FAA Pavement Design

AC 150/5320-6E, Airport Pavement Design and Evaluation

- Completely revised in 2008
- New design methodologies for Rigid and Flexible pavements
- Software dependent design procedures
- Addresses modern airplane parameters
Chapter 2
Soil Investigations and Evaluation
Chapter 2
Soil Investigations and Evaluation

- Very few significant changes
- Still uses Unified Soil Classification (USC) system
- Reference to ASTM 2487

<table>
<thead>
<tr>
<th>GW</th>
<th>CL</th>
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<tbody>
<tr>
<td>GP</td>
<td>ML</td>
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<td>PT</td>
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<td>SC</td>
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Chapter 2  
Soil Investigations and Evaluation

Same minimum subsurface boring recommendations

Same soil testing recommendations

<table>
<thead>
<tr>
<th>AREA</th>
<th>Minimum spacing</th>
<th>Minimum depth</th>
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<tbody>
<tr>
<td>RWY/TWY</td>
<td>200 ft interval</td>
<td>10 ft</td>
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<tr>
<td>Other areas</td>
<td>1 per 10,000 sq ft</td>
<td>10 ft</td>
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<tr>
<td>Borrow areas</td>
<td>As necessary</td>
<td>As necessary</td>
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</table>
Chapter 2
Soil Investigations and Evaluation

Continues to split soil compaction requirements based upon 60,000 lb gross weight airplane

$< 60,000$  ASTM D 698  Standard Proctor

$> 60,000$  ASTM D 1557  Modified Proctor
Chapter 2
Soil Investigations and Evaluation

Soil Strength Parameter for RIGID pavement

Resilient Modulus \( E \) (psi) or Modulus of Subgrade Reaction – \( k \)-value (pci)

- Design value – “conservative selection”
- \( k \)-value can be estimated from CBR

\[
k = \left[ \frac{1500 \times \text{CBR}}{26} \right]^{0.7788} \quad (k \text{ in pci})
\]
Chapter 2
Soil Investigations and Evaluation

Modulus of Subgrade Reaction – k-value (pci)

• Removed the statement:

  "Rigid pavement is not too sensitive to k-value and an error in estimating k will not have a large impact on rigid pavement thickness"

Design comparisons show that FAAFIELD thickness design is more sensitive to k-value (converted to E) than the previous Westergaard-based procedure.
With the 3D finite element design procedure, the sensitivity of k-value to rigid design is increased. Errors in selection of k-value can generate noticeable changes in the required pavement thickness.

Example not indicative of all situations
Chapter 2
Soil Investigations and Evaluation

Seasonal Frost

- Same Frost Groups (FG-1, FG-2, FG-3 & FG-4)

- Determination of Depth of Frost Penetration
  - Based on local Engineering experience
  - i.e. local construction practice, building codes, etc.
  - No nomographs or programs provided
Chapter 3
Pavement Design
Chapter 3 - Pavement Design

- Completely New Chapter

- Covers standard pavement design procedures for both flexible and rigid pavement

- Applies to pavement designed for airplanes with gross weights exceeding 30,000 lbs

- Design procedure requires the use of computer program, i.e. FAARFIELD
Chapter 3 - Pavement Design

FAARFIELD 1.0 – Screen Shots

Main Window

Structure Window

Options Window

Aircraft Data Windows

Notes Window
Chapter 3 - Pavement Design

- Rigid Pavement Design based on 3-Dimensional Finite Element model
  - Westergaard design procedure no longer used.

- Flexible Pavement Design based on Layered Elastic design procedure
  - US Corp of Engineers CBR Method no longer used.
Traffic Models

- New procedures require that ALL anticipated traffic be included in the traffic model.
- Concept of “design aircraft” is no longer used
- Cumulative Damage Factor (CDF) replaces need for design aircraft procedure.
Chapter 3 - Pavement Design

Traffic Model - Cumulative Damage Factor

- Sums Damage From *Each* Aircraft
  - Based upon its unique pavement loading characteristics and
  - Location of the main gear from centerline

- DOES NOT use the “design aircraft” method of condensing
  all aircraft into one design model
Chapter 3 - Pavement Design

Traffic Model - Cumulative Damage Factor

- Sums Damage From **Each** Aircraft - Not From “Design Aircraft”

\[
CDF = \frac{\text{number of applied load repetitions}}{\text{number of allowable repetitions to failure}}
\]

- When CDF = 1, Design Life is Exhausted
Traffic Model - Cumulative Damage Factor

- CDF is Calculated for each 10 inch wide strip over a total 820 inch width.
- Each strip treated as a 30X30 panel for analysis
- Gear location and wander considered for each aircraft
- Use Miner’s rule to sum damage for each strip

**Must Input Traffic Mix, NOT “Design Aircraft”**
Chapter 3 - Pavement Design

Traffic Model - Cumulative Damage Factor

Critical location
Chapter 3 - Pavement Design

Traffic Model - Cumulative Damage Factor

<table>
<thead>
<tr>
<th>Airplane Name</th>
<th>Gross Taxi Weight (lbs)</th>
<th>Annual Departures</th>
<th>% Annual Growth</th>
<th>Dep</th>
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<tr>
<td>Adv. B722-100</td>
<td>210,000</td>
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<td>B747-400</td>
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<td>B777-200 ER</td>
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## Sample Aircraft Traffic Mix CDF Contribution

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<thead>
<tr>
<th>Aircraft Name</th>
<th>Gross Weight</th>
<th>Annual Departures</th>
<th>CDF Contribution</th>
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<tr>
<td>Sngl Whl-30</td>
<td>30,000</td>
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<tr>
<td>Dual Whl-30</td>
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*Condition specific and not a general representation of noted aircraft*
Sample Aircraft Traffic Mix CDF Contribution

Condition specific and not a general representation of noted aircraft
Sample Aircraft Traffic Mix CDF Contribution

Condition specific and not a general representation of noted aircraft
Large Aircraft Traffic Mix Gear Locations

- B-777-200
- B-747-400
- A-330
- B-767-200
- A-300-B2
- B-757
- B-727
- B-737-400
- MD-83
- MD-90-30
- DC-9-50
- DW 100,000
- Regional Jet 700
- Regional Jet 200
- DW 45,000
- DW 30,000
- SW 30,000
Chapter 3 - Pavement Design

Remember

Must use the entire traffic mixture

No more “Design Aircraft”

Comparisons between new and previous design procedures using “design aircraft” for the traffic model will result in significant errors
Chapter 3 - Pavement Design

Traffic Model – Airplane Characteristics

- FAARFIELD program currently provides 198 different aircraft models
- Each model is unique with respect to gross load, load distribution, wheel spacing, and tire pressure
- Gear types identified in accordance with FAA Order 5300.7
  - Eliminates “widebody” terminology
Chapter 3 - Pavement Design

Traffic Model – Gear Naming Convention

Main Gear Designation Body/Belly Gear Designation

# X # / # X #

# of gear types in tandem
(A value of 1 is omitted for simplicity.)

Gear type, e.g. S, D, T, or Q

# of main gears in line on one side of the aircraft
(Assumes gear is present on both sides. The value indicates number of gears on one side. A value of 1 is omitted for simplicity.)

Total # of body/belly gears
(Because body/belly gear may not be symmetrical, the gear must identify the total number of gears present and a value of 1 is not omitted if only one gear exists.)

Gear type, e.g. S, D, T, or Q

# of gear types in tandem
(A value of 1 is omitted for simplicity.)
Chapter 3 - Pavement Design

Traffic Model – Gear Naming Convention

- Single $S$
- Dual $D$
- Triple $T$
- Quadruple $Q$
### Traffic Model – Gear Naming Convention

<table>
<thead>
<tr>
<th>Single</th>
<th>Dual</th>
<th>Triple</th>
<th>Quadruple</th>
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<tbody>
<tr>
<td>2 Singles in Tandem</td>
<td>2 Duals in Tandem</td>
<td>2 Triples in Tandem</td>
<td>2 Quadruples in Tandem</td>
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<tr>
<td>3 Singles in Tandem</td>
<td>3 Duals in Tandem</td>
<td>3 Triples in Tandem</td>
<td>3 Quadruples in Tandem</td>
</tr>
</tbody>
</table>
Chapter 3 - Pavement Design -- Examples

S
Single Wheel

D
Dual Wheel

2D
Dual Tandem

3D
B777

2D/D1
DC-10

2D/2D1
A340-600
Chapter 3 - Pavement Design -- Examples

2D/2D2
B747

2D/3D2
A380

C5
Lockheed C5
Chapter 3 - Pavement Design

Traffic Model – Pass to Coverage (P/C) Ratio

- Lateral movement is known as airplane wander and is model by statistically normal distribution.
  - Standard Deviation = 30.435 inches (773 mm)

- (P/C) -The ratio of the number of trips (or passes) along the pavement for a specific point on the pavement to receive one full-load application.

- 6E utilizes new procedure for determining P/C
Chapter 3 - Pavement Design

Traffic Model – Pass to Coverage (P/C) Ratio

- Rigid Pavement
  One Coverage = One full stress application to the bottom of the PCC layer

- Flexible Pavement
  One Coverage = One repetition of maximum strain at the top of the subgrade layer
Chapter 3 - Pavement Design

Traffic Model – Pass to Coverage (P/C) Ratio

- 6E (FAARFIELD) uses the concept of “Effective Tire Width”

- Rigid Pavement – Effective width is defined at the surface of the pavement (equal to tire contact patch) (same as previous P/C procedures)

- Flexible Pavement – Effective width is defined at the surface of the subgrade layer
Traffic Model – Pass to Coverage (P/C) Ratio

Flexible pavement P/C ratio varies with depth of pavement.
Chapter 3 - Pavement Design – Frost Design

FROST DESIGN - 3 options

- Complete Frost Protection
  - Remove frost susceptible materials to below frost depth

- Limited Frost Protection
  - Remove frost-susceptible material to 65% frost depth
  - Limits frost heave to tolerable level

- Reduced Subgrade Strength
  - Reduce subgrade support value
  - Design adequate load carrying capacity for weakened condition
Chapter 3 - Pavement Design – Typical Sections

- Airport pavements are generally constructed in uniform, full width sections

- Variable sections are permitted on runway pavements

  Designer should consider:
  
  - Practical feasibility – complex construction operations
  - Economical feasibility – cost of complex construction
Chapter 3 - Pavement Design – Typical Sections

Variable sections permitted on runway pavements

- Full pavement thickness
- Outer edge thickness (based on 1% of normal traffic)
- Pavement thickness tapers to outer edge thickness
- Transitions

Design using arrival traffic only
Chapter 3 - Pavement Design – Typical Sections

Variable sections permitted on runway pavements

1. Minimum 12” up to 36”
2. For runways wider than 150’, this dimension will increase.
3. Width of tapers and transitions on rigid pavements must be an even multiple of slabs, minimum one slab width.

- Full pavement thickness
- Outer edge thickness (1% traffic)
- Pavement thickness tapers to outer edge thickness
RIGID PAVEMENT DESIGN

AC 150/5320-6E, Airport Pavement Design and Evaluation

CHAPTER 3, Section 3 – Rigid Pavement Design
Typical Rigid Pavement

- Portland Cement Concrete (PCC)
- Subbase Course **
- Subgrade

** Stabilization required when airplanes exceeding 100,000 lbs are in the traffic mixture.
### Chapter 3 Section 3 – Rigid Pavement Design

FAA Specifications For:

<table>
<thead>
<tr>
<th>Surface</th>
<th>SUBBASE</th>
<th>SUBGRADE</th>
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<tr>
<td>P-501</td>
<td>P-154</td>
<td>P-152</td>
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<tr>
<td>P-208</td>
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<td>P-155*</td>
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<td>P-209</td>
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<td>P-157*</td>
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<td>P-211</td>
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<td>P-301</td>
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<td>P-304*</td>
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<td>P-306*</td>
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<td>P-403*</td>
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<tr>
<td>Rubblized PCC</td>
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* Chemically Stabilized Materials
3-Dimensional Finite Element Design

- NEW procedure
- Rigid design uses 3-D finite element method (3D-FEM) for direct calculation of stress at the edge of a concrete slab.
- Predictor of pavement life
  - Maximum Stress at pavement edge
  - Assumed failure position – bottom at slab edge
CRITICAL LOAD CONDITION ASSUMPTIONS

- Maximum stress at pavement edge
- 25% Load Transfer to adjacent slab
Chapter 3 Section 3 – Rigid Pavement Design

CRITICAL LOAD CONDITION ASSUMPTIONS

• Maximum stress at pavement edge
• 25% Load Transfer to adjacent slab
Chapter 3 Section 3 – Rigid Pavement Design

TOP DOWN CRACKING DUE TO EDGE OR CORNER LOADING NOT INCLUDED IN DESIGN

• Maximum stress due to corner or edge loading condition
• Risk increases with large multi-wheel gear configurations
• These conditions may need to be addressed in future procedures
Chapter 3 Section 3 – Rigid Pavement
Design Observed Cracking at NAPTF
Chapter 3 Section 3 – Rigid Pavement Design Observed Cracking – Airbus PEP test

Pavement Test by AIRBUS

Corner cracking and longitudinal panel cracking
Chapter 3 Section 3 – Rigid Pavement Design

Possible Critical Load Locations- Considering Slab Curling

Critical for Bottom-Up Crack

Critical for Top-Down Crack
Chapter 3 Section 3 – Rigid Pavement Design

Pavement Structural Design Life

- Default “design life” is for 20 years
- Structural design life indicates pavement performance in terms of allowable load repetitions before SCI = 80.
- Structural life is determined based upon annual departures multiplied by 20 (yrs). This value may or may not correlate with calendar years depending upon actual pavement use.
- Pavement performance in terms of surface condition and other distresses which might affect the use of the pavement by airplanes is not directly reflected in the structural design life.
Chapter 3 Section 3
Rigid Failure Model as Implemented in FAARFIELD

Rigid pavement failure model in FAARFIELD

\[
\frac{DF}{F_c} = \left[ \frac{F_s'bd}{1 - \frac{SCI}{100}(d - b) + F_s'b} \right] \times \log C + \left[ \frac{1 - \frac{SCI}{100}(ad - bc) + F_s'bc}{1 - \frac{SCI}{100}(d - b) + F_s'b} \right]
\]

where:
\( a = 0.5878, \ b = 0.2523, \ c = 0.7409, \ d = 0.2465, \)
\( C = \) coverages
\( SCI = \) Structural Condition Index
\( F_s' = \) is a compensation factor that accounts for a high-stiffness (stabilized) base.
\( F_c = \) calibration factor = 1.13

**Note:** Equation is linear in \( \log (C) \) for any value of \( F_s' \)
This is a departure from LEDFAA rigid failure model.
Initial cracking occurs at the same time for aggregate and stabilized subbase.

Stabilized section performs better (longer life) after initial cracking.
Rigid Failure Model as Implemented in FAARFIELD

\[
\frac{DF}{F_c} = \left[ \frac{F'_b d}{(1 - \frac{SCI}{100})(d - b) + F'_b} \right] \times \log C + \left[ \frac{1 - \frac{SCI}{100}}{1 - \frac{SCI}{100}}(ad - bc) + F'_b c \right]
\]

\( F_c \) is the calibration, or scaling, factor. It is not derived from analysis of full-scale data, but rather from comparison of the uncalibrated failure model with corresponding designs based on the design chart method in AC 150/5320-6D. In FAARFIELD 1.1, \( F_c \) has a value of 1.13.
FAARFIELD versus Westergaard

Mix 3 - IAD RWY 1L (B727 design aircraft)
Chapter 3 - Pavement Design

Westergaard procedure

FAARFIELD procedure

18.26” PCC
8” Stabilized Base

17.38” PCC
(17.61 with P401 base)
8” P-306 Base

SUBGRADE  k = 160
Chapter 3 - Pavement Design

Westergaard procedure

18.25 “ PCC
8” Stabilized Base
SUBGRADE k = 160

16.52 “ PCC
SUBGRADE k = 323

Effective k = 323

FAARFIELD procedure
Chapter 3 Section 3 – Rigid Pavement Design

REQUIRED INPUT VARIABLES

- Subgrade support conditions
  - k-value or Modulus
- Material properties of each layer
  - Modulus for all layers (flexural strength for PCC)
  - Thickness for all layers except surface PCC
  - Poisson’s Ratio – fixed in FAARFIELD
- Traffic
  - Frequency of load application
  - Airplane characteristics
    - Wheel load, wheel locations, & tire pressure
Chapter 3 Section 3 – Rigid Pavement Design

Subgrade Characteristics

- Subgrade assumed to have infinite thickness
- FAARFIELD accepts Resilient Modulus $E_{SG}$ or k-value (only necessary to enter one value)
  - Converts k-value to modulus
    \[
    E_{SG} = 26k^{1.284}
    \]

$E_{SG}$ = Resilient modulus of subgrade, in psi
k = Foundation modulus of the subgrade, in pci

AASHTO T 222, Nonrepetitive Static Plate Load Test of Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements
Subgrade Characteristics

k-value can be estimated from CBR value

\[ k = \left[ \frac{1500 \times CBR}{26} \right]^{0.7788} \]

k = Foundation modulus of the subgrade, in pci

Allowable range of k-value in FAARFIELD – 17.2 to 361.1
Chapter 3 Section 3 – Rigid Pavement Design

Subbase Layer Characteristics

- Minimum material requirements
  - P-154, P-208, P-209, P-211, P-301, P-304, P-306, P-401, P-403, & rubblized PCC

- Up to three subbase layers allowed in FAARFIELD
  (minimum of one required)
Subbase Layer Characteristics

- Stabilization required with airplanes exceed 100,000 lbs
- Aggregate materials - modulus dependent on thickness
  - Modulus calculated by FAARFIELD based on thickness
- 4 inch minimum thickness requirement
Portland Cement Concrete Layer Characteristics

- Minimum material requirements
  - P-501

- Flexural Strength as design variable
  - FAA recommends 600 – 700 psi for design purposes
  - FAAARFIELD will allow 500 – 800 psi
  - ASTM C 78 Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
    - Modulus fixed at 4,000,000 psi

- 6 Inch minimum thickness requirement
- Thickness rounded to the nearest 0.5 inch
Chapter 3 Section 3 – Rigid Pavement Design

Design Flexural Strength versus P-501 Specification

- Design Strength can be 5% greater than P-501 28-day strength
- e.g. P-501 = 650 psi then design at 680 psi
- Factors to Consider:
  - Capability of the industry in a particular area to produce desired strength
  - Flexural strength vs. cement content data from prior projects at the airport
  - Need to avoid high cement contents, which can affect concrete durability
  - Whether early opening requirements necessitate using a lower strength than 28-day
  - ASR Concerns
Chapter 3 Section 3 – Rigid Pavement Design

Traffic Input for Rigid Pavement Design

- **Airplane characteristics**
  - 198 Airplane models currently available in FAARFIELD
  - Wheel load – determined automatically based on gross weight
  - Wheel locations – Internal to FAARFIELD aircraft library
  - Tire pressure – Internal to FAARFIELD

- **Frequency of load application**
  - Entered as annual departures
    - Arrival traffic ignored
    - User determines percent of total airport volume
• FAARFIELD either places the gear perpendicular or parallel to the edge of a slab.
• FAARFIELD makes this determination.
3-D Finite Element Model
Chapter 3 Section 3 – Rigid Pavement Design

Key Advantages of 3-D Model

- Correctly models rigid pavement features - slab edges and joints.
- Provides the complete stress and displacement fields for the analyzed domain.
- Handles complex load configurations easily.
- No inherent limitation on number of structural layers or material types.
- Not limited to linear elastic analysis.
Disadvantages of 3D-FEM

- May require long computation times.
- Pre-processing and post-processing requirements.
- Solution are mesh-dependent.
  - In theory, the solution can always be improved by refining the 3D mesh.
  - Improvement comes at the expense of time.
3D Finite Element is:

- A method of structural analysis.
- Applicable to a wide range of physical structures, boundary and loading conditions.

3D Finite Element is not:

- A design method or procedure.
- An exact mathematical solution.
- Always preferable to other analysis models.
Structures and Models

In finite element analysis, it is important to distinguish:

- The physical structure
- The idealized model
- The discretized (approximate) model
Improvement in Solution Time

- Approximate time for B-777 stress solution:
  - July 2000: 4 - 5 hours
  - July 2001: 30 minutes
    (single slab with infinite element foundation)
  - May 2002: 2 - 3 minutes
    (implement new incompatible modes elements)
  - Current version implemented in FAARFIELD:
    10 seconds or less
Chapter 3 Section 3 – Rigid Pavement Design

Rigid Pavement Joint Types and Details
Chapter 3 Section 3 – Rigid Pavement Design

Rigid Pavement Joint Types and Details

- 5 joint types provided in 5320-6E
  - **Isolation Joints**
    - Type A – Thickened Edge
    - Type A-1 Reinforced Isolation Joint
  - **Contraction Joints**
    - Type B – Hinged
    - Type C – Doweled
    - Type D – Dummy
  - **Construction Joints**
    - Type E – Doweled
Isolation Joints

Type A – Thickened Edge

NON-EXTRUDING PREMOLDED COMPRESIBLE MATERIAL

DETAIL 1

TO THE NEAREST JOINT BUT NOT LESS THAN 10' (3 m)

Te = 1.25 T TO NEAREST 1" (3mm) BUT AT LEAST T + 2" (5mm)

TYPE A THICKENED EDGE

1/4" (6mm) Radius or Chamfer

Sealant Material 1/4" - 3/8" (6-10mm) Below Surface

3/4"±1/8" (19±3mm)

Rod Backup Material

Non-Extruding Premolded Compressible Material ASTM D-1751 or 1752

3/4"±1/8" (19±3mm)
Isolation Joints

- **Type A-1 – Reinforced**

BAR SIZE AND SPACING TO BE DETERMINED BY CALCULATIONS

1/4" (6 mm) RADIUS OR CHAMFER

SEALANT MATERIAL 1/4" - 3/8"
(6 - 10 mm) BELOW SURFACE

3/4" +/- 1/8"
(19 +/- 3 mm)

NON-EXTRUDED PREMOLDED COMPRESSIBLE
MATERIAL ASTM D-1751 OR 1752

MIN. 3" (75 mm)
CLR. (TYP.)

2' (61 cm)

TYPE A-1 REINFORCED
Chapter 3 Section 3 – Rigid Pavement Design

Rigid Pavement Joint Types and Details

- **Contraction Joints**
  - **Type B – Hinged**

![Diagram of Type B Hinged Joint]

- **OPTIONAL CHAMFER**
  - 1/4" BY 1/4" (6mm BY 6 mm)

- **SEALANT MATERIAL**
  - 1/4" - 3/8" (6 - 10 mm) BELOW SURFACE

- **BACKER ROD**
  - 1 1/4" (32 mm) MINIMUM

TIE BAR 30" (76 cm) LONG ON 30" (76 cm) CENTERS

**TYPE B HINGED**
Chapter 3 Section 3 – Rigid Pavement Design

Rigid Pavement Joint Types and Details

- **Contraction Joints**
  - **Type C – Doweled**

![Diagram of Type C Doweled Joint]

- **Optional Chamfer**
  1/4" BY 1/4" (6mm BY 6 mm)

- **Sealant Material**
  1 1/4" (32 mm) Minimum
  T/4 +/- 1/4" (6 mm)

- **Backer Rod**

- **Paint and Oil One End of Dowel**

**Type C Doweled**
Chapter 3 Section 3 – Rigid Pavement Design

Rigid Pavement Joint Types and Details

Contraction Joints

Type D – Dummy

![Diagram of Type D Dummy Joint](image)
Rigid Pavement Joint Types and Details

Construction Joints

- Type E – Doweled

**Diagram: Type E Doweled Joint**

- Paint and oil one end of dowel.
- T/2 ± d/2
- Sealant material 1/4” - 3/8” (6 - 10 mm) below surface.
- Optional chamfer 1/4” by 1/4” (6mm by 6mm).
- Backer rod 1 1/4” (32 mm) minimum.
Chapter 3 Section 3 – Rigid Pavement Design

Rigid Pavement Joint Types and Details

- Beveled Joint Detail
  - Intended to reduce chipping and spalling attributed to snow plows

```
OPTIONAL CHAMFER
1/4" BY 1/4" (6mm BY 6mm)

W

D

CONSTRUCTION JOINT BETWEEN SLABS

SEALANT MATERIAL 1/4" - 3/8" (6 - 10 mm) BELOW SURFACE

1 1/4" (32 mm) MINIMUM

BACKER ROD
```
Rigid Pavement Joint Types and Details

- **Dowel Bar Spacing at Slab Corner**
### TABLE 3-17. DIMENSIONS AND SPACING OF STEEL DOWELS

<table>
<thead>
<tr>
<th>Thickness of Slab</th>
<th>Diameter</th>
<th>Length</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-7 in (152-178 mm)</td>
<td>¾ in¹ (20 mm)</td>
<td>18 in (460 mm)</td>
<td>12 in (305 mm)</td>
</tr>
<tr>
<td>7.5-12 in (191-305 mm)</td>
<td>1 in¹ (25 mm)</td>
<td>19 in (480 mm)</td>
<td>12 in (305 mm)</td>
</tr>
<tr>
<td>12.5-16 in (318-406 mm)</td>
<td>1 ¼ in¹ (30 mm)</td>
<td>20 in (510 mm)</td>
<td>15 in (380 mm)</td>
</tr>
<tr>
<td>16.5-20 in (419-58 mm)</td>
<td>1 ½ in¹ (40 mm)</td>
<td>20 in (510 mm)</td>
<td>18 in (460 m)</td>
</tr>
<tr>
<td>20.5-24 in (521-610 mm)</td>
<td>2 in¹ (50 mm)</td>
<td>24 in (610 mm)</td>
<td>18 in (460 mm)</td>
</tr>
</tbody>
</table>

¹Dowels noted may be solid bar or high-strength pipe. High-strength pipe dowels must be plugged on each end with a tight-fitting plastic cap or mortar mix.
Chapter 5 – Pavements For Light Aircraft

Rigid Pavement – Joint Steel For Heavy Duty Pavement

**All Tie Bars**

- 5/8 inch Deformed Bars (16 mm)
- 30 inch long (76 mm)
- 30 inch center (76 mm)
### Rigid Pavement Joint Spacing

**TABLE 3-16. RECOMMENDED MAXIMUM JOINT SPACINGS - RIGID PAVEMENT WITH OR WITHOUT STABILIZED SUBBASE**

<table>
<thead>
<tr>
<th>Part I, without Stabilized Subbase</th>
<th>Slab Thickness</th>
<th>Joint Spacing&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>inches</td>
<td>inches</td>
<td>millimeters</td>
</tr>
<tr>
<td>6</td>
<td>152</td>
<td>12.5</td>
</tr>
<tr>
<td>6.5-9</td>
<td>165-229</td>
<td>15</td>
</tr>
<tr>
<td>&gt;9</td>
<td>&gt;229</td>
<td>20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part II, with Stabilized Subbase</th>
<th>Slab Thickness</th>
<th>Joint Spacing&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>inches</td>
<td>inches</td>
<td>millimeters</td>
</tr>
<tr>
<td>8-10</td>
<td>203-254</td>
<td>12.5</td>
</tr>
<tr>
<td>10.5-13</td>
<td>267-330</td>
<td>15</td>
</tr>
<tr>
<td>13.5-16</td>
<td>343-406</td>
<td>17.5&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>&gt;16</td>
<td>&gt;406</td>
<td>20</td>
</tr>
</tbody>
</table>

**Notes:**
1. Transverse and longitudinal joint spacing.
2. For typical runway and taxiway geometries, the corresponding longitudinal joint spacing is 18.75 ft. (5.7 m).
3. Joint spacings shown in this table are maximum values that may be acceptable under ideal conditions.
4. Smaller joint spacings should be used if indicated by past experience.
5. Pavements subject to extreme seasonal temperature differentials or extreme temperature differentials during placement may require shorter joint spacings.
Chapter 3 Section 3 – Rigid Pavement Design

Rigid Pavement Joint Layout

- Expansion Joint
- Doweled or Dummy Joint
- Tied or Doweled Joint
- Doweled Contraction Joint

Fillet May Be Marked On Full or Partial Panels

Reinforce All Odd Shaped Slabs

2 Feet (0.61m) Minimum
CHAPTER 4
AIRPORT PAVEMENT OVERLAYS AND RECONSTRUCTION
Chapter 4 – Airport Pavement Overlays.

OVERLAY TYPES

- **Rigid**
  - PCC over existing flexible pavement (whitetopping)
  - PCC bonded to existing PCC
  - PCC unbonded to existing PCC
    - Deleted partially bonded PCC

- **Flexible**
  - Hot Mix Asphalt over existing flexible pavement
  - Hot Mix Asphalt over existing rigid pavement
Overlay design requires the FAARFIELD program

Input variables include:

- Existing pavement structure
  - Including material properties and traffic requirements

- Existing pavement condition
  - Rigid – use Structural Condition Index (SCI)
  - Flexible – requires engineering judgment
Chapter 4 – Airport Pavement Overlays.

Structural Condition Index (SCI)

- Derived from the Pavement Condition Index as determined by ASTM D 5340 Airport Pavement Condition Index Surveys
- SCI is computed using only structural components from the PCI survey (6 of 15 distress types)
  - SCI will always be greater than or equal to the PCI
Structural Condition Index (SCI)

- SCI = 80 – FAA definition of structural failure
  - 50% of slabs with structural crack

Pavement with an SCI = 80 and no durability issues can appear to be in surprisingly good condition.

Pavement with SCI > 80 but with durability issues can look severely failed.
### Chapter 4 – Airport Pavement Overlays.

**Structural Condition Index (SCI)**

**TABLE 4-1. RIGID PAVEMENT DISTRESS TYPES USED TO CALCULATE THE STRUCTURAL CONDITION INDEX, (SCI)**

<table>
<thead>
<tr>
<th>Distress</th>
<th>Severity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corner Break</td>
<td>Low, Medium, High</td>
</tr>
<tr>
<td>Longitudinal/Transverse/Diagonal Cracking</td>
<td>Low, Medium, High</td>
</tr>
<tr>
<td>Shattered Slab</td>
<td>Low, Medium, High</td>
</tr>
<tr>
<td>Shrinkage Cracks (cracking partial width of slab)*</td>
<td>Low</td>
</tr>
<tr>
<td>Spalling–Joint</td>
<td>Low, Medium, High</td>
</tr>
<tr>
<td>Spalling–Corner</td>
<td>Low, Medium, High</td>
</tr>
</tbody>
</table>
Chapter 4 – Airport Pavement Overlays.

Cumulative Damage Factor Used (CDFU)

- SCI = 100 when there is no visible distress contributing to reduction in SCI (no structural distress types)
- Condition of existing pavement described by CDFU
Chapter 4 – Airport Pavement Overlays.

Cumulative Damage Factor Used (CDFU)

Log Coverages (n)

Structural Condition Index (SCI)

SCI =

100

80 < SCI < 100

No load related distresses (cracks)

LOG SCALE – COVERAGES

100 % CDFU

CDFU < 100

STBS

AGBS

80 < SCI < 100
Cumulative Damage Factor Used (CDFU)

CDFU defines amount of structural life used

For structures with aggregate base

\[ CDFU = \frac{L_U}{0.75 L_D} \quad \text{when } L_U < 0.75 L_D \]

\[ = 1 \quad \text{when } L_U \geq 0.75 L_D \]

- \( L_U \) = number of years of operation of the existing pavement until overlay
- \( L_D \) = design life of the existing pavement in years

FAARFIELD modifies this relationship for stabilized subbase to reflect improved performance
Chapter 4 – Airport Pavement Overlays.

Overlay on Rubblized Concrete Pavement

- Design process is similar to New PCC
- Rubblized PCC layer is available in FAARFIELD
  - Recommended modulus values 200,000 to 400,000 psi
  - Thinner PCC layers warrant lower modulus values

<table>
<thead>
<tr>
<th>Slab Thickness (inches)</th>
<th>Moduli (ksi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 to 8</td>
<td>100 – 135</td>
</tr>
<tr>
<td>8 – 14</td>
<td>135 - 235</td>
</tr>
<tr>
<td>&gt; 14</td>
<td>235 - 400</td>
</tr>
</tbody>
</table>
Chapter 5
Pavements for Light Aircraft
Chapter 5 - Pavements For Light Aircraft

Pavement design for airplanes weighing less than 30,000 lbs

- Flexible pavement design procedure requires FAARFIELD
- Rigid pavement design procedure – fixed thickness
- Aggregate - Turf pavement
Chapter 5 – Pavements For Light Aircraft

198 total airplanes in FAARFIELD

- 50 airplanes ≤ 30,000 lbs
- 67 airplanes ≤ 60,000 lbs
- 79 airplanes < 100,000 lbs
Chapter 5 – Pavements For Light Aircraft

Rigid Pavement – airplanes weighing less than 30,000 lbs

- Portland Cement Concrete surface course requirements
  - P-501
  - State Standards permitted for < 30,000 lbs

- Minimum thickness = 5 inches < 12,500 lb
  6 inches 12,501 to 30,000 lbs

- Maximum Slab Size
  12.5 x 15.0 (ft) (3.8 x 4.6 m)
Chapter 5 – Pavements For Light Aircraft

Rigid Pavement – Joint Steel For Light Duty Pavement

**All dowels**
- 3/4 inch diameter  (19 mm)
- 18 inch Long  (460 mm)
- 12 inch on center  (300 mm)

**All Tie Bars**
- No. 4 Deformed Bars
- 20 inch long  (510 mm)
- 36 inch center  (0.9 m)
CHAPTER 7

PAVEMENT DESIGN FOR AIRFIELD SHOULDERS
Chapter 7 – Pavement Design For Airfield Shoulders

- Shoulders are primarily intended to provide
  - Protection from erosion and generation of debris from jet blast
  - Support for airplanes running off the primary pavement
  - Enhanced drainage
Chapter 7 – Pavement Design For Airfield Shoulders

Shoulder must provide sufficient support for unintentional or emergency operation of any airplane in the traffic mix.

Must also provide support for emergency and maintenance vehicle operations.
Chapter 7 – Pavement Design For Airfield Shoulders

- Minimum section provided by Chapter 7 will not perform in the same fashion as full strength pavement
  - Expect considerable movement and possible rutting with single operations
  - Shoulder pavement should be inspected after every operation.
Chapter 7 – Pavement Design For Airfield Shoulders

Shoulder Design Procedure

- Uses FAARFIELD to determine “most demanding airplane”
- Evaluate proposed shoulder section for each airplane based on 10 operations
- Does not use composite traffic mixture
Shoulder Design Procedure – Material Requirements

- **Asphalt**
  - P-401/403 or similar local material specifications
  - Minimum compaction target density – 93% max theo. density
  - Minimum thickness = 3 inches

- **Portland Cement Concrete**
  - P-501 or similar local material specifications
  - Minimum flexural strength = 600 psi
  - Minimum thickness = 6 inches
Chapter 7 – Pavement Design For Airfield Shoulders

Shoulder Design Procedure – Material Requirements

Base Material

- FAA specifications or similar local material specifications
- Expect CBR ≥ 80
- Minimum thickness = 6 inches
  - May be reduced to 4 inch minimum if asphalt surface increased by 1 inch

Subbase Material

- FAA specifications or similar local material specifications
- Expect CBR ≥ 20
- Minimum thickness = 4 inches (practical construction limit)
Thank You

Questions?