Pavement Thickness Design for Canadian Airports

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Introduction

• Research Rationale
  – Aging airport pavement infrastructure
  – Heavier aircraft
  – International state-of-the-art design programs

• Scope
  – Flexible and rigid airport pavement design methods
  – Canadian airport data

• Objectives
  – To determine the sensitivity of the pavement design methods to their input parameters
  – To evaluate the Transport Canada design method
Methodology

Stage 1
Data Collection

- Data Requirements
- Sources of Data

Stage 2
Data Organization

- Aircraft Traffic & Volumes
- Climate
- Pavement Structure

Stage 3
Within Program Sensitivity Analysis

- Traffic Sensitivity Analysis
- Climate Sensitivity Analysis
- Subgrade Sensitivity Analysis

Stage 4
Between Program Data Analysis

- Design Methods vs. Transport Canada
Airport Pavement Design Methods

Flexible
- Transport Canada (TC)
- Federal Aviation Administration (FAA) CBR Method
- FAA Layered Elastic Design (LEDFAA)
- Asphalt Institute SW-1
- Australian Airport Pavement Structural Design System (APSDS)

Rigid
- Transport Canada (TC)
- Federal Aviation Administration (FAA) Westergaard Method
- FAA Layered Elastic Design (LEDFAA)
- FAA Finite Element Design (FEDFAA)
- American Concrete Pavement Association AIRPAVE 2000
Sources of Data

Airport Region

Altantic: 34%
Quebec: 20%
Ontario: 13%
Prairie: 0%
Pacific: 13%
Northern: 13%

Airport Type

National Airport System: 60%
Regional/Local: 13%
Arctic: 7%
Remote: 7%
Unclassified: 13%
## Within Program Results – Flexible Equivalent Granular Thickness

<table>
<thead>
<tr>
<th>Analysis</th>
<th>TC</th>
<th>FAA</th>
<th>LEDFAA</th>
<th>SW-1</th>
<th>APSDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBR</td>
<td>S - VS for HVF W for MVF I for LVF &amp; XCW</td>
<td>M - S for NSB S for NSB M for SB S for SB</td>
<td>S – VS for all</td>
<td>VS for all</td>
<td>VS for all</td>
</tr>
<tr>
<td>FI</td>
<td>VS for HSS I for LSS</td>
<td>I for all SS</td>
<td>N/A</td>
<td>*W for all SS</td>
<td>N/A</td>
</tr>
<tr>
<td>MGW</td>
<td>S-VS for HSS I for LSS</td>
<td>VS for all SS</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Wheel Load</td>
<td>W-M for LSS I for HSS</td>
<td>I for all SS</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Legend:
- CBR=California Bearing Ratio
- VS=very strong
- HVF=high volume facility
- HSS=high subgrade strength
- NSB=non-stabilized base
- XCW=extreme cold weather climates
- FI=Freezing Index
- S=strong
- M=moderate
- W=weak
- I=insignificant
- MGW=Maximum Gross Weight
- MVF=medium volume facility
- MSS=medium subgrade strength
- SB=stabilized base
- LVF=low volume facility
- LSS=low subgrade strength
- * = Mean Average Air Temperature
## Within Program Results – Rigid PCC Slab

<table>
<thead>
<tr>
<th>Analysis</th>
<th>TC</th>
<th>FAA</th>
<th>LEDFAA</th>
<th>FEDFAA</th>
<th>AIRPAVE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CBR</strong></td>
<td>W for LVF</td>
<td>W for XLVF</td>
<td>NC for XLVF</td>
<td>NC for XLVF</td>
<td>VS for all</td>
</tr>
<tr>
<td></td>
<td>S-VS for HFV</td>
<td>VS for others</td>
<td>VS for others</td>
<td>S-VS for others</td>
<td></td>
</tr>
<tr>
<td><strong>FI</strong></td>
<td>I for all</td>
<td>I for all</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>MGW</strong></td>
<td>L for HSS</td>
<td>S for all</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>M for LSS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wheel Load</strong></td>
<td>S-VS for all</td>
<td>I for all</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Gear Load</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>L-M for all</td>
</tr>
<tr>
<td><strong>Tire contact area</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>S for all</td>
</tr>
</tbody>
</table>

Legend:
- **CBR** = California Bearing Ratio
- **FI** = Freezing Index
- **MGW** = Maximum Gross Weight
- **VS** = very strong
- **S** = strong
- **M** = moderate
- **W** = weak
- **I** = insignificant
- **HVF** = high volume facility
- **MVF** = medium volume facility
- **LVF** = low volume facility
- **HSS** = high subgrade strength
- **MSS** = medium subgrade strength
- **LSS** = low subgrade strength
- **NSB** = non-stabilized base
- **SB** = stabilized base
- **XLVF** = extreme low volume facility
- **NC** = no change
Between Program Flexible Results

- Subgrade strength & annual growth
  ➔ statistically significant
- Change in subgrade strength more significant than an ↑ in traffic of up to 10%
- TC with frost protection & FAA with stabilized base
  ➔ most conservative flexible pavement structure
- LEDFAA and FAA with stabilized base most closely relate to TC flexible design output
Between Program Rigid Results

- Subgrade strength & annual growth ➔ statistically significant
- Change in subgrade strength more significant than an increase in traffic of up to 10%
- FEDFAA and TC with no frost protection = thinnest PCC slab thicknesses
- TC with frost protection and FAA = thickest PCC slab thicknesses
- FAA > LEDFAA > FEDFAA
- FAA & AIRPAVE most closely relate to Transport Canada rigid design output
Conclusions - Flexible

- Flexible pavement thickness decreases or remains unchanged as the subgrade strength increases.
- The FAA flexible pavement thickness increases dramatically once the subgrade is reduced to a CBR of 6 (weak subgrade strength).
- FAA flexible = f (design aircraft maximum gross weight).
- LEDFAA, FEDFAA, SW-1, APSDS more sensitive to subgrade (vs. traffic).
Conclusions - Rigid

- TC rigid PCC slab thickness = $f$ (design aircraft wheel load)
- TC rigid TPT = $f$ (Freezing Index)
- AIRPAVE = $f$ (tire contact area)
- FEDFAA = thinnest PCC slab thickness
- FAA > LEDFAA > FEDFAA
Recommendations

- Geometric design analysis
  - impact on pavement design and performance
- Comparison new design methods (FAARFIELD)
- New state-of-the-art designs do not necessarily account for the climatic conditions experienced in Canada
- Incorporate economic analysis into the design and planning stage