Aircraft Wandering Impact in Airfield Pavement Design Consideration

Australian Aviation Association (AAA)
Airfield Pavements and Lighting Forum 2021
Key Issues To Be Covered

1. Understanding of Aircraft Wandering Impact
2. Theoretical Sensitivity Check on Airfield Design WITH or WITHOUT Wandering Impact
3. Sensibility in Adopting Wandering Impact Adjustment – FAA's Advice
4. Brief Overview of Design Methodology Based on Previous FAA Design CBR method
5. Are We Conservative Enough In Design?
Pass to Coverage Ratio (P/C Ratio)

1. Aircraft Wander
   Aircraft travel along pavement section often not in perfect straight line or same path. Refers as Aircraft Wander

2. Pass to Coverage
   \( X \) nos. trips/passes on a unit area to complete a full load application

3. A full coverage occurs
   when a unit of pavement experiences maximum response induced by aircraft

4. Flexible pavement
   maximum strain occurs on top of subgrade

5. Rigid pavement
   maximum stress occurs at underside of PCC

FAARFIELD uses concept of effective tire width to calculate P/C ratio
Effective Tyre Width

(Refer to AC150-5320-6F, Section 3.12.8)
AIRCRAFT WANDER - Where?
AIRCRAFT WANDER

✓ Witzak refers ‘Wandering’ as Standard Deviation of Normalised Transverse Traffic Distribution. (σ)

<table>
<thead>
<tr>
<th>Pavement Type</th>
<th>Wandering (mm), σ</th>
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<tbody>
<tr>
<td>Highway</td>
<td>300 (1 ft)</td>
</tr>
<tr>
<td>Airfield Taxiway</td>
<td>600 - 1000 (2-3.5 fts)</td>
</tr>
<tr>
<td>Runway, Take Off Mode</td>
<td>2300 - 4500 (7-15 fts)</td>
</tr>
<tr>
<td>Runway, Landing Mode</td>
<td>4000 - 6000 (13-20 fts)</td>
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</tbody>
</table>

✓ Two aspects
  - Probable Location of Maximum Load Repetitions;
  - Relative degree of Damage per pass as wander effect increase
Predicted and observed airfield pavement distresses (Figure 4.17 (from Witzak), Principle of Pavement Design 2nd edition, Yoder Witzak)
What About Parking Aprons?
Theoretical Calculation
Wander vs. No Wander Impact

1A. Original Annual Aircraft Movements
1B. Converted Coverages of Original Annual Aircraft Movements

2A. 4x increase in Critical Aircraft Movements (B777-10X)
2B. Converted Coverages of 4x increase in Critical Aircraft
Design Parameters Input
Theoretical Calculation
Wandering vs. No Wandering Impact

<table>
<thead>
<tr>
<th>Design Subgrade CBR (%)</th>
<th>PCC Slab Thickness (mm)</th>
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<tbody>
<tr>
<td>2%</td>
<td>602.6</td>
</tr>
<tr>
<td>3%</td>
<td>577.4</td>
</tr>
<tr>
<td>4%</td>
<td>548.1</td>
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<tr>
<td>5%</td>
<td>524.1</td>
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<tr>
<td>6%</td>
<td>509.4</td>
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<tr>
<td>7%</td>
<td>487.7</td>
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<tr>
<td>8%</td>
<td>466.5</td>
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<tr>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>11%</td>
<td></td>
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</tbody>
</table>
Sensibility in Adopting No Wander Impact – FAA Unofficial Response

From: Louisa Pang <louisa.pang@mottmac.com>
Sent: Thursday, January 28, 2021 1:26 AM
To: Brrl, David (FAA) <david.brrl@faa.gov>
Subjects: FAARFIELD 1.43 - Wandering & Pass to Coverage
Importance: High

Hello David,

Am writing this to get a clarification/confirmation from you about FAARFIELD 1.42 program.

However, it came to my attention recently when one of our design peer reviewers raised a question about our taxiway design recently that we need to recalculate all aircraft movements using pass to coverage ratio in computing the structural thickness, to reflect no-wandering impact in taxiway. My interpretation of this query means that instead of 100,000 departures movements of 4226.560, the actual movements to be inputted into the program should be 120,000 equivalent coverages (100,000 x 1.20 [FIC]). This has again being raised by another consultant in another Aircraft Parking Apron project recently to reflect absolute no-wandering impact.

My question to you, what is the typical FAA practice in this? Haven’t found a clear guidance in searching AC 150 5300-6F.

I used to use the British Defence Estate Guide Design and Maintenance Guide (DMG27) that refer to total coverages of various aircraft to a converted representative Design aircraft in pavement structural design as well as PCN-ACN evaluation. Unfortunately, this guideline has rarely been used or perhaps, none existent anymore.

Am attaching a sample that I computed for recently. We never convert the aircraft movements to coverage in order to reflect no-wandering in Parking Aprons.

Rgds,
LP
Dear Louise,

The standard practice for FAA thickness design is to use the same aircraft traffic distribution for all features (runway, taxiway, apron). We assume that there is already sufficient conservatism in the design method, so that we need not be concerned about correcting for more concentrated movements on aprons. However, if you choose to increase the number of passes by multiplying by the P/C ratio in case of known zero wander, that will add an additional level of conservatism. The built-in wander width (70 in.) was originally developed for taxiways. In your case, the design traffic levels for the mix aircraft are already so high that realistically, increasing traffic further will not have much of an effect from a fatigue point of view. Using the example you sent me:

1. For the original traffic levels, FAA gives P-209 thickness = 152 mm.
2. If you increase the departures of all mix aircraft by a factor equal to the P/C ratio, obtain new P-209 thickness = 202 mm. This is an increase of only 1 cm and can probably be ignored, especially as you will specify 200 mm.

not technically correct to lump them into one “equivalent” aircraft type. This would cause all aircraft to be concentrated at the same offset, with the result that the designed thickness could be too high.

Regards,

David R. Brill, P.E., Ph.D.,
Program Manager – Airport Pavement Technology
Federal Aviation Administration
Airport Technology R&D Branch
William J. Hughes Technical Center, ANG-E202
Atlantic City International Airport, NJ 08405
Total Cumulative Damage
(Refer to AC150-5320-6F)

3.12.10.2 In the program implementation, CDF is calculated for each 10-inch (254-mm) wide strip along the pavement over a total width of 820 inches (20.8 m). Pass-to-coverage ratio is computed for each strip assuming that traffic is normally distributed laterally, and that 75 percent of passes fall within a "wander width" of 70 inches (1.778 mm). Statistically, this results in a normally distributed wander pattern with a standard deviation of 30.435 inches (773 mm). The CDF for design is taken to be the maximum CDF computed over all 82 strips. Even with the same gear geometry, airplanes flying different distances will experience different CDFs.

3.12.6.8 Total Cumulative Damage.
FAARFIELD analyzes the damage to the pavement for each airplane and determines a final thickness for the total cumulative damage of all aircraft in the evaluation. FAARFIELD calculates the damaging effects of each airplane in the traffic mix based upon its gear spacing, load, and location of gear relative to the pavement centerline. Then the effects of all airplanes are summed under Miner's law. Since FAARFIELD considers where each airplane loads the pavement, the pavement damage associated with a particular airplane may be isolated from one or more of the other airplanes in the traffic mix. When the cumulative damage factor (CDF) sums to a value of 1.0, the structural design conditions have been satisfied.
Why Transit from Equivalent Coverages of A Design Aircraft Method to Departures of A Fleet Mix Method?

“The old CBR-based FAA design method used equivalent coverages of a representative design aircraft. However, FAARFIELD uses a CDF-based method that takes account of the different track widths for each aircraft.

Because the aircraft in the traffic mix operate at different offsets from the centerline, it is not technically correct to lump them into one “equivalent” aircraft type. This would cause all aircraft to be concentrated at the same offset, with the result that the designed thickness could be too high.”

Dr. David Brill (FAA)

(Refer to AC150-5320-6F, Section 3.12.2)
Are We Conservative Enough in Parking Apron Design (Without Wander Correction)?

1. Gate Capacity
   max 12 nos. aircraft daily turnarounds

2. Construction Tolerance
   10 to 15 mm extra

3. Growth rate
   Rounding Up or slightly higher

4. Concrete Strength Gain
   5 – 10% of Targeted Flexural Strength

5. Aircraft Ramp Design Weight
   5% higher than Maximum Take Off Weight (MTOW)

6. Superiority of Fine Crushed Rock (FCR)
   Better than P209 Cr-Agg

7. Reconfiguration of Gates over Design life

8. Retiring Fleet Mix
Thank you