Analysis of CC2 Rigid Pavement Test Data From the FAA's National Airport Pavement Test Facility

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FAA Airport Technology R&D Program

- Effort conducted at the William J. Hughes Technical Center, Atlantic City, NJ, USA.
- Sponsor: FAA Office of Airport Safety and Standards, Washington, DC.
- Provide support for development of FAA pavement standards (Advisory Circulars).
- http://www.airporttech.tc.faa.gov/

National Airport Pavement Test Facility - Background

- Commissioned on April 12, 1999.
- Joint venture of FAA and Boeing Co.
- Primary Objectives:
  - Provide additional traffic data for incorporation in new FAA thickness design procedures.
  - Provide full-scale pavement response and failure information for use in airplane landing gear design and configuration studies.
  - Reexamine the CBR method of design for flexible pavement ACN (6-wheel gear).

National Airport Pavement Test Facility - Specifications

- Test pavement: 900 ft long by 60 ft wide.
- Test vehicle: Up to 12 aircraft tires at wheel loads up to 75,000 lbs.
- Dynamic data acquisition (20 samples/second).
- Static data acquisition (4 samples/hour).

Construction Cycles

A construction cycle is defined as the complete cycle of planning, construction, trafficking, posttraffic testing, and demolition, needed to obtain a set of usable data.

- CC1: Initial construction, consisted of 6 flexible and 3 rigid test items.
- CC2: Rigid pavement reconstruction
  - Test strip and free standing test slab
  - Three new rigid test items
- CC3: Flexible pavement reconstruction.
  - Four conventional flexible test items.

CC2 - Objectives of Test

- Main Objectives:
  - Compare rigid pavement life and performance for different support conditions.
  - Compare pavement life and performance for 4- and 6-wheel gear traffic.
  - Obtain data on pavement performance as measured by the Structural Condition Index (SCI) versus traffic repetitions.
  - Other objectives included comparing interior and edge stresses under gear loads, and measuring shrinkage and curling of the concrete slabs.
**CC2 Test Item Layout**

- MRC: Medium-Strength / Rigid / Conventional (aggregate) foundation
- MRG: Medium-Strength / Rigid / Slab placed directly on Grade
- MRS: Medium-Strength / Rigid / Stabilized base (econocrete)

**Detail Plan of PCC Test Item**

- 4.57 x 4.57 m (15 x 15 ft) SLABS, TYP.
- 22.86 m (75 ft) TRANSITION

**Profile of CC2 Test Items**

- MRC: 30.5 cm (12 in) PCC Surface
- MRG: 30.5 cm (12 in) PCC Surface
- MRS: 30.5 cm (12 in) PCC Surface

**Structural Design Data for CC2 Test Items**

<table>
<thead>
<tr>
<th>Test Item</th>
<th>MRC</th>
<th>MRG</th>
<th>MRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCC Surface</td>
<td>30.5 cm (12 in) PCC (P-501)</td>
<td>30.5 cm (12 in) PCC (P-501)</td>
<td>30.5 cm (12 in) PCC (P-501)</td>
</tr>
<tr>
<td>Subbase 1</td>
<td>25.4 cm (10 in) agreg. subbase (P-154)</td>
<td>none</td>
<td>15.2 cm (6 in) econocrete base (P-306)</td>
</tr>
<tr>
<td>Subbase 2</td>
<td>none</td>
<td>none</td>
<td>21.9 cm (8.6 in) agreg. subbase (P-154)</td>
</tr>
<tr>
<td>Subgrade</td>
<td>Clay (CH) k=35.3 MPa/m (130 pci)</td>
<td>Clay (CH) k=38.0 MPa/m (140 pci)</td>
<td>Clay (CH) k=38.0 MPa/m (140 pci)</td>
</tr>
</tbody>
</table>

**Gear Load Dimensions for CC2 Traffic Tests**

- 144.8 cm (57 in) (a) 6-wheel gear
- 144.8 cm (57 in) (b) 4-wheel gear

**Traffic Summary for CC2 Test Items**

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Type</th>
<th>Apr-Jun 2004</th>
<th>Jul-Sep 2004</th>
<th>Oct-Dec 2004</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRC-North</td>
<td>4-wheel</td>
<td>12675</td>
<td>0</td>
<td>0</td>
<td>12675</td>
</tr>
<tr>
<td>MRC-South</td>
<td>4-wheel</td>
<td>5405</td>
<td>0</td>
<td>0</td>
<td>5405</td>
</tr>
<tr>
<td>MRC-North</td>
<td>6-wheel</td>
<td>21186</td>
<td>9834</td>
<td>0</td>
<td>31020</td>
</tr>
<tr>
<td>MRC-South</td>
<td>4-wheel</td>
<td>21162</td>
<td>9834</td>
<td>0</td>
<td>30996</td>
</tr>
<tr>
<td>MRS-North</td>
<td>6-wheel</td>
<td>20262</td>
<td>0</td>
<td>0</td>
<td>20262</td>
</tr>
<tr>
<td>MRS-South</td>
<td>4-wheel</td>
<td>21162</td>
<td>9834</td>
<td>0</td>
<td>30996</td>
</tr>
</tbody>
</table>
**Performance Monitoring**
- Visual Distress Surveys.
  - ASTM D 5340-93 and FAA AC 150/5380-6.
  - Daily up to 10,000 passes. Weekly after 10,000 passes.
- Embedded Sensors.
  - Responses monitored for early indication of cracking.
- Nondestructive Tests.
  - HWD every 15 wander (990 passes) up to 10,000 passes. Every 30 wander after 10,000 passes.
- Destructive Testing.
  - Cores to investigate origin of cracks.

**Final Distress Maps**

**Structural Condition Index (SCI)**
- SCI is structural component of rigid PCI.
  - Only load related distress types are considered (e.g., L/T/D cracks, corner breaks, shattered slab).
  - SCI is always equal to or higher than PCI for the same pavement feature.
  - Joint and corner spalling was excluded from the SCI computation for CC2 test items.
- SCI definition is not the same as “Structural PCI” as adopted by the U.S. Navy (MicroPAVER).

**Micro PAVER Computations**
- Record structural distresses based on visual surveys.
- Treat each test item (north side or south side) as a sample unit.
- Follow ASTM procedures for counting distresses and assigning severity levels.

**SCI Versus Coverage Analysis**
- Plot SCI as a function of applied coverages.
  - P/C ratio is computed from wander pattern.
  - All slabs in sample unit versus inside traffic lane only.
- Obtain linear regression of SCI versus log(C).
  - Intercept with SCI=100 line yields \( C_0 \) (conv. to 1st crack).
  - Intercept with SCI=0 line yields \( C_f \) (conv. to full failure).
  - New rigid design concerned with coverages to SCI=80.
  - Lower portions of failure curve (below SCI = 80) are important for overlay designs.
Regression Data for Analysis of SCI Versus Coverages

<table>
<thead>
<tr>
<th>Test Item</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Full Failure,</th>
<th>P/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRC-N</td>
<td>-187.4</td>
<td>512.15</td>
<td>3182.1</td>
<td>461</td>
<td>2.0</td>
</tr>
<tr>
<td>MRC-S</td>
<td>-248.38</td>
<td>598.03</td>
<td>3292.7</td>
<td>546</td>
<td>4.51</td>
</tr>
<tr>
<td>MRC-N</td>
<td>-247.03</td>
<td>941.57</td>
<td>3006.4</td>
<td>2351</td>
<td>4.71</td>
</tr>
<tr>
<td>MRC-S</td>
<td>-286.86</td>
<td>915.72</td>
<td>3086.4</td>
<td>2608</td>
<td>4.71</td>
</tr>
<tr>
<td>MRG-N</td>
<td>-247.03</td>
<td>941.57</td>
<td>3006.4</td>
<td>2351</td>
<td>4.71</td>
</tr>
<tr>
<td>MRG-S</td>
<td>-246.96</td>
<td>935.12</td>
<td>3006.4</td>
<td>2351</td>
<td>4.71</td>
</tr>
<tr>
<td>MRS-N</td>
<td>-231.66</td>
<td>871.13</td>
<td>3306.2</td>
<td>2210</td>
<td>2.71</td>
</tr>
<tr>
<td>MRS-S</td>
<td>-231.66</td>
<td>871.13</td>
<td>3306.2</td>
<td>2210</td>
<td>2.71</td>
</tr>
</tbody>
</table>

\* SCI = A \log(C) + B

Distress Modes in CC2 Test Items

- Measured uplift at all corners was kept minimal (0.38 mm / 15 mils or less).
- Top-down cracks were not eliminated in either the outside or inside lanes.
  - Inside lanes: Received traffic from both wheels. Both top-down and bottom-up fatigue cracks were observed.
  - Outside lanes: Received either no traffic (MRC) or traffic from only one wheel of the dual gear. Top-down cracks were observed.
- Top-down cracks appeared first on outside slabs, even though those slabs received relatively less traffic.

Fatigue Cracks Observed in CC2 Test Items

- Core Sample showing a bottom-up crack in test item MRS-South

Fatigue Cracks Observed in CC2 Test Items

- Top-down crack observed in outside lane of test item MRC-North

SCI Evaluation

- To avoid distortion of the SCI-vs.-coverage analysis due to the early appearance of top-down cracks in the outside lanes, only those slabs receiving traffic from both tires of the dual gear (i.e., the 5 inside slabs) were included in the SCI sample units.
- For SCI evaluation, no distinction was made between visible top-down and bottom-up cracks.

Results: Stabilized and Nonstabilized Test Items

- Deterioration of SCI is best represented by a model that is linear in log of coverages, regardless of whether a stabilized base is used.
- In general, CC2 test results support the principle that higher-quality subbases extend pavement life.
- Additional durability is reflected in the slope of SCI-vs.-log(C) trendline. In general, stabilized base structures exhibited the flattest slope, followed by conventional, and (lastly) slab-on-grade structures.
- Exception was MRS-S.
SCI vs. Coverage Curves for Stabilized Base Test Items

Design Factor vs. Coverages

- Design Factor (DF) = ratio of concrete flexural strength to maximum calculated bending stress.
- LEDFAA model based on Rollings (1988) regression:
  - DF = 0.5234 + 0.3920 \log(C_o) coverages to onset of cracking
  - DF = 0.2967 + 0.3881 \log(C_F) coverages to full failure (SCI 0)
- Recompute design factors for all test items using FEDFAA (3D-FEM) edge stress.
- Evaluate parameters including 7 new NAPTF data points.
- Preliminary analysis - design factors subject to change as we continue to characterize the material properties.

Conclusions

- Rigid pavement full-scale traffic tests recently completed at the FAA's National Airport Pavement Test Facility provided pavement performance and failure data for three new rigid pavement test items and a test strip.
- The performance data were analyzed using the SCI concept to obtain coverages to initiation of structural cracking and to full structural failure.
- The test results are currently being analyzed in conjunction with previous full-scale tests and will be used to update the failure model for rigid pavement and overlay design in future FAA design software.

Questions?