Defining Australian Rigid Aircraft Pavement Practice

Sean Jamieson  MSc (Civil), BEng, CPEng

Sean.Jamieson@research.usc.edu.au
Outline

• Background and Context
  – History of Australian airport pavement design guidance
  – Aim and method of the research

• Subgrade considerations

• Sub-base considerations

• Drainage considerations

• Concrete
  – Thickness determination
  – Strength characterization
  – Jointing systems
Historical practices relating to Australian aircraft pavements was substantially based on the US Army Corps of Engineers design procedures with criteria and performance data modified to suit Australian conditions.

Design and practice specification and guidance was managed centrally by the Department of Works.

On disbandment of the Department, individual consultant companies amended previous standard practice to reflect their new knowledge and experience.

By the 1990s, in response to new commercial aircraft, Australian consultants started to favour the tools and methods published by the FAA.
The aim of this research

• No defined rigid pavement practice due to:
  – Disbandment of the Commonwealth Department of Housing and Construction
  – Individual consultancies introducing lessons learnt from own experience
  – Influence of FAA design tools and philosophies.

• This research aims to define Australia rigid aircraft pavement practice through survey of recent capital projects

• Areas of practice that were the focus of this survey were:
  – Subgrade characterisation and proof
  – Sub-base considerations
  – Drainage
  – Concrete strength, thickness and panel size.
  – Jointing systems
Reference projects surveyed

- 17 significant airfield projects from 2002-2020
- 10 different locations across Australia
- Traffic mainly included large multi-wheeled civilian passenger aircraft or military aircraft
- Subgrade types for reference projects ranged from clays to sands
- Projects completed by multiple design companies, for multiple airport clients
Subgrade

• Subgrade characterisation
  – Traditionally undertaken through a plate bearing test to determine modulus of subgrade reaction (k-value) directly
  – Australian practice has move towards conversions of a laboratory measured soaked-CBR value to equivalent k-value

• Subgrade compaction and proof requirements
  – Compaction requirements in Australia are dependent on whether the soil is in cut, or in fill, and whether cohesive material or not
  – Traditionally, Australia used heavy 200 tonne rollers (Supercompactors)
  – However, these have generally been replaced by vibrating and impact rollers
  – Marco rollers and/or 15t steel drum used for proof rolling
### Subgrade

<table>
<thead>
<tr>
<th>Subgrade Type</th>
<th>Compaction Standards to reference density</th>
<th>Compaction Equipment</th>
<th>Proof Rolling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand fill</td>
<td>First 1000mm compacted to 100%. 1000-1500mm compacted to 98%.</td>
<td>A combination of vibrating steel drum roller of at least 15t mass and pneumatic tyred roller with at least 5.5t per 1,000kpa tyre.</td>
<td>A combination of either/or a Marco (pneumatic tyre) roller, typically 8 - 10t per wheel and 800-1,000kpa tyre pressure, and a 15t steel drum roller. Weight and pressure requirements vary with depth. Rolling effort ranges from 6 – 12 coverages.</td>
</tr>
<tr>
<td>Cut</td>
<td>Ranging from 95-100% for first 150-500mm.</td>
<td></td>
<td>Fully loaded 20 T water trucks have also been used for subgrade proof rolling.</td>
</tr>
</tbody>
</table>
Drainage

• Surface drainage
  – Surface grades were aligned with MOS 139
  – Drainage channels included slotted surface drainage and grated drains
  – Also provision for environmental drainage control and fire hazard controls on aprons.

• Sub-surface drainage
  – Typically only included where the subgrade was a reactive clay or moisture-sensitive silt.
The purpose of the sub-base is to provide a uniform and durable support for the concrete slab, a sound platform for the construction of the concrete slab, and prevent pumping and erosion of fine material from the subgrade (Munce, 1985).

Traditionally, unbound sub-bases were used, with no de-bonding layer and a proof roll regime.

Current practice is to use a bound sub-base 150-200mm thick with a de-bonding layer.

Some specifications still required proof-rolling for bound sub-bases. This could induce ruts and anchor the concrete base.
Concrete Design Flexural Strength

• Traditional practice of 4.5MPa design flexural strength:
  – with a note that the mixture design must target an average strength of no less than 4.8MPa to achieve the characteristic value (which in Australia is the 95%-ile value).

• 4.8MPa is now the dominant basis of design.
  – The change to 4.8MPa design means that the mixture design must target an average strength of ~5.4MPa assuming a 10% coefficient of variation.

• Increase in flexural strength will reduce the pavement thickness, but can result in unworkable concrete mixtures and high shrinkage.

• Australian practice vs USA Practice
  – Aus = 95% (19/20 exceeding strength) / accept or not accept
  – USA = 80% (4/5 exceeding strength) / pay factors
Thickness determination

- Calculated based on:
  - The projected aircraft traffic (typically 40 years)
  - Concrete flexural strength
  - Subgrade support condition
  - Sub-base layer characteristics

- A mix of FAA advisory design charts, historic Australian Commonwealth Department charts and FAA design software

- FAAFIELD most common tool in recent projects.
  - Note: USA uses 80%-ile for characteristic strength vs Aus 95%-ile.

![Figure 2. Comparison of 95%-ile (4.5 MPa) and 80%-ile (4.9 MPa) concrete strengths.](image)
Panel Size

- Traditional panel size was 7.5m by 7.5m, with 5m a 5m for hotter climates
- Gradual reduction to 5m x 5m slabs
- All slabs, were either square, or almost-square, with l:w ratio ≤ 1.25
- Reflects that smaller panels are less susceptible to centre-slab cracking
Joint types

- Traditional practice included keyed and formed joints, and formed and tied joints. However, since 2011, this practice has been phased out.

- Predominant joint types today are doweled construction joints for longitudinal joints and dummy contraction joints for transverse joints.

- Other special purpose joints used as required.

<table>
<thead>
<tr>
<th>Joint Type</th>
<th>FAA equivalent</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keyed and formed</td>
<td>-</td>
<td>Used in RP2 only (2003) for longitudinal and transverse</td>
</tr>
<tr>
<td>Keyed and formed</td>
<td>-</td>
<td>Used in RP2 only (2003) for last slab in both directions</td>
</tr>
<tr>
<td>with dowel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formed and doweled</td>
<td>Type E – Doweled Construction Joint</td>
<td>Used in 16 out of 17 RP for longitudinal joint. Used in 16 out of 17 RP for last transverse joint.</td>
</tr>
<tr>
<td>Sawn and un-</td>
<td>Type D – Dummy Contraction Joint</td>
<td>Used in 16 out of 17 RP for transverse joints.</td>
</tr>
<tr>
<td>doweled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>doweled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolation joint</td>
<td>Type A – Thickered Edge Isolation joint</td>
<td>Used to separate pavements of different sizes and/or structures.</td>
</tr>
</tbody>
</table>
Summary and recommendations

- A combination of historical guidance, individual experiences and FAA influence has evolved Australian practice.

- Survey of recent airfield project has provided the typical practice for Australian rigid pavements.

- Going forward, consideration to have a national guidance document for rigid pavement practice (similar to what has been done for the AAPA Airport Asphalt model specification).

<table>
<thead>
<tr>
<th>Element</th>
<th>Sub-element</th>
<th>Typical Australian practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subgrade preparation</td>
<td>Subgrade Characterisation</td>
<td>Characterised as a k-value, estimated by conversion from a characteristic soaked CBR value measured in the laboratory.</td>
</tr>
<tr>
<td></td>
<td>Compaction Requirements</td>
<td>First 1500 mm for sand fills controlled to 98-100% of the reference density. First 150-500 mm for in-situ subgrades controlled to 95-100% the reference density.</td>
</tr>
<tr>
<td></td>
<td>Compaction equipment</td>
<td>Combination of vibrating steel drum roller of at least 15 t mass and a pneumatic tyred roller with at least 5.5 t per 1,000 kPa tyre.</td>
</tr>
<tr>
<td></td>
<td>Proof rolling</td>
<td>Combination of a 40 t Marco roller, typically 10 t per wheel and 1,000 kPa tyre pressure, and/or a 15 t steel drum roller.</td>
</tr>
<tr>
<td>Drainage</td>
<td>Surface drainage</td>
<td>Included for environmental and fire hazard controls. Surface level grades aligned with regulatory requirements.</td>
</tr>
<tr>
<td></td>
<td>Sub-surface drainage infrastructure</td>
<td>Not included for well-draining (sand and gravel) subgrades in free-draining environments. Included for reactive subgrades in poor-draining (clay and silt) environments.</td>
</tr>
<tr>
<td>Concrete details</td>
<td>Sub-base provisions</td>
<td>150-200 mm of crushed rock, lean mix concrete or cement treated crushed rock. Second sub-base layer of crushed rock, and/or stabilised subgrade for weaker in-situ soils.</td>
</tr>
<tr>
<td></td>
<td>Concrete strength</td>
<td>Characterised by flexural strength and in the range of 4.5-4.8 MPa. Specification to ensure the designed flexural strength is exceeded during construction.</td>
</tr>
<tr>
<td></td>
<td>Concrete thickness</td>
<td>Determined for the specific project, to accommodate 40 years of predicted aircraft traffic, using a range of recognised computer software or charts, most commonly FAARFIELD.</td>
</tr>
<tr>
<td></td>
<td>Panel (slab) size</td>
<td>Varied to suit project standards, but typically 4-6 m and approximately square.</td>
</tr>
<tr>
<td></td>
<td>Joint system details</td>
<td>Sawn (and not dowelled) transverse contraction joints and formed (and dowelled) longitudinal construction joints, with other special purpose joints used some circumstances, and tied (deformed bar) joints avoided.</td>
</tr>
</tbody>
</table>
THANKS FOR YOUR ATTENTION