and verification, and placing the proper equipment and personnel on-site helps ensure pavement quality. With quality mix designs, high pavement production, and proper site management, contractors can produce first-rate products within shorter project schedules. Even though these pavement systems support different loads from a variety of tire configurations, minimal differences exist between airfield and highway pavement materials and mix designs. Airfield pavements primarily deviate in aspects of project management and contracting, with minor differences identified in the other two categories.

In terms of mix design approval processes, contractors voiced dissatisfaction with the current costly WSDOT internal HMA verification process. Rather than contractors being required to pay $10,000 per verification just to receive potentially faulty results, they voiced interest in seeing WSDOT transition to a verification process similar to what the FAA and DoD implements. This type of approval system, according to the interviewed contractors, places responsibility for verifying mix performance on certified labs rather than on a state agency with relatively inexperienced staff. This type of change in policy warrants a conversation between WSDOT and contractors about the existing HMA verification process.

5.2 Applications and Recommendations

Elements of this research can be educational resources, particularly for students interested in working in construction consulting. Airfield projects are rare in HMA paving, and CMs in the field may never have seen airfield paving concepts before the project start date. Yet, the interviewed contractors agreed that working with inexperienced CMs on airfield projects can result in miscommunications with owners and project delays. Therefore, exposing students to airfield paving concepts in construction curriculum may help CMs in the field better understand contractor concerns while improving communication with owners about issues during paving operations. Concepts about airfield paving, including some conclusions from this research, will be implemented in CEE 421, *Pavement Design and Construction*, at the University of Washington. Also, making information about airfield pavement design and construction aspects available on open-source websites (like Pavement Interactive, an online, open-source collection of articles related to paving) gives personnel in industry and education alike access to these research results (Muench, Mahoney, & White, 2010). Integrating airfield paving lessons into construction curriculum may help to alleviate contractors' frustrations with inexperienced CMs working on critical airfield paving projects.

Results from this paper also encourage a review of currently available USAF airfield pavement and project management training. Currently, the Air Force Institute of Technology (AFIT) Civil Engineer School offers two airfield pavements-related courses: WENG 550, *Airfield Pavement Design and Maintenance*, and WENG 555, *Airfield Pavement Construction Inspection* (AFIT, 2020a). The latter trains students "to implement quality assurance/quality control measures during the design and construction of airfield pavements" (AFIT, 2020b). The course covers pavement system design, asphalt and concrete mix design and paving operations, and contract management with general inspection. Research results warrant a review of WENG 555, and possibly WENG 550, to ensure the course includes contractor perspectives and opinions. Discussing contractor perspectives, particularly regarding administrative and financial burdens, could give government representatives a greater understanding of the full scope of paving projects and prepare students for what to expect on the job site. By better understanding contractor issues and feedback, government representatives gain competence and confidence in their duties as pavement inspectors. Government entities rely on the private sector to execute vital infrastructure improvement jobs, so maintaining strong partnerships with responsible and responsive contractors is essential to project success.

If further research is conducted on this topic, special consideration should be given to two topics: administrative burdens of airfield paving projects and an evaluation of WSDOT's processes compared to other state DOTs in the Pacific Northwest. Throughout the interviews, contractors noted higher administrative burdens affiliated with airfield projects. To fully quantify these additional demands, a survey should be conducted to assess how many additional manhours and resources are required to not only competitively bid for an airfield paving project, but also to mobilize and complete the work. This research may also highlight how much more expensive airfield projects are for paving contractors to execute as compared to highway projects. Also, contractors expressed interest in understanding why variations exist between state DOT specifications and requirements in the Pacific Northwest. All three interviewed contractors have completed projects in the neighboring states of Oregon and Idaho, and they noted that despite having similar construction concerns and climates, each state requires different specifications and processes. A review of state DOT specifications and mix design approval processes can identify these differences, and additional engagement between WSDOT representatives and other state DOT members will be necessary to discuss possible regional changes. Outcomes from this meeting-of-the-minds could result in new pavement guidance for Pacific Northwest states and make paving across state lines easier for contractors. While policy changes would require coordination between respective state DOTs, a research project related to current state practices could catalyze regional policy changes.

5.3 Conclusions

Several resources exist that describe best design and construction practices for highway and airfield HMA paving. However, most documents either are academic resources or work to aid owners and their representatives with technical paving concepts. Few resources note contractors' perspectives and approaches to either highway or airfield paving, nor do they acknowledge risks associated with these projects which influence contractors' behavior. While contractors in Washington are accustomed to working with WSDOT specifications and personnel, airfield paving projects are rare and require contractors to work with unique teams while complying with restrictive specifications during shorter project schedules. Giving voices to contractors and understanding the issues they face while maintaining, repairing, and constructing paved highway and airfield assets is vital information for owners and owner representatives. This awareness prepares these latter groups to make better project-related decisions while anticipating potential issues and developing symbiotic relationships with paving industry partners.

5.4 DISCLAIMER

The author thanks the contractors involved in this research for their willingness to participate and for sharing their perspectives. The views expressed in this thesis are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. Government

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APPENDIX A: INTERVIEW QUESTIONS

Contracting and Project Management

1. How does your organization decide what projects to bid on? Is the criteria the same for highway and airfield projects?
2. What differences are there in managing airfield vs highway projects?
3. How does your organization prepare to execute an airfield paving project, and is this process different than what you do prior to a highway paving project? Preparations could include hiring additional personnel, etc.
4. How much administrative burden do airfield projects have compared to highway projects? Burdens could include security clearances, coordination with airfield operations, etc.

<u>Risk</u>

1. What risks do you consider when bidding airfield projects versus highway projects?
2. As a contractor, what is the #1 risk associated with highway projects? Airfield projects?

<u>Contracts and Contract Claims</u>

1. For contract claims, are there differences between claims for airfield projects and claims for highway projects? If so, why?
2. Is there a difference in compensation between federal and state paving jobs? If so, what is the range (in percent) of compensation differences?
3. What organization typically provides the best project specifications, and what makes this organization stand out?

<u>Compensation/Pay Factors</u>

1. Do you encounter pay factors for both airfield and highway projects? If so, are the pay factors used on highway or airfield projects preferred, and why?
2. Do the pay factors adequately compensate contractors for the work needed to meet or exceed project requirements?

<u>Personnel and Training</u>

1. How many crew members do you typically plan to mobilize for a large highway paving job? Is this number similar to what you plan for on an airfield job?
2. How are security clearance concerns addressed for airfield paving projects?
3. What trainings do your crews complete when working on a highway paving project? Are additional trainings required prior to working on an airfield paving project? If so, what are these additional trainings?

Construction Practices and Management

Construction Site Management

1. How does your paving productivity compare between airfield and highway projects? On average, what is your production rate for airfield paving, and what impacts this rate?
2. Typically, are different plant and aggregate storage setups required for airfield jobs as compared to highway paving jobs?

Foreign Object Debris (FOD) Mitigation

1. What FOD mitigation measures does your organization implement for an airfield paving job, but not for a highway job?
2. For both airfield and highway projects, how is FOD prevention priced?

Paving Operations

2. Please describe typical placement operations for both airfield and highway projects.
   a. In airfield projects, how often (as a percent) is an MTV used to aid placement?
   b. In highway projects, how often (as a percent) is an MTV used to aid placement?

Night Paving Operations

1. How often is night paving needed for an airfield project? How does this rate compare to a highway project? Please provide your answer in percentage of projects.
2. How does night paving impact productivity and paving quality, regardless of project type?
3. Are there any additional safety concerns to be considered during night paving operations on an airfield paving project?

Mat Density and Longitudinal Joints

1. What are typical mat and longitudinal joint densities (% of theoretical) for both airfield and highway projects?
2. What are the major issues for achieving sufficient densities for airfield and highway projects?
3. What do you use to verify mat and joint densities for these projects?
4. How do you measure the quality of longitudinal joints on an airfield project? How do these processes differ from your methods used on highway projects?

Weather Concerns

1. What weather-related paving differences have you noticed for airfield and highway projects in Eastern Washington vs. Western Washington?

Pavement Materials and Mix Design

1. Who typically performs mix designs for highway and airfield projects: owners or contractors?
2. How satisfactory is the interaction between contractor and owner in regards to the mix design process? If not satisfactory, how can it be improved?
3. Are gyratory compactor/volumetric mix designs required for both airfield and highway projects?

Nominal Max Aggregate Size (NMAS)

1. Do you prefer either 3/8” or ½” NMAS mixes? Please identify a preferred NMAS for both airfield and highway projects.

Voids in Mineral Aggregate (VMA)

1. Do specified ranges of VMA for airfield and highway projects cause issues for your organization?

Asphalt Content and Binder Type

1. What are typical asphalt contents for airfield and highway projects, respectively?
2. What typical binder types and binder additives are used on airfield and highway paving projects? If your answer varies by state, please identify the state you’re referencing.

Reclaimed Asphalt Pavement (RAP) Use

1. What is the average percentage of RAP allowed on airfield and highway projects?
2. Are there limitations on which HMA layers can contain RAP? If limitations exist, why does the owner limit RAP usage, in your opinion?

Perpetual Pavement/Long Lasting Pavements

1. Have your paving practices, regardless of project type, changed with the trend of placing long-lasting pavements?
2. Do you foresee long-lasting pavements increasing the HMA thickness on airfield or highway pavements?

APPENDIX B: CONTRACTOR 1 INTERVIEW SUMMARY

Contracting and Project Management

5. How does your organization decide what projects to bid on? Are the criteria the same for highway and airfield projects?
    a. Same Criteria
        i. How much work do we have at the time?
        ii. How much work have we committed to already?
        iii. What are the risks involved in the project?
    b. Different Criteria
        i. How much more intense will this airfield project be (i.e., timelines, administrative burden, internal quality control testing/monitoring/documenting, etc.), and what is our organization willing to sacrifice to take this work on? Airfield projects are **larger administrative burdens and require that contractors have a more robust QC process** to meet contract requirements for documentation/monitoring. Third-party labs may be involved in the project, and third-party construction managers (CMs) will serve as the owner representatives. Third-party oversight is rare in DOT work.
        ii. Is there prequalification for the project? If we meet the prequalification criteria, do we have the manpower, experience, and resources to complete the job, or do we need to make adjustments?
            1. For a Boeing Field project, the majority of contractors (~80%) in WA could not bid due to prequalifications.
            2. Large contractors have advantages by being able to bring in experienced personnel from other areas of the country, having many crews assigned to the project, and having necessary equipment (MTVs, etc.).
        iii. How much work does our company already have in progress, or have we already committed to before bidding on airfield paving projects? What is the organization willing to sacrifice if it wins an airfield paving job?
        iv. Have we included airfield-specific requirements into our bid (Foreign Object Debris (FOD) mitigation, badging/training, heightened liquidated damages/penalties, test sections, delays due to security measures at job site, etc.)?
        v. Can our organization handle the financial risk?
            1. **Liquidated damages are harder to avoid on an airfield project** than on a highway project. Liquidated damages for a Department of Transportation (DOT) is a formula versus an airfield's liquidated damages are based on other factors important to the owner.

            a. Logistics and difficulty of the project, impact on airfield operations, number of runways to support airfield operations during closures, etc.
        2. Liquidated damages could be upwards of 10x larger than state DOT damages.
        3. Due to strict project time schedules, weather delays pose a greater threat to contractors and can make avoiding liquidated damages more difficult.
        4. For the Boeing Field runway paving job (2006), liquidated damages were $360,000/day; airfield only had one runway, so a 19-day full closure was required for the job.

6. What differences are there in managing airfield vs highway projects?
    a. Because airport projects don't come around very often, typically that results in a "unique set of [third-party] construction managers, owners, and third-party testing." Unlike DOT work where contractors typically see similar people on projects over the year, team dynamics on airfield jobs may be frustrating based on the relationships between parties involved in the project.
    b. For large airfield projects, arranging for additional paving crews to be available and having enough senior company members available to supervise all shifts.
        i. For larger projects, paving teams may be working double or triple shifts, depending on the project schedule and potential delays.
    c. Construction teams may work with construction management teams who do not work on airfield projects regularly, and there may be relatively junior construction managers serving as the owner's representative. Also, communication with the owner may be delayed due to having to work through a third-party representative, which can lead to issues if operations have a high tempo.
7. How does your organization prepare to execute an airfield paving project, and is this process different than what you do before a highway paving project? Preparations could include hiring additional personnel, etc.
    a. **Highways:** By bidding the project, the contractor is assumed qualified for the job.
    b. **Airfields:** For more critical airfield paving projects, owners may choose to prequalify contractors.
        i. If prequalifying, national firms have an advantage by having the capabilities to source experienced personnel from other offices.
        ii. Airfield projects are typically paved in the height of paving season (mid-summer in WA) due to project criticality and specifications (spec).
        iii. A contractor may run two or three crews per shift for 24-hour operations on large projects. Therefore, upwards of nine crews may be needed for one job, thereby limiting the capacity for additional work beyond this project.
8. How much administrative burden do airfield projects have compared to highway projects? Burdens could include security clearances, coordination with airfield operations, etc.

a. Airfield paving projects typically have **greater** administrative burdens.
    i. **Security clearances**: Security clearances vary between civilian and military airports. For civilian airports, contractors are typically given limited access to the airfield through certain gates and have a "travel corridor." For military airfield work, each truck is inspected before entering the base, which needs to be accounted for in material delivery and in bidding.
    ii. **Coordination with airfield operations**. If you are working on an airfield that will remain operational throughout the construction project, ensure compliance with airfield operations guidance and communication requirements. For trucks coming onto the site, additional time for proper airfield crossing training and driving routes should be discussed. Traffic control plans are vital.
    iii. **More documentation.** The contractor is integrated into quality control and oversight from the beginning. Requires daily documentation of internal testing and charting, which is subsequently submitted daily to the construction manager. Typically, these documents are not required submittals for a DOT job, but they are more used for internal review.

<u>Risk</u>

3. What risks do you consider when bidding airfield projects versus highway projects?
    a. For Airfields…
        i. **Schedule limitations and potential missed milestones.**
        ii. **Higher liquidated damages and more capital at risk.**
        iii. **Limits the ability to bid for/complete other work.**
            1. Airfield project represents a large percentage of a contractor's annual budgeted work
            2. Requires additional resources to finish within time limits
            3. Must be paved during the height of paving season.
4. As a contractor, what is the #1 risk associated with highway projects? Airfield projects?
    a. **Highways:** Jobsite Safety
        i. Most work is done at night near traffic.
        ii. Productivity is limited due to site access and time limitations.
        iii. DOT has started changing paving strategy due to budget restraints and has requested that contractors mill-and-inlay in single lanes. Poses risk because traffic may become more confused with traffic diversions.
    b. **Airfields:** Time Delays, with Subsequent Liquidated Damages
        i. Time delays, while impacting project schedule, could also impact a company's reputation.

<u>Contracts and Contract Claims</u>

4. For contract claims, are there differences between claims for airfield projects and claims for highway projects? If so, why?

a. **Highways:** DOT projects have fewer time constraints and cost factors. Contractors are more comfortable working with DOT on claims. DOT claims are on force-account, and claims can last years until resolution.
    i. **Interviewer Note:** A force account is a payment method used "to reimburse the Contractor for all costs associated with the Work, including costs of labor, small tools, supplies, equipment, specialized services, materials, applicable taxes and overhead and to include a profit commensurate with those costs" (WSDOT, 2020).
b. **Airfields:** Airfield projects are more like "customized" projects, and claims are negotiated through the project CM to the owner. Third-party dynamics and unfamiliarity with the CMs on airfield projects can make claims more frustrating on airfield projects. Owners can be difficult and may be more demanding due to project impacts on flying operations. Yet, CMs don't want to remain tied to a job too long beyond the project schedule, so they want to avoid outstanding claims.
    i. **Interviewer's Note:** Commercial airports rely on airlines for income; therefore, airfield closure is a major financial impact.

5. Is there a difference in compensation between federal and state paving jobs? If so, what is the range (in percent) of compensation differences?
    a. Approximately a 5% profit difference between highways and airfields.
    b. **Highways:** Profit percentages between 8-10%
    c. **Airfields:** Profit percentages between 10-15%
        i. Airfield paving is typically more expensive per ton unless highway paving has many start-and-stops (which decreases productivity).
        ii. Airfield may have higher mark-up for additional administrative burdens.
6. What organization typically provides the best project specifications, and what makes this organization stand out?
    a. "Best specs" here defined as Familiarity with Specs vs. Spec Tolerance.
    b. **Highways:** Contractors are more familiar with DOT specs, which makes understanding project specifications easier relative to airfield paving.
    c. **Airfields:** FAA and DoD have tighter tolerances/higher quality specs. They require additional information from contractors about their pavement (electronic profile information, etc.) that are not requested by the DOT.
        i. Airfields have different profile elevation standards than highways. The International Roughness Index (IRI) is used for highways, while deviation from tight/precise surface elevation design is used for airports.

<u>Compensation/Pay Factors</u>

3. Do you encounter pay factors for both airfield and highway projects? If so, are the pay factors used on highway or airfield projects preferred, and why?
    a. **Both highway and airfield projects have pay factors.**
        i. **Highways:** Under WSDOT specifications, contractors can earn up to 5% bonus per ton of asphalt for higher quality work.
        ii. **Airfields:** Contractors can never be paid more than 100% for the pay item. Any pay factors earned are used to offset less-than-satisfactory

values. For examples, a 103% pay factor can be used to offset a 97% pay factors. If contractors fall too far below specifications, they run the risk of not being paid for placed asphalt or being requested to remove-and-replace.

4. Do the pay factors adequately compensate contractors for the work needed to meet or exceed project requirements?
    a. As long as all bidders are using the same requirements for project bidding, the pay factor arrangement is fair.
    b. **While both highways and airfield projects have pay factors, they are used differently.**
        i. **Highways:** Contractors are motivated by additional pay to perform higher quality work. Pay factors compensate contractors for extra work that went into potentially extending the life of the new pavement (i.e., higher compaction equals longer life, thereby leading to higher pay factors).
        ii. **Airfields:** Pay factors are used to ensure elevated performance is maintained to meet higher specifications; these pay factors can be used to “even out” performance across the various asphalt lots.

Personnel and Training

4. How many crew members do you typically plan to mobilize for a large highway paving job? Is this number similar to what you plan for on an airfield job?
    a. **Highways:** One paving crew required for the majority (~95%) of highway projects.
        i. **Exception:** If several lanes are closed or the roadway is fully closed during construction, there may be a case for multiple crews.
    b. **Airfield:** Two to three crews typically used. Two crews for mainline paving, and one group for fillets and aprons.
        i. With an intense project schedule, double- or triple-shifts may be required, leading to upwards of 6 to 9 crews working on one project.
        ii. Due to project time constraints and potential weather issues, **contractors typically pay more overtime during an airfield projects in Washington**. For weekend work, double-time is requested for crews (union contracts).
5. How are security clearance concerns addressed for airfield paving projects?
    a. Security training and badging is required for all personnel accessing the site, including nonmilitary airports. Training requirement includes support personnel (mechanics, refuelers, etc.) who may need access to the site and truck drivers.
    b. Background checks may be required for military airfield work.
        i. Background check requirements add to the logistics of a project. Knowing truck drivers in advance gives the contractor time to complete all security training before the project start date.
        ii. If a substitute truck driver is needed, there may be a delay in operations until security training is completed. In some cases, a person who

completed the security training could ride along in the cab with an untrained driver, thereby avoiding wait time for security clearance.

6. What trainings do your crews complete when working on a highway paving project? Are additional trainings required prior to working on an airfield paving project? If so, what are these additional trainings?
    a. **Highways:** Limited additional training is required. Mostly includes discussions about project logistics and safety.
    b. **Airfield:** May include specific classes related to airfield paving
        i. FAA/CM firms may conduct "Airfield Paving 101" classes to brief differences between highway vs. airfield paving (FOD, cut-back joints, etc.)
        ii. In the project schedule: **at least one day for security/badging, one for training.**

Note: While not included in questioning, it was noted that airfield close-out is more complicated because contractors must wait 21 days after paving to groove and stripe airfield pavement.

Construction Practices and Management

Construction Site Management

3. How does your paving productivity compare between airfield and highway projects? On average, what is your production rate for airfield paving, and what impacts this rate?
    a. **Airfield paving is more productive** (in tons per hour) than highway paving.
        i. **Airfield Productivity:** 250 tons/hour
        ii. **Highway Productivity:** 175-200 tons/hour (with crews working at night with limited access).
    b. **Highways:** Highway paving crews can rarely close multiple lanes and pave in echelon; frequent starts/stops due to traffic and changes in site access. Difficult to sustain high productivity
    c. **Airfield:** Higher productivity attributed to the capability for multiple crews paving simultaneously, which is aided by runway closures or displaced thresholds during operations. Multiple crews can pave in the same section, covering more area with wider paving lanes and fewer interruptions and cold joints.
        i. For Boeing Field, 106,000 tons of asphalt were laid in 19 days for 20 hours/day. Production rate: 280 tons per hour.
4. Typically, are different plant and aggregate storage setups required for airfield jobs as compared to highway paving jobs?
    a. **Asphalt plant setups are typically the same.** The only difference is that for airfield-supporting plants, having sufficient aggregate piles crushed and on-hand ahead of time is critical as to not impact paving timelines.
    b. **Airfields:** Owners may specify that contractors have two plants available to support paving operations.
        i. Plants do not have to be the same size; however, the extra plant should be able to meet paving demands for a few hours while the main plant is repaired. Adequate stockpiling was required for the alternate location.

        ii. The ability to source/bid additional plants was identified as an advantage for large asphalt companies because bidding for asphalt from another supplier can be expensive.

<u>Foreign Object Debris (FOD) Mitigation</u>

3. What FOD mitigation measures does your organization implement for an airfield paving job, but not for a highway job?
    a. FOD mitigation, while not necessarily a priority for highway paving, is **essential for airfield projects.**
        i. FOD patrols are conducted daily to keep the site "pristine," and a final FOD walk is done before opening the airfield for operations.
        ii. Requires additional manual labor for airfield clean-up and more route sweeping within project boundaries and along truck haul route.
        iii. FOD is a huge issue for military paving projects.
    b. On airfield projects, contractors may receive unique requests or operate differently than they would on a highway project for FOD mitigation.
        i. Reduced glass beads content in airfield striping paint
            1. At Renton Airport, the owner requested using fewer glass beads in airfield paint because glass beads had damaged aircraft in the past. Resulted in contractor bringing a reflectivity expert in from Virginia to help with the project.
        ii. Pretacking to ensure tack is completely broke
        iii. Using an additive to make trackless tack.
    c. For highways, having traffic on milled pavement helps to clean pavement; however, there are safety risks for motorcyclists on milled pavement.
4. For both airfield and highway projects, how is FOD prevention priced?
    a. For proper FOD mitigation, two full-time sweepers plus FOD patrol crew (working approximately two hours) required.
    b. Line items like adequate FOD mitigation are easy items to forget in bids because airfield projects are rare, and companies don't bid on them often.

<u>Paving Operations</u>

3. Please describe typical placement operations for both airfield and highway projects.
    a. In airfield projects, how often (as a percent) is an MTV used to aid placement? For highway projects?
        i. **100%, regardless of project type**.
            1. **Interviewer's Note:** MTV use is required under FAA and DoD specifications for paving in certain areas of the airfield.
        ii. MTVs have demonstrably improved asphalt paving quality, which has been recognized widely by the asphalt paving industry.
            1. **Highways:** Close quarters on highway paving projects limit potential MTV use unless the project involves a full closure.

2. **Airfields:** Because of available space on airfields, MTVs increase production, decrease variability in paving done by differently skilled crews, and creates consistency across a paved surface.

<u>Night Paving Operations</u>

4. How often is night paving needed for an airfield project? How does this rate compare to a highway project? Please provide your answer in percentage of projects.
    a. **Highways:** 70-80% of jobs paved at night. The ability to pave during daylight hours in WA is rare, leading to more night paving-only arrangements.
    b. **Airfields:** 50% of the project schedule involves night paving because of 24-hour construction schedule. For smaller airfields with limited traffic, air operations could be restricted to certain times; however, for most projects, airfield traffic is lighter at night, and night paving is required to meet the project schedule.
5. How does night paving impact productivity and paving quality, regardless of project type?
    a. **Highways:** Production may decrease at night due to limited hours of operations (causing starts/stops). Also, it's more difficult for the tack coat to break at night because of dewpoint.
    b. **Airfields:** Night paving impacts are minimal, assuming ambient temperatures remain suitable for paving.
6. Are there any additional safety concerns to be considered during night paving operations on an airfield paving project?
    a. **Airfields:** Airfield projects require sufficient lighting for workers and quality control, so lights must be hooded or pointed away from air traffic to reduce interference with aircraft. CM teams may specify the required number of lights.
        i. Shadows may appear to be pavement defects during nighttime quality inspections, particularly shadows from rubber tire rollers (used on airfields, not highways). Contractors may need to demonstrate pavement quality to CMs during the first few days of nighttime paving.

<u>Mat Density and Longitudinal Joints</u>

5. What are typical mat and longitudinal joint densities (% of theoretical) for both airfield and highway projects?
    a. **Highways:**
        i. **Mat Density:** 92% of theoretical
        ii. **Joint Density:** No specified density. The state will randomly test for density six inches off the joint.
        iii. **Interviewer's Note:** WSDOT data shows that the average mat density of roads is ~93.5% of theoretical (zero voids)
    b. **Airfield:** FAA specifications authorize the use of either Marshall or Gyratory
        i. **Mat Density:** Surface course density is 98.3% of Marshall density
        ii. **Joint Density:** Joint density specifications are tougher for airfields. Joints are cut back using a beveled-edge wheel cutter that is attached to the grater. Therefore, a skilled grate operator is critical to ensuring airfield

joints are straight lines for further paving. Also, cores are taken on the joint for density testing

c. The FAA requires a control strip placed before project commencement, though contractors are not compensated for it. If a test section location cannot be identified on the airfield (i.e., not in the P-401 area), a test section may be placed at the project site.
    i. If the test section meets project specifications, it may remain in place; otherwise, it must be removed.
    ii. Other test section locations outside the P-401 area may not have the same base materials as what will be experienced on the airfield, but control strip pavement can stay in place.

6. What are the major issues for achieving sufficient densities for airfield and highway projects?
    a. **Highways:** Limited time and site access, thin lifts impact compaction.
        i. Contractors sacrifice compaction time to prep roadway for traffic.
        ii. Highway pavement lifts are normally no greater than 1.8 inches (15 hundredths), so there isn't much time to achieve adequate compaction before the pavement cools
        iii. There may be issues with the tack not completely breaking, which could result in pavement slipping on the tack.
    b. **Airfield:** Ensuring quality joints.
        i. Cutting back the joints must be done carefully, and equivalent coverage should be given to the joint as it is to the mat. By cutting back low-density material, joint density is more reflective of mat density.
        ii. Typically, compaction on airfield mats is not an issue because airfield pavement lifts are thicker (appx. 2.5 inches) and tend to retain heat more readily.
7. What do you use to verify mat and joint densities for these projects?
    a. **Nuclear density gauges are used in both cases to measure density**.
    b. **Airfield**: Cores are required to be taken on the joint, under FAA guidance.
        i. More emphasis is placed on cores than readings from field gauges (nuclear or non-nuclear). This emphasis seems short-sighted.
            1. Cores take significantly longer than results from other gauges used in the field.
            2. Cores for acceptance add complexity to airfield pavement projects, especially on multiplayer pavement projects.
            3. Typically, CMs are not staffed sufficiently to keep pace with fully competent contractors, which complicates issues like identifying core locations.
            4. Damage caused by taking cores can be problematic.
        ii. Have used non-nuclear gauges, and though there may be a slight difference in accuracy, this difference is made up by the fact that more

readings can be captured with non-nuclear gauges and pavement patterns identified faster than can be seen with nuclear methods.

iii. **Interviewer Note:** Contractor use of non-nuclear gauges for QC appears to be widespread in the US, and ASTM standards apply to these gauges. Research reports recommend that calibration to cores is needed for all types of gauges. An example of a non-nuclear gauge is the Trans Tech PQI 380.

8. How do you measure the quality of longitudinal joints on an airfield project? How do these processes differ from your methods used on highway projects?
    a. **Highways:** WSDOT uses a sloping step joint. Having a skilled roller operator who can confine the joint while it's being rolled is critical. The pavement has no confining edge, so it tends to spread.
    b. **Airfields:** Requires cutting back the joint and validating density with nuclear gauges. Setting the rolling pattern will ensure a uniform density across the mat (and, subsequently, on the cutback joint) and having a confining edge for the pavement to run against aids compaction. Ensure that joints are flooded with tack and not be pushed some other direction.

<u>Weather Concerns</u>

2. What weather-related paving differences have you noticed for airfield and highway projects in Eastern Washington vs. Western Washington?
    a. **Highways:** Contractors can negotiate for non-working days due to weather. They are not penalized by the state; the only "penalty" is having a mobilized crew that is unable to produce that day due to weather.
    b. **Airfields:** Generally, no allowance for non-working days due to strict project timelines. Contractors may willingly spend additional money to pave aggressively at night to avoid liquidated damages and project delays.
    c. Biggest weather concerns, by region
        i. Western Washington: Rain
        ii. Eastern Washington: Low ambient temperature

Pavement Materials and Design

4. Who typically performs mix designs for highway and airfield projects: owners or contractors?
    a. **Highways:** Two-step process with WSDOT. Contractors make the design, submit to WSDOT, then WSDOT verifies the design.
    b. **Airfields:** The mix design is verified through an accredited, third-party lab (typically) because most contractors don't have an accredited lab.
5. How satisfactory is the interaction between contractor and owner in regards to the mix design process? If not satisfactory, how can it be improved?
    a. **Highways:** Contractors are used to the WSDOT "hand-holding" system, so the interaction between contractor and owner is okay most of the time. Issues typically arise when contractors are trying to "short circuit" the process or when state gyratory compaction values are not meeting up with contractors' values.

b. **Airfield:** The FAA uses prescriptive mix designs; from the CMs' perspective, if the mix meets minimum design standards, the mix is okay. CMs may not see larger issues with the mix because they rarely work on pavement jobs.
    i. **Interviewer's Note:** "A prescriptive specification is one that includes clauses for means and methods of construction and composition of the mix rather than defining performance requirements." (Source: https://www.nrmca.org/research_engineering/P2P/About5.htm)
c. PG binders are used for both highway and airfield mixes.
d. **Aside:** In Oregon, mix designs are run through the Oregon Asphalt Paving Association, which maintains an accredited lab. Oregon DOT treats this lab as the gatekeep of their organization.

6. Are gyratory compactor/volumetric mix designs required for both airfield and highway projects?
    a. **Highways:** Yes, gyratory compactor or volumetric mix designs are required.
    b. **Airfields:** You can now use either a Marshall or a gyratory (Superpave) mix design.
        i. **Interviewer's Note:** Gyratory mix design was just recently accepted as a design for the FAA (as of July 2014 FAA AC 150/5370-10). The only concern voiced about continuing to use Marshall mix design is that the mix designs tend to have more binder (1 to 2 tenths more); however, higher binder content aids compaction efforts.

<u>Nominal Max Aggregate Size (NMAS)</u>

2. Do you prefer either 3/8" or ½" NMAS mixes? Please identify a preferred NMAS for both airfield and highway projects.
    a. **Highways:** 3/8" NMAS mixes are preferred. Mixes have higher binder contents, are easier to pave, and more impermeable. Though additional binder in the mix and increased aggregate crushing will generate higher costs, the pavement may see more long-term crack resistance. Also, Hamburg testing has helped determine the quality of 3/8" mixes earlier than before.
        i. Currently, 60-65% of WSDOT work is a 3/8" mix. However, certain project locations (bridge decks, etc.) could cause issues for contractors.
    b. **Airfields:** Nearly all airfields have ½" NMAS mixes. 3/8" NMAS mixes are rare if ever used.
    c. If contractors follow the rule of thumb of keeping the lifts 3-5 times thicker than the mix's NMAS, there should be no issues with the pavement.

<u>Voids in Mineral Aggregate (VMA)</u>

2. Do specified ranges of VMA for airfield and highway projects cause issues for your organization?
    a. **WSDOT and FAA VMA values are nearly the same.**
    b. The FAA specification is more lenient than WSDOT; however, the latter's VMA values are only used during mix design and are not needed for acceptance. As long as a mix does not collapse on contractors, VMA isn't viewed as a big deal.

c. **Interviewer's Note:** VMA is impacted by variability in a material's bulk specific gravity (Roberts, 1996). Small changes to the bulk specific gravity can change the mix's VMA.

<u>Asphalt Content and Binder Type</u>

3. What are typical asphalt contents for airfield and highway projects, respectively?
    a. **Highways:** For ½" mix, 5.2-5.3% asphalt content. For 3/8", 5.8-6.1% asphalt content.
    b. **Airfields:** ½" mix had 5.5-5.6% asphalt.
4. What typical binder types and binder additives are used on airfield and highway paving projects? If your answer varies by state, please identify the state you're referencing.
    a. Western Washington
        i. **Highways:** PG 58H-22; interstate highways would use "V."
        ii. **Airfields:** 58V-22 is typical (equivalent to a PG 70-22). Boeing Field mix (which was paved approximately 13 years ago) used a standard 64-22.
    b. Eastern Washington
        i. **Highways:** PG 64H-28

<u>Reclaimed Asphalt Pavement (RAP) Use</u>

3. What is the average percentage of RAP allowed on airfield and highway projects?
    a. **Highways:** 20%. There is one producer that makes a high-RAP mix design, so the average may be approximately 22%. However, WSDOT is thinking of decreasing the percentage of RAP.
    b. **Airfields:** The airfield surface course still cannot have any RAP in it, but the FAA spec allows up to 20% in the base courses (which requires the use of spec P-403 versus P-401).
4. Are there limitations on which HMA layers can contain RAP? If limitations exist, why does the owner limit RAP usage, in your opinion?
    a. The only limitation in RAP usage is for the top two surface courses on airfield pavement. WSDOT has specifications that delineate high-RAP mixes, and the FAA's P-403 contains guidance for the use of RAP in airfield base courses.

<u>Perpetual Pavement/Long Lasting Pavements</u>

3. Have your paving practices, regardless of project type, changed with the trend of placing long-lasting pavements?
    a. **Highways:** WSDOT increased the compaction standards and tightened the VMA spec in 2016. While these changes have helped, different methods should be used to attain higher binder contents and compaction for mixes than what has been proposed.
        i. WSDOT mixes are still on the coarse side of the maximum density line despite having tighter control of the gradation bands, and contractors can only use 5% natural sand in the mixes. All these issues occurred because ½" NMAS mixes have lower binder contents, making them a bit dry.

    ii. Contractors now check the bulk specific gravities of their mixes twice during the process: once with the mix design, and once when the paving process begins.
  b. **Airfields:** No input from the FAA on long-lasting airfield pavements.
4. Do you foresee long-lasting pavements increasing the HMA thickness on airfield or highway pavements?
  a. **Highways:** Budget issue; if municipalities could afford thicker pavements, they would choose to install thicker pavements. Currently, no WSDOT pavement has base failing issues. Failure comes from top-down cracking.
    i. Most organizations use mill-and-fill pavement replacement methods. Due to constant mill-and-fill replacement, areas may experience scabbing between pavement layers, or contractors may pave over semi-loose pavement, causing scabbing on the pavement's surface.
  b. **Airfields**: No impacts to airfield pavements.

Note: While not included in questioning, it was noted that there are issues with WSDOT's statistical (or percent within limits) specification. WSDOT does not clearly identify allowance for outlier results.

APPENDIX C: CONTRACTOR 2 INTERVIEW SUMMARY

Contracting and Project Management

1. How does your organization decide what projects to bid on? Are the criteria the same for highway and airfield projects?
    a. Tends to bid for large paving jobs, unless the project is too small for the company to be competitive for.
    b. **Typically prefer highway paving projects.**
        i. **Highways:** Lower risk, less restrictive specifications than airfield specs. **Airfields:** Higher risk, but greater reward for completing airfield work; typically has less competition due to lack of familiarity with specs. Specs are tighter, and mix may be different than what paving companies are used to.
            1. Example: For the interviewee's most recent airfield project, the aggregate was required to have 100% fractured faces. The material could not be sourced locally, so the company had to import the aggregate.
2. What differences are there in managing airfield vs highway projects?
    a. **Management, project preparation, and pavement methods used for both project types are similar**.
        i. **Airfield**: Requires additional equipment, and may need multiple crews to pave in echelon to avoid making cold joints in the pavement. Airfield projects are time-constrained, making hitting pavement production requirements important.
3. How does your organization prepare to execute an airfield paving project, and is this process different than what you do prior to a highway paving project? Preparations could include hiring additional personnel, etc.
    a. **Airfield**: Emphasis has to be placed on securing the proper rolling equipment and identifying reliable plants near the project site. If multiple crews will be working together, communication and coordination between these teams should be addressed
        i. The company had issues with team miscommunications in the past, both for airfield and highway projects (example: not choosing a person to be in charge of "cut off" at the end of the day). Typically, team dynamics iron out after the first couple of days on a project.
4. How much administrative burden do airfield projects have compared to highway projects? Burdens could include security clearances, coordination with airfield operations, etc.
    a. **Airfields:** Control charts are frequently requested by project engineers, so more contractor involvement with QC than for highways. Control charts are rarely requested otherwise; typically used only for internal tracking of mix quality.
    b. **Aside:** For Sound Transit projects, contractors are seeing an uptick in administrative burden (additional drug testing, safety training, etc.). Sending

employees for training is expensive, both in time off the job and in wages (union employees).

Risk

5. What risks do you consider when bidding airfield projects versus highway projects?
    a. **Highways:** Similar risks as airfields, but spec bar is lower.
        i. Compaction is becoming an emphasis for WSDOT.
        ii. Mat density specification was recently increased to 91.5% theoretical maximum density (TMD) and may increase to 92%.
    b. **Airfield:**
        i. Mix typically costs more due to higher binder content in the mix.
        ii. FAA-required test sections are risks; requirements to pass are tight, and they consume crew time and materials.
            1. Typically try to pave test sections where the airfield needs paving done off the airfield (frontage road, etc.). Goal: to avoid ripping up new pavement that didn't meet FAA specs.
            2. In some cases, test sections can be placed in the "P-401 area," and they can remain in place if they meet spec. Otherwise, removal required.
            3. On a recent project, the interviewee's company completed four test sections for one 50-gyration mix because they were seeing too much compaction.
6. As a contractor, what is the #1 risk associated with highway projects? Airfield projects?
    a. **Highways:** Achieving compaction, especially when paving at night with thin lifts. There's limited time to compact before the mix gets too cool.
    b. **Airfields:**
        i. A full day of paving is classified as a lot (with 4 sublots, n=4), and those lots determine pay for that paving day. If issues arise with the early lots, companies may not have enough time to make mix corrections before issues start impacting that day's pay. WSDOT's n=15 is preferred.
        ii. Test section is a financial risk.
        iii. Marshall mix designs can have density compliance issues.

Contracts and Contract Claims

7. For contract claims, are there differences between claims for airfield projects and claims for highway projects? If so, why?
    a. **Highways:** Working through claims is easier with WSDOT because contractors are familiar with state pavement engineers and have established relationships.
    b. **Airfields:** More difficult working through claims because typically working with an engineer/consultant you may never have worked with. Construction managers (CMs) on-site have to take the claim back to the FAA, and it seems like there's hardly any contact with the FAA by the contractors.
8. Is there a difference in compensation between federal and state paving jobs? If so, what is the range (in percent) of compensation differences?

    a. **Airfields:** Contractors cannot earn a bonus, but can use pay factors over 100% to offset pay factors that fall below 100%. Also, air voids spec is tighter; the company had a failed test section because of that spec.
    b. **Highways:** For highway work, up to a 5% bonus can be earned.
9. What organization typically provides the best project specifications, and what makes this organization stand out?
    a. The "best spec" is probably the easiest one to meet.
    b. Cities and counties in Washington are probably the best, with straightforward specifications and a simpler mix design process. Sometimes mix designs from 4 years ago can still be accepted.
    c. Federal Highway Administration (FHWA) also has good specs.
    d. Overall, specifications are not confusing, if you take time to read/understand them.

<u>Compensation/Pay Factors</u>

5. Do you encounter pay factors for both airfield and highway projects? If so, are the pay factors used on highway or airfield projects preferred, and why?
    a. Yes, nearly every job has pay factors, including county projects. However, the FAA's are the least desirable.
6. Do the pay factors adequately compensate contractors for the work needed to meet or exceed project requirements?
    a. As long as everyone is offered the same pay factors, contractors can bid accordingly. The interviewee's company doesn't expect to receive pay factors, but rather treats them like an earned bonus.

<u>Personnel and Training</u>

7. How many crew members do you typically plan to mobilize for a large highway paving job? Is this number similar to what you plan for on an airfield job?
    a. **Highways:** Depending on the paving job, two crews may be required, but that's not always the case.
    b. **Airfields:** Typically hire two to four additional people: two to support rolling efforts, and two for cutting the cold joint on an FAA project. Typically, two crews for airfield jobs.
8. How are security clearance concerns addressed for airfield paving projects?
    a. Security requirements for airfield projects vary.
        i. Seattle-Tacoma International Airport (Sea-Tac) and Portland International Airport are the most difficult for security due to additional training and background check requirements.
        ii. For King County/Boeing Field, badging was required but wasn't extensive. Badging was not required for truck drivers.
        iii. For smaller jobs, no identification may be required.
    b. **For military installations**: Typically, truck drivers are required to register/have base-issued identification before entering the site. Also, depending on the

installation, there may be checkpoints to gain entry to job site. In some cases, DoD project specs are tougher to meet than the FAA's.

   c. **Side note:** Our interviewee's company stopped bringing their nuclear density gauges onto military installations because base officials wanted additional testing on these gauges. Now, they contract with a private testing company for nuke density testing rather than bringing their equipment.

9. What trainings do your crews complete when working on a highway paving project? Are additional trainings required prior to working on an airfield paving project? If so, what are these additional trainings?
   a. **Airfields:** Typically host various meetings to review project requirements (minimizing cold joints, etc.), plus general safety and compaction classes.
   b. **Highways:** No additional training outside of general safety training and compaction classes.

Construction Practices and Management

Construction Site Management

5. How does your paving productivity compare between airfield and highway projects? On average, what is your production rate for airfield paving, and what impacts this rate?
   a. **Higher production** on airfield projects than on highway/street projects.
   b. **Highways:** Traffic impacts working hours and limits productivity. Difficult to achieve high production on city street projects. To meet productivity requirements, contractors pave at night, unless WSDOT or the city grants an extended closure. Typically, 55-hour closures are used for crack-and-seal overlays.
   c. **Airfields:** Probably have higher production compared to other work. During a Portland airport paving project, nearly 4,000 tons of asphalt per day were routinely paved.
6. Typically, are different plant and aggregate storage setups required for airfield jobs as compared to highway paving jobs?
   a. No, the same aggregate is used for both plant setups. The interviewee's company has plants near almost every airfield in Western Washington, so it can support paving at various locations. The company previously used portable plants for airfield paving projects in the San Juan Islands (with aggregate sources from off-island sites) but hasn't used this technology for any other projects.

Foreign Object Debris (FOD) Mitigation

5. What FOD mitigation measures does your organization implement for an airfield paving job, but not for a highway job?
   a. **Highways:** FOD mitigation is not a high emphasis item outside of when contractors are grinding.
   b. **Airfields:** Contractors have to be meticulous about sweeping.
6. For both airfield and highway projects, how is FOD prevention priced?

a. The interviewee’s company specializes in paving, so it typically subcontracts additional work (e.g., sweeping, electrical, drainage) on airfields to other organizations.

Paving Operations

4. Please describe typical placement operations for both airfield and highway projects.
    a. In airfield projects, how often (as a percent) is an MTV used to aid placement?
        i. **Mainline Paving**: MTV used 100% of the time.
        ii. **For smaller projects**, MTV wasn’t used because the project was small and involved paving at different locations across the airfield.
    b. In highway projects, how often (as a percent) is an MTV used to aid placement?
        i. **Mainline Paving:** MTV used 100% of the time.
        ii. Elsewhere on the highway or for smaller projects, MTV usage varies.
    c. **Aside:** For smaller paving companies, justifying the purchase of an MTV is difficult if a company isn’t awarded projects requiring them. Having access to this equipment gave the interviewee’s company an advantage over smaller companies.

Night Paving Operations

7. How often is night paving needed for an airfield project? How does this rate compare to a highway project? Please provide your answer in percentage of projects.
    a. **Highways:** Most work is done at night to reduce impacts from traffic.
    b. **Airfield:** For most airfield pavement projects, the interviewee’s company paved during the day. They haven’t done night paving on an airfield in a while, and in those scenarios, they paved at night due to the 24-hour project schedule.
    c. Use standard lighting equipment for paving at night, regardless of project type. Additional time may be needed at the beginning/end of the shift for lighting set-up/take-down.
8. How does night paving impact productivity and paving quality, regardless of project type?
    a. Interviewee’s company tries to not have night paving impact productivity.
    b. Pavement quality issues can occur during night paving.
        i. Rollers may miss sections more easily.
        ii. Pavement could experience shoving or cracks, which are hard to see at night.
    c. Distresses can make mat texture worse during night paving operations, but companies hope mat distresses can be fixed with minor repair work.
9. Are there any additional safety concerns to be considered during night paving operations on an airfield paving project?
    a. **Highways:** Paving at night is **more dangerous**. Traffic may be confused by traffic changes, drunk drivers pose a threat, and truck drivers may not be able to see well when they’re backing up.

b. **Airfields:** Night paving is better because you do not have active traffic. Still have issues with poor visibility for truck drivers and while working around the paver. Slips, trips, and falls could be more hazardous at night.

Mat Density and Longitudinal Joints

9. What are typical mat and longitudinal joint densities (% of theoretical) for both airfield and highway projects?
    a. **Highways:** In Washington, no joint density spec, but WSDOT will test randomly every six inches along the joint.
    b. **Airfields:** Joints are cutback six inches. Joint density must be 90.5% TMD, and nuke gage measurements/cores are taken on the joint. The surface course must be 92.8% TMD.
10. What are the major issues for achieving sufficient densities for airfield and highway projects?
    a. **Airfields:** Biggest issue is the upper limit on compaction, especially for the 50-gyration mix. The interviewee's company failed four test sections on one airfield job due to too much compaction. For airfield projects, contractors want to achieve as much compaction as possible, so they hardly ever worry about having too high of compaction. If joint specifications aren't met, penalties are incurred.
    b. **Highways:** Limited time to meet compaction due to thin lifts and ambient temperatures.
11. What do you use to verify mat and joint densities for these projects?
    a. In both highway and airfield cases, we use nuclear density gages for verifying mat and joint density.
    b. **Airfields:** Contractors are required to core for acceptance. Measure the density with the nuke gage before the core is taken and then compare that measurement to the core's actual density.
    c. The interviewee's company has used non-nuclear gages before, but in their experience, results weren't consistent enough for their company to be comfortable using them.
12. How do you measure the quality of longitudinal joints on an airfield project? How do these processes differ from your methods used on highway projects?
    a. **Highways:** No cutting the joint, and no density tests on the joint. No coring is required to verify compaction.
    b. **Airfields:** Cores are taken on the joint to verify longitudinal joint quality. With cores, it may take nearly 24 hours for density results, whereas contractors can verify the density with a nuke gage before the pavement cools.

Note: Airfields typically do not experience secondary compaction; hence, the heightened density spec.

Weather Concerns

3. What weather-related paving differences have you noticed for airfield and highway projects in Eastern Washington vs. Western Washington?
    a. Late season paving is an issue in Western Washington.

i. **WSDOT:** Wearing course cannot be paved from 1 October to 1 April.
ii. **FAA:** No paving cutoff date.
iii. While our interviewee's company typically doesn't pave in Eastern Washington, he noted that paving contractors may have an easier time enforcing WSDOT's paving window due to cooler temperatures.
iv. In Western Washington, owners sometimes want us to pave late into the season, like the airfield his company finished this November.

b. **Aside:** Pavement typically performs better if paved the job early in the paving season and exposed it to traffic and hot weather before winter hits. If contractors wait until later, the pavement seems to suffer more from the weather (e.g. rain) and exposure to studded tire wear in Western Washington.

Pavement Materials and Design

7. Who typically performs mix designs for highway and airfield projects: owners or contractors?
    a. **Highways:** Contractors do the mix designs, which are subsequently validated by WSDOT. The interviewee's company submitted about 20 gyratory mix designs in 2019 to the state.
    b. **Airfields:** Airfield mixes must be certified by an accredited lab, which we do not have internally. In the past, we've used the same lab that's conducting the acceptance testing for our mix designs. We have been using more gyratory mixes than previously, so our selection is limited to labs that run those tests. We don't currently have a local lab capable of doing these verifications.
8. How satisfactory is the interaction between contractor and owner in regards to the mix design process? If not satisfactory, how can it be improved?
    a. **Highways:** WSDOT verifies mix designs and charges $10,000 to do so. If the mix doesn't meet spec, WSDOT can reject the mix, and it costs another $10,000 to verify another mix.
    b. **Airfield:** The FAA uses a prescriptive mix, so as long as you follow their "checklist," there should be no issues.
9. Are gyratory compactor/volumetric mix designs required for both airfield and highway projects?
    a. **Highways:** Gyratory is required.
    b. **Airfields:** Either Marshall or gyratory.
    c. **Aside:** During his time in pavements, the interviewee noted that, as an industry, contractors have had to learn the impacts that VMA and air voids have on the pavement. When he first started, "we gave all our rock to the state and they did the mix design, or for an airport, we gave it to somebody else and they [did] the mix design… and now, it's a pay factor, [so] you have to learn what it is."

<u>Nominal Max Aggregate Size (NMAS)</u>

3. Do you prefer either 3/8" or ½" NMAS mixes? Please identify a preferred NMAS for both airfield and highway projects.

a. **I like the look of 3/8" HMA better**. It may be more impermeable, but I don't know that it results in a better product. Compaction is critical to pavement quality, regardless of NMAS. Also, I think there is a greater risk of aggregate segregation with larger NMAS mixes.
b. **Airfields:** Done one 3/8" mix at an airfield; otherwise, ½" specified mix. However, the FAA recently changed its gradation specification, making the mix finer. This change makes mix specifications harder to meet.

<u>Voids in Mineral Aggregate (VMA)</u>

3. Do specified ranges of VMA for airfield and highway projects cause issues for your organization?
    a. The lower the VMA, the less oil is used in the mix. It's to the contractor's advantage to keep VMA within spec but low. VMA is highly influenced by fine aggregate specific gravity, and there have been issues with variability in testing.
    b. **Highways:** Contractors can pass their mix design with WSDOT if they are within 1% of the specification (due to VMA being impacted by variability with fine aggregate specific gravity). However, following the state's mix verification test, the state uses its VMA value, which may be different than the value the contractor initially had with their design.
    c. **Airfields:** For the FAA, our interviewee's company has an independent lab make and verify their mix designs, and they can use the same value for VMA throughout the process.

<u>Asphalt Content and Binder Type</u>

5. What are typical asphalt contents for airfield and highway projects, respectively?
    a. Asphalt content varies widely, depending on the aggregate source/quality.
    b. **Highways:** Asphalt content varies by plant. The lowest asphalt content is 5.1% for a ½" 100-gyration mix. Highest asphalt content is 6.1% for a ½", 75-gyration mix.
    c. **Airfields:** Typically, mixes contain 2-4 tenths more oil than highway mixes.
6. What typical binder types and binder additives are used on airfield and highway paving projects? If your answer varies by state, please identify the state you're referencing.
    a. Previously, the same binder was used on both highways and airfields in Western Washington. In both cases, a common binder is 64-22. Counties are starting to follow suit and use similar binders to WSDOT specs.

<u>Reclaimed Asphalt Pavement (RAP) Use</u>

5. What is the average percentage of RAP allowed on airfield and highway projects?
    a. 20% RAP is standard for both highway and airfield base layers (P-403 specifications). The FAA has only recently started allowing RAP in mixes.
6. Are there limitations on which HMA layers can contain RAP? If limitations exist, why does the owner limit RAP usage, in your opinion?
    a. Limited RAP usage in various layers "is due to people using RAP in a bad way and not getting a good product, and that happened 30 years ago... people are still worries about [RAP usage]."

b. However, mixes with RAP over 40% have been shown to have significant performance issues, and the best binders for these types of mixes haven't been identified yet.

Perpetual Pavement/Long Lasting Pavements

5. Have your paving practices, regardless of project type, changed with the trend of placing long-lasting pavements?
    a. Paving practices have not changed because of the long-lasting pavement trend, but the understanding of how the depth of pavement impacts where stresses show up in the pavement has improved. Contractors and roadway agencies are seeing cracking on top of the pavement, not in lower layers.
6. Do you foresee long-lasting pavements increasing the HMA thickness on airfield or highway pavements?
    a. **Airfields:** No. In his observation, out interviewee notes that airfields do not appear to distress the same way highways do. They appear to "rot just from sitting there not being used, but it doesn't seem like they've failed from traffic."
    b. **Highways:** WSDOT understands the importance of having thicker pavements. For the cities and counties, they understand the principle, but money isn't available for new roads. Rather, the agencies are continuing with maintenance for now.

APPENDIX D: CONTRACTOR 3 INTERVIEW SUMMARY

Contracting and Project Management

9. How does your organization decide what projects to bid on? Is the criteria the same for highway and airfield projects?
    a. **Highway and airfield project bidding principles are completely different due to risk.**
        i. **FAA:** More risk, stricter criteria, higher liquidated damages (LDs).
            1. Pullman Airport: $8,000 every 15 minutes for LDs on 7-day, 24-hour project
        ii. **WSDOT:** Less risk, lower LDs (at least in Eastern Washington).
            1. Western Washington may see higher LDs due to traffic density.
            2. WSDOT typically has a longer contract paving window than FAA.
    b. When deciding on projects to bid on, contractors use two basic criteria:
        i. How many projects have we already committed to?
        ii. What time of year are we bidding?
            1. Later in the year, companies may already have several commitments for next year, which may influence how much percentage they put on additional work.
10. What differences are there in managing airfield vs highway projects?
    a. **There are minimal differences between managing airfield and highway jobs.**
        i. Differences with FAA: Pavement laydown (due to higher compaction limits); tighter grade/elevation tolerances.
        ii. Differences with WSDOT: Ride bonus, which is not offered with the FAA.
    b. **Management is more involved on an airfield project** due to the higher risk tolerances. Interviewee "had to be on every airport job his company had," but he didn't feel he needed to be as involved with WSDOT jobs ("I can do those over the phone.").
11. How does your organization prepare to execute an airfield paving project, and is this process different than what you do prior to a highway paving project? Preparations could include hiring additional personnel, etc.
    a. **Elite paving crews are selected for airfield jobs, which impacts bidding if a company is already committed to DOT work.**
        i. Different mobilization costs (if bringing teams in from outside the region); additional costs for having employees "out of town" and not in their normal region.
        ii. Slightly different relations with DOT personnel, at least early in the project.
            1. Pulling elite crews causes "minor grief" for DOT personnel; typically resolved early in the project.

        a. DOT feels their project isn't given the same priority as an airfield job, and they are no longer working with the paving crew they're used to.
        b. Sometimes have issues understanding contractor's priorities assigned to projects.
      2. From the contractor's perspective, airfield and highway projects don't have the same priority. Airfields are higher priority due to additional risks, stricter specifications, FAA being less forgiving of deficiencies, etc.
  b. **FAA:** If pavement does not meet specification, they are more apt to request it be "ripped out" versus coming to terms and continue working despite deficiencies, like WSDOT.
    i. WSDOT may dock pay but rarely requests pavement be ripped out.
    ii. Perhaps for WSDOT, it's more about public perception and being good stewards of funding.

12. How much administrative burden do airfield projects have compared to highway projects? Burdens could include security clearances, coordination with airfield operations, etc.
  a. **Airport projects have more detailed submittals with earlier due dates.**
    i. FAA: Requires mix designs be submitted 30 days before paving starts, and 10 days before placing P-209, base course.
      1. If there are mix design issues or the mix gets rejected, the threat of heightened LDs looms.
      2. FAA typically moves pretty quickly on mix design approval.
    ii. WSDOT: Requires less submittals, though mix design has to go through headquarters verification testing.
      1. WSDOT has 25 days to verify the pavement; typically, testing takes that whole time.
      2. Rejected mix designs from WSDOT results in another 25-day delay, which puts contractors at risk of LDs.
        a. "The Materials Lab at WSDOT doesn't understand the effect of a mix design being rejected, which causes another 45-day delay to the contract and [increases] the risk to the contractor to meet the contractual days without going into liquidated damages."
      3. WSDOT has been having issues with tightening the VMA spec this year, which led to several mix designs being rejected.
        a. Tightening the spec could increase contract prices because of the additional risk to contractors.
  b. The interviewee feels frustration with the strained relationship between contractors and WSDOT over spec writing and mix design test results.

<u>Risk</u>

7. What risks do you consider when bidding airfield projects versus highway projects?

    a. **Airfields:** #1 Compaction, #2 Testing, #3 Grade
    b. **WSDOT**: #1 HMA Testing, #2 Compaction, #3 IRI
        i. The main issue with testing is the inexperience and turnover of testing staff and general lack of training.
            1. The staff does not realize that failing a mix design could mean penalties for contractors.
        ii. Delayed test results frustrate contractors because of the risk in 1) how different organizations test, and 2) consequences resulting from a failed test.
        iii. The testing results coming out of WSDOT testing are the results used, not the contractor's. This issue has historically raised questions about DOT testing methods/procedures.
8. As a contractor, what is the #1 risk associated with highway projects? Airfield projects?
    a. See above.

<u>Contracts and Contract Claims</u>

10. For contract claims, are there differences between claims for airfield projects and claims for highway projects? If so, why?
    a. **FAA: Claims are almost an impossibility**; the FAA doesn't negotiate. Specs are so high already, and just like the "rip out poor pavement" mentality, there is little potential for negotiation.
        i. "If you want to go to court with FAA, they'll go to court with you." The spec is already high, so FAA says, "Move on, you know the specs."
    b. **WSDOT:** Typically, WSDOT will negotiate and work to keep pavement in place, despite it being deficient (which results in a pay cut for the contractor).
11. Is there a difference in compensation between federal and state paving jobs? If so, what is the range (in percent) of compensation differences?
    a. **FAA:** Contractors can only make 100% on the project (no additional bonus money), despite heightened risks.
        i. Contractors' compensation on an airfield project comes from padding a contract for the additional risk.
            1. Contractors assume the worst will happen on an airfield job, like multiple test sections, grade issues, etc.
            2. Contractors may request a recore; FAA uses only that recore value, regardless of whether it is better or worse than the original value.
    b. **WSDOT:** Contractors can make "bonus money."
        i. Contractors assume they can secure bonuses, despite potentially having issues along the way.
12. What organization typically provides the best project specifications, and what makes this organization stand out?
    a. **Each agency has its good and bad aspects.**
    b. **FAA:** Contractors know they are facing tighter specs and know what they're facing.

        i. Primary Issue: FAA is moving to gyratory specifications whereas they used to only use Marshall. Specifications are changing.
    c. **ODOT/WSDOT:** Similar specs.
        i. For WSDOT, specs can change from region-to-region under General Special Provisions (GSPs).

<u>Compensation/Pay Factors</u>

7. Do you encounter pay factors for both airfield and highway projects? If so, are the pay factors used on highway or airfield projects preferred, and why?
    a. **FAA:** Contractors can't make more than 100% on airfield projects, so they compensate for potential issues by padding project bids.
    b. **WSDOT:** Contractors take into account the bonus money they can achieve on the project.
8. Do the pay factors adequately compensate contractors for the work needed to meet or exceed project requirements?
    a. **Pay factors are very just as they are.**
        i. However, pay factors are only as good as the testing which validates them.
            1. The pay factors are adequate, but correct QA testing is critical, and the testers are only as good as their training.
            2. Contractors want to try to educate testers to 1) ensure tests are run properly and accurate data is provided, and 2) to build relationships and help them be more prepared for the next job.
    b. **FAA:** Contractors keep to 2,000 tons/day.
        i. Risk is too high on pay lots to warrant going beyond that tonnage.
        ii. 4 joint cores, 4 mat cores, 8 VMAs, 8 V_as are required for a 2,000-ton lot.
    c. **WSDOT:** 2,000 tons could be one test, so the risk is significantly lower.

<u>Personnel and Training</u>

10. How many crew members do you typically plan to mobilize for a large highway paving job? Is this number similar to what you plan for on an airfield job?
    a. **Both jobs have the same amount of people (8-man crews).**
        i. Interviewee requires himself to be at an airfield job, but not a WSDOT job.
        ii. Elite paving crews (i.e., the most experienced) are mobilized for airfield paving. Teams understand the criticality of the project and have experience with the specs.
        iii. May have issues with nerves for some members of these teams, because they're aware of the high risks involved in the project.
11. How are security clearance concerns addressed for airfield paving projects?
    a. "It sucks."
        i. Security clearances are time-consuming.
            1. All-day class is required before personnel being able to access the job site, including truck drivers.

        2. Regardless of the size of an airfield project, the class is required for every project.
    ii. Trucks must be labeled as specified, and gate guards/gate passes are required to help truck traffic.
    iii. Security and safety are strictly enforced on airfield jobs; violations may result in personnel being taken off the job.
    iv. In comparison to WSDOT projects, access to WSDOT projects is no issue.
  b. FAA requires a weekly, 2-hour in-depth meeting to go over various project aspects: testing, mix values, grade tolerances, safety, trucking, etc. Required for management.
    i. Though the meeting is two hours, the company cannot pave at that time; therefore, meeting delay cuts into half a day of paving, sometimes.
  c. Biggest nemesis on airfield projects: Truck Drivers
    i. Issues with DOT-specified driving hours. Exceeding weekly driving hours not only impacts the driver but also the company, because that driver will need to be replaced.
    ii. Training extra drivers is critical; don't want to delay a project because new truck drivers haven't been through the FAA training.

12. What trainings do your crews complete when working on a highway paving project? Are additional trainings required prior to working on an airfield paving project? If so, what are these additional trainings?
  a. No additional training outside of safety meetings for either job.
  b. Drug tests for certain projects, but haven't historically had any issues.

Construction Practices and Management

Construction Site Management

7. How does your paving productivity compare between airfield and highway projects? On average, what is your production rate for airfield paving, and what impacts this rate?
  a. **FAA:** 2,000 tons/day for an airport, due to testing and sublot requirements. Contractors bid accordingly.
  b. **WSDOT:** average 3,000 tons/day, but if the project is close to the plant servicing the project, contractors may bid 4,000 tons/day.
8. Typically, are different plant and aggregate storage setups required for airfield jobs as compared to highway paving jobs?
  a. Stockpile setups are the same.
    i. No RAP on an airport job (rarely see a P-403 specification).
    ii. Airfield projects typically require more binder due to the lower design voids and higher in-place density.

Foreign Object Debris (FOD) Mitigation

7. What FOD mitigation measures does your organization implement for an airfield paving job, but not for a highway job?
  a. **Mitigation measures are the same for both projects.**

        i. FAA is stricter regarding site clean-up, so contractors sweep more often. However, debris is relatively minimal as compared to some WSDOT projects (example: I-90).
        ii. The biggest FOD issue on an airfield is cab debris from truck drivers, particularly if switching day- and nighttime drivers at the project site. Interviewee suggested that contractors consider advocating for drivers to clean their cabs before arriving on-site.

8. For both airfield and highway projects, how is FOD prevention priced?
    a. **FOD prevention treated the same on airfield and highway projects**.
        i. For airfield projects, contractors may require more sweeping to be done, but the equipment used is the same.

<u>Paving Operations</u>

5. Please describe typical placement operations for both airfield and highway projects.
    a. In airfield projects, how often (as a percent) is an MTV used to aid placement?
        i. 100% of the time; full-time requirement.
    b. In highway projects, how often (as a percent) is an MTV used to aid placement?
        i. Typically, 100% of the time, unless the project is too small to warrant/fit it.
            1. MTV has multiple benefits, not only for the contractor but also for the DOT.
            2. "We love to have the Shuttle Buggy out there. I think it's great; [it] holds a lot of mix, saves segregation, keeps you from having cyclic density so bad. It's a benefit to us."

<u>Night Paving Operations</u>

10. How often is night paving needed for an airfield project? How does this rate compare to a highway project? Please provide your answer in percentage of projects.
    a. **FAA:** Rarely done. Only paved one airport at night, due to the project schedule (Pullman, 7-day, 24-hour closure).
    b. **WSDOT:** – Mix of day and night paving, but mostly day paving in Eastern Washington. However, night paving is preferred at locations with high traffic densities to avoid impacts to the traveling public.
11. How does night paving impact productivity and paving quality, regardless of project type?
    a. **The night paving window is a risk.**
        i. Unlike with day paving, where a plant can be run ~10 hours, the night paving window may only allow 4-hours of plant time per night.
        ii. Contractors hope to run 300 tons per hour, but due to the shortened window, not much paving can be done per night, which impacts the bid and project contractual days.
        iii. Contractors may bid as low as 1,000 tons/day on a project, which impacts the project timeline.

    b. Contractors are penalized for being on-site after the paving window, so plant shut-down times have to be hard-stop times.

12. Are there any additional safety concerns to be considered during night paving operations on an airfield paving project?
    a. **Airfield:** No live traffic, and any traffic on the airfield is scheduled. Contractors have time to stop production, move off the airfield, and conduct FOD clean up before aircraft arrival.
    b. **Highway**: Greatest risk is live traffic and the speed of that traffic.
        i. Drivers are not paying attention to construction zone signage, which is placing both drivers and construction personnel at risk. Are current project signage and lighting requirements enough?
        ii. Beware of truck drivers backing up at night. Performance on-site toward the end of the week (as people get tired) is worse, which raises safety concerns.

<u>Mat Density and Longitudinal Joints</u>

13. What are typical mat and longitudinal joint densities (% of theoretical) for both airfield and highway projects?
    a. **FAA**: 96.5% mat, 93.3- 95.3% for joints, based on Marshall density. However, FAA is moving to theoretical max density (TMD)
        i. For the Pendleton Airport, it was 96.5% TMD for the mat.
        ii. Interviewee voiced concern about the extremely high compaction of HMA on airfields.
    b. **WSDOT:** 93.5% average mat density, with mat density ranging between 93%-95%. Minimums: 91.5% for WSDOT, and 92% for ODOT.
        i. Additional binder (0.1-0.2%) can aid compaction; compaction is costly.
14. What are the major issues for achieving sufficient densities for airfield and highway projects?
    a. No, as long as the base course (or P-209 layer) is properly compacted. Additional binder in the asphalt mix (because FAA is designed on 3.0 V_a) aids during compaction.
15. What do you use to verify mat and joint densities for these projects?
    a. Nuke in both cases; the interviewee’s company owns its own nuke gages.
16. How do you measure the quality of longitudinal joints on an airfield project? How do these processes differ from your methods used on highway projects?
    a. Airfields are flat, whereas highways have superelevation.
        i. If centerline joints on highways were compared to airfield joints, “the pinching of those two differences are night-and-day.”
        ii. WSDOT uses a diluted tack and pinching, whereas, with an airfield, the roller operators have to complete that joint a different way.
    b. Echelon (or side-by-side) paving is preferred as compared to having to cut longitudinal joints. For this style of paving, 2-3 crews will be used (but it’s rare).
        i. If contractors can keep pavement temperatures above 175 degrees Fahrenheit, joints don’t have to be cut. However, if the pavement dips

below this value, contractors must wait to cut the joints until the internal temperature of the pavement is less than 135 degrees Fahrenheit. Waiting for the internal temperature to drop results in a time delay ("easily 3 hours of downtime"). Plus, cutting joints requires FOD mitigation.

   ii. For most projects, the contractor must sawcut joints, including on the control strip.
   iii. If multiple crews are used, they are fed out of the same plant to avoid having to submit and test additional mix designs from another plant.

Weather Concerns

4. What weather-related paving differences have you noticed for airfield and highway projects in Eastern Washington vs. Western Washington?
   a. Western Washington: Moisture issues and fewer days of nice weather to pave.
   b. Eastern Washington: Not many weather delay days. Not nearly as much moisture, so tack breaks quickly.
   c. Regardless of the region: **if the weather calls for rain, the FAA will not allow paving that day**. The FAA will make the weather call in the morning and inform the contractor whether paving will happen that day.
      i. FAA "gives a [weather] day automatic; you don't have to fight for it, and you move on."
      ii. This process is the opposite of WSDOT's, who typically leaves determining weather days to the contractors, and then the parties have to coordinate rain/weather days.

Pavement Materials and Design

10. Who typically performs mix designs for highway and airfield projects: owners or contractors?
   a. **FAA:** An AMRL-certified lab does the mix design. Two certified labs are located in Central/Eastern Washington, and the lab must have a Professional Engineer (PE) to approve mixes.
   b. **WSDOT:** Contractors design the mix, then send them to headquarters for validation.
11. How satisfactory is the interaction between contractor and owner in regards to the mix design process? If not satisfactory, how can it be improved?
   a. **FAA:** Relationship is "cut-and-dry." FAA looks at the data provided by the engineering lab to confirm compliance with the specifications, and then the contractor is responsible for showing performance on the test strip.
      i. Risk and responsibility for mix design quality/performance is solely on the contractor, once the mix is approved by the certified lab.
      ii. The big item is getting P-401 design completed early, if possible, so design approval does not impede paving and contract timeline.
   b. **WSDOT:** Good interaction across the board, but continued testing issues have strained the relationship between WSDOT and contractors.

        i. WSDOT keeps some risk by running its mix validation processes, which costs contractors $10,000 per mix design. This method has minimal, if any, benefit for contractors.
        ii. In a way, the FAA method was preferred by the interviewee over WSDOT's current "risk partnering" system.

12. Are gyratory compactor/volumetric mix designs required for both airfield and highway projects?
    a. **FAA:** Depends on the job; Marshall or gyratory may be specified.
    b. **WSDOT:** Gyratory for all projects.

<u>Nominal Max Aggregate Size (NMAS)</u>

4. Do you prefer either 3/8" or ½" NMAS mixes? Please identify a preferred NMAS for both airfield and highway projects.
    a. **FAA:** ½"
    b. **WSDOT:** Selected NMAS depends on where the roadway is.
        i. **3/8" should not be used on interstates or mountain passes.**
            1. 3/8" mix has too much liquid and not enough aggregate to support loads, so it's susceptible to rutting.
            2. In Eastern Washington, because of higher temperatures, pneumatic compaction impacts pavement, and the region suffers from freeze-thaw.
            3. Current WSDOT 3/8" NMAS gradation is cause for concern and needs to be rewritten, according to the interviewee.
        ii. ½" mix is better for high-traffic roadways (like I-90) and mountain passes that are susceptible to truck traffic. Contractors have to work harder to meet density, but it may be less vulnerable to pneumatic compaction (secondary consolidation).

<u>Voids in Mineral Aggregate (VMA)</u>

4. Do specified ranges of VMA for airfield and highway projects cause issues for your organization?
    a. No; the VMA specifications are not currently an issue.
        i. However, in the case of WSDOT, if contractors are not allowed to change other aspects of the mix design (gradation, etc.), meeting VMA requirements will become more difficult, thereby impacting HMA quality.

<u>Asphalt Content and Binder Type</u>

7. What are typical asphalt contents for airfield and highway projects, respectively?
    a. **½" for FAA at 75-gyration**: 5.8% oil content (with 3% V_a)
        i. For airfield projects, contractors like to have higher binder contents to meet compaction specifications. Idea: Run low air voids and high compaction.
        ii. Typically, a 75-gyration is specified, but sometimes, a 50-blow gyration will be spec'd. However, from a contractor's perspective, the mix has too much liquid in it; 125-gyration mix is at the opposite extreme.

b. **½" for WSDOT at 75-gyration**: 5.4% oil content (with 4% V_a).
   i. Spec-ing 100-gyration roadway requirement depends on ESAL limits.
c. The difference in binder content between highway and airfield is due to the difference in air voids. Typically, there is a 3-4 tenths difference.

8. What typical binder types and binder additives are used on airfield and highway paving projects? If your answer varies by state, please identify the state you're referencing.
   a. **FAA:** PG 70-28, 70% ER
      i. WSDOT used to request 60% ER.
   b. **WSDOT**: Mostly use 64H (like a 70-28), 64V (for SMA mixes), and some 64S.
   c. No different additives between the two project types.
      i. However, WSDOT has seen a decrease in antistrip use since implementing the Hamburg Test. Question: Is the Hamburg catching indications of raveling?
         1. Interviewee thinks raveling potential can be related to the aggregate source. For example, if contractors are running granite vs. basalt aggregate.

<u>Reclaimed Asphalt Pavement (RAP) Use</u>

7. What is the average percentage of RAP allowed on airfield and highway projects?
   a. **FAA:** Most times, 0%.
      i. P-403 could have 20%, but P-403 is rarely used.
   b. **WSDOT:** Company doesn't go over 20% of RAP. Beyond 20%, WSDOT designates that mix as a "high-RAP" mix and outlines various other requirements (example: dedicated stockpiles, etc.).
8. Are there limitations on which HMA layers can contain RAP? If limitations exist, why does the owner limit RAP usage, in your opinion?
   a. **FAA:** No RAP in surface course.
   b. **WSDOT:** No additional limitations, unless specified by the region.
   c. **ODOT:** No RAP in the wearing course; may have RAP in the base course.

<u>Perpetual Pavement/Long Lasting Pavements</u>

7. Have your paving practices, regardless of project type, changed with the trend of placing long-lasting pavements?
   a. With the specifications currently provided by WSDOT for 3/8" HMA, "I think [WSDOT's] getting exactly what they need to get."
      i. Though contractors could provide WSDOT with better products, their actions are limited by the current specifications. Contractors need more latitude in the design parameters of mixes if they are to be able to work with WSDOT on this idea of "long-lasting pavements."
8. Do you foresee long-lasting pavements increasing the HMA thickness on airfield or highway pavements?
   a. **The thickness of the pavement system may not change, but the asphalt lift thicknesses must be designed to have the proper NMAS-to-lift-thickness ratio to aid pavement performance.**

b. Thin lifts are hurting WSDOT.
    i. Thin lifts are used due to budget constraints.
    ii. Though thin lifts save money in the short run, they have a shorter lifespan and break down before strategic maintenance can be used.
c. 3/8" mix works best for thin lifts; ½" mix is too dry to meet compaction.
d. Thin lifts not meeting the proper NMAS-to-lift-thickness ratio are at risk of early failure.
    i. They will look similar to highly-compacted asphalt pavements on FAA projects (a "crack seal nightmare").
    ii. Aggregate in a ½" mix can be larger than ½" (as long as it passes through the ¾" sieve), and without the proper lift thickness, contractors break aggregate as they compact the mix.

APPENDIX E: GLOSSARY OF TERMS

Term	Definition
Commercial Service	Public-use airports that enplane a minimum of 2,500 passengers annually through a scheduled passenger service (Wells, 2000).
Primary	Commercial, public-use airports handling, at minimum, 0.01% of passengers enplaning at U.S. airports annually (Wells, 2000).
Large Hub	Airports that support, at minimum, 1% of the U.S.'s total enplanements (Wells, 2000).
Medium Hub	Airports that support 0.25% to 1% of the U.S.'s total enplanements (Wells, 2000).
Small Hub	Airports that support 0.05% to 0.25% of the U.S.'s total enplanements (Wells, 2000).
Nonhubs	Airports that support fewer than 0.05% of the U.S.'s total enplanements; value must exceed 10,000 enplanements (Wells, 2000).
Other	Commercial airports that enplane between 2,500 to 10,000 passengers annually (Wells, 2000).
Force Account	"The objective… is to reimburse the Contractor for all costs associated with the Work, including costs of labor, small tools, supplies, equipment, specialized services, materials, applicable taxes and overhead and to include a profit commensurate with those costs" (WSDOT, 2020).
General Aviation	Airports that enplane less than 2,500 passengers annually and typically used by business or private aircraft, not regular commercial service (Wells, 2000).
Methods-Based Specifications	Methods-based specifications explicitly outline construction methods and materials to be implemented by contractors throughout the paving process (LaVassar, Mahoney, & Willoughby, 2009).
National Plan of Integrated Airport Systems (NPIAS)	Comprised of all reliever and commercial service airports, as well as a collection of publicly-owned general aviation airports (Wells, 2000).
Nominal Maximum Aggregate Size (NMAS)	"One sieve larger than the first sieve to retain more than 10% [of the aggregate]" (Mallick & El-Korchi, 2013).
Pavement Lot	A lot is a designated quantity of pavement, produced under similar conditions, upon which pay for pavement quality is assessed (USACE, 2013); for example, for DoD work, a pavement lot typically includes 2,000 tons of HMA (USACE, 2017).
Reliever	General aviation airports which work to relieve congestion at primary airports while increasing general aviation access to communities (Wells, 2000).
Voids in Mineral Aggregate (VMA)	Describes the volume of voids between a compacted HMA's aggregate particles, and lower minimum VMA values are associated with higher NMASs (Roberts, 1996).