Airport Pavement Design and Evaluation

AC 150/5320-6F

Overview of Changes

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Overview

- **AC 150/5320-6F Airport Pavement Design and Evaluation**
  - What's Different
  - FAARFIELD v1.305 vs v1.41
- **All Pavement Design in Chapter 3**
- **Defined 'regular' use**
- **Tables for Minimum Layer Thickness**
- **Detail Transition Hot Mix Asphalt (HMA) to PCC**
- **Revised Text and Examples to FAARFIELD v1.41**
- **Added Appendix on Nondestructive Testing**

AC 150/5320-6F Organization

Chapter	Topic
1	Airport Pavements – Their Function and Purpose
2	Soil Investigations and Evaluation
3	Airport Pavement Design
4	Pavement Rehabilitation
5	Pavement Structural Evaluation
6	Pavement Design for Shoulders
Appendix A	Soil Characteristics
Appendix B	Design of Structures
Appendix C	Nondestructive Testing (NDT) using falling-weight type impulse load devices
Appendix D	Reinforced Isolation Joint
Appendix E	Related Reading Material

AC 150/5320-6F Why Change

- **Updated FAARFIELD v1.41**
  - AC is what issues update
- **Just Airport Pavement Design**
  - no longer a separate chapter on light duty design since all designs require use of FAARFIELD
- **Tables of minimums based upon weight**
- **More emphasis on evaluation**
- **step by step examples**

FAA Pavement Design

- **Flexible Pavement**
  - Layer elastic theory
- **Rigid Pavement**
  - Three-dimensional finite element theory
- **Requires FAA computer program FAARFIELD**
  - FAA Rigid and Flexible Interactive Elastic Design

Selection of Pavement Type

1.3.2 Selection of Pavement Type.

1.3.2.1 With proper design, materials, construction, and maintenance, any pavement type can provide the desired pavement service life. Historically, airport pavements have performed well for 20 years as shown in *Operational Life of Airport Pavements*, (DOT/FAA/AR-04/46). However, no pavement structure will perform for the desired service life without using quality materials installed and maintained with timely routine and preventative maintenance.

1.3.2.2 The selection of a pavement section requires the evaluation of multiple factors including cost and funding limitations, operational constraints, construction time-frame, cost and frequency of anticipated maintenance, environmental constraints, material availability, future airport expansion plans, and anticipated changes in traffic. The engineer must document the rationale for the selected pavement section and service life in the engineer's report.

Selection of Pavement Type

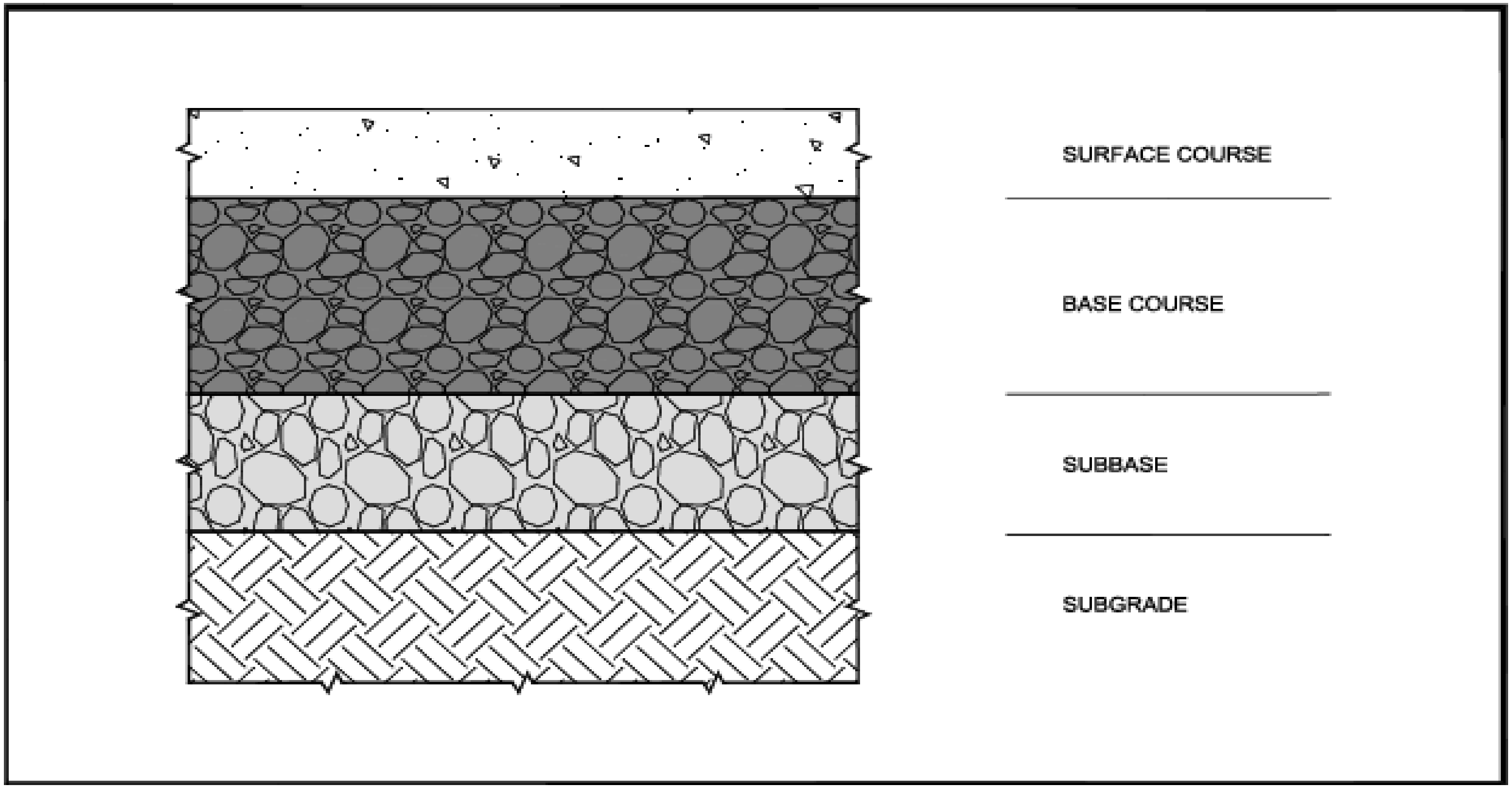
Remember what you need the pavement to do:

- **Provide a surface to safely operate aircraft**
- **Provide one that is smooth, durable, FOD-free surface, properly drained and with adequate macro / micro texture to facilitate control of aircraft**

Selection of Pavement Type

- It is assumed that all alternatives will achieve desired result
- Cost Effectiveness Analysis following OMB A-94

Typical Pavement Structure



Typical Pavement Structure

- **Surface:** Surface courses typically include Portland cement concrete (PCC) and Hot-Mix Asphalt (HMA).
- **Base:** Base courses generally fall into two classes: unstabilized and stabilized.
  - **Unstabilized bases:** crushed and uncrushed aggregates.
  - **Stabilized bases:** crushed and uncrushed aggregates stabilized with cement or asphalt.
- **Subbase:** Subbase courses consist of granular material, which may be unstabilized or stabilized.
- **Subgrade:** Subgrade consists of natural or modified soils.

Minimum Layer Thickness
Flexible Pavement Structures

Table 3-3. Minimum Layer Thickness for Flexible Pavement Structures, Inches (mm)

Layer Type	FAA Specification Item	Maximum Airplane Gross Weight Operating on Pavement, lbs (kg)		
		<12,500 (5 670)	< 100,000 (45 360)	≥100,000 (45 360)
HMA Surface[1, 2,3]	P-401, Hot Mix Asphalt (HMA) Pavements	3 in. (75 mm)	4 in. (100 mm)	4 in. (100 mm)
Stabilized Base	P-401 or P-403; P-304; P-306[4]	Not Required	Not Required	5 in. (125 mm)
Crushed Aggregate Base[5,6]	P-209, Crushed Aggregate Base Course	3 in. (75 mm)	6 in. (150 mm)	6 in. (150 mm)
Aggregate Base[5,7,8]	P-208,Aggregate Base Course	3 in. (75 mm)	Not Used[7]	Not Used
Subbase[5,8]	P-154, Subbase Course	4 in. (100 mm)	4 in. (100 mm) (If required)	4 in. (100 mm) (if required)

AC 150/5320-6F

- Lots of information in the footnotes
- When substituting material consider what you need the material to do

Notes:

1. P-601-Fuel Resistant Hot Mix Asphalt may be used to replace the top 2 in (75 mm) of P-401 where a fuel resistant surface is needed; structurally, P-601 considered same as P-401.
2. Additional HMA surface above minimum typically in 0.5-inch (10-mm) increments.
3. P-403 may be used as surface course < 12,500 pounds (5,760 kg) or for HMA base or leveling course.
4. Use of P-306 requires FAA approval on federally funded projects to assure adequate measures taken to control potential for reflective cracking.
5. Use the larger of the thicknesses in this table or the thickness calculated by FAARFIELD rounded to the nearest 0.5 inch (10 mm). Additional thickness may be required for frost protection above minimums.
6. P-209, Crushed Aggregate Base Course, when used as a stabilized base course, is limited to pavements designed for gross loads of 100,000 pounds (45,360 kg) or less, except as noted in paragraph 3.6, Stabilized Base Course.
7. P-208, Aggregate Base Course, when used as a base course, is limited to pavements designed for gross loads of 60,000 pounds (27,220 kg) or less.
8. P-219 Recycled Concrete Aggregate Base Course may be used as an aggregate base or subbase. How P-219 will perform is related to the quality of the material it is made from combined with the method used to process it into an aggregate base.

Structural Layer Thickness vs Construction Layer Thickness

- **<u>Minimum Construction Lift Thickness</u>**
  - 4-6 x nMAS
  - Gradation 1 3 inches
  - Gradation 2 2 inches
  - Gradation 3 1-1/2 inches
- **<u>Research supports thicker lifts perform better</u>**

Subgrade Support

2.1.3.2 → The design value for subgrade support should be conservatively selected to ensure a stable subgrade and should reflect the long term subgrade support that will be provided to the pavement. The FAA recommends selecting a value that is one standard deviation below the mean. Where the mean subgrade strength is lower than a California Bearing Ratio (CBR) of 5, it may be necessary to improve the subgrade through stabilization or other means in order to facilitate compaction of the subbase. When the design CBR is lower than 3, it is required to improve the subgrade through stabilization or other means. See paragraph 2.6.

CBR < 5 **Recommend** Improvement

CBR < 3 **Require** Improvement

Subgrade Drainage

- See AC 150/5320-5, Appendix G for design guidance on subsurface drainage
- Soil k < 20 ft/day: subsurface drainage layer recommended

Chapter 3 Pavement Design

- **Design Guidance for Airfield Pavements**
  - All pavement designs require FAARFIELD
    no differentiation between light and aircraft > 30K
  - Tables of Minimum Layer Thickness by weight

- **Stabilized Base Course**
  - Full Scale Performance Tests prove that pavements with stabilized bases have superior performance
  - Exception: < 5% Traffic > 100K and < 110K

Pavement Life

- **Structural Life**: Strength to carry loads
- **Functional Life**: Acceptable Service relative to: foreign object debris (FOD), Skid Resistance or roughness
- **FAARFIELD Structural Life** = **Design Life**

- **Theoretically** possible to perform for any period
- **Actual Life** f(airplane mix, quality of materials and construction, routine & preventative maintenance)

Pavement Life

Typically, pavements on federally funded FAA projects are designed for a 20 year structural life. Designs for longer periods may be appropriate at airfields where the configuration of the airfield is not expected to change and where future traffic can be forecast with relative confidence beyond 20 years. A longer design life may be appropriate for a runway at a large hub airport where the future aircraft traffic can be forecast and where both the location and size of the runway and taxiways is not anticipated to change. However, when designing a taxiway at a smaller airport it may be more prudent to design for no more than 20 years, than to try to forecast the composition and frequency of future activity. Many airports have significant changes planned, but whether these plans ultimately become reality depends on local economic conditions, (e.g. business upturns or downturns at the fixed base operator (FBO), and the number and composition of based aircraft). Typically a life cycle cost effectiveness analysis is utilized to support design periods other than 20 years. However, fiscal constraints (i.e. funds available) may dictate which pavement section(s) and design life is considered.

Longer life not appropriate for all airports

No Maintenance = Reduced Life

3.10.4 All pavements will require routine and/or preventative maintenance during the service period. For a pavement to achieve its design life, routine crack sealing and applications of pavement seal coats will be required for flexible pavements; and crack sealing, joint sealant repair/replacement and isolated panel replacement will be required for rigid pavement. Due to deterioration from normal use and the environment, rehabilitation of surface grades and renewal of skid-resistant properties may also be needed for both flexible and rigid pavements.

No pavement will achieve its design life without routine and preventative maintenance.

Traffic

- **In general design for ‘regularly’ using aircraft**
- **‘Regular’ use 250 annual departures (500 operations)**
- **Sensitivity analysis for occasional or seasonal**
  - Design Section
  - After adjusting structure for rounding and construction evaluate impact of all aircraft

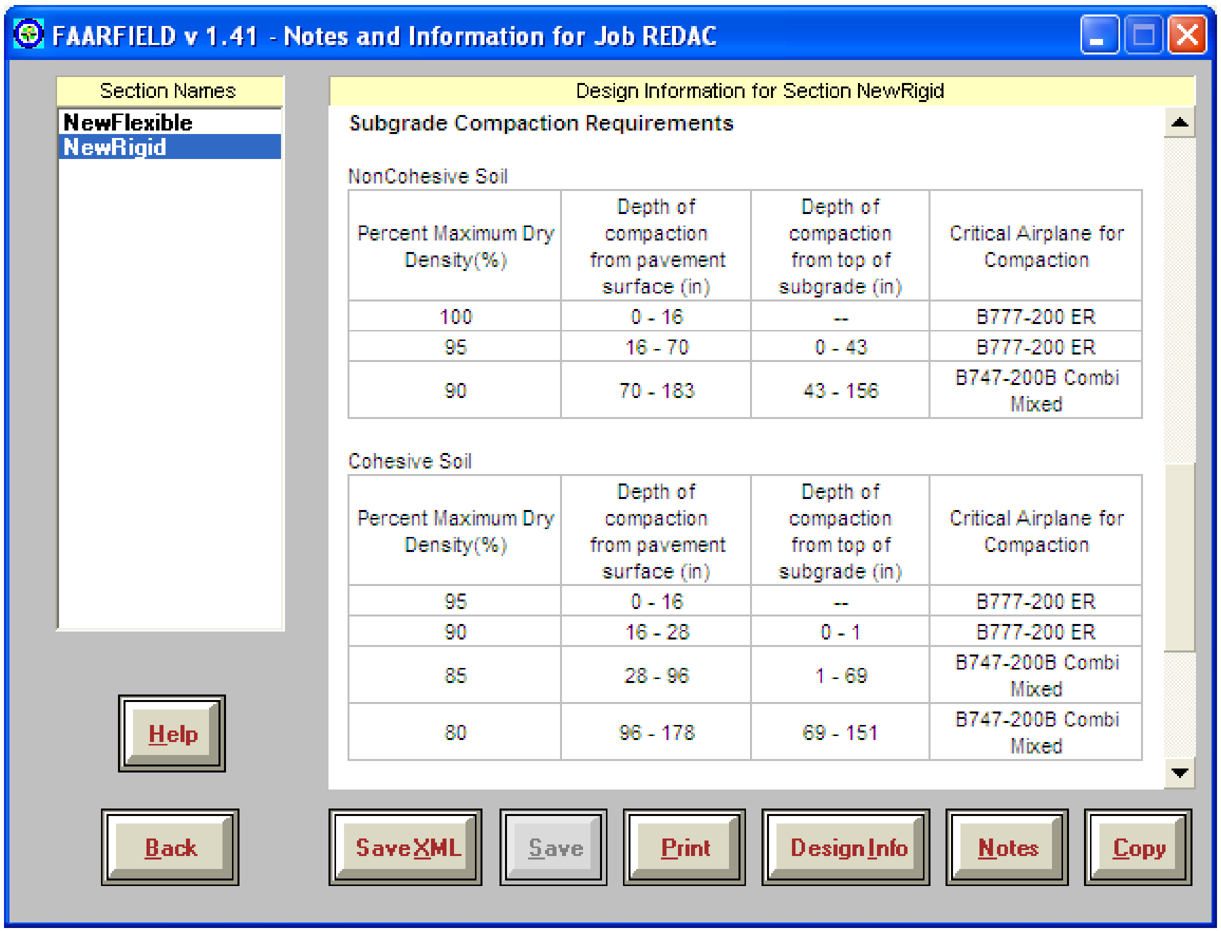
FAARFIELD 1.4 – What's New?

FAARFIELD 1.4 has:

- Completely revised flexible and rigid failure models based on newest full-scale test data.
- Improved, more accurate 3D finite element model.
- Completely rewritten concrete overlay design procedure.
- Support for user-defined gear configurations.
- Updated aircraft library aligned with COMFAA 3.0.
- Automated, software-based compaction criteria.
- All data files now stored in document directories.
- Automatically generates PDF design report.

Automated Compaction Criteria

Computes compaction control points for rigid & flexible pavements.


FAARFIELD v 1.41 - Notes and Information for Job REDAC

Section Names
- NewFlexible
- NewRigid

Design Information for Section NewRigid

Subgrade Compaction Requirements

NonCohesive Soil

Percent Maximum Dry Density(%)	Depth of compaction from pavement surface (in)	Depth of compaction from top of subgrade (in)	Critical Airplane for Compaction
100	0 - 16	--	B777-200 ER
95	16 - 70	0 - 43	B777-200 ER
90	70 - 183	43 - 156	B747-200B Combi Mixed

Cohesive Soil

Percent Maximum Dry Density(%)	Depth of compaction from pavement surface (in)	Depth of compaction from top of subgrade (in)	Critical Airplane for Compaction
95	0 - 16	--	B777-200 ER
90	16 - 28	0 - 1	B777-200 ER
85	28 - 96	1 - 69	B747-200B Combi Mixed
80	96 - 178	69 - 151	B747-200B Combi Mixed

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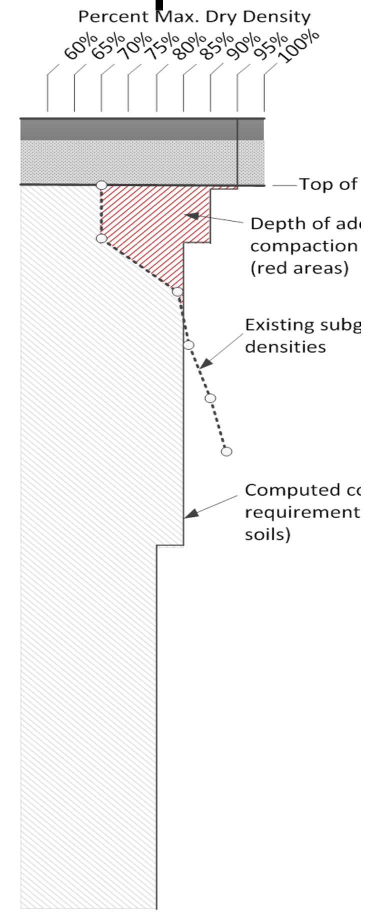


Compaction Tables

Percent of Max. Dry Density

Depth from Surface

Depth from Top of Subgrade

Critical Airplane for Compaction

Subgrade Compaction Requirements

NonCohesive Soil

Percent Maximum Dry Density(%)	Depth of compaction from pavement surface (in)	Depth of compaction from top of subgrade (in)	Critical Airplane for Compaction
100	0 - 34	0 - 5	A380 Belly
95	34 - 105	5 - 76	A380 Belly
90	105 - 177	76 - 148	A380 Belly

Cohesive Soil

Percent Maximum Dry Density(%)	Depth of compaction from pavement surface (in)	Depth of compaction from top of subgrade (in)	Critical Airplane for Compaction
95	0 - 30	0 - 1	A380 Belly
90	30 - 78	1 - 50	A380 Belly
85	78 - 127	50 - 98	A380 Belly
80	127 - 174	98 - 145	A380 Belly

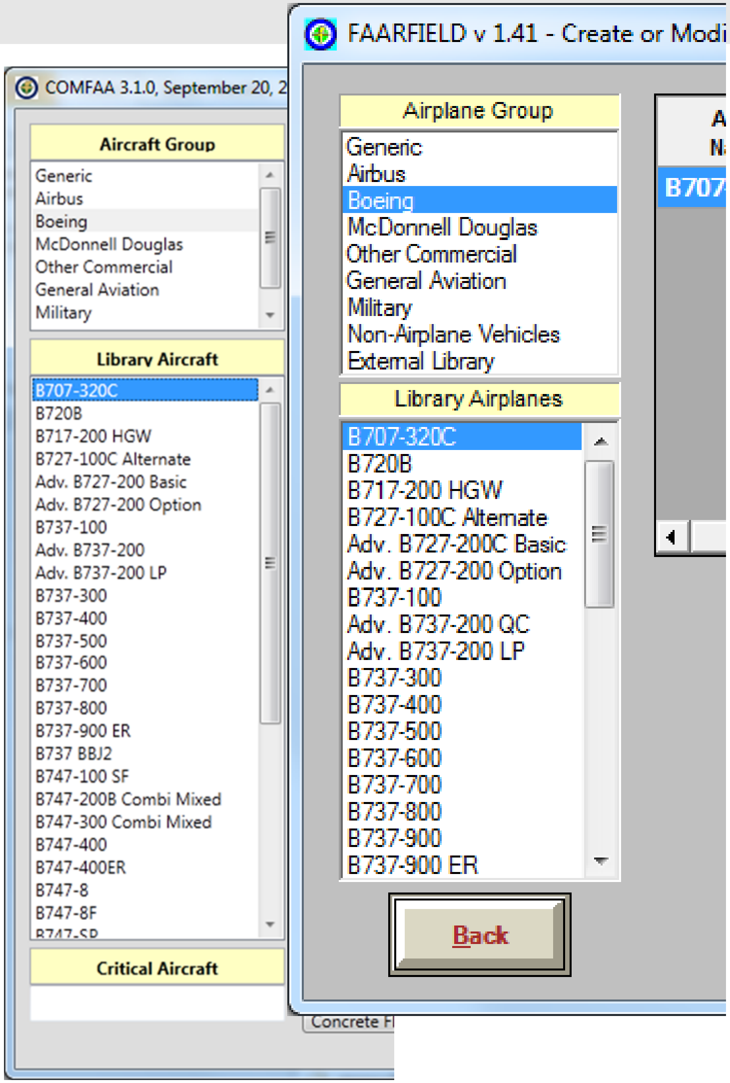
Subgrade Compaction Notes:

1. Noncohesive soils, for the purpose of determining compaction control, are those with a plasticity index (PI) less than 3.
2. Tabulated values indicate depth ranges within which densities should equal or exceed the indicated percentage of the maximum dry density as specified in item P-152.
3. Maximum dry density is determined using ASTM Method D 1557.
4. The subgrade in cut areas should have natural densities shown or should (a) be compacted from the surface to achieve the required densities, (b) be removed and replaced at the densities shown, or (c) when economics and grades permit, be covered with sufficient select or subbase material so that the uncompacted subgrade is at a depth where the in-place densities are satisfactory.
5. For swelling soils refer to AC 150/5320-6E paragraph 313.

Modified Proctor (Heavy Load)

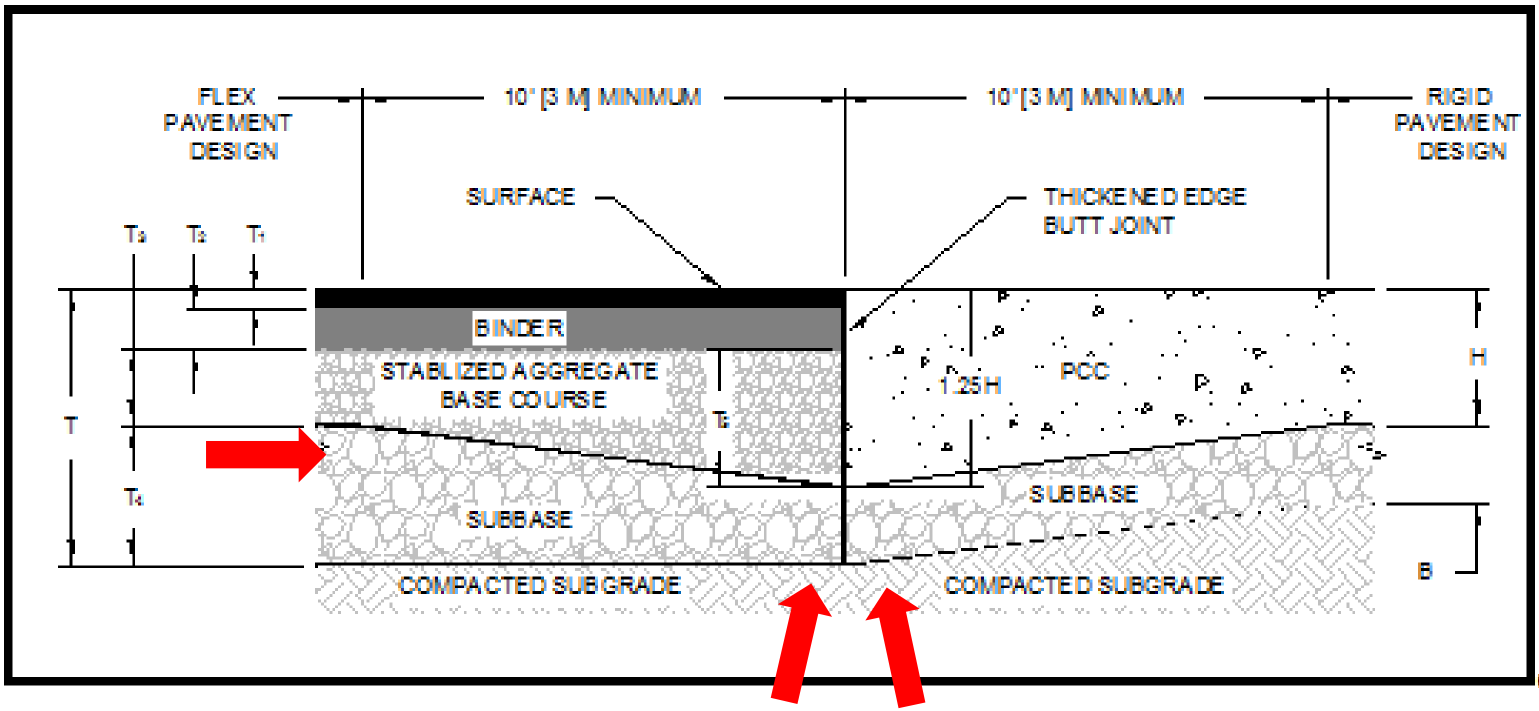
Aircraft Libraries

- **FAARFIELD & COMFAA aircraft libraries aligned to the extent possible.**
- **All Multigear AC split into main & belly, but linked for weight & activity**
- **Included new aircraft:**
  - A350-900 (Preliminary)
  - B747-8
  - B787-9
  - Embraer Fleet



Typical Details (new)

Figure 3–18. Transition between PCC and HMA Pavement Sections



Note: Not shown, but good idea to seal joint between HMA and PCC

Overlay Design

- **Reason for Rehabilitation**
  - Why is pavement ready for rehabilitation
  - Structural, material distress, other

- **Start with condition assessment**
  - Complete assessment of pavement materials and structural integrity
  - Thickness, condition, nature and strength of each layer
- **Design must correct reason for rehabilitation**

Overlay

- **FAARFIELD overlay design**
  - Layered Elastic and finite element analysis
- **Four types of overlay**
  - HMA overlay of flexible or rigid
  - PCC overlay of existing flexible or rigid
- **Structural Overlay**
  - Minimum 3”
  - Thicker overlays better long term performance
- **Non-Structural Overlay**
  - Minimum 2”

Preparation for Overlay

- **Defective areas in base, subbase and subgrade must be corrected**

Reporting Weight Bearing Strength

- Aircraft Classification Number / Pavement Classification Number (ACN/PCN)
- ICAO Standardized Method
- USA Procedure in AC 150/5335-5C
- FAA Software Program COMFAA & Excel Spreadsheet to facilitate evaluation
- Report on FAA MasterRecord 5010

Chapter 6: Pavement Design for Shoulders

- **Paved shoulders**
  - Required for Aircraft Group IV and higher
  - Recommended Aircraft Group III
- **Stabilized Shoulders**
  - Recommended Aircraft Group I & II
  - (Turf, aggregate-turf, soil cement, lime or bituminous stabilized soil)
- **Most Demanding of**
  - 15 Passes of most demanding airplane or anticipated traffic from maintenance vehicles

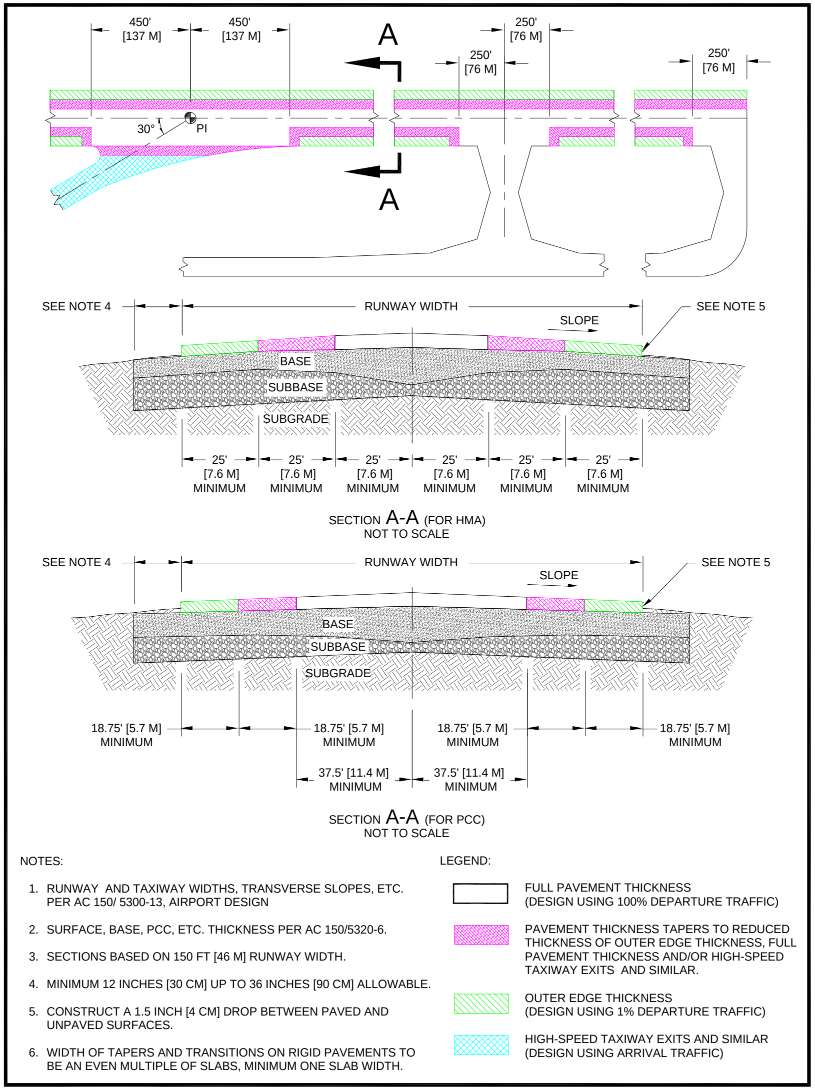
Chapter 6: Pavement Design for Shoulders

Table 6–1. Minimum Shoulder Pavement Layer Thickness

Layer Type	FAA Specification Item	Minimum Thickness, in (mm)
HMA Surface	P-401, P-403	4.0 (100)
PCC Surface	P-501	6.0 (150)
Aggregate Base Course	P-209, P-208,	6.0 (150)[1]
Subbase (if needed)	P-154	4.0 (100)

Appendix E: Variable Section RW

- **No change still allowed (just rarely done)**
  - Keel 100% traffic
  - Outer edge 1% traffic
  - transitions between



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