Airfield and Highway Pavements 2021

Airfield Pavement Technology

Selected Papers from the Proceedings of the International Airfield and Highway Pavements Conference 2021

>> June 8–10, 2021

Edited By
Hasan Ozer, Ph.D.
John F. Rushing, Ph.D., P.E.

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TRANSPORTATION & DEVELOPMENT INSTITUTE

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The Transportation & Development Institute
of the American Society of Civil Engineers

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Preface

Airfield and highway pavements are critical components of our transportation infrastructure. Increasing demand on these assets creates a unique challenge for researchers and practitioners to find sustainable solutions to managing their life-cycle. The airfield and highway pavements specialty conference is a unique setting where the world's foremost experts in pavement design, construction, maintenance, rehabilitation, modeling, management, and preservation meet and present most recent developments in the pavement engineering area. Building on the success of our past conferences, the 2021 International Airfield and Highway Pavements Conference of ASCE's Transportation and Development Institute (T&DI) displayed the adaptive nature of our profession as we held our first completely virtual event from June 8-10, 2021.

The 2021 virtual conference was designed to feature plenary sessions and panel discussions on important topics facing government agencies and industry. Technical breakout sessions allowed researchers and practitioners to present deeper technical content on breakthrough practices and technologies. The virtual poster session allowed "on-demand" access to cutting edge research.

The proceedings of the 2021 International Airfield and Highway Pavements Conference have been organized into three publications and are described as follows:

Vol I: Airfield and Highway Pavements 2021: Pavement Design, Construction, and Condition Evaluation
This volume includes papers concerning mechanistic-empirical pavement design methods and advanced modeling techniques for highway pavements, construction specifications and quality monitoring, accelerated pavement testing, rehabilitation and preservation methods, pavement condition evaluation, and network-level management of pavements.

Vol II: Airfield and Highway Pavements 2021: Pavement Materials and Sustainability
This volume includes papers describing laboratory and field characterization of asphalt binders, modifiers and rejuvenators, asphalt mixtures and modification, recycled and waste materials in asphalt mixtures, unbound base/subgrade materials and stabilization, pavement life-cycle management, interactions of pavements and their environment, and recent advances in cementitious materials characterization and concrete pavement technology. In this volume, we also included papers introducing cutting edge innovative and sustainable technologies used in pavement applications.

Vol III: Airfield and Highway Pavements 2021: Airfield Pavement Technology
This volume includes papers on recent advances in the area of airfield pavement design, construction, and rehabilitation methods, modeling of airfield pavements, use of

accelerated loading systems for airfield pavements, and airfield pavement condition evaluation.

The papers have undergone a rigorous peer review by at least two to three international highway pavement and airfield technology experts and a quality assurance process before becoming a publication of ASCE – the world's largest publisher of Civil Engineering content.

The success of the conference is a tribute to the incredible efforts of the leadership team consisting of Conference Co-Chairs (Hasan Ozer, John Rushing, and Zhen Leng) and Advisory Board (Imad Al-Qadi and Scott Murrell) along with an outstanding Conference Steering Committee (Amit Bhasin, Rick Boudreau, Zeijao Dong, Jeffrey Gagnon, Tom Harman, Andreas Loizos, Geoffrey Rowe, Injun Song, Leif Wathne, and Richard Willis) and terrific support from ASCE T&DI staff. The efforts of the Conference Scientific Committee are graciously acknowledged for their role in reviewing papers and providing critical feedback to the authors.

We thank everyone who attended the virtual conference and hope to see everyone again in 2023!

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Contents

Defining Australian Rigid Aircraft Pavement Design and Detailing Practice

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ABSTRACT

Since the privatization of the major Australian airports in the 1990s, there has been no centralized body for the definition of Australian aircraft pavement design practice. Consequently, there is now no clearly defined practice followed in Australia for aircraft pavements, including the design and detailing of rigid pavements. This research defines Australian rigid aircraft pavement design and detailing practice by surveying 17 designs completed over 20 years. Subgrade preparation, testing, and proving as well as sub-base layer materials and thicknesses were considered, as were the basis of thickness calculation, concrete strength assumed in design and required during construction, as well as the size of slabs, joint types, and joint details. The findings provide a reference for rigid aircraft pavement designers, as well as providing a basis against which future research can be contextualized. It is recommended that a nationally consistent design and detailing practice be reestablished in the future.

INTRODUCTION

There are over 350 paved airports in Australia (White 2018) with surface types ranging from sprayed seals, to asphalt, to concrete. Although the majority of aircraft pavements are of a flexible construction, rigid pavements are commonly used in areas that have slow moving or stationary aircraft, or have a high risk of exposure to fuels and other hydrocarbons, such as runway thresholds and parking aprons.

Rigid aircraft pavements are typically comprised of an unreinforced 40 mm sized Portland cement concrete base over a granular or bound sub-base, constructed on a natural, improved or imported subgrade (AAA 2017). The pavement is jointed to control shrinkage cracking, but relies on dowel bars or aggregate interlock across the joints to achieve effective load transfer between adjacent slabs. The structural thickness determination has typically been based on 40-years of projected aircraft traffic in Australia (AAA 2017), which is longer than the 20-years commonly used in the USA (FAA 2016).

Prior to the 1990s, Australia had a centralised department that controlled the design and specification guidance for rigid airfield pavement practice (Munce 1985). However, since the disbandment of this department and the privatisation of airports in the 1990s (Eames 1988), there has been no clearly defined practice for aircraft pavement design and specification in Australia, including the design and detailing of rigid pavements. As a consequence, more varied practices are expected to have developed over time.

This research aims to define the current Australian practice for rigid aircraft pavement design, detailing and specification, through a review of 17 aircraft pavement projects designed over the last 20 years. Elements of rigid pavement practice evaluated include the underlying pavement support platform issues, such as subgrade preparation, testing and proving, sub-base layer materials and thicknesses, as well as the concrete base details, including the basis of thickness determination, flexural concrete strength and how the flexural strength acceptance testing is specified. Other details evaluated include the size of the slabs, joint types and joint dowelling/tying arrangements. Conclusions address the current practices used for Australian rigid aircraft pavement design and detailing, as well as recommendations for a return to a more standardised approach.

BACKGROUND

History of Australian airport pavement design guidance

Prior to and immediately following World War II, there were only a small number of aircraft pavement technical specialists within Australia (Rodway 2011). During this time, airports were owned and managed by the Commonwealth Government, with the design, construction, and maintenance practices for aircraft pavements coordinated by the Commonwealth Department of Works (AAA 2017), later renamed the Department of Housing and Construction. Specific to rigid aircraft pavement practice, the Department published and maintained various materials including (Rodway 2015):

- General guidance on thickness calculation methods (DHC 1974).
- Standardised rigid pavement design detail drawings (DHC 1977).
- Standardised specifications for the construction of rigid pavements (DHC 1975).
- Commentaries explaining the basis of the standardised specification requirements.

The Department of Housing and Construction disbanded in 1982, later followed by the cessation of direct airport management by the Commonwealth in 1998 (Eames 1998). Airports were then handed to private corporations, mining companies and local Government bodies. The exception being the Department of Defence, which continues to manage 28 sealed airfields in support of military training and operations on behalf of the Commonwealth (AAA 2017).

Following the airport privatisation process, the design and construction responsibility was transferred to the new airport companies, which generally relied upon consulting engineers to provide appropriate design solutions (Rodway 2015). This approach was mirrored by the Department of Defence, who also use civilian consulting engineers for the design and technical specification of their aircraft pavement network. Many of the consulting companies employed the individual technical specialists that previously worked for the Commonwealth Departments and had access to the various materials formerly centrally controlled and maintained.

Initially there was little change in rigid aircraft pavement design and construction specification practice. However, over time individuals amended the standard documents to reflect their own new knowledge and experience. Because these changes were made by individuals, or by individual companies, the previously standardised and generally uniform practice evolved and became more diverse.

By the 1990s, significant new knowledge was generated in the USA, primarily by the Federal Aviation Administration (FAA), largely in response to new commercial aircraft with six wheeled landing gears, such as the B777 and the A380. Additionally, the FAA completed its long transition from chart-based to computer-based methods, which including layered elastic and finite element models for aircraft pavement thickness determination. Consequently, a number of Australian design consultants started to favour the tools and methods published by the FAA and some have included these elements in their thickness design and construction specification.

Australian historical rigid pavement practice and FAA influence

The historical practices relating to Australian aircraft pavements was based substantially on the US Army Corps of Engineers (the Corps) design procedures at the time (1970s) with criteria and performance data modified to suit Australian conditions (Munce 1985). Particular to the historical Australian practice was the use of unbound materials for sub-base layers, the use of k-value associated with the subgrade, without considering any sub-base improvement contribution, a strong focus on proof rolling of granular layers, and the use of keyed joints and large slabs (7.5 m by 7.5 m) for jointing arrangements.

Unbound sub-bases were used because Australian experience showed they performed satisfactorily and were more economical than bound or semi-bound sub-base materials (Munce 1985). However, the unbound sub-base material was subjected to increased levels of quality controls to prevent pumping under load and a significant proof rolling regime was used to verify sub-base layer performance.

The use of k-value without modification for combined sub-base contribution was considered conservative and was applied to sub-base courses less than one metre thick. Furthermore, the k-value was limited to a maximum value of 80 kPa/mm, even when the actual results were higher (Munce 1985).

With the introduction of larger multi-wheeled aircraft, the difference between common military and commercial aircraft increased and Australian practices became more and more influenced by the work being done in the USA by the FAA, reflecting the reduced applicability of the Corps methods to large commercial aircraft pavements. For example, design tools became computer-based instead of chart-based, recommendations for stabilised bases for larger aircraft traffic were introduced (FAA 2016), keyed joints were replaced by dowelled joints due to evidence of failure under heavy aircraft loads (Ahlvin 1991), and slab sizes were reduced to 4-6 m.

Due to the divestment in Commonwealth ownership of airports in the 1990s, and the associated disbandment of the Department of Housing and Construction, as well as the introduction of FAA design tools, there is now no clearly defined practice followed for rigid aircraft pavement design and specification in Australia. This research aims to address that by extracting the current practices for rigid aircraft pavement design and detailing from a survey of designs prepared over the last 20 years.

METHODS

A total of 17 significant rigid aircraft pavement development projects were surveyed from 10 different locations across Australia (Table 1 and Figure 1). These reference projects predominately included large multi-wheeled civilian passenger aircraft for non-military airports, and large multi-wheeled military aircraft such as the C-17 and KC-30 (modified A330) for Royal Australian Air Force (RAAF) bases. The exceptions being reference project (RP) 13, RP15 and RP16, that were designed for C-27J Spartan tactical-lift aircraft, small pilot-trainer light aircraft and military fighter jet aircraft, respectively. Subgrade types for reference projects ranged from clays to sands. Projects were completed by multiple design companies, for multiple airport clients, ensuring a suitably representative range of designs was included in the definition of Australian rigid aircraft pavement practice.

Where available, basis of design reports, drawings and construction specifications were surveyed to determine similarities and differences between key elements of rigid pavement practice, in order to determine a typical practice across Australia. This included subgrade requirements, sub-base requirements, concrete strength and thickness requirements, as well as joint types and details. The subsequent sections summarise the findings of the survey.

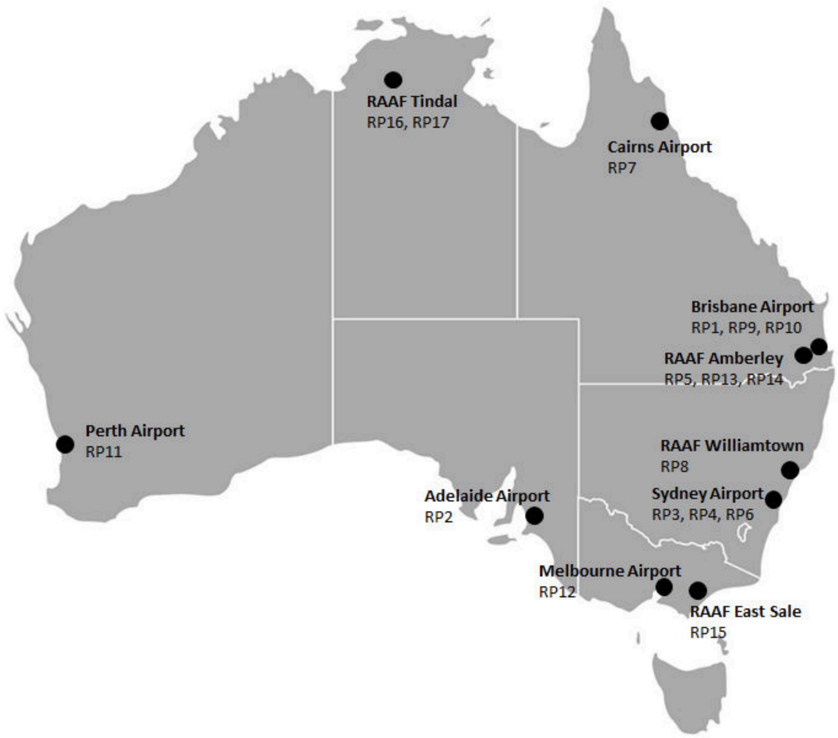

Figure 1. Aircraft pavement reference project locations

Table 1. Aircraft pavement reference project details

Reference	Airport	Project	Year of design
RP1	Brisbane airport	International Southern Apron Expansions (SAE)	2002
RP2	Adelaide Airport	International airport construction	2003
RP3	Sydney Airport	Bay 24 modifications	2004
RP4	Sydney airport	Taxiway G alignment	2005
RP5	RAAF Amberley	Multi-role Tanker Transport (MRTT) apron works	2006
RP6	Sydney airport	SW sector bay 73	2007
RP7	Cairns airport	Domestic apron upgrade	2007
RP8	RAAF Williamtown	Jet Explosive Ordnance Area (EOA)	2007
RP9	Brisbane airport	Taxiway B7-B8	2008
RP10	Brisbane airport	International Apron Bays 72 and 73	2008
RP11	Perth airport	Bays 8 -11 reconstruction	2010
RP12	Melbourne airport	Runway upgrade	2010
RP13	RAAF Amberley	C-27 Spartan Apron	2016
RP14	RAAF Amberley	C-17 Great Northern Apron	2017
RP15	RAAF East Sale	Air 5428 Pilot Training Apron	2018
RP16	RAAF Tindal	F-35 Operational Readiness Platform	2020
RP17	RAAF Tindal	KC-30 concrete areas	2020

DEFINING PRACTICE

Subgrade characterisation

The Westergaard principles (Huang 1993) on which modern rigid aircraft pavement design methods still rely, are based on a modulus of subgrade reaction (k-value) to characterise the support to the concrete slab offered by the subgrade material. Traditionally, plate bearing tests were