Standards for Specifying Construction Of Airports

FAA Standard Materials in FAARFIELD Thickness Design

Presented to: X ALACPA Seminar on Airport Pavements and VIII FAA Workshop

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Outline of Presentation

- **Advisory Circular 150/5370-10F.**
  - Standard materials for flexible pavement construction.
  - Standard materials for rigid pavement construction.
  - Conventional and stabilized base materials.
  - Quality control, acceptance, percent within limits.
- **AC 150/5370-10F standard materials in FAARFIELD design.**
- **Use of alternate (non-standard) materials in FAA thickness design.**

AC 150/5370-10F

- **Standards for Specifying Construction of Airports.**
- **Most recent version – released 30 Sept 2011.**
- **Required to be used for all projects funded under an Airport Improvement Program (AIP) grant (U.S.).**
- **Available at:** **http://www.faa.gov/airports/resources/advisory_circulars/**

U.S. Department
of Transportation

Federal Aviation
Administration

Advisory Circular

Subject: Standards for Specifying Construction Of Airports	**Date:** 9/30/2011 **Initiated by:** AAS-100	**AC No:** 150/5370-10F **Change:** NA

1. PURPOSE. This advisory circular (AC) provides standards for the construction of airports. Items covered in this AC include general provisions, earthwork, flexible base courses, rigid base courses, flexible surface courses, rigid pavement, fencing, drainage, turfing, and lighting installation.

2. APPLICATION. The Federal Aviation Administration (FAA) recommends the guidelines and specifications in this AC for materials and methods used in the construction of airports. In general, use of this AC is not mandatory. However, use of this AC is mandatory for all projects funded with federal grant monies through the Airport Improvement Program (AIP) and with revenue from the Passenger Facility Charge (PFC) Program. See Grant Assurance No. 34, "Policies, Standards, and Specifications," and PFC Assurance No. 9, "Standards and Specifications."

3. CANCELLATION. This AC cancels AC 150/5370-10E, Standards for Specifying Construction of Airports, dated September 30, 2009.

4. PRINCIPAL CHANGES. This AC contains the following changes:

a. Document page numbers reformatted and section number/title added to bottom of each page to facilitate searching document. Tables reformatted for clarity. Minor text edits for grammar, punctuation and acronyms throughout the AC.

b. Page iii and Page 1: Deleted information on obtaining printed copies of advisory circular.

c. Paragraph 40-09 Final Clean Up renumbered as 40-08.

d. Paragraph 50-03: Added statement about discrepancies within cited standards for testing occurring and the contractor's responsibility to bring any apparent discrepancy within standard test methods to the engineers attention.

e. Paragraph 60-01, a and b: Added the Addendum and clarified manufacturer statement.

f. Paragraph 90-06 PARTIAL PAYMENTS replaced with new Subsection 90-06 to be consistent with the Disadvantaged Business Enterprise (DBE) retainage provision requirements of 49 CFR § 26.29.

g. Paragraph 90-08 PAYMENT OF WITHHELD FUNDS revised to reflect changes made to Subsection 90-06 PARTIAL PAYMENTS.

h. Section 120: Updated Nuclear testing method. Deleted ASTM D 2922 Density of Soil in Place by the Nuclear Density Method. Added ASTM D 6938 In-Place Density and Water Content of Soil and

Included Specifications (Partial List)

- **Earthwork**
  - P-152 Excavation & Embankment
  - P-154 Subbase Course
- **Flexible Base Course**
  - P-209 Crushed Aggregate Base Course
  - P-219 Recycled Concrete Aggregate Base Course
- **Rigid Base Course**
  - P-301 Soil-Cement Base Course
  - P-304 Cement-Treated Base Course
  - P-306 Econocrete Base Course
- **Flexible Surface Courses**
  - P-401 Plant Mix Bituminous Pavement
  - P-403 Plant Mix Bit. (Base, Leveling or Surface Course)
- **Rigid Surface Course**
  - P-501 Portland Cement Concrete Pavement
- **Miscellaneous**
  - P-603 Bit. Tack Coat
  - P-604 Compression Joint Seals
  - P-609 Seal Coats and Bit. Surface Treatments
  - P-620 Runway and Taxiway Painting
  - P-621 Saw-cut Grooves

Standard Materials for Flexible Pavement Construction

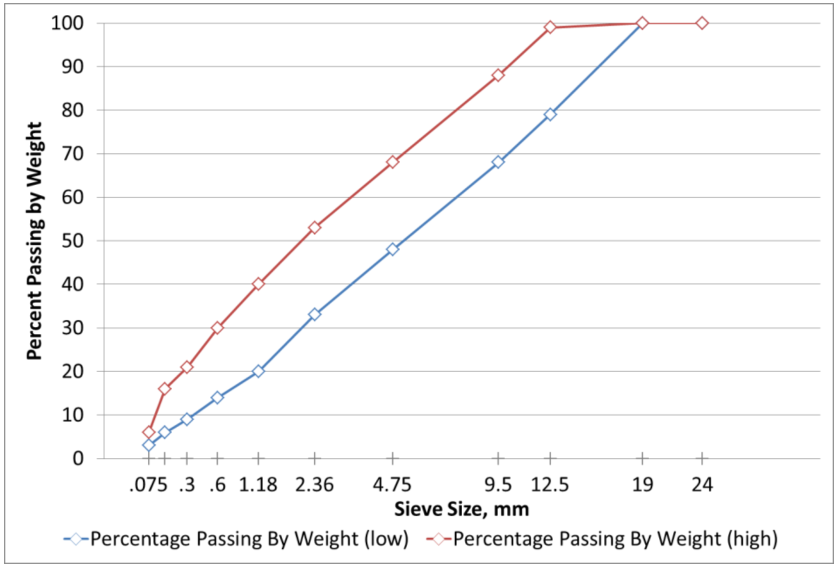
- **Flexible surface courses for pavements handling aircraft 12,500 lbs. (5670 kg) or above must conform to item P-401.**
- **Item P-403 can be used for:**
  - HMA stabilized base courses;
  - Leveling courses;
  - Surfaces of shoulders or pavements for aircraft less than 12,500 lbs. (5670 kg) gross weight.
- **Any material meeting P-401 will also meet P-403. (Reverse is not true.)**
- **Standard base course (unstabilized) is item P-209.**
- **Subbase courses conform to item P-154.**

Item P-401
Plant Mix Bituminous Pavements

- **P-401 specification covers:**
  - Material requirements;
  - Mix design (job mix formula);
  - Construction methods;
  - Acceptance requirements;
  - Contractor quality control (QC);
  - Method of payment and pay adjustment factors.
- **Note that the AC cannot be used "by reference." The engineer must make appropriate insertions where indicated by brackets [...] in the text.**

P-401 Mix Design

- **Mix design is based on Marshall criteria:**
  - Use 75 blows if aircraft gross weight is 60,000 lbs. or more.
  - 50 blows for < 60,000 lbs.
- **Aggregate gradation and minimum VMA are specified based on max. particle size.**
- **Alternate criteria based on Superpave Gyratory Compactor (SGC) are given in EB 59A. Considered a modification to standards.**



Aggregate Gradation Limits for Item P-401 (3/4 inch/19 mm maximum stone size)

P-401 Acceptance Criteria

Characteristic	Acceptance Criteria
Marshall Stability and Flow	PWL > 90%
Air Voids	PWL > 90%
Mat Density	PWL > 90%
Joint Density	PWL > 90%
Thickness	Max. deficiency on any sampled point = ¼ in. Average thickness > indicated for each lift.
Smoothness	Allow. variation on 16-foot straightedge = ¼ in.
Grade	Allow. variation = ½ in. from plan elevation.

Notes:
PWL = Percent within limits.
When P-401 Superpave is used, Marshall stability and flow are not evaluated for acceptance.

Item P-403
(Base and Leveling Course, Shoulders)

- **The P-403 specification is similar to Item P-401, except:**
  - Marshall design criteria for stability, flow and air voids are not as stringent.
  - Acceptance based on mat and joint density, thickness, smoothness and grade only (no evaluation of stability and flow from plant material).
  - Density is based on a straight acceptance limit (96% for mat density, 94% for joint density). PWL is not used.

Standard Materials for Rigid Pavement Construction

- **Portland cement concrete surface courses must conform to Item P-501.**
- **Standard material is jointed plain concrete pavement (JPCP).**
  - Embedded steel concrete or continuous reinforced concrete pavement (CRCP) may be used.
  - Thickness requirement is the same as JPCP.
- **Standard subbase (unstabilized) is item P-209.**
- **Stabilized subbase (required for aircraft heavier than 100,000 lbs. / 45,360 kg) can conform to:**
  - Item P-304 (cement-treated base)
  - Item P-306 (econocrete base)
  - Item P-403 (plant mix bituminous, base & leveling course)

Item P-501

Portland Cement Concrete Pavements

- **P-501 specification covers:**
  - Material requirements;
  - Mix proportions, cementitious materials, admixtures;
  - Construction methods;
  - Acceptance requirements;
  - Contractor quality control (QC);
  - Method of payment and pay adjustment factors.
- **Note that the AC cannot be used “by reference.” The engineer must make appropriate insertions where indicated by brackets […] in the text.**

P-501 Mix Design

Flexural Strength Test (ASTM C 78) on Concrete Beam Specimen

- **Mix design is based on achieving 28-day flexural strength (ASTM C 78).**
  - Minimum flexural strength 600 psi.
  - 28-day compressive strength can be specified when aircraft weight is under 30,000 lbs. (13,500 kg).
- **Cementitious materials:**
  - Minimum cementitious material = 564 lbs./CY (335 kg/m^3)
  - Maximum water/cementitious materials ratio = 0.45
  - Flyash and Ground Blast Furnace Slag (GBFS) may replace up to 55% of portland cement.

P-501 Acceptance Criteria

Characteristic	Acceptance Criteria
Flexural Strength (C 78)	PWL > 90%
Thickness	PWL > 90%
Smoothness	Allow. variation on 16-foot straightedge = ¼ in.
Grade	Lateral alignment of pavement edge ± 0.10 ft. Vertical deviation from plan grade ± 0.04 ft.
Edge Slump (for slip form)	15% or less of free edge > ¼ in.; 0% > 3/8 in.
Dowel Bar Alignment	Misalignment not to exceed 2% in either plane.

Notes:
PWL = Percent within limits.

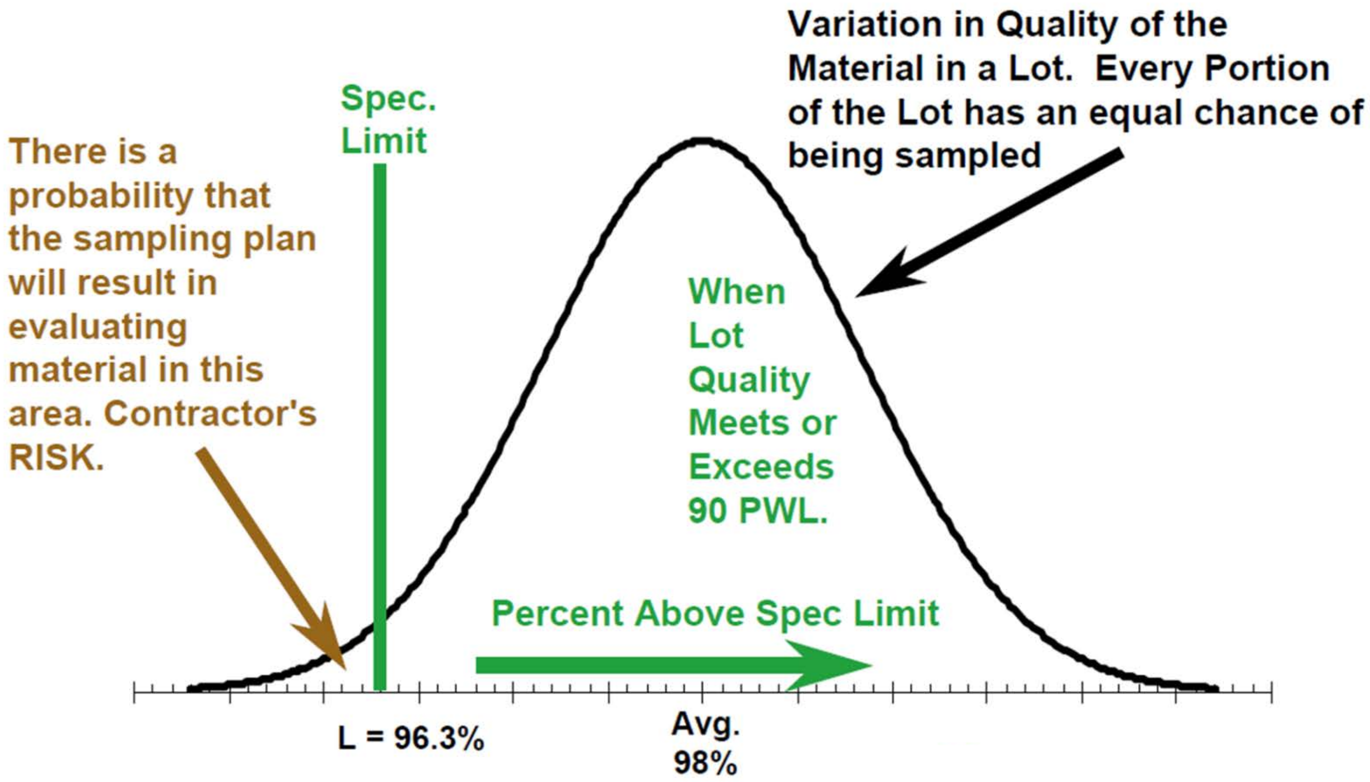
Quality Control – HMA and PCC

- **QC is the responsibility of the contractor.**
- **AC 150/5370-10F General Provision Section 100 requires a Contractor Quality Control Program when P-401 or P-501 is in the project.**
- **Specification items P-401 and P-501 contain minimum items to be included in the Contractor Quality Control Program.**
  - Addresses labs and technicians.
  - Processes include lab production, plant production and field placement.
  - Some processes require the contractor to use statistical quality control measures (run and range charts).

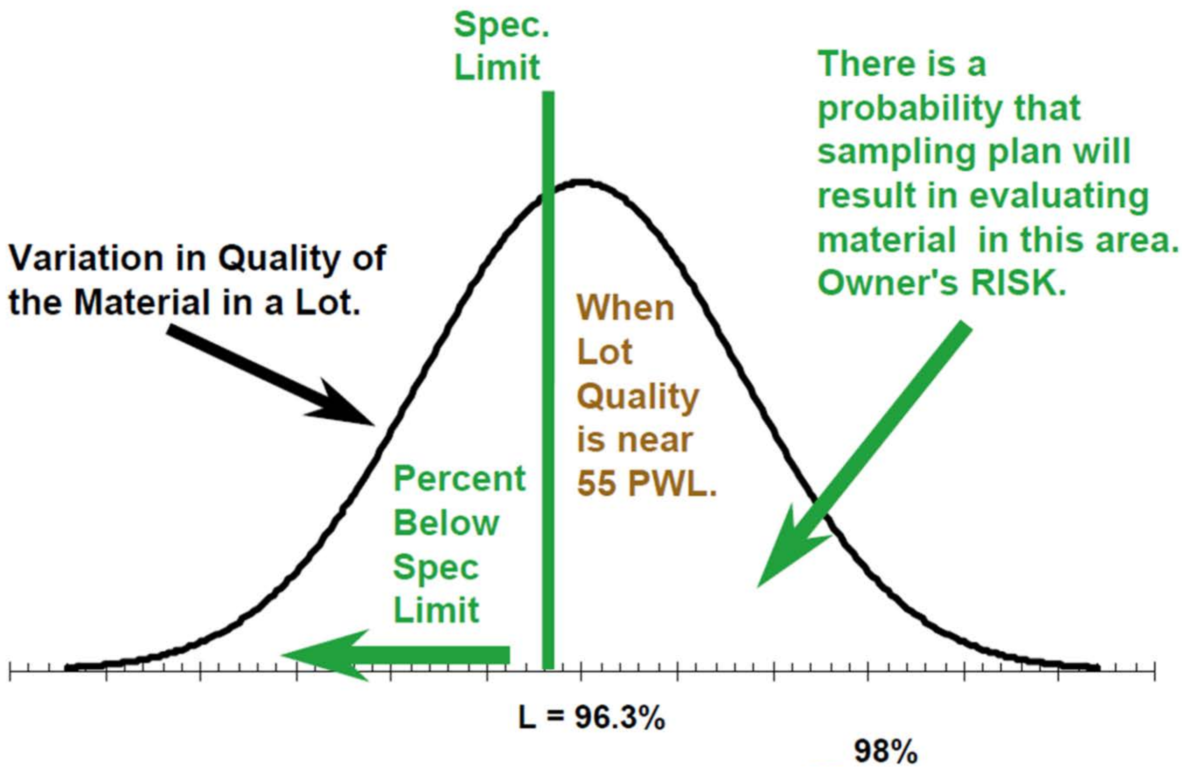
Percent Within Limits (PWL)

- **Method of estimating is given in Section 110 of AC 150/5370-10F.**
- **Method recognizes that there is a degree of uncertainty (risk) associated with acceptance plans when small fractions of material are used to evaluate a day's production.**
- **FAA pay adjustment schedules based on PWL help balance risk levels between contractor and owner.**
- **Contractor is encouraged to maintain production quality at the specified level or higher in order to offset risk.**

Risk at Acceptable Quality (P-401)



Risk at Rejectable Quality (P-401)



FAA Acceptable Quality (P-401)

- **FAA acceptance criteria were developed by assuming that processes exhibit normal variation in quality as follows:**

Acceptance Item	Variability
Mat Density (surface course)	1.30%
Mat Density (base course)	1.55%
Joint Density	2.10%

- **For mat density, the contractor can achieve 90 PWL (100% pay) for a lot by targeting 98% with 1.30% variability.**
- **Each day's production is evaluated. Pay is based on daily evaluation of 4 random samples (one sample per sublot).**

FAA Pay Adjustment Schedule
Based on PWL for P-401 and P-501

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
96 – 100	106
90 – 95	PWL + 10
75 – 89	0.5 x PWL + 55
55 – 74	1.4 x PWL -12
Below 55	REJECT

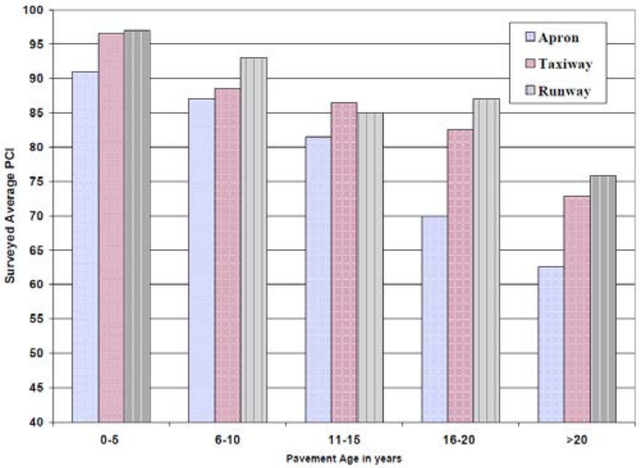
FAA Standard Materials and Design Life

- **FAA pavements are designed to meet a 20-year design life standard. AC 150/5320-6E states:**
  Pavements designed and constructed in accordance with FAA standards are intended to provide a minimum structural life of 20 years that is free of major maintenance if no major changes in forecast traffic are encountered. Rehabilitation of surface grades and renewal of skid-resistant properties may be needed before 20 years because of destructive climatic effects and the deteriorating effects of normal usage.
- **The thickness design given by FAARFIELD is valid, assuming that the standards for materials, construction practices, and quality control are all met.**
- **If not, then the pavement may not achieve the design life.**

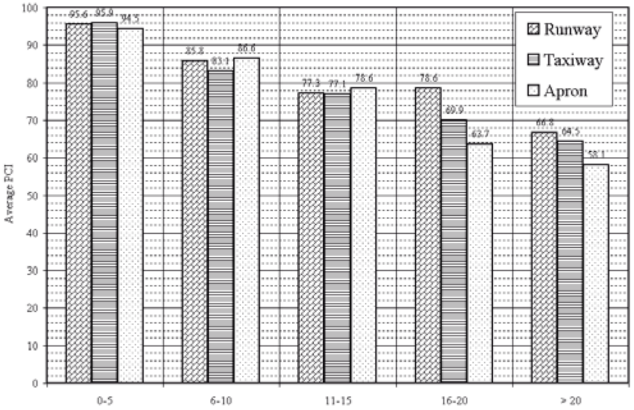
FAA 2004 Operational Life Study

- **Evaluated field data from 30 airports in 10 U.S. states.**
  - 15 million m^2 (161 million square ft.).
  - Rigid and flexible.
  - Grouped by feature, age & size.
- **Concluded that flexible and rigid pavements designed to FAA standards provided in excess of 20 years of structural life (SCI > 80).**
- ***"While the structural performance of flexible and rigid pavements were comparable, a difference in functional performance was noted."***

Rigid Pavements



Flexible Pavements



Structural Life vs. Functional Life

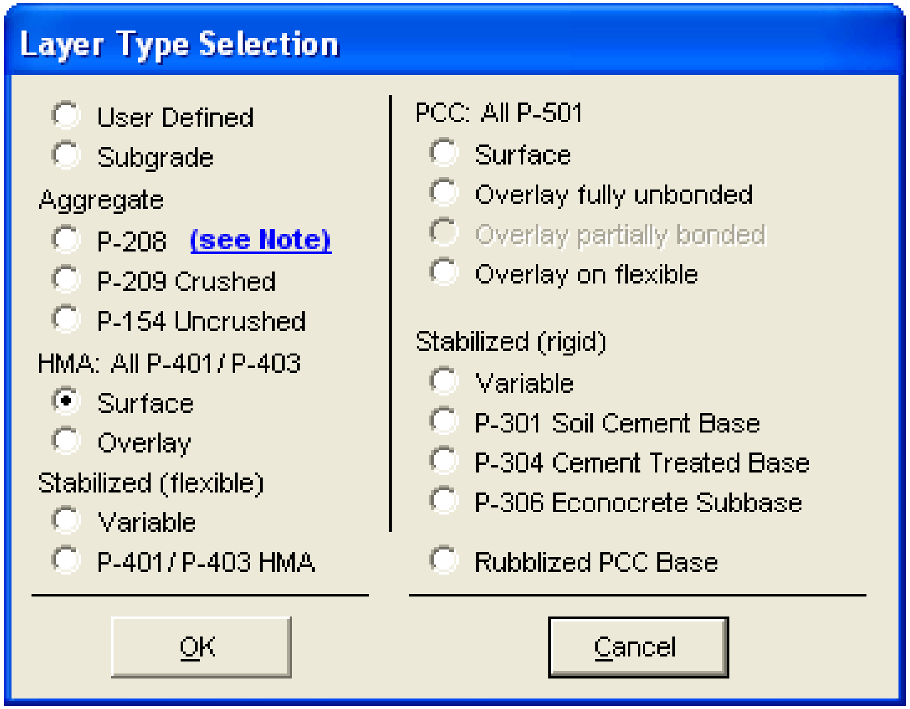
- **Structural Life**
  - Applies only to the ability of the pavement structure to support the forecast aircraft loads.
  - Failure characterized by fatigue cracks, deep structural rutting.
  - FAARFIELD thickness design considers only structural life.
- **Functional Life**
  - Considers non-structural distresses such as low friction, surface rutting and distortion, that may impact safety of aircraft operations.

Material & Construction Failures

- Asphalt: Joint failures, slippage, stripping, groove collapse.
- PCC: Joint fraying and spalling, ASR damage.
- May reduce usable life below 20 years and/or require early intervention.
- Non-structural failures – not considered in FAARFIELD thickness design.

AC 150/5370-10F Materials Used in FAARFIELD Design

- **Most structural layer types in FAARFIELD refer to specification items in AC 150-5370/10F.**
- **The assumption is that if pavement layers are constructed according to FAA standards, they will have uniform, predictable design properties.**
- **This is also the justification for setting limits on input values for standard materials in FAARFIELD.**



Design Properties of Standard Layers in FAARFIELD

Item	Layer Type	E, psi (MPa)	Poisson's Ratio
P-401	HMA Surface/Overlay	200,000 (1379)	0.35
P-403	HMA Base	400,000 (2758)	0.35
P-501	Portland Cement Concrete	4,000,000 (27,580)	0.15
P-306	Econocrete Base	700,000 (4826)	0.20
P-304	Cement-Treated Base	500,000 (3447)	0.20
P-301	Soil-Cement Base	250,000 (1724)	0.20
P-209	Crushed Aggregate Base	computed	0.35
P-208	Aggregate Base	computed	0.35
P-154	Subbase Course	computed	0.35

Recommended Material Parameters for Design from LEDFAA Sensitivity Study (1994)

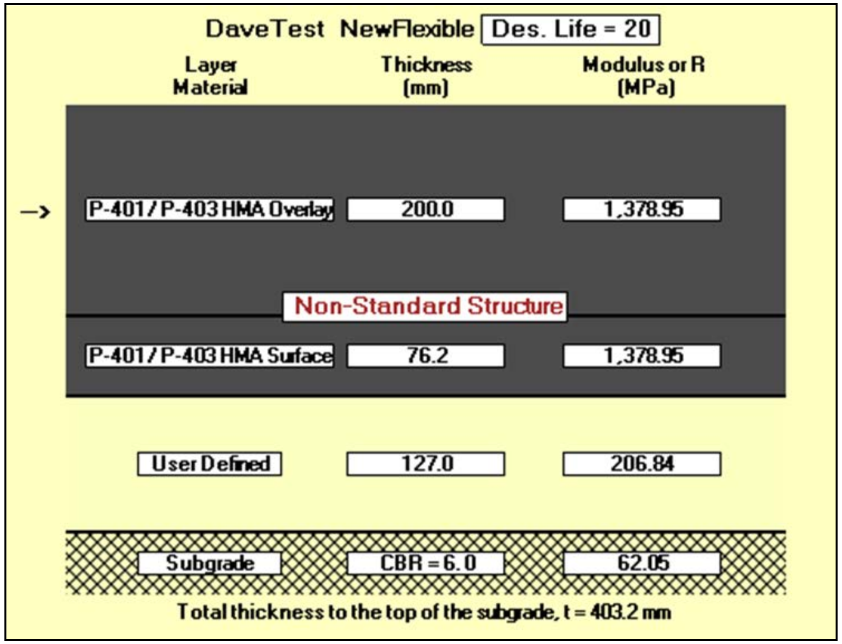
RECOMMENDED MATERIAL PARAMETERS FROM SENSITIVITY STUDY

	Eac	v1	Epcc	v2	R	Estbsl	v3	Estbs2	v4	Esb	v5	Esg	v6
FLEXIBLE PAVEMENT	200000	0.35	n/a	n/a	n/a	150000	0.25	400000	0.2	modulus	0.35	CBR rel.	0.35
RIGID PAVEMENT	n/a	n/a	4003059	0.15	647	250000	0.25	500000	0.2	modulus	0.35	k rel.	0.4
FLEXIBLE OVERLAY ON FLEXIBLE PAVEMENT	200000	0.35	n/a	n/a	n/a	150000	0.25	400000	0.2	modulus	0.35	CBR rel.	0.35
RIGID OVERLAY PARTIALLY BONDED ON RIGID PAVEMENT	n/a	n/a	0.15	0.15	647	250000	0.25	500000	0.2	modulus	0.35	k rel.	0.4
RIGID OVERLAY UNBONDED ON RIGID PAVEMENT	n/a	n/a	0.15	0.15	647	250000	0.25	500000	0.2	modulus	0.35	k rel.	0.4
FLEXIBLE OVERLAY ON RIGID PAVEMENT	200000	0.35	0.15	0.15	647	250000	0.25	500000	0.2	modulus	0.35	k rel.	0.4

Note: v1 is the Poisson Ratio for hot mix asphalt (AC)
v2 is the Poisson Ratio for Portland cement concrete (PCC)
v3 is the Poisson Ratio for low quality stabilized base (STBS1)
v4 is the Poisson Ratio for high quality stabilized base (STBS2)
v5 is the Poisson Ratio for subbase (SB)
v6 is the Poisson Ratio for subgrade (SG)

Alternate and Nonstandard Materials in FAARFIELD Design

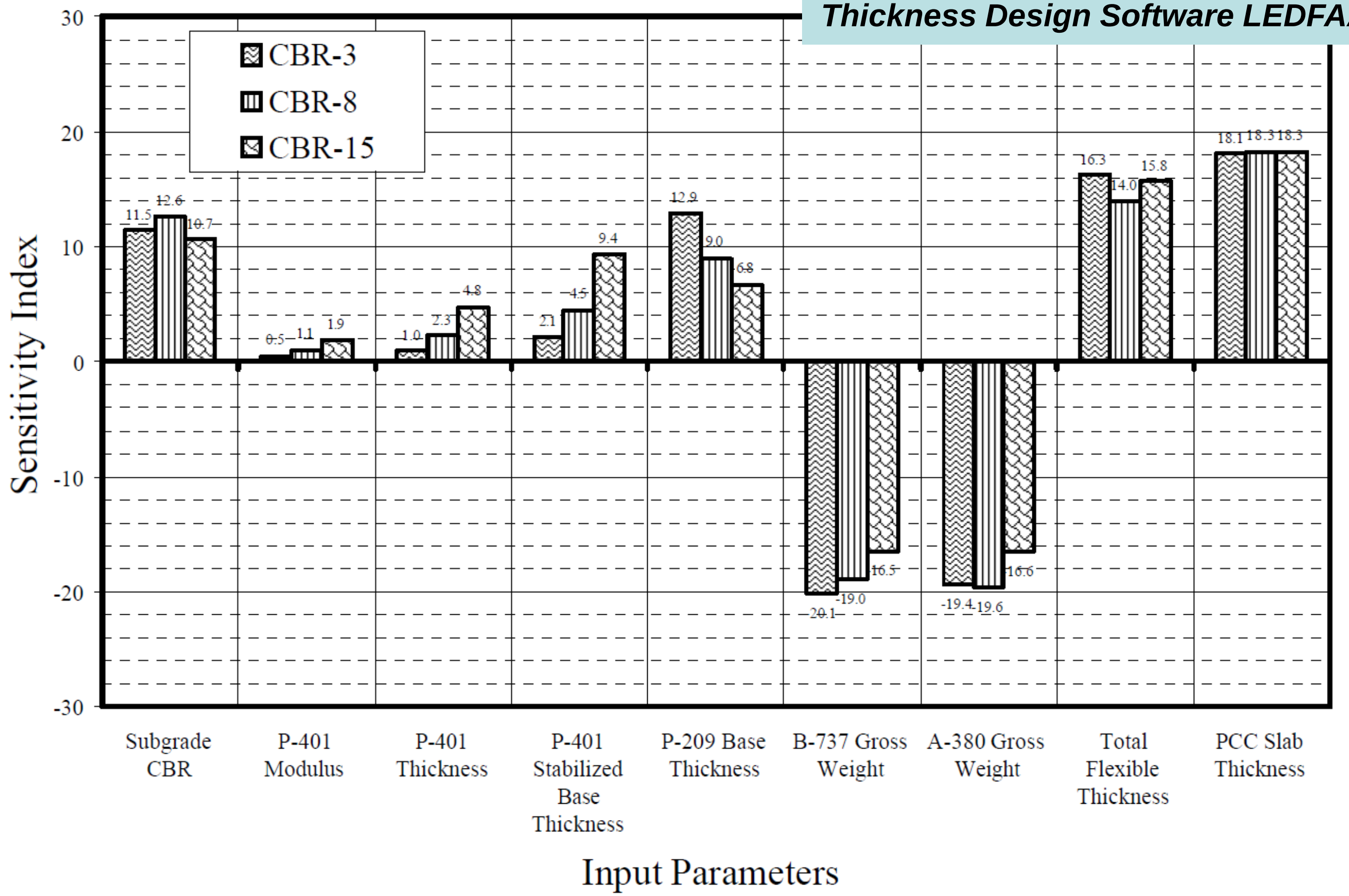
- **Situation may arise due to:**
  - Local unavailability of standard FAA materials.
  - International location (non-U.S.).
  - Overlay on an existing damaged or non-standard section.
- **In addition, many spec materials permitted in AC 150/5320-6E do not have standard properties assigned in FAARFIELD.**



Non-Standard Structure in FAARFIELD

Sensitivity of FAARFIELD Thickness to Various Input Parameters

Garg, Guo and Hayhoe: ***Parametric Sensitivity Analysis for the FAA's Airport Pavement Thickness Design Software LEDFAA-1.3*** **(2005)**



Sensitivity of FAARFIELD Thickness

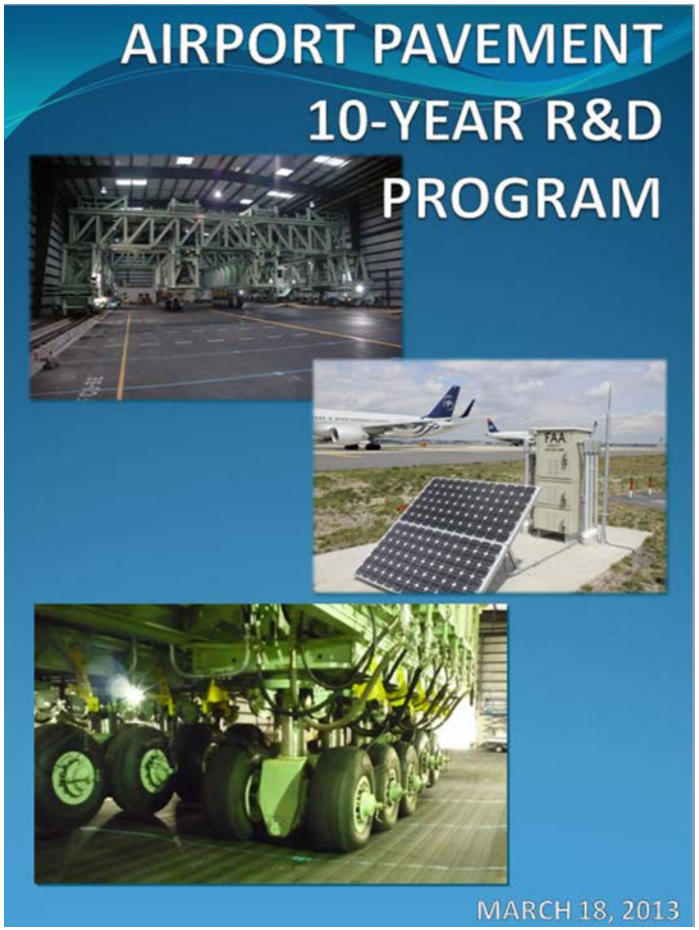
- Pavement life is most sensitive to total pavement thickness (flexible) and PCC slab thickness (rigid), followed by subgrade CBR and aircraft gross weight.
- Life is relatively insensitive to HMA modulus, especially at low CBR.
- This shows that for design purposes a wide range of asphalt specifications can reasonably be represented by the P-401 layer.
- User-defined layer may be used in special circumstances (e.g., seasonal effects).
- Similarly, a wide variety of granular base materials can be represented by the P-209 model.

Equivalence with FAA Materials

- **No official guidance for use of non-FAA materials. Needs to be evaluated on a case-by case basis considering:**
  - Material characterization and testing.
  - Variability.
  - Construction methods and acceptance.
- **Limited comparative testing has been done between French and U.S. standard materials.**
  - Memorandum of Agreement (MoA) between the FAA and Direction Generale del'Aviation Civile (DGAC) – France.
  - Considered bound (asphalt) and unbound materials commonly used in airport pavement construction in both countries.
  - Complicated because of a lack of agreement on standard structures and test methods.

Bringing 40-Year Life to Reality

FAA 10-Year R&D Plan



AIRPORT PAVEMENT 10-YEAR R&D PROGRAM

ESTIMATED TOTAL PROGRAM COST - $129 MILLION

AIRPORT PAVEMENT 10-YEAR R&D PROGRAM MILESTONE												
Fiscal Year	12	13	14	15	16	17	18	19	20	21	22	Total Cost ($M)
Airport Pavement Design ($35M)												
Project No. 1: Extending Design Life to 40 Years for Airport Pavements												4.5
Project No. 2: Semi-Accelerated Full-Scale (SAFS) Rigid Pavement Test												5.0
Project No. 3: Validated Reflection Cracking Model for HMA Overlay Design												6.0
Project No. 4: Failure Criteria for Top-Down Cracking in Rigid Airport Pavements												3.0
Project No. 5: FAARFIELD-Based ACN/PCN Methodology												4.5
Project No. 6: New LCCA Integrated Design Procedures												12.0
Airport Pavement Materials ($42M)												
Project No. 1: Advanced Characterization of Paving Materials												22.0
Project No. 2: Use of Additives and Nanoparticles to Improve Performance of Airport Pavement Materials												5.0
Project No. 3: Use of Data and Results From Airport Pavement Instrumentation and Field Testing Studies												15.0
Airport Pavement Evaluation ($52M)												
Project No. 1: Improvements to FAA Airport Pavement Software Programs												14.5
Project No. 2: Development of New Roughness Standards for In-Service Airport Pavement												3.0
Project No. 3: Pavement Surface Profile Data Collection, Processing, and Analysis												11.0
Project No. 4: Nondestructive Pavement Testing												23.5

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