Airport Concrete Paving Fundamentals

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A Brief History of Airport Pavements

• The “heavy” plane in the 1930’s was the DC-3
  • 25,000 lb. gross weight
  • Pavement designed for gasoline trucks not planes
  • Pavements were 6” thick

• Early airports were built the same as highways
A Brief History of Airport Pavements

• With World War II came:
  • B-29 Superfortress – 140,000 lbs.
  • 12” pavements
  • Existing 6” slabs overlaid with another 6” or 7” of concrete

• And Airfields were constructed with amazing speed
  • Layout in April 1942
  • Construction started in May 1942
  • Airfield activated September 1, 1942
A Brief History of Airport Pavements

At the end of WW II and into the Korean War...

• B-36 with 150,000 lb. per single wheel gear
• Pavement thickness up to 20 to 27 inches
• Realization that airfield concrete pavements are different than roadway pavements!

26” of concrete at Lubbock AFB in Texas
A Brief History of Airport Pavements

• Channelization of Aircraft
  • B-47 caused premature distresses just 2 years into service (~1954)
  • 230,000 lbs.
  • 6x anticipated loading

• Perfect storm of changes
  • Steerable nosewheels
  • Painted taxistripes
  • Increased ease of preparation for flight
A Brief History of Airport Pavements

Introduction of Slipform Paver – 1st used by Corps at Luke AFB in 1970

Slipform paver in Iowa circa 1964
Concrete Pavement Types

• Jointed Plain (JPCP)
  • Undoweled
  • Doweled
• Jointed Reinforced (JRCP)
• Continuously Reinforced (CRCP)

Nearly All Airfield Pavements
Jointed Plain (JPCP)

Plan

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<td>12.5 to 20 ft. On Airfields</td>
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Profile

Undoweled or Doweled
Steel Placement

• Airport jointed concrete pavement typically has no distributed steel except special cases or odd-shaped panels.

• Doweling depends on standards & aircraft loads

• Both transverse and longitudinal joints may be doweled where required
Stress Dissipation in Concrete Pavements

Concrete spreads the load over a large area and keeps pressures on the subgrade low.
Airport Concrete Pavement Terminology

- Pavement Penetration
- Pavement thickness
- Longitudinal joint
- Transverse joint
- Surface texture & grooving
- Dowel bar or tiebar
- Concrete Slab or Panel
- In-Pavement Lighting
- Base & subbase
- Subgrade
Unique Aspects of Airport Concrete Pavement

- Runway, taxiway & apron paving requires multi-lane paving
- Fill-in lane paving requires special care not encountered on roadway paving
Critical Design Considerations

• Subgrade support – uniformity & stability
  • Max k-value increased from 300 pci to 500 pci in 1950’s

• Base and subbase – uniformity, stability & drainage provisions
  • Channelized traffic led to pumping
  • Curves developed to relate k at the surface of the base to base thickness and subgrade k

• Slab thickness – Support aircraft loadings

• Concrete properties – Uniformity, workability, strength & durability
Critical Design Considerations

- Jointing details – layout, load transfer, isolating pavement penetrations & sealing

<table>
<thead>
<tr>
<th>Pavement Thickness</th>
<th>Joint Spacing in 1956 (Corps of Engineers)</th>
<th>Joint Spacing Today (FAA - No Stabilized Base)</th>
<th>Joint Spacing Today (FAA - Stabilized Base)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 8”</td>
<td>12.5’ – 15’</td>
<td>12.5’ – 15’</td>
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<tr>
<td>8” – 10”</td>
<td>15’ – 20’</td>
<td>15’ – 20’</td>
<td>12.5’</td>
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<tr>
<td>&gt; 10”</td>
<td>20’ – 25’</td>
<td>20’</td>
<td>15’ - 20’</td>
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</table>
Concrete Pavements Must Deliver:

- Acceptable service life
- Relatively low required maintenance & rehabilitation
- Functional performance:
  - Smoothness
  - Safety
  - No FOD
- Structural performance
Pavement Performance

Age or Aircraft Loadings

Structural/Functional Condition

Min. Acceptable Rating

Premature Distress (Unexpected)

Progressive Distress (Expected)
# Premature vs. Progressive Distress

<table>
<thead>
<tr>
<th>Premature Distress</th>
<th>Progressive Distress</th>
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<tbody>
<tr>
<td>Develops within a short period after concrete placement</td>
<td>Develops gradually over a period of time</td>
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<tr>
<td>Within ~90 days of placement:</td>
<td>Develops as a result of repeated aircraft loadings</td>
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<tr>
<td>• Often materials or construction related</td>
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<tr>
<td>Within 3 to 5 years of opening to traffic:</td>
<td>Develops as a result of environmental conditioning</td>
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<tr>
<td>• Sign of inadequate design features</td>
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<tr>
<td>• Sign of marginal as-built pavement layers</td>
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<tr>
<td></td>
<td>Anticipated or expected</td>
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**What about materials durability distresses?**

*Some are premature & some are progressive*
Popouts
D-Cracking
“This document is meant to serve as a guide for assessing potential ASR structures in the field. As such, laboratory testing, such as petrographic analysis, should be conducted in order to confirm the presence of ASR in hardened concrete.”

-Alkali-Silica Reactivity Field Identification Handbook (Published by FHWA, Dec. 2011)
Corner Breaks
Weakened Surface
Joint Spalling
Sliver Spalling
Bug Holes
What is Quality?

- An inherent property
- Depends on what is asked for
- A quality product:
  - Meets the customer’s needs
  - Meets (or exceeds) expectations
  - Performs well for purpose
If the Quality Goal is...

Avoid Problems that Reduce Pavement Performance...

Which is Better?

A well-designed, poorly-constructed pavement
or a
poorly-designed, well-constructed pavement?

Neither!

To meet the quality goal requires the designer (Engineer) and builder (Contractor) working together as a team for the desired outcome.
Quality in Pavement Construction...

• Quality must be designed and built into a project – not be hit or miss

• Good materials and construction practices are key to achieving the promise of a good airport concrete pavement design

• Specifications are a BIG deal... An assessment of pavement quality depends on
  • Meeting intent of specifications
  • Meeting test requirement parameters
The Conundrum – Quality Cannot be Specified!

• Specifications don’t always say what they mean
• Current specifications rely on tests that are only surrogates for quality
  • Strength
  • Thickness
  • Air content
  • Smoothness
• Construction team needs to understand the balances among these sometimes competing factors
Conformance to the Specifications

Vital that requirements are:

• Reasonable (target the average bidder)
• Meaningful (not arbitrary)
• Measurable (by testing)
• Well defined (account for test variability)
• Hold true (do not conflict w/ other requirements)
Implications of Poor Quality

To Owner/Engineer:
• Lower serviceability
• FOD risks
• Early or frequent maintenance and rehabilitation
• Frequent disruptions to aircraft operations
• Higher ownership costs

To Contractor:
• Lowers pride in workmanship
• Impacts reputation
• Impacts pre-qualification
• Lowers profitability
• Challenges insurability
• Higher financial burden
Minimizing Problems = Reducing Variability

Low Standard Deviation

High Standard Deviation

MEAN
Sources of Variability

To Reduce Variability:

• Understand the magnitude of the different sources
• Monitor and attempt to reduce each type.
Input Variability Impacts Output Variability

Process Control Minimizes Input Variability

Variations in Material & Production

Performance Variability

Input

Output

Process Control

Performance Variability

Materials

Production

Tolerances
Effects of Variability

HIGH VARIABILITY

LOW VARIABILITY

AVERAGE STRENGTH

STRENGTH MARGIN

SPECIFIED STRENGTH

PERCENTAGE OF LOW TESTS

TEST STRENGTH

FREQUENCY
Effects of Variability

Curves Based on 650 psi Design Strength
n=4 Sublots

EXPECTED LOT PAY FACTOR (%)

AVERAGE LOT STRENGTH (psi)

STD. DEV = 100 psi
STD. DEV = 60 psi
STD. DEV = 40 psi
The Fundamentals are Vital

• It will be your creation
• It requires your teamwork
• Take pride in your workmanship
• Do it right the first time
• Results should provide expected service life

Every Project is a reflection of the Contractor, Engineer, and Owner!