FAA Airport Pavement Technology Program

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Outline
- AC 150/5320-6D “Airport Pavement Design and Evaluation” with associated computer program for design.
- National Airport Pavement Test Facility (NAPTF) Overview.
- Engineering Brief EB-65 “Minimum Requirements to Widen Existing 150-ft. (45-m) Wide Runways for Airbus A380 Operations.”
- 4- and 6-Wheel ACN’s from full-scale test data.
- FEDFAA and NAPTF Rigid Pavement Test Results.

Relevance of FAA Advisory Circulars
- In the U.S.A., for airport pavement construction projects at large airports to be eligible for Federal Government AIP funding (up to 90 percent of cost), the requirements of FAA advisory circulars must be met.

AC 150/5320-6D Change 3 – Design

Advisory Circular

Newest Thickness Design Charts in the AC
Design Charts are Based On:
- CBR method for new and overlaid flexible pavements.
- Westergaard edge stress for new rigid pavements.
- Westergaard edge stress plus empirical formulas for overlaid rigid pavements.
- Gradual development over a period of more than 30 years.

LEDFAA 1.3 Incorporated in the AC with Change 3
- LEDFAA is based on a layered elastic computational library program (called LEAF) included as an integral part of LEDFAA.
- LEAF has a completely new mathematical and program structure compared to other layered elastic programs (BISAR, JULEA, etc.).
- Source code is available for download with BAKFAA (see later).
- Comprehensive documentation available for download with BAKFAA.
- No restriction on public use.

LEDFAA 1.3 User Interface
The program is intended to replace the design charts. The user interface is therefore kept as simple as possible.

LEDFAA 1.3 Flexible Thickness Design for Multiple Gears
- The B-747 nomographs in AC 150/5320-6D were produced with equivalent single wheel loads computed using 16 wheels.
- LEDFAA 1.2 (LEDNEW) computes subgrade strain for one four-wheel gear and then applies that strain to all sixteen wheels to compute CDF.
- LEDFAA 1.3 computes subgrade strain for all wheels in the main landing gear.
- In this regard, LEDFAA 1.3 design philosophy is compatible with 6D but not with LEDFAA 1.2 or the ICAO ACN flexible methodology.

Significant Features of LEDFAA with Change 3
- Allowed as an alternate design procedure to the design charts of chapters 3 and 4 of AC 150/5320-6D.
- Required for projects with mixes including 6-wheel aircraft and new aircraft not closely approximated by existing design charts.
- Future aircraft will be added to LEDFAA - not as new design charts in chapters 3 and 4.

Multiple-Gear Flexible Pavement CDF Computation in LEDFAA 1.3
Multiple-Gear Flexible Pavement CDF Computation in LEDFAA 1.3

- Compute the vertical strain in the subgrade over a grid under the wheels in response to the loads from all of the wheels in the main landing gears (16 for B-747 and 20 for A380):
  - Find the maximum strain in the wing gear area and find CDFs assuming a twin-gear aircraft.
  - Find the maximum strain in the body gear area and find CDFs assuming a twin-gear aircraft.

LEDFAA 1.3 – Rigid Thickness Design for Multiple Gears

- Individual gears on multiple-gear aircraft such as the A380 are treated as belonging to separate aircraft:
  - Compute interior and edge stress for wing gear and treat as a dual-tandem twin-gear aircraft to calculate CDF.
  - Compute interior and edge stress for body gear and treat as a triple-dual-tandem twin-gear aircraft to calculate CDF.

Outline

- National Airport Pavement Test Facility (NAPTF) Overview.

AC 150/5370-11A – Nondestructive Testing

- Covers only deflection measuring devices, primarily impulse (FWD/HWD).
- Available equipment and recommendations for setup, operation, plate size, load, etc.
- Objectives of NDT tests: joint efficiency, backcalculation, void detection, etc.
- Data analysis, primarily backcalculation and rehabilitation design. Compares available computer programs.

AC 150/5370-11A Data Analysis

- Comprehensive review of backcalculation closed-form methods and layered elastic iterative methods.
- Load and life evaluations from backcalculated values.
- Design of new pavements and overlaid pavements using backcalculated values in LEDFAA.
- Examples using BAKFAA.

BAKFAA Computer Program
For flexible pavements, the ACNs initially computed for B-777 (6-wheel gears appeared to be unreasonably high).

- The FAA had similar concerns about the existing CBR method for 6-wheel gears.
- Other theoretical models/methods not good enough to resolve the problem.
- Full-scale traffic test data to structural failure the only way.
- A380 also has 6-wheel body gears.
**Test Vehicle**

- 75,000 lbs (335 kN) max. load per wheel.
- 2.5 mph (4 km/h) traffic test speed.

**CC1 MFC Flexible Test Item Crushed Aggregate Base**

- Upheaval signifying shear failure in structure.

**Trench in CC3 LFC2 Flexible**

**CC3 North, 6-Wheel Track**

**CC3 LFC1 Center Line, 6-Wheel Load, (run after outside lanes failed)**

- Subgrade CBR = 4.3 (increased after construction due to drainage).

**CC-3 PHASE-2: LFC-1 CL TRAFFIC TESTS**
CC3-LFC1 Traffic Results Summary

- A relatively small change in subgrade CBR can produce a very significant change in the magnitude and character of flexible pavement structural performance.
- Very large deformations can occur at, say, 5 passes, even when the life to the failure criterion is as large as 100 passes.
- This is the basis for the 240 coverage requirement in Engineering Brief No. 65, “Minimum Requirements to Widen Existing 150-Foot Wide Runways for Airbus A380 Operations.”

Outline

- A380 747-400 on runways
- CC3 LFC1 6-Wheel Traffic Test Results
- Why Engineering Brief # 65

Why Engineering Brief # 65

- Standard FAA guidance says that the A380 requires a 200 foot (60m) runway and that the outer 50 feet (15m) of a 200 foot (60m) runway must be 0.7T of full pavement.
- Airports were asking for temporary relief from this requirement due to time restraints and cost.

Figure 3-1

AC 150/5320-6D
Minimum Design of outer 50 feet (15m) each side of 200-foot (60m) runway must accommodate a total of 240 coverages of A380 (from NAPTF results).

Asphalt surface must be 5 inches (127mm) or greater of ACC (P-401 or high quality State DOT mix). Normal requirement for wide-body aircraft.

Grading, Marking and Lighting must meet current design standards

New shoulders must be provided for 200-foot (60m) runway

Summary of NAPTF Flexible Pavement Full-Scale Test Results

<table>
<thead>
<tr>
<th>Wheel Configuration</th>
<th>Test Item</th>
<th>Wheel Load, lbs</th>
<th>Repetitions to Failure</th>
<th>Coverages to Failure</th>
<th>Design Thickness in cm</th>
<th>Subgrade CBR</th>
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</thead>
<tbody>
<tr>
<td>CC1-MFS</td>
<td>CC3-LFC2</td>
<td>65,000</td>
<td>1,584</td>
<td>1,099</td>
<td>37</td>
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</tr>
</tbody>
</table>

Post-MWHGL equation:

\[ t = \sigma \left( \frac{P}{8.1 \text{CBR}} \right) \]

Pre-MWHGL equation:

\[ t = \frac{\sigma}{\alpha} \left( \frac{P}{8.1 \text{CBR}} \right) \]

Computation of Alpha Factor

Pass/Coverage ratios calculated from surface coverages in test wander pattern:

- 4-Wheel = 2.36 for CC3 and 2.06 for CC1
- 6-Wheel = 1.57

Subgrade CBR = trench measurements.

Total structure thicknesses are known.

Contact area = 265 square inches.

Compute Alpha using COMFAA.

CBR Equations

\[ t = \frac{\sigma}{\alpha} \left( \frac{P}{8.1 \text{CBR}} \right) \]

\[ \frac{t}{P} \alpha = \frac{\sigma}{8.1 \text{CBR}} \]

\[ \sigma = \frac{P}{8.1 \text{CBR}} \alpha \]

Change the Input Alpha until the design thickness is equal to the test structure thickness.
**Outline**

- AC 150/5320: Airport Pavement Design and Evaluation
- AC 150/5370: Use of Nondestructive Testing in Evaluation of Airport Pavement
- FEDFAA LEDFAA, FAA’s Rigid Pavement Technology Program
- FEDFAA and NAPTF Rigid Pavement Test Results.

**Procedure for Converting NAPTF Structures to Equivalent MWHGL Structures (Example)**

Steps:
- (a) real structure, 29.0 in.
- (b) convert 2 in. AC to 3.2 in. CA (E.F. 1.6)
- (c) add 3.2 in. CA to exist. 8 in. CA = 11.2 in. CA
- (d) convert 5.2 in. CA to 8.3 in. SQS (E.F. 1.6)
- (e) convert 16 in. HQS to 19.2 in. SQS (E.F. 1.2)
- (f) equivalent MWHGL structure, 36.5 in.

**4- and 6-Wheel Alpha Factors for Base-to-Subbase Equivalency = 1.4**

Alpha factor quadratic curve fit intercepts at 10,000 coverages:
- 6-wheel: \( \alpha = 0.8060 \)
- 4-wheel: \( \alpha = 0.7178 \)

From MWHGL report:
- 4-wheel: \( \alpha = 0.825 \)
- 6-wheel: \( \alpha = 0.788 \)

**4- and 6-Wheel Alpha Factors for Base-to-Subbase Equivalency = 1.6**

Alpha factor quadratic curve fit intercepts at 10,000 coverages:
- 6-wheel: \( \alpha = 0.832 \)
- 4-wheel: \( \alpha = 0.795 \)

From MWHGL report:
- 4-wheel: \( \alpha = 0.825 \)
- 6-wheel: \( \alpha = 0.788 \)

**Development of FAA Standards for Airport Pavement Thickness Design**

- LEAPFAA
- Rigid Pavement
- Full-Scale Test Data
- 3D FEM Single-Edge
- LEAPFAA Models
- Evaluation
- FAA and NAPTF
LED FAA Flexible Failure Model
For All Available Full-Scale Test Data Points

NAPTF Rigid Pavement CC2
Traffic Test Item Layout

Placing Concrete in
Checkerboard Pattern

CC2 Test Items - Results

Achievements – New Computer Programs and Full-Scale Test Data

FAA Airport Pavement Technology Program

09/13/2005
Our Website

http://www.airporttech.tc.faa.gov