The 2016 Eastern Region Annual Airports Conference

Workshop for Hot Mix Asphalt Pavement for Airports

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Presentation outline

- Objective of the workshop
- The consultant's role
  a) Pavement design
  b) Specifications for hot mix bituminous materials
- Eastern Region laboratory Procedures Manual (ERLPM) versus Asphalt Institute MS-2 manual
- How this workshop helps me? – List of people familiar with ERLPM
- Workshop agenda

Objective of this workshop

- Make sponsors, consultants, contractors, testing labs and material suppliers familiar with the FAA requirements for hot mixed bituminous pavement specifications
- P-401 and P-403 specifications found in AC 150/5370-10 (currently 10G)
- Use of ERLPM versus Asphalt Institute MS-2. References to ERLPM recently removed in national P-401 and P-403 specs.
- List of people familiar with ERLPM and NICET
- Eastern Region and other regions

The consultant's Role

- Pavement Design: Selection of pavement structure
- Preparing contract specifications for each layer using approved FAA specification and selecting the appropriate elements
- Apply for modification of standards when needed

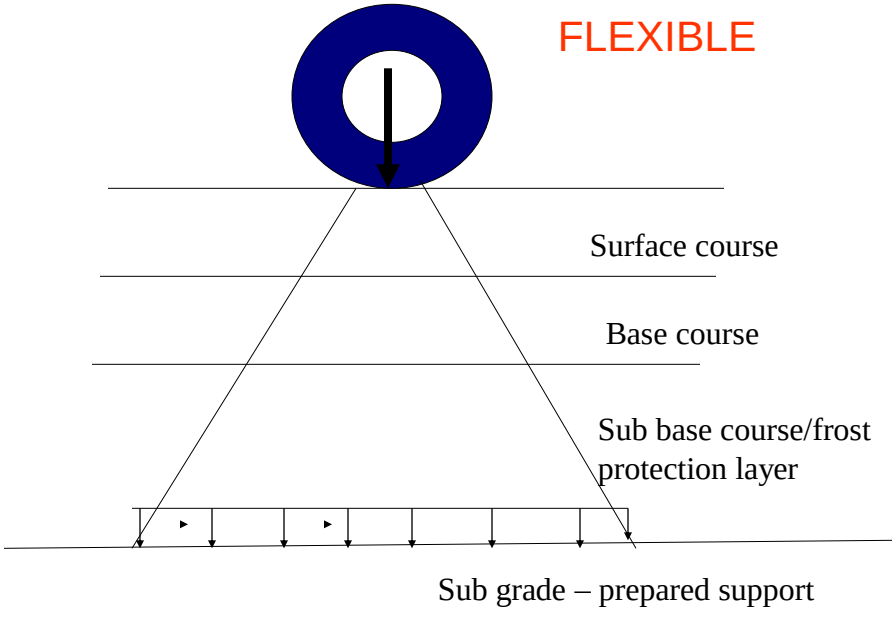
Pavement Design

- Arrangement of layers to transmit loads (aircraft) to a prescribed area on the surface of the earth
- Philosophy of load distribution: two philosophies

a) Loads are transmitted gradually, like a trapezoid, from the surface of the pavement to the top level of soil (flexible)

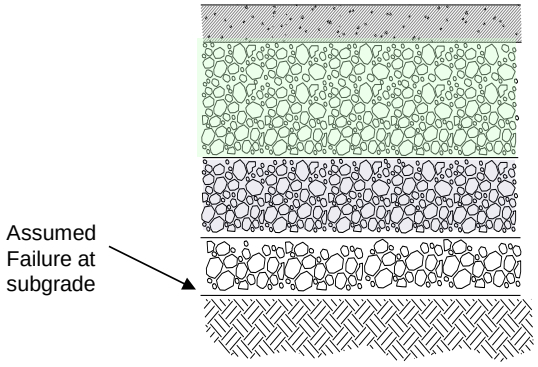
b) Loads are widely distributed like a beam (Rigid)

- Sub grade: level surface of soil where pavement layers will be placed. Strength expressed in CBR for flexible pavement and K value for rigid pavement
- Bituminous pavement is considered flexible pavement



Typical Flexible Pavement Structure

Basic Premise of CBR method:
Provide sufficient "cover" above each layer to protect that layer from shear failure



Hot-Mix Asphalt Surface

Base Course (Minimum CBR=80)
(May Require Stabilization)

Subbase (Minimum CBR=20)
(May Require Stabilization)

Frost Protection (As Appropriate)

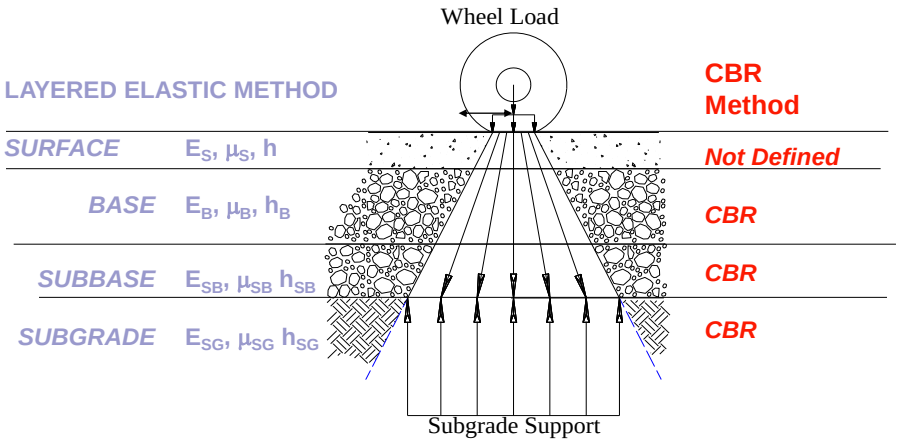
Subgrade

CURRENT DESIGN METHOD

LAYERED ELASTIC DESIGN
LEDFAA/FAARFILED

Flexible Pavement Failure Modes

Layered Elastic theory versus CBR procedure

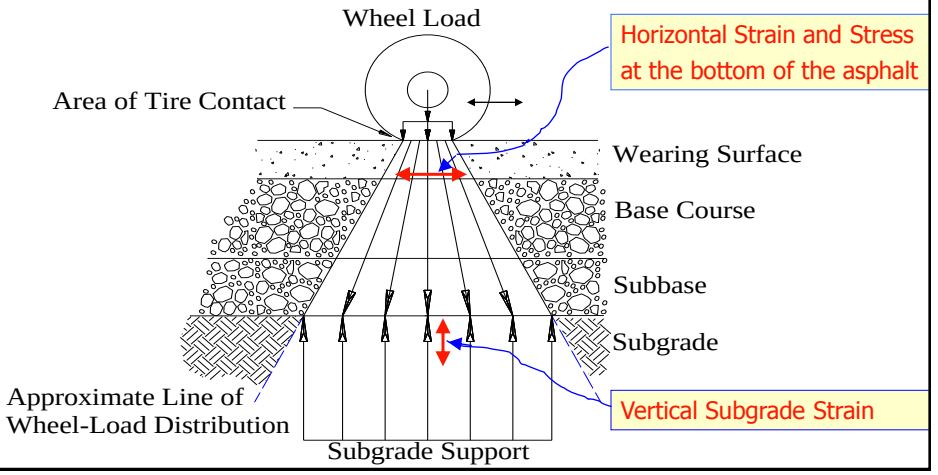


E = Elastic Modulus
μ = Poisson's Ratio

h = thickness
CBR = California Bearing Ratio

Flexible Pavement Failure Modes

Pavement failure modes in LEDFAA are the same as all flexible design methods



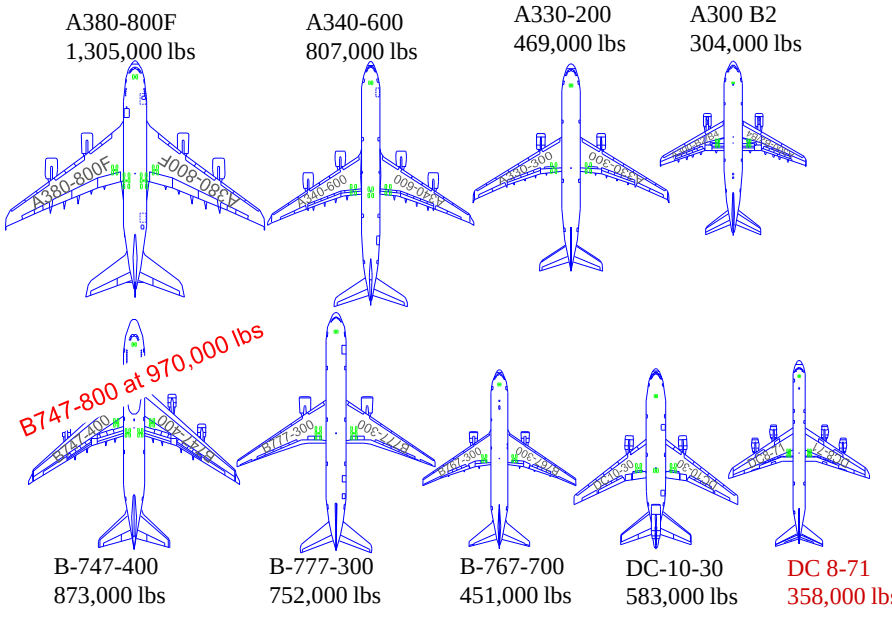
Flexible Pavement Design

Three Basic Design Parameters

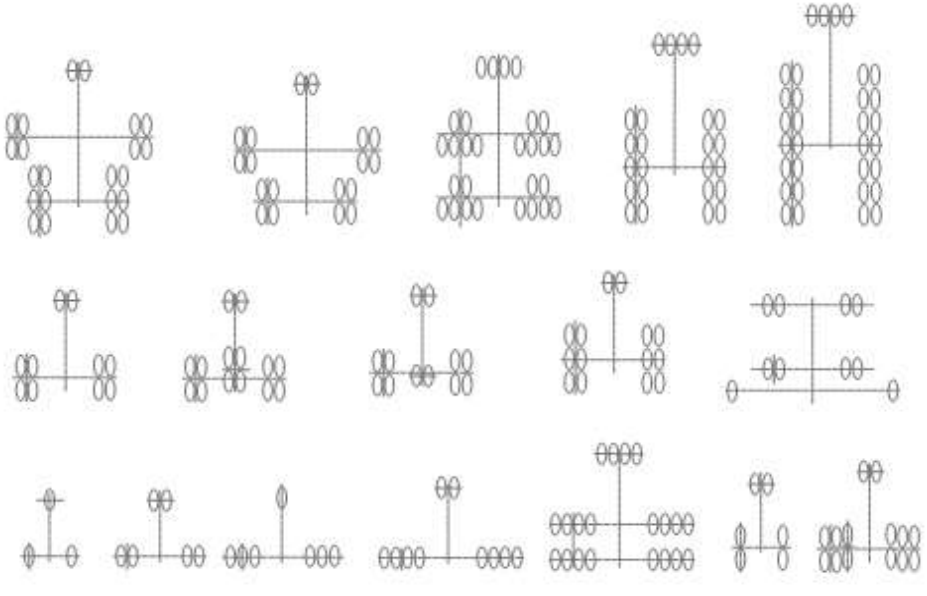
- Subgrade Support
  - (CBR)
- Types of Aircraft
  - Gear type and Gross Load
- Traffic
  - Annual Departures

Type of Aircraft: Aircraft weight

Aircraft Grew in Size



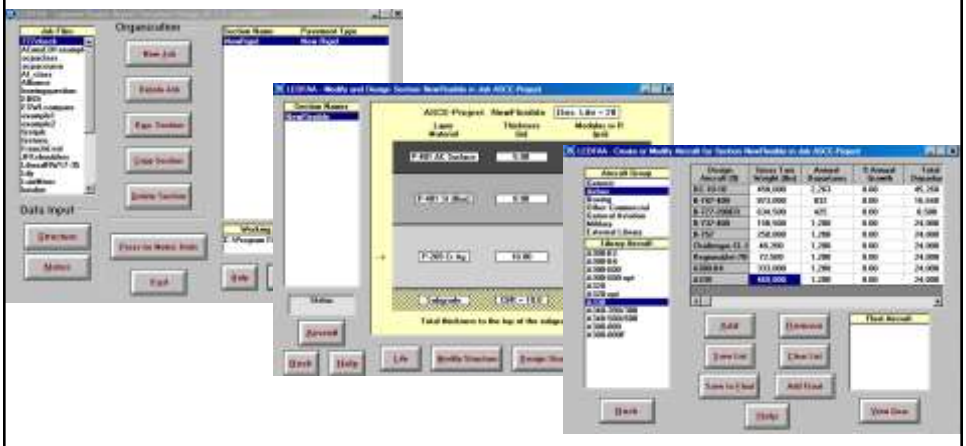
Sample Gear Configurations



CUMULATIVE DAMAGE FACTOR (CDF) for Traffic Model

- Sums Damage From *Each* Aircraft - Not From Equivalent Aircraft
- CDF = Summation n_i / N_i where:
  - n_i = number of load repetitions from individual aircraft
  - N_i = allowable load repetitions of individual aircraft
- When CDF = 1, Design Life is Exhausted
- Must Input Traffic Mix, **NOT** Equivalent Aircraft

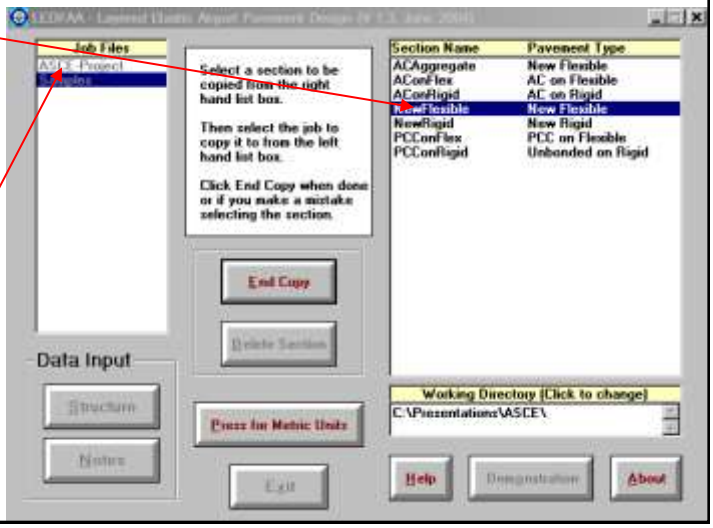
LEDFAA now FAARfield



Computer Design

Click on desired pavement section

Then click on the project where the section will be saved

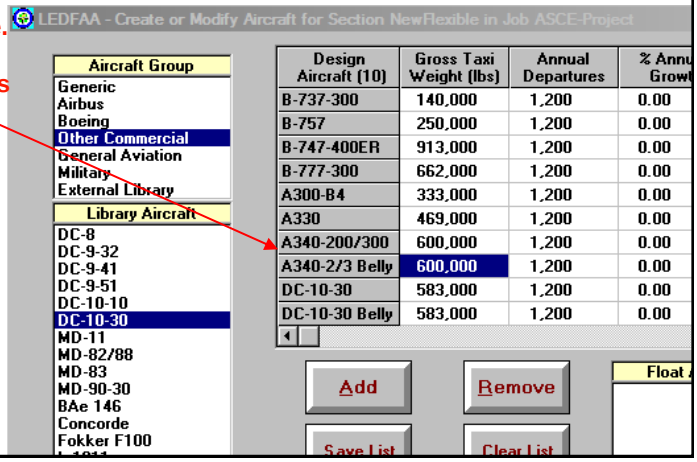


Pavement Design

Enter Traffic Mixture

Certain aircraft may appear in the list twice. This is to address the presence of wing gears and belly gears

LEDFAA treats these as two aircraft however the weight and departures are interlocked

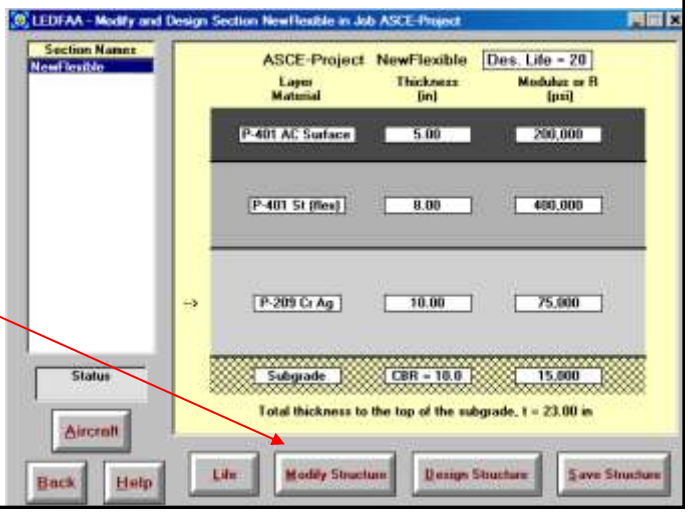


LEDFAA v1.3 Sample Design

Working with a pavement section

The selected sample pavement will appear

The structure may be modified if desired

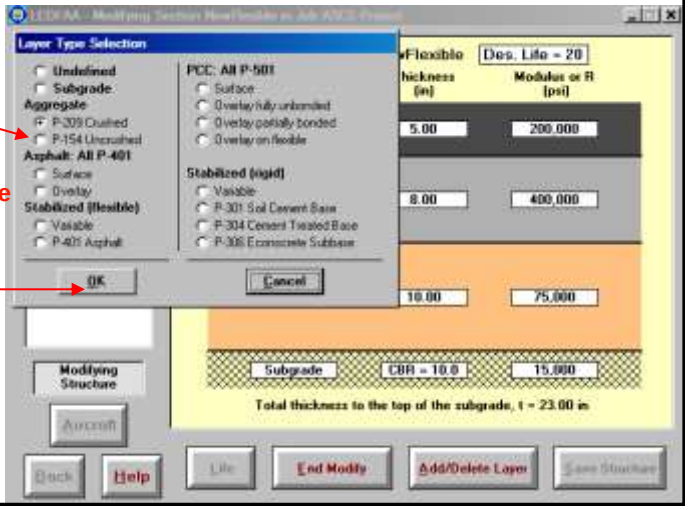


LEDFAA v1.3 Sample Design

Modifying a pavement section

Select the layer type you want to include
Change P-209 to P-154 in this example

Click OK



Preparing contract specifications from FAA approved specs

- AC150/5370-10G
- Three bituminous specifications, P-401, P-403 and P-601.
- Section 110 for calculating Percent Within Limits (PWL)

Specification for Hot Bituminous pavement AC 150/5370-10G

- P-401 Surface course as defined by AC 150-5320-6 Requires most testing and estimates a quality level. It must be used in the calculate top layer
- P-403: base (binder) course, stabilized sub-base course, less than 12,500 lbs. aircraft Has a pass/fail
- For perimeter roads use state highway specs

401-1.1 This item shall consist of pavement courses composed of mineral aggregate and asphalt cement binder (asphalt binder) mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross-sections shown on the plans. Each course shall be constructed to the depth, typical section, and elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

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This specification is intended to be used for the surface course for airfield flexible pavements subject to aircraft loadings of gross weights greater than 12,500 pounds (5670 kg) and is to apply within the limits of the pavement designed for full load bearing capacity.

The dimensions and depth of the "surface course" this specification applies to shall be as defined by the Engineer's pavement design performed in accordance with advisory circular (AC) 150/5320-6, Airport Pavement Design and Evaluation.

For courses other than the surface course, such as stabilized base courses, binder courses and/or truing and leveling courses; for pavements designed to accommodate aircraft gross weights of 12,500 pounds (5670 kg) or less; and for pavements intended to be used for roads, shoulder pavements, blast pads, and other pavements not subject to full aircraft loading, specification Item P-403 may be used.

State highway department specifications for materials may be used for access roads, perimeter roads, and other pavements not subject to aircraft loading. When state highway specification are approved, include all applicable/approved state specifications in the contract documents. The use of state highway department specifications requires a modification to standards.

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Consultant decision on P-403

- Specification for Stabilized Bituminous Base
- Binder Course
- Truing and Leveling Courses
- Testing requirement has been reduced: pass/fail condition

ITEM P-403 PLANT MIX BITUMINOUS PAVEMENTS
(BASE, LEVELING OR SURFACE COURSE)
DESCRIPTION

403-1.1 This item shall consist of a **[ ]** course composed of mineral aggregate and bituminous material mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross sections shown on the plans. Each course shall be constructed to the depth, typical section, and elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

****

Specify base and/or leveling course(s). Surface course may also be specified but only for those pavements designed to accommodate aircraft of gross weights less than or equal to 12,500 pounds (5,670 kg) or for surface course of shoulders, blast pads, service roads, etc. Item P-401 is to be specified for surface courses for pavements designed to accommodate aircraft gross weights greater than 12,500 pounds (5,670 kg).

This specification is to be used as a base or leveling course for pavements designed to accommodate aircraft of gross weights greater than 12,500 pounds (5,670 kg). State highway department specifications may be used in lieu of this specification for access roads, perimeter roads, stabilized base courses under Item P-501, and other pavements not subject to aircraft loading, or for pavements designed for aircraft gross weights of 12,500 pounds (5,670 kg) or less.

Where a state highway department specification is to be used in lieu of this specification, the state specification must have a demonstrated satisfactory performance record under equivalent loadings and exposure. When a density requirement is not specified by a state specification, it is to be modified to incorporate the language found in paragraphs 403-5.1, 403-5.2 and 403-5.3. When state highway specification are approved, include all applicable/approved state specifications in the contract documents.

Writing the specification P-401

- Selection of aircraft weight
- Selection of gradation and asphalt cement
- Compaction Method (Marshall or Gyratory)
- Use of recycle material (RAP)?
- Selection of method of payment
- Use of Notes to the engineer
- Deviating from standards, what to do?

First selection - Aircraft weight

- 12,500 lbs. but less than 60,000 Lbs.
- 60,000 lbs. or more

Compacting Effort

- Marshal method: falling mass of standard weight and falling distance. There are number of blows on each face of the specimen (75 or 100): Regular P-401
- Gyratory compactor: gyratory apparatus with standard weight and angle. Spec identify number of gyrations in function of aircraft weight.

Differences between the methods

6 inches diameter mold

4 Inches diameter mold

- Impact Hammer
  - 10 lbs
  - 18" Drop
- Compact with 50 or 75 blows per side depending on aircraft weight
  - -> 60k lbs = 75
  - -< 60k lbs = 50

MARSHAL COMPACTION SPECIFICATIONS

Test Property	PAVEMENTS DESIGNED FOR AIRCRAFT GROSS WEIGHTS OF 60,000 LBS. OR MORE OR TIRE PRESSURES OF 100 PSI OR MORE	Pavements Designed for Aircraft Gross Weights Less Than 60,000 Lbs. or Tire Pressures Less Than 100 Psi
Number of Blows	**75**	**50**
Stability, pounds (Newton)	**2150 (9564)**	**1350 (6005)**
Flow, 0.01 in. (0.25 mm)	**10-14**	**10-18**
Air Voids (percent)	**2.8-4.2**	**2.8-4.2**
Percent Voids in Mineral Aggregate (minimum)	**See Table 2**	**See Table 2**

Test Property	Pavements Designed for Aircraft Gross Weights of 60,000 Lbs (27216 kg) or More or Tire Pressures of 100 psi or More	Pavements Designed for Aircraft Gross Weights Less Than 60,000 Lbs (27216 kg) or Tire Pressures Less Than 100 psi
Number of compactor gyrations	75	50
Target Air Voids (percent)	3.5	3.5
Percent Voids in Mineral Aggregate (minimum)	See Table 2	See Table 2

Second selection Aggregate gradation

- Large aggregates use less asphalt. Used as binder courses
- Smaller size aggregates (3/4” or 1/2”) used as surface course

Table 3. Aggregate - HMA Pavements

Sieve Size	Percentage by Weight Passing Sieves		
	Gradation 1	Gradation 2	Gradation 3
1 inch (25 mm)	100	--	--
3/4 inch (19 mm)	76-98	100	--
1/2 inch (12 mm)	66-86	79-99	100
3/8 inch (9 mm)	57-77	68-88	79-99
No. 4 (4.75 mm)	40-60	48-68	58-78
No. 8 (2.36 mm)	26-46	33-53	39-59
No. 16 (1.18 mm)	17-37	20-40	26-46
No. 30 (0.600 mm)	11-27	14-30	19-35
No. 50 (0.300 mm)	7-19	9-21	12-24
No. 100 (0.150 mm)	6-16	6-16	7-17
No. 200 (0.075 mm)	3-6	3-6	3-6
Asphalt percent:			
Stone or gravel	4.5-7.0	5.0-7.5	5.5-8.0
Slag	5.0-7.5	6.5-9.5	7.0-10.5

Then Engineer should only use Gradation 3 for leveling course, airfield shoulders, and roadways.

A coarse gradation is defined as a gradation passing below the restricted zone. The restricted zone is defined in the Asphalt Insitute's Manual Superpave, Series 2 (SP-2).

Third selection
Void in Mineral Aggregates (VMA)

- Provide longevity of the mix
- Selected from maximum size aggregates
- Eastern Region used to allow 2% less than national standards.

* The Eastern Region has traditionally allowed a reduction of 2 % for each size. This practice will be eliminated and approved on a case by case situation

TABLE 2. MINIMUM PERCENT VOIDS IN MINERAL AGGREGATE

Maximum Particle Size		•Minimum Voids in Mineral Aggregate, percent
in.	**mm**	**Percent**
½	12.5	16
¾	19.0	15
1	25.0	14
1-½	37.5	13

Eastern Region allowed a reduction of 2 percent, but not any more

Table 2. Minimum Percent Voids In Mineral Aggregate (VMA)

Aggregate (See Table 3)	Minimum VMA
Gradation 3	16%
Gradation 2	15%
Gradation 1	14%

Fourth Selection
Binder material (Asphalt)

- Old systems : AC and Penetration
- Performance Grade composed of two numbers representing higher and lower temperature of the areas: PG 64-22
- Based on Highway Research program. For airport there is a need to increase the high temperature value (Bumping requirement)
- Some binders used Polymer Modified additives

Understanding PG binders

- PG stand for Performance Grade
- Compose of two number:

a)the first one meaning the High temperature the pavement is exposed to

b) The second one is the Low temperature the pavement is expose to. Starts with a minus sign

PG 64 -22

64: meets all requirements up to this temperature in ^{0}C

-22: meets all requirements down to this temperature in ^{0}C

Some rules of PG binders

- Grades are in 6 ^{0}C increments, high or low
- The highest the first number the stiffer the binder is
- The lowers the second number is more resistance to thermal cracking
- Greater difference between the number more robust the binder is but more expensive
- If the difference is 92 or more the binder is modified
- PG 70-22 = 70 –(-22) = 70 + 22 = 92

More information for selecting binder

- Use grade typically use for the area where the airport is located. More information can be found in www.asphaltinstitute.org
- Grades above the -22 in the low end are not recommended. Little experience available
- Grades below 64 in the high end, let's say 58, may result in tender mixes
- Grades above 76 in the high end are very stiff and difficult to compact

Example

- Local PG used PG 64-22
- Pavement is a taxiway to serve +100,000 lbs aircraft
- Bumping requirement: 2
- 64 + 6 + 6 = 76 (not too stiff to compact)
- -22 is the lowest we want to go
- PG 76-22

Required Grade Bump

Aircraft Gross Weight,High Temperature Adjustment to Binder Grade

All Pavement Types	
≤ 12,500 lbs (5670 kg)	--
< 100,000 lbs (45360 kg)	1 Grade
≥ 100,000 lbs (45360 kg)	2 Grade

PG grades above a –22 on the low end (e.g., PG XX–16 or PG XX-10) are not recommended. Limited experience has shown an increase in block cracking with -16 or -10 grade asphalts. Typically, when the PG spread between the high and low temperature is 92 or more, the asphalt cement binder has been modified. A PG Plus Test will be required to determine if the asphalt cement binder has been properly modified. Use the PG Plus Test found in the Asphalt Institute's State Binder Specification Database for the project location. When a State does not specify a PG Plus Test, use ASTM D6084 with a minimum elastic recovery of 70%.

Fifth selection
Quality acceptance criteria

- Marshall acceptance limits
- Gyratory Compactor (SP) acceptance limits

Table 5: Marshall Acceptance Limits

TEST PROPERTY	Pavements Designed for Aircraft Gross Weights of 60,000 Lbs. or More or Tire Pressures of 100 Psi or More		Pavements Designed for Aircraft Gross Weights Less Than 60,000 Lbs. or Tire Pressures Less Than 100 Psi	
Number of Blows	75		50	
	Specification Tolerance Limits		Specification Tolerance Limits	
	L	U	L	U
Stability, minimum, pounds	1800	--	1000	--
Flow, 0.01-inch	8	16	8	20
Air Voids Total Mix, percent	2	5	2	5
Surface Course Mat Density, percent	96.3	[101.3]	96.3	[101.3]
Base Course Mat Density, percent	95.5	101.3]--	95.5	[101.3]
Joint density, percent	93.3	--	93.3	--

Table 5. Gyratory Acceptance Limits For Air Voids, Density

TEST PROPERTY	Specification Tolerance	
	L	U
Air Voids Total Mix (%)	2	5
Mat Density (%)	96.3	101.3
Joint Density (%)	93.3	-

Other acceptance criteria

- Thickness. Thickness of each lift of surface course shall be evaluated by the Engineer for compliance to the requirements shown on the plans. Measurements of thickness shall be made by the Engineer using the cores extracted for each sublot for density measurement
- Smoothness. The final surface shall be free from roller marks. After the final rolling, but not later than 24 hours after placement, the surface of each lot shall be tested in both longitudinal and transverse directions for smoothness to reveal all surface irregularities exceeding the tolerances specified
- Transverse measurements. Transverse measurements will be taken for each lot placed. Transverse measurements will be taken perpendicular to the pavement centerline each 50 feet (15m) or more often as determined by the Engineer.

Payment Options

Table 6. Price adjustment schedule1 (one side)

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 PWL + 55
55 – 74	1.4 PWL – 12
Below 55	Reject 2*

1 Although it is theoretically possible to achieve a pay factor of 106% for each lot, actual payment above 100% shall be subject to the total project payment limitation specified in paragraph 401-8.1.

2 The lot shall be removed and replaced. However, the Engineer may decide to allow the rejected lot to remain. In that case, if the Engineer and Contractor agree in writing that the lot shall not be removed, it shall be paid for at 50% of the contract unit price and the total project payment shall be reduced by the amount withheld for the rejected lot.

Table 6. Price Adjustment Schedule 1 (double sides)

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
93 – 100	103
90 – 93	PWL + 10
70 – 89	0.125 PWL + 88.75
40 – 69	0.75 PWL + 45
Below 40	Reject 2*

1 Although it is theoretically possible to achieve a pay factor of 103% for each lot, actual payment above 100% shall be subject to the total project payment limitation specified in paragraph 401-8.1.

2 The lot shall be removed and replaced. However, the Engineer may decide to allow the rejected lot to remain. In that case, if the Engineer and Contractor agree in writing that the lot shall not be removed, it shall be paid for at 50% of the contract unit price and the total project payment shall be reduced by the amount withheld for the rejected lot.

Other criteria -Smothness

Table 7. Profilograph Average Profile Index Smoothness Pay Facto

Inches/miles per 1/10 mile	Short Sections	Pay Factor
0.0 - 7	00.0 - 15.0	100%
7.1 - 9	15.1 - 16	98%
9.1 - 11	16.1 - 17	96%
11.1 - 13	17.1 - 18	94%
13.1 - 14	18.1 - 20	92%
14.1 - 15	20.1 - 22	90%
15.1 and up	22.1 and up	Corrective work required1

Options to pay bonus

- Any percentage above 100% can be used to compensate penalties
- Depending on importance of the [project the sponsor may select “actual payment” however, he(she) is risking funds allocations.
- Change order are subject to Grant limits.

What to expect in contract documents

- One P-401 with one gradation or,
- One P-401 specification with two gradation. Usually the gradation at the bottom is grater (1 - 3/4” maximum size aggregates) because it uses less asphalt, and the smaller aggregate size gradation at the top (1/2” maximum size aggregate) for more smooth surface
- One P-401 on top and P-403 on the bottom

What is the ERLPM

- Eastern Region Laboratory Procedures Manual
- Born in the Eastern Region to use statistical methods to determine quality versus range or media (average)
- Origen – Military specs
- Document to be used in combination with P-401. required in Eastern Region
- Provide forms for project submittal - Appendices

ERLPM

- Section 1: Definitions
- Section 2: Development of JMF
- Section 3: Quality Assurance – Plant produced material
- Section 4: Field Density
- Section 5: Laboratory Equipment
- Section 6: Random Sampling
- Section 7: Quality Control
- Section 8: Method to estimate PWL

ERLPM - Appendices

- Appendix A: Material acceptance
- Appendix B: Sample of mix design
- Appendix C: Contractor Quality Control
- Appendix D: PWL calculation-plant material
- Appendix E: In-place density calculation

Workshop objectives

- Discuss principles and practices of Job Mix Formula
- Discuss use of SuperPave design in airport (EB 59)
- Discuss principles and practices for sampling and testing bituminous mixes
- Discuss principles and practices to determine Quality Assurance of material
- Explain statistical methods to determine quality of materials and pay factors
- Present Contractor testing plan to control the quality of the material and mixes
- What happen after this workshop?

Benefits of this workshop

- Knowledge of FAA specifications
- Knowledge of statistic al analysis
- Form to submit/approve JMF
- Form to record testing
- Form to calculate pavement quality
- Job seeking

Material distributed

- ERLPM Appendices
- Specifications P-401 and P-403
- Table for ASTM E 178
- Test to be completed and submitted to FAA

Documents in electronic format

- ERLPM (PDF)
- Specification in words
- Engineering Brief 59 (SuperPave)
- Computer software
- Exam #18
- Current list of people familiar with ERLPM

AGENDA

- Mix Design – Cindy LeFleur
- Random Sampling – Guillermo Felix
- Quality Assurance – Patrick Kiernan
- Statistical Analysis – Carl Steinhauer
- Computer Software – Guillermo Felix
- Contractor's Quality Control – John Savastio
- ERLPM Test and List – Guillermo Felix

How many of you are

- Consultants?
- Testing laboratories?
- Contractors?
- Material supplier?
- Government?

Questions you are bringing to this workshop