FAA Airport Pavement R&D Update

Presented to: ALACPA 2018
By: Jeffrey Gagnon, P.E.
Date: May 30, 2018
Presentation Outline

• Introduction
• Construction Cycle 8
• Geosynthetics
  – Load cell tests
  – Full Scale Tests
• Construction Cycle 9
Airport Pavement R&D Section

- **Research Conducted at the FAA William J. Hughes Technical Center, Atlantic City, NJ, USA.**
  - Aviation Research Division

- **Sponsor: FAA Office of Airport Safety and Standards (AAS-100), Washington, DC.**
  - Greg Cline & Doug Johnson

- **Provide Support for Development of FAA Pavement Standards**
  - Advisory Circulars

- **10 Full-Time FAA Personnel**
  - CSRA Support Contractor
Airport Pavement R&D Section
Facility Layout
National Airport Pavement Test Facility (NAPTF)

Facility Facts:

- FAA / Boeing (CRDA) Partnership at $21M
- Opened April 1999
- Fully Enclosed Facility
- Accelerated Traffic Testing
- 900 ft. x 65 ft. of Test Pavement Surface
- Full-scale Pavement Structures and Landing Gear Loads

Test Vehicle Facts:

- Fully Automated & Programmed Wander Patterns
- Up to 5-dual wheel configuration
- Roughly 1.3 Million lbs.
- Up to 75,000 lbs. per wheel
# National Airport Pavement and Materials Research Center (NAPMRC)

## Facility Facts:
- Dedication Ceremony August 2015
- Indoor and Outdoor Testing Capability
- Accelerated Traffic Testing
- Outdoor: 150ft. x 300ft. & Indoor: 72ft. x 300ft.
- Accelerated resurfacing

## Heavy Vehicle Simulator – (HVS-A) Facts:
- Temperature Control Capability
  - Up to 150°F
- Capacity 10,000 - 100,000 lbs.
- Single & Dual-Wheel Configuration
  - Dual (B737-800)
- Fully Automated & Programmed Wander Patterns up to 6 ft.
FAA NextGen Pavement Materials Lab

- 2010: Laboratory Opened
- 2013: AASHTO Material Reference Laboratory (AMRL)
- 2013: Cement and Concrete Reference Laboratory (CCRL)
- Full Test Capabilities: Asphalt, Concrete, Soils
- Advanced Test Capabilities:
  - Asphalt Pavement Analyzer (APA)
  - Asphalt and Concrete beam fatigue
  - Semi-Circular Beam (SCM)
  - Disk-Shaped Compact Tension (DCT)
- Benefits to the NAPTF:
  - Quality Control of Testing
  - Expedient Testing of Materials During Construction
  - Perform Advanced Materials Characterization On-site
  - Development of Performance Based Specification
Airport Pavement R&D Four Major Pavement Focal Areas

Pavement Thickness Design
- FAARFIELD 1.4
- Concrete or Asphalt
- Support Anticipated Aircraft Loads for Design Life (20 Year)
- Avoid Premature Failure
- Minimize Construction Cost

Aircraft / Airport Compatibility
- Support ICAO Compatibility Criteria (ACN-PCN Method)
- Improvements
  - New Alpha Factors
  - ICAO Tire Pressure Categories
  - Computer Program - COMFAA
- Changes Adopted by US and Worldwide

Airport Pavement Management
- FAA PAVEAIR Program
- Free Web Based Management Software
- Airports Manage Pavement Inventory
- FAA to Monitor AIP Grants
- Nondestructive Testing and Evaluation
  - Roughness
  - Smoothness

Advanced Pavement Materials
- New Technologies
  - Reduce Construction Cost
  - Improve Durability
  - Environmental Benefit
- Active R&D
  - Warm Mix Asphalt
  - Establish standards for Gyratory Mix Design
  - Characterizing Subgrade Soil
  - Deicing Agents

FAA Airport Pavements R&D Update
May 30, 2018
Construction Cycle 8 Update - Concrete

**Primary Objectives**

- **PCC-on-Rigid Overlay Test:** Test PCC overlay on existing PCC with target SCI of between 50-80 (Follow-on to CC4 overlay tests)
- **Evaluate Comparative Joint Performance:**
  - Longitudinal Joint: doweled versus alternate sinusoidal key
  - Transverse Joint: doweled versus undoweled (dummy)
- **Improve FAARFIELD Failure Model:** Test full-scale slab strength & fatigue strength for different concrete strength and foundation conditions

**Secondary Objectives**

- Develop overload criteria for rigid pavements
- Effect of k-value vs. CBR in characterizing rigid subgrade
Construction Cycle 8 Test Layout

Construction is scheduled to be completed and trafficking begin Fall 2017
Traffic Test Summary

- Gear configuration
  - North 6-Wheel; South 4-Wheel

- Traffic test
  - Started Oct 10, 2017
  - 55k lbs wheel load
  - 10 wanders/day, Monday – Thursday
  - 50 days (Jan 17th), 30960 passes

- SCI
  - North 11 (trafficking stopped on Jan 17, 2018)
  - South 8 (trafficking stopped on Jan 11, 2018)
Observations

1. Minor surface cracking prior to trafficking
2. South side showed structural cracks earlier and failed earlier
3. On both sides:
   - Dominant distresses were corner breaks and longitudinal cracks.
   - Linear cracks were reflected from Phase I longitudinal joints.
4. North side
   - Random, tight, isolated interior surface cracks in the early stage of trafficking
5. South side
   - More corner breaks
# As-built Properties

<table>
<thead>
<tr>
<th>Layer</th>
<th>Property</th>
<th>North</th>
<th>South</th>
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</thead>
<tbody>
<tr>
<td>PCC OL</td>
<td>Thickness, in</td>
<td>9.012</td>
<td>9.024</td>
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<tr>
<td></td>
<td>271-day R, psi</td>
<td>688</td>
<td>712</td>
</tr>
<tr>
<td>HMA Int</td>
<td>Thickness, in</td>
<td>1.464</td>
<td>1.356</td>
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<tr>
<td>PCC UL</td>
<td>Thickness, in</td>
<td>9.264</td>
<td>9.252</td>
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<td>179/172-day R, psi</td>
<td>610</td>
<td>638</td>
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<tr>
<td>P-154 Subbase</td>
<td>Thickness, in</td>
<td>10.78</td>
<td>10.88</td>
</tr>
<tr>
<td></td>
<td>k-value, pci</td>
<td>216</td>
<td>272</td>
</tr>
<tr>
<td>Subgrade</td>
<td>CBR</td>
<td>7.2</td>
<td>7.4</td>
</tr>
<tr>
<td></td>
<td>k-value, pci</td>
<td>110</td>
<td>131</td>
</tr>
</tbody>
</table>
Performance (SCI) curve
Performance (SCI) curve

\[ SCI = 100.0 - 181.6 \, C_N + 81.6 \, C_N^2 \]

\[ C_N = \frac{C - C_0}{C_F - C_0} \]
Performance (SCI) curve

SCI = -97.256C_N + 100

R^2 = 0.9448

• IPRF Report 04-02 and 06-03
The Performance (SCI) curve shows the relationship between SCI and Coverage.

The data for North and South are plotted as circles, with the following linear equations:

1. For North: \( y = -0.0094x + 100 \)
   \( R^2 = 0.8281 \)

2. For South: \( y = -0.0139x + 100 \)
   \( R^2 = 0.9785 \)
Performance (SCI) curve

- North
- South
- Rollings

SCI vs. CN graph showing performance data for North, South, and Rollings.
Performance (SCI) curve

SCI = -101.39CN + 100
R² = 0.918
Preliminary Findings

OL performance, North vs. South

i. Initial SCI (conditions) from Phase I Overload Test
ii. Excessive slab corner movement (OL-UL separation) on the south side
iii. UL damage during Overlay Test

Conservatism in FAARFIELD failure model

i. Distress pattern
ii. Deterioration rate
iii. Dependence on maximum stress (energy approach?)
iv. Effect of AC interlayer

Agreement between measured and predicted transverse joint stiffness
Future Work

• Post-traffic test to
  • Examine the damage (conditions) of UL and AC interlayer
  • Re-visit the relationship between SCI and existing PCC material properties (E-Ratio vs. SCI).
• Integrate CC8 data analysis into CC4
  • Slab thickness (9-in vs. 7.5-in)
  • Flexural strength (650 psi vs. 550 psi)
  • Support condition (intermediate vs. low)
  • Joint (undoweled vs. doweled)
Geosynthetics

• Geosynthetics Materials Association (GMA)
  – Overview
    • Literature Review
      – current industry research on applications of Geosynthetics
        – Soil Stabilization
        – Unbound Aggregate Layer Reinforcement
    • Presentation of Literature Review to FAA October 6, 2016
    • Establish draft specification for use of Geosynthetics
      – Goal - Incorporate into AC 150/5370-10H Update
        – Obtain/Analyze data through full scale testing
          • Cyclic Plate Load tests
          • Current CC9 design includes two cross-sections with Geotextile/Geogrids
        – Modify Specifications for Pavement Design/Construction based on full scale testing results.
          • Goal – Include geotextile/geogrid material properties into design software
AC 150/5370-10G
Issued: July 21, 2014
Standards for Specifying Construction of Airports

Advisory Circular

AC 150/5370-10H
Draft Issued: Nov 2, 2017
P-154 Subbase Course

Item P-154 Subbase Course

Item P-154 can be used as a subbase under flexible and rigid pavement.

DESCRIPTION

154-1.1 This item shall consist of a subbase course composed of granular materials compacted on a prepared subgrade or underlying course in accordance with these specifications, and in conformity with the dimensions and typical cross-section shown on the plans.

MATERIALS

154.2.1 Materials. The subbase material shall consist of hard durable particles or fragments of granular aggregates or recycled asphalt pavement (RAP) or recycled concrete pavement (RCP). This material will be mixed or blended, as needed, with fine sand, clay, stone dust, asphalt millings, or other similar binding or filler materials produced from approved sources. This mixture must be uniform and shall comply with the requirements of these specifications as to gradation, soil contents, and shall be capable of being compacted into a dense and stable subbase. The material shall be free from vegetative matter, lumps or excessive amounts of clay, and other objectionable or foreign substances. Pit-run material may be used, provided the material meets the gradation requirements specified.

When non-freeze susceptible material is required, the maximum allowable material passing the No. 200 (75 μm) sieve shall be reduced from 0-5% to 0-1%. The Engineer should reference the geotechnical report.

Gradation Requirements

<table>
<thead>
<tr>
<th>Sieve designation</th>
<th>Percentage by weight passing sieves</th>
<th>When recycled pavement (RAP or RCO) is used</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 inch (75 mm)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>1 1/2 inch (37.5 mm)</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>3/4 inch (19.0 mm)</td>
<td>70-100</td>
<td>70-100</td>
</tr>
<tr>
<td>No. 10 (2.00 mm)</td>
<td>20-100</td>
<td>20-100</td>
</tr>
<tr>
<td>No. 40 (425 μm)</td>
<td>5-60</td>
<td>5-60</td>
</tr>
<tr>
<td>No. 200 (75 μm)</td>
<td>0-5%</td>
<td>0-5%</td>
</tr>
</tbody>
</table>

Geogrid material acceptance is based on ASTM D 4759. Insert specific geogrid property requirements above as necessary to describe salient features of the geogrid.

The use of geogrid must be supported and designed by a geotechnical engineer; and approved by the FAA. The FAA does not consider any reductions in pavement structure for the use of any geosynthetics.

The FAA is currently researching the use of geosynthetics with aircraft loadings.
Pavement Base Courses
P-208/209/210/211/212/213/219

210-2.3 Separation fabric. [ Not used. ] [ Separation fabric shall be Class 2, 0.02 sec⁻¹ permittivity per ASTM D4491, 0.60 mm max average roll value apparent opening size per ASTM D4751. ]

The use of a geotextile to prevent mixing of a subgrade soil and an aggregate subbase/base is appropriate for pavement structures constructed over soils with a California bearing ratio ≥ 3.

Generally, on airport projects a Class 2 fabric with a permittivity of 0.02 and apparent opening size of 0.60 mm will be sufficient.

See AASHTO M288 for additional notes regarding separation fabrics.
Geosynthetics

- Completed Phase 1 Cyclic Plate Load tests with U.S. Army Corps of Engineers at Vicksburg MS.
  - Comments provided to report – Cyclic Plate Testing of Geogrid Reinforced Airport Pavements
  - Final draft submitted 1st Q 2017. USACE addressing Comments
Geosynthetics

- **Traffic Benefit Ratio** - Defined in AASHTO R 50-09 Standard Practice for Geosynthetic Reinforcement of the Aggregate Base Course of Flexible Pavement Structures

\[
TBR = \frac{\text{Cycles to failure of reinforced}}{\text{Cycles to failure of unreinforced}}
\]

<table>
<thead>
<tr>
<th>ITEM</th>
<th>CYCLES @ 2 in. Deformation</th>
<th>TBR</th>
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<tbody>
<tr>
<td>Control</td>
<td>1369</td>
<td>1.0</td>
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<tr>
<td>TX140</td>
<td>4295</td>
<td>3.1</td>
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<tr>
<td>BX1200</td>
<td>26234</td>
<td>19.2</td>
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<tr>
<td>Huesker 30/30</td>
<td>34901</td>
<td>25.5</td>
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</table>
Geosynthetics

- **Awarded Phase 2 Cyclic Plate Testing of Geosynthetics**
  - 24-month period of performance
  - Geotextiles positioned at subgrade/subbase interface

- **Materials Selected**
  - Tensar BX1200
  - Tensar TX 140
  - Huesker Fornit 40/40
  - Tencate RS580i

- **Quantify Benefit of Material**
  - Traffic Benefit Ratio

- **Predictive Models**

- **Recommend Specification**
Geosynthetics

Phase I – Base/Subbase Interface
Deformation to 2.25 inches: 30,000 Cycles

Phase II – Subbase/Subgrade Interface
Deformation to 2.25 inches: 50,900 Cycles
## Geosynthetics

<table>
<thead>
<tr>
<th>Phase 2</th>
<th>Test Item</th>
<th>Cycles @ 1&quot; Deformation</th>
<th>Cycles @ 2&quot; Deformation</th>
<th>TBR @1&quot; Deformation</th>
<th>TBR @2&quot; Deformation</th>
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<tbody>
<tr>
<td>Geosynthetic on subgrade</td>
<td><em>Control w/Sand</em></td>
<td>304</td>
<td>1,278</td>
<td>1</td>
<td>1</td>
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<td>Control w/LMS</td>
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<tr>
<td></td>
<td>BX1200</td>
<td>9,720</td>
<td>44,960</td>
<td>32.0</td>
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<td>TX140</td>
<td>1,460</td>
<td>9,890</td>
<td>4.8</td>
<td>7.7</td>
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<td></td>
<td>Fornit 40</td>
<td>4,100</td>
<td>17,600</td>
<td>3.3</td>
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<td></td>
<td>RS580i</td>
<td>2,575</td>
<td>20,830</td>
<td>8.5</td>
<td>16.3</td>
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<table>
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<th>Phase 1</th>
<th>Test Item</th>
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<th>Cycles @ 2&quot; Deformation</th>
<th>TBR @1&quot; Deformation</th>
<th>TBR @2&quot; Deformation</th>
</tr>
</thead>
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<tr>
<td>Geosynthetic on subbase</td>
<td><em>Control w/Sand</em></td>
<td>304</td>
<td>1,278</td>
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<td>34,901</td>
<td>29.7</td>
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</table>
Construction Cycle 9 - Asphalt

• Objectives
  – Verify/Refine/Modify fatigue model based on the ratio of dissipated energy change (RDEC)
  – Effect of P-209 layer thickness on pavement life
  – Effects of geogrids on flexible pavement performance
  – Cement Treated Drainable base performance
  – Strain criterion for allowable overload
## CC 9 layout

<table>
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<tr>
<th>0</th>
<th>0.65</th>
<th>1.05</th>
<th>1.20</th>
<th>1.65</th>
<th>1.80</th>
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<th>3.00</th>
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<tr>
<td>LFS-1N</td>
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<td>LFS-3N</td>
<td>LFS-4N</td>
<td>LFS-5N</td>
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<td></td>
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<tr>
<td>Fatigue Model</td>
<td>Fatigue Model</td>
<td>Geosynthetics</td>
<td>Drainable Base</td>
<td>Overload</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

15° Transition

12" Wonder Pattern
CC 9 North Cross Section
CC 9 South Cross section
Future Research

- Geosynthetics Reinforcement
- “Green” technologies such as Warm Mix Asphalt (WMA)
- Stone Matrix Asphalt (SMA)
- Recycled Asphalt Pavement (RAP)
- Full Depth Reclamation (FDR)
- Polymer Modified Binders
- Shear failure of HMA
- Performance of HMA overlays on Flexible & Rigid Pavements
- Nanotechnology for Improved Material Properties
- Advanced Materials Research
- Advanced Performance Based Laboratory Testing Methods

**Practical research to support the field & ADO offices is the goal**

*Increased Pavement Life – Reduced Cost – Minimum Down Time*
Thank You - Questions

FAA Technical Center Airport Pavement R&D
http://www.airporttech.tc.faa.gov
or
Just Google - NAPTF