Airfield Asphalt Pavements

John Duval, P.E.

Alaska Asphalt Pavement Summit
November 18-19, 2013
Anchorage, Alasks

New Large Aircraft

Boeing 747-8

MTOW
987,000 lb

Airbus A380

MTOW
1,235,000 lb

The Near Future

The Seattle Times
Winner of Nine Pulitzer Prizes

Business / Technology

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IN THE NEWS: Pharma's windfall | Top restaurants | Health-care exchange | Seawall project | Steve Sarkisian

Originally published November 5, 2012 at 8:56 PM | Page modified November 6, 2012 at 11:49 AM

Boeing considers wingtips that fold on its next big jet

Passengers on the future 777X may be surprised to see its wingtips unfolding in a design that lets the Boeing jet's immense wingspan fit at airport gates.

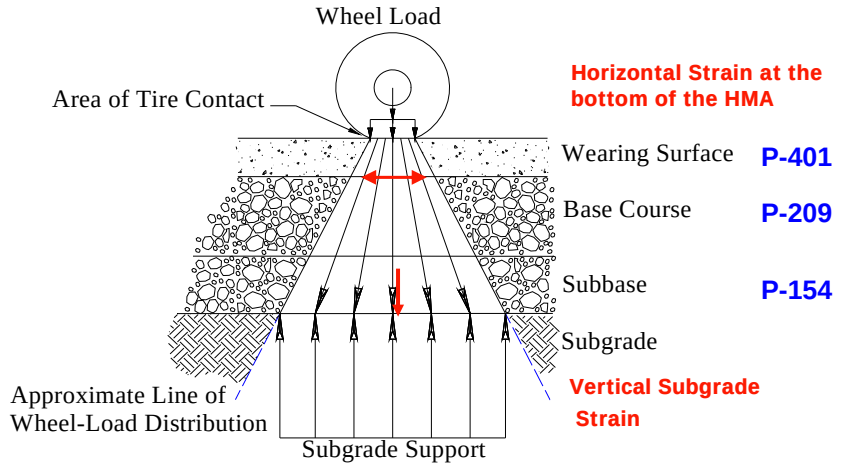
By Dominic Gates
Seattle Times aerospace reporter

MTOW: 775,000 lb

Overview

- Pavement Design/Evaluation
- Materials
  - Aggregates
  - Asphalt Binders
- Mix Design
  - Marshall
  - Gyratory
- Construction
  - Placement
  - Compaction
- Maintenance (Preservation)
  - Sealers
  - Crack Sealing/Patching

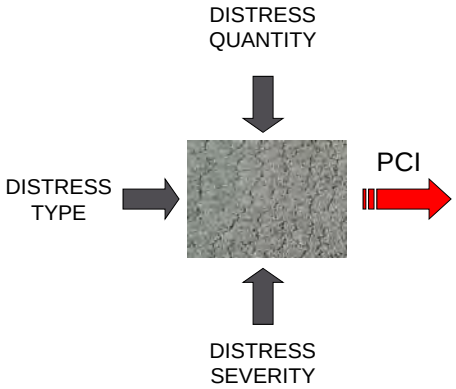
Flexible Pavement Systems



Visual Evaluation

- Distinguish between distress categories
  - Load
  - Environmental
  - Other
- Compute PCI

PCI Rating



PCI	COLOR	RATING
100 – 86		GOOD (EXCELLENT)
85 – 71		SATISFACTORY(VERY GOOD)
70 – 56		FAIR (GOOD)
55 – 41		POOR (FAIR)
40 – 26		VERY POOR (POOR)
25 – 11		SERIOUS (VERY POOR)
10 – 0		FAILED (FAILED)

Reference: ASTM D 5340-12

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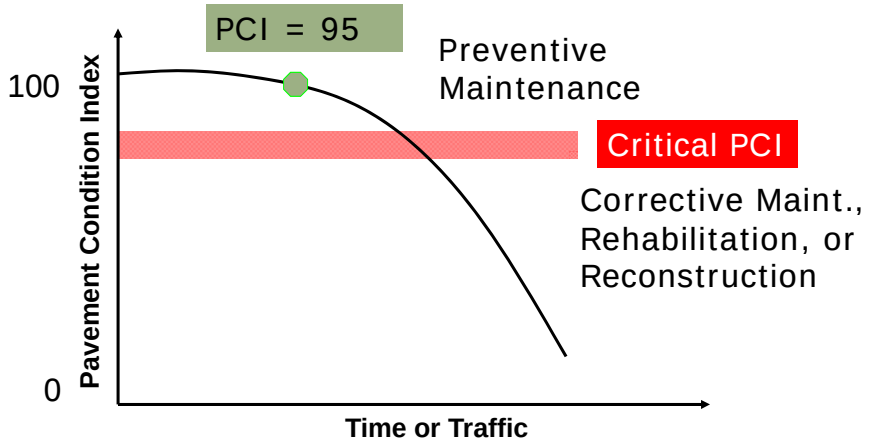
Pavement Deterioration Curve



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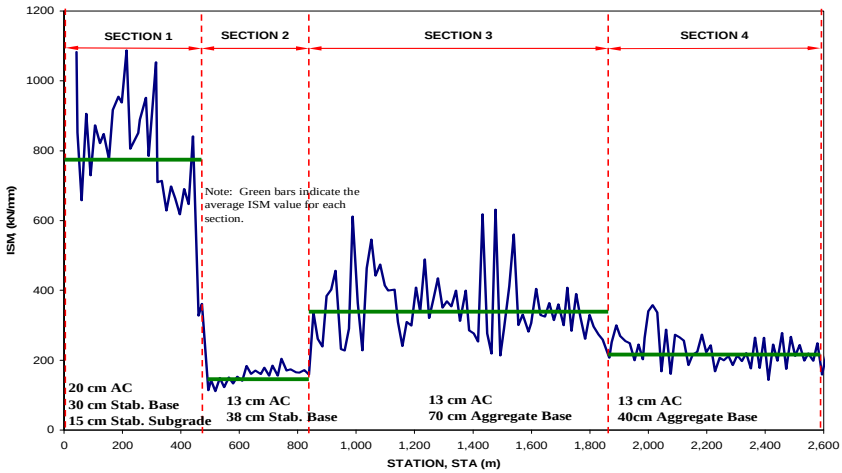
Testing

- Destructive
  - Test Pits
- Semi-Destructive
  - Boring/Coring
  - Penetrometer
- Non-Destructive
  - Deflectometer
  - Ground Penetrating Radar

Typical ISM Profile



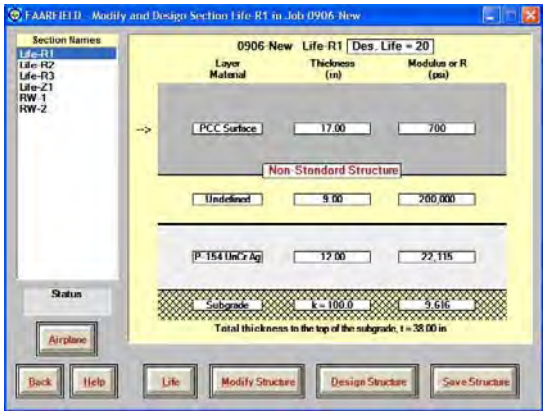
Airport Pavement Design/Evaluation

- Aircraft Type, Frequency & Weights
  - Weight much more important than frequency
- Subgrade
- Structure
  - P-401
  - P-209
  - P-154
  - Stabilized Bases
- Design/Evaluate for Remaining Structural Life
  - 20 Years

Photo Courtesy Konstantin von Wedelstaedt

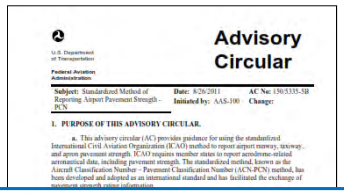
FAA Pavement Design/Evaluation

- Aircraft Library
  - B747-8
  - A380
- Layer Properties
- Design Life
  - 40 Year Design Life?



Pavement Classification Number

- FAA AC 150/5335B
- August 26, 2011
- ICAO Standard



U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: Standardized Method of Reporting Airport Pavement Strength - PCN

Date: 8/26/2011 **AC No:** 150/5335-5B

Initiated by: AAS-100 **Change:**

1. PURPOSE OF THIS ADVISORY CIRCULAR.

a. This advisory circular (AC) provides guidance for using the standardized International Civil Aviation Organization (ICAO) method to report airport runway, taxiway, and apron pavement strength. ICAO requires member states to report aerodrome-related aeronautical data, including pavement strength. The standardized method, known as the Aircraft Classification Number – Pavement Classification Number (ACN-PCN) method, has been developed and adopted as an international standard and has facilitated the exchange of pavement strength rating information.

2. EFFECTIVE DATE.

Effective **three years** after the issue date of this AC, all public-use paved runways at primary airports serving air carrier aircraft should (will, if mandatory through the Applicability paragraph, below) be assigned gross weight and PCN data using the guidance provided in this AC. Effective **five years** after the issue date of this AC, all public-use paved runways at nonprimary commercial service airports serving air carrier aircraft should (will, if mandatory through the Applicability paragraph, below) be assigned gross weight and PCN data using the guidance provided in this AC.

Pavement Classification Number

- Compute PCN using COMFAA or PCASE
- Example PCN
  - 64/F/B/W/T
- Report on Form 5010 Airport Master Record
- Example ACN
  - 53/F/B/W/T
- Example ACN/PCN
  - 0.82

64 = relative pavement strength

2X Sgl Wheel Load (Mg)

F = Pavement Type Code

F=Flexible

B= Subgrade Strength Code

B=(8<CBR<13)

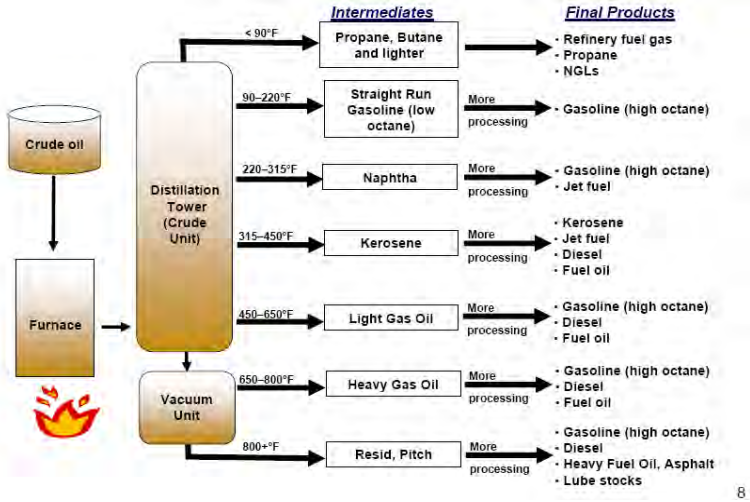
W = Tire Pressure Code

W=Unlimited

T = Evaluation Type

Components of an Asphalt Mix

Basic Refining Concepts



Source: Asphalt Institute

Binder in Hot Mix Asphalt

- Asphalt binder is one of two primary components of Hot Mix Asphalt (HMA)
  - Least in terms of weight (roughly 5-8%), but most expensive
- Binder is the "glue" that holds the aggregate together in HMA
  - Influences behavior of HMA
    - High temperature, low temperature, aging

Source: Asphalt Institute

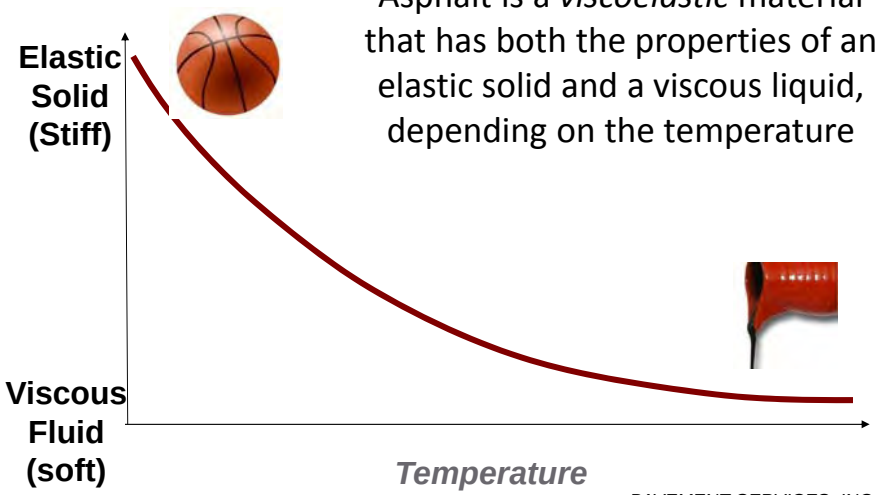
Asphalt Behavior Depends On:

- Temperature
- Time of Loading
- Aging (properties change with time)

Source: Asphalt Institute

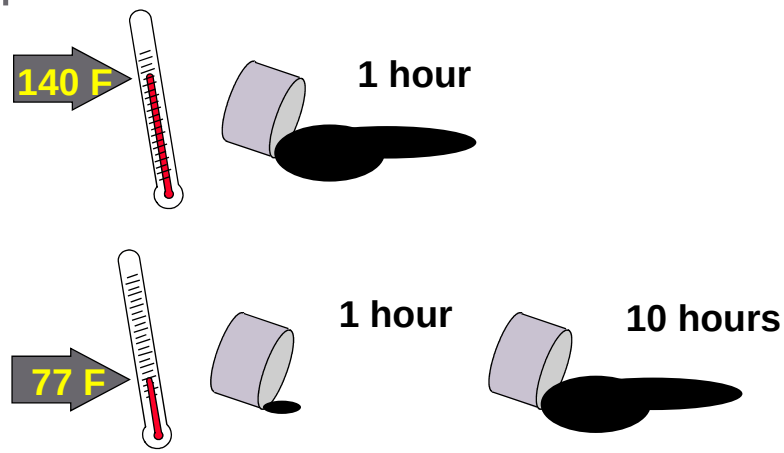
Asphalt Behavior at Varying Temperatures

Asphalt is a *viscoelastic* material that has both the properties of an elastic solid and a viscous liquid, depending on the temperature



Source: Asphalt Institute

Asphalt Flow Behavior



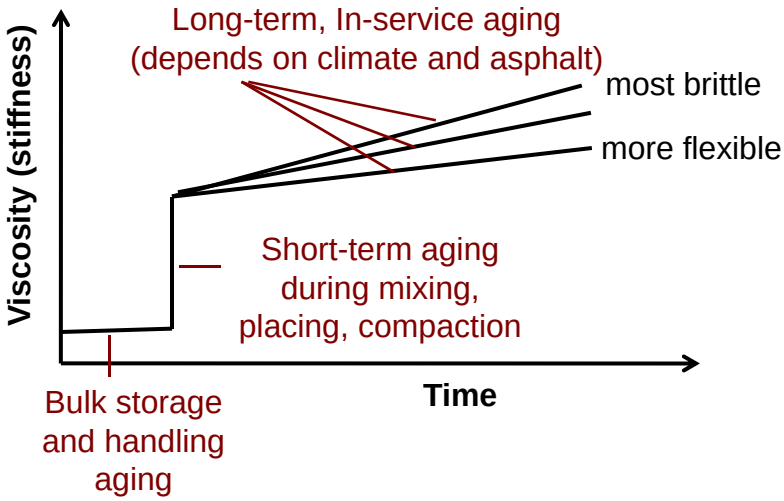
At in-service temperatures

Source: Asphalt Institute

Asphalt Flow Behavior

Source: Asphalt Institute

Aging



Source: Asphalt Institute

"Ideal" Asphalt Binder

- Higher stiffness at high in-service temperatures for increased stability (no shoving and rutting)
- Lower stiffness at low in-service temperatures for less brittle behavior (no thermal cracking and block cracking)
- Less aging over time for continued flexible behavior (improved long-term durability, no raveling, cracking)

Source: Asphalt Institute

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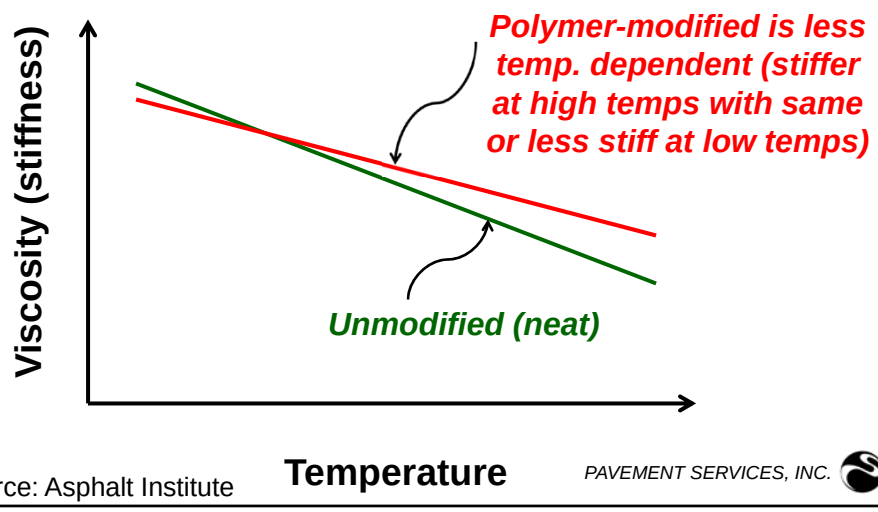
Polymer-modified Asphalt Binder



Source: Asphalt Institute

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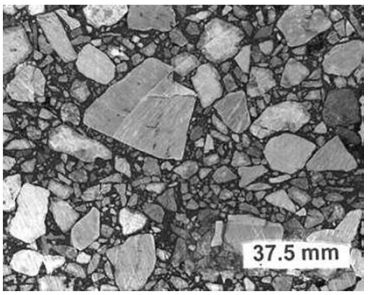
ADOT&PF Standard P-401 Binders

Performance Grade AASHTO M 320	Softening Point AASHTO T 53	Toughness ASTM D 5801	Tenacity ASTM D 5801
PG 52-28	N/A	N/A	N/A
PG 58-28	120° F, min.	110 in lbs, min.	75 in lbs, min.
PG 64-28	125° F, min.	110 in lbs, min.	75 in lbs, min.

Role of Aggregates in HMA

- Aggregates usually make up 94-96% by weight, or 85-90% by volume of an asphalt paving mixture
- Aggregates are the main load-bearing components within asphalt paving mixtures!



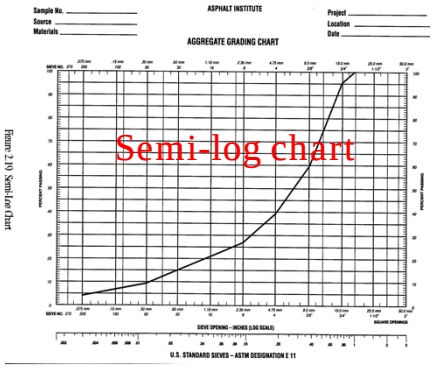
Aggregates

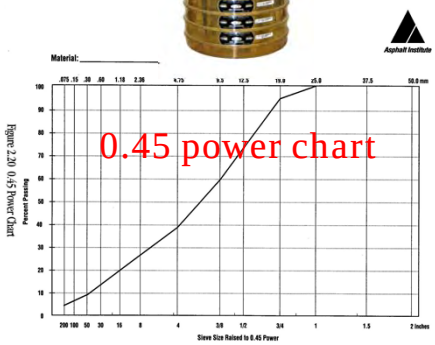
- Natural aggregates
- Processed aggregates
- Synthetic or manufactured aggregates
- Reclaimed Asphalt Pavement (RAP)

Aggregate Properties

- Particle Size
- Particle Shape
- Gradation
- Cleanliness
- Toughness
- Surface Texture
- Absorptiveness
- Affinity for Asphalt
- Specific Gravity

Aggregate Gradation





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Aggregate Size Definitions

100
100
90
72
65
48
36
22
15
9
4

- ***Maximum*** Aggregate Size
  - One size larger than nominal maximum size
- ***Nominal Maximum*** Aggregate Size
  - One size larger than the first sieve to retain more than 10%
- Both definitions are based on the standard ASTM sieve nest

100
99
89
72
65
48
36
22
15
9
4

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P-401 Mixture Classifications

- Four gradation bands in Table 3, different maximum particle sizes
  - 1 1/4 in
  - 1 in
  - ¾ in
  - ½ in
- All of these mixtures are dense-graded
  - Continuous distribution of particle sizes

eference: ADOT P-401

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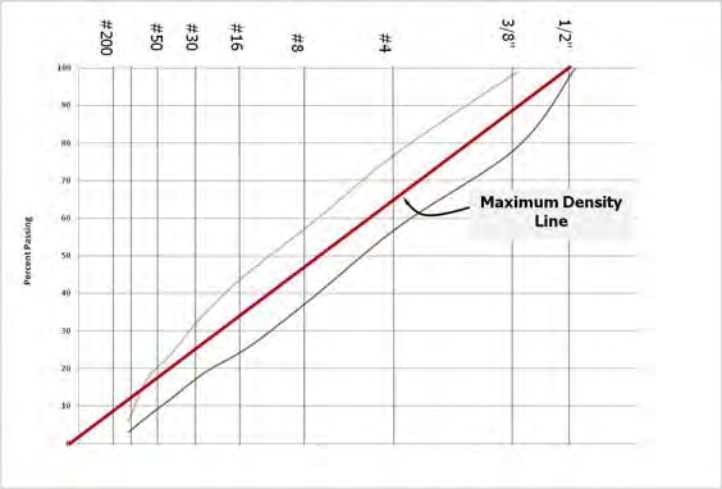
½" Max Aggregate Size Gradation



Reference: AC 150/5370-10F

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Mix Design Objective

"…to determine the combination of asphalt cement and aggregate that will give long lasting performance…"

- Reference: Asphalt Institute MS-2, *Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types*

Desirable Mixture Properties

We want:

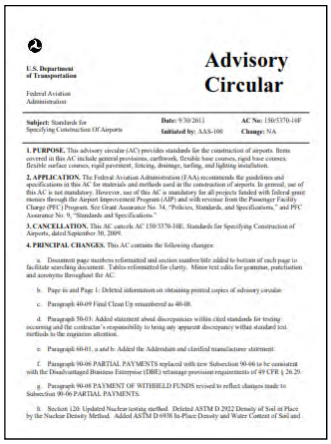
- Stability
- Durability
- Impermeability
- Workability
- Flexibility
- Fatigue Resistance
- Skid Resistance

We do *not* want :

- Rutting or shoving
- Cracking or raveling
- Permeable pavements
- Difficulty in handling
- Cracking after repeated loading
- Slick pavement surface

P-401: Marshall Mix Design

- Directly references AI MS-2 for use in developing the HMA mixture design
- Marshall Method of mix design



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.

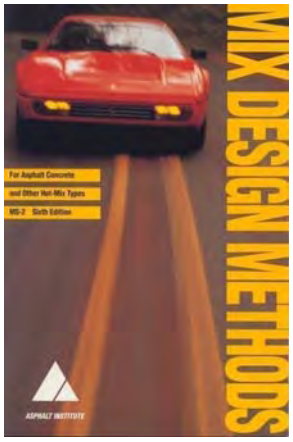
d. Paragraph 50-03: Added statement about discrepancies within cited standards for testing: occurring and the contractor's responsibility to bring any apparent discrepancy without standard test methods to the engineers attention.

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 provisions 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



Reference: AC 150/5370-10F

Preparation of Marshall Test Specimens

- Compact specimens with Marshall hammer
  - 10 lbs hammer
  - 18" drop
  - ASTM D 6926 requires a manually-operated hammer. Mechanical hammers must be correlated with the standard.
- Compact with 50 or 75 blows per side depending on design
  - <60,000 lbs = 50 blows
  - ≥60,000 lbs = 75 blows

Marshall Criteria, P-401 Table 1

Test Property	Gross Wt ≥ 60 kips or Tire Pressures ≥ 100 psi	Gross Wt < 60 kips or Tire Pressures < 100 psi
No. of Blows	75	50
Stability, lbs (min)	2150	1350
Flow, 0.01 in	10 - 14	10 - 18
Air Voids, %	2.8-4.2	2.8-4.2

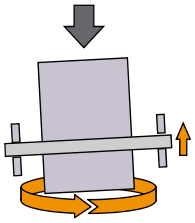
Reference: AC 150/5370-10F

Advisory Circular 150/5370-10G (Draft)

- Item P-401 Plant Mix Bituminous Pavement
- Item P-403 Hot-Mix Asphalt (HMA) Pavements (Base, Leveling or Surface Course)
  - In both specifications, the use of the Gyratory Compactor for design of HMA is a "tailoring option" that is available to all engineers on all projects. The AC contains no limitations to the use of on airport projects.

Gyratory Mix Design

- Gyratory
  - 600Kpa Pressure
  - 30 RPM
  - 1.25o Angle
- Better Simulation of Loading
- Compact to Number Gyrations:
  - ≥ 60k lbs, N_{des} = 75
  - < 60k lbs, N_{des} = 50



6” Diameter Mold

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P-401 Gyratory Mix Design Criteria

	Pavements Designed for Aircraft Gross Weight >= 60 Kips or Tire Pressure >= 100 psi	Pavements Designed for Aircraft Gross Weight < 60 Kips or Tire Pressure < 100 psi
No. of Gyrations	75	50
Air Voids, %	2.8-4.2	2.8-4.2
VMA, %		
Gradation 3	16	16
Gradation 2	15	15
Gradation 1	14	14

Reference: AC 150/5370-10G Draft

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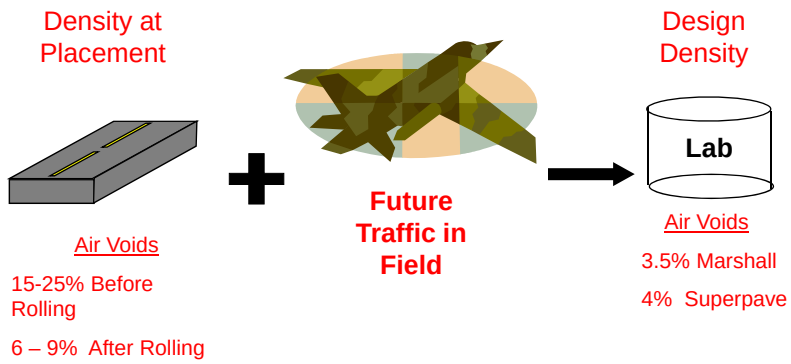
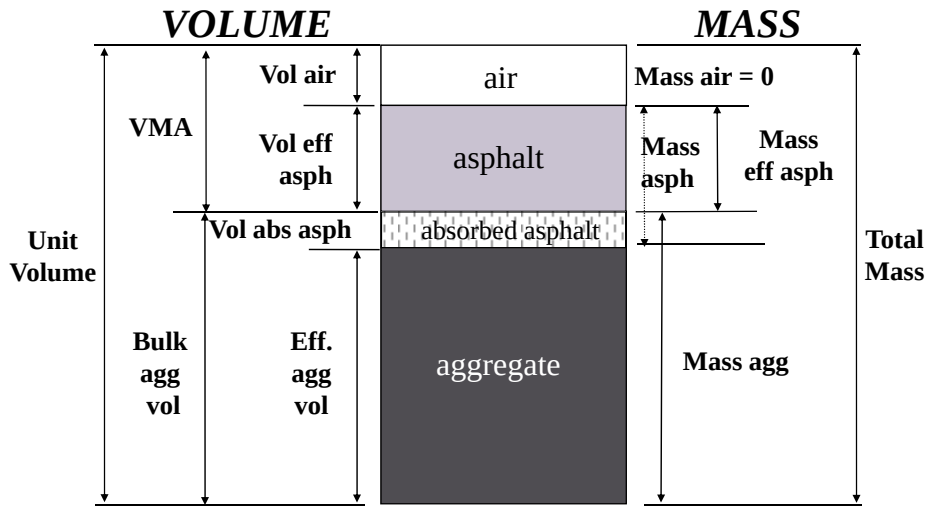
Laboratory Compactive Effort

Selected to match the in-place density of HMA after several years of loading in field



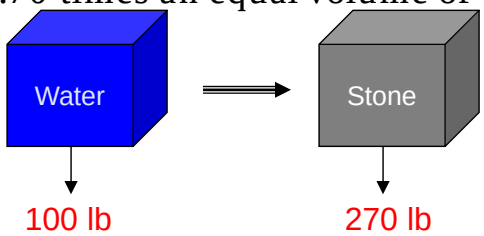
Component Diagram



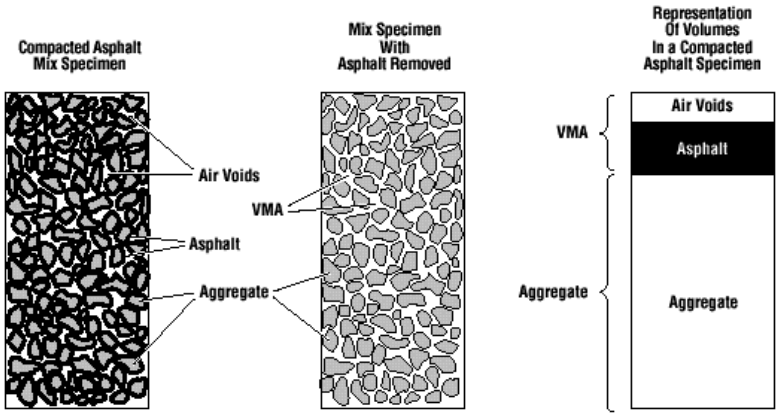
Reference: AI MS-2, Fig. 4.2

Specific Gravity

- Ratio of a material's weight to the weight of an equal volume of water
  - Dimensionless number (no units attached)
- Specific Gravity = 2.70 means that the rock weighs 2.70 times an equal volume of water



VMA-Illustrated (MS-2)



Note: For simplification, the volume of absorbed asphalt is not shown.

Figure 3.01 Voids in the Mineral Aggregate (VMA) in a Compacted Mix Specimen

Mixture Criteria, P-401 Table 2

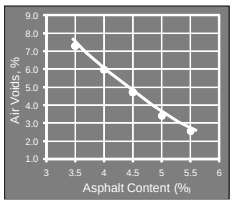
Maximum Particle Size	Minimum VMA
½ in (12.5 mm)	14 %
¾ in (19.0 mm)	13 %
1 in (25.0 mm)	12 %
1 1/4 in (37.5 mm)	11 %

Reference: ADOT P-401

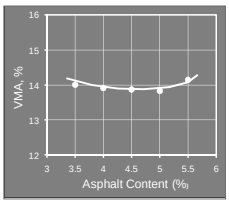
Interpretation of Volumetric Test Data

Plot averages vs. asphalt content

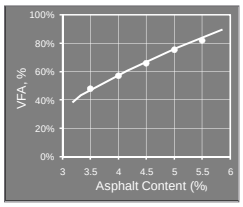
V_a



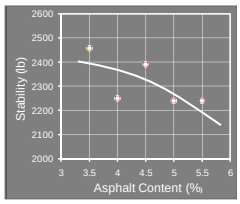
VMA



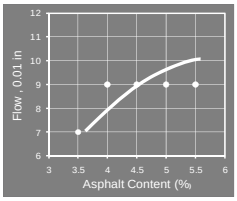
VFA



Stability



Flow

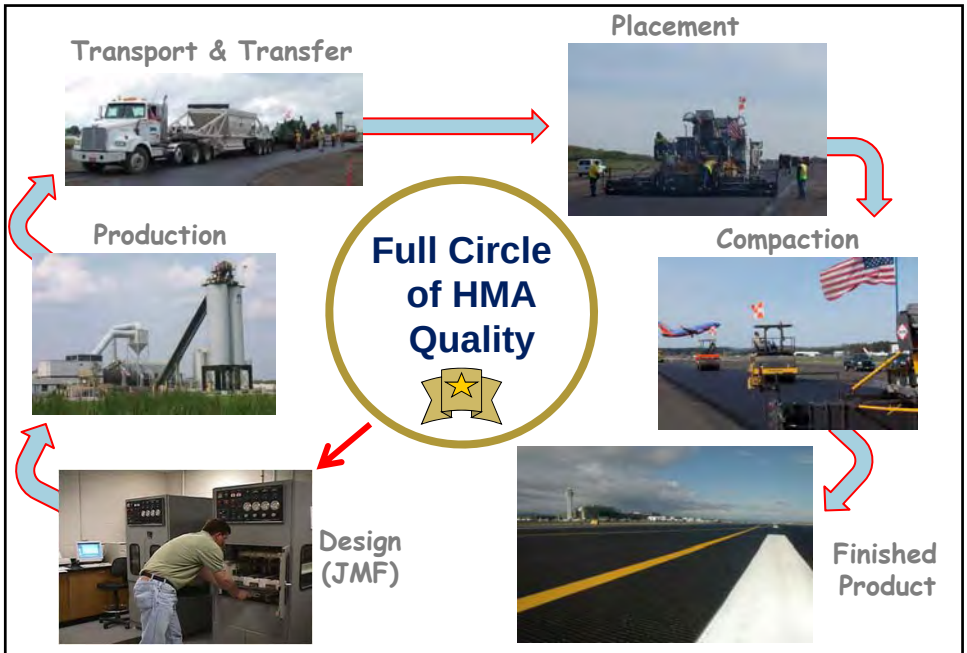


Questions on Materials and Mix Design Methods ?

Photo Courtesy Steve Muench

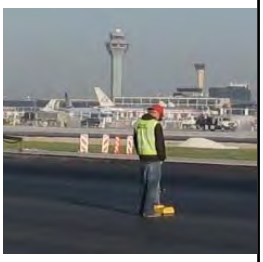
Aggregate Base Preparation

- Mix to proper moisture content
- Best Practice –place base aggregate with a paver
- Place in 4 – 8 inch compacted lifts
- Condition to desired moisture content
- Compact to percentage of proctor specified
- Apply prime coat and allow to cure



Pre-project start meeting

- Discuss project scope and expectations
  - Mention areas that ar
    cause for concerns
    - traffic issues
    - unusual requireme
  - Equipment needed fo
    project- is it ava
    - Daily producti
      expectation
  - Testing procedu
    agency requiren



Repair Fatigue Cracking

- Possible Causes
  - Weak base/subgrade
  - Thin pavement
  - Poor Drainage
  - Overloading
- Bottom-up cracking
- Typically with Rutting

Full-Depth Patching is **Localized Reconstruction**

Cold Milling

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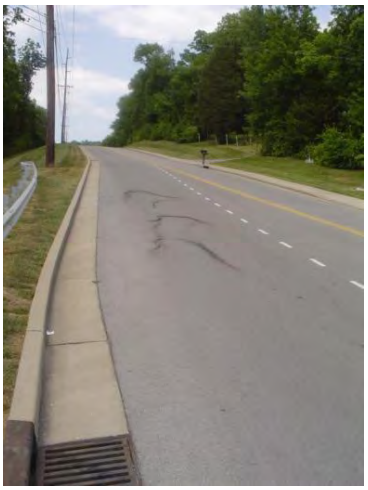
Surface After Milling

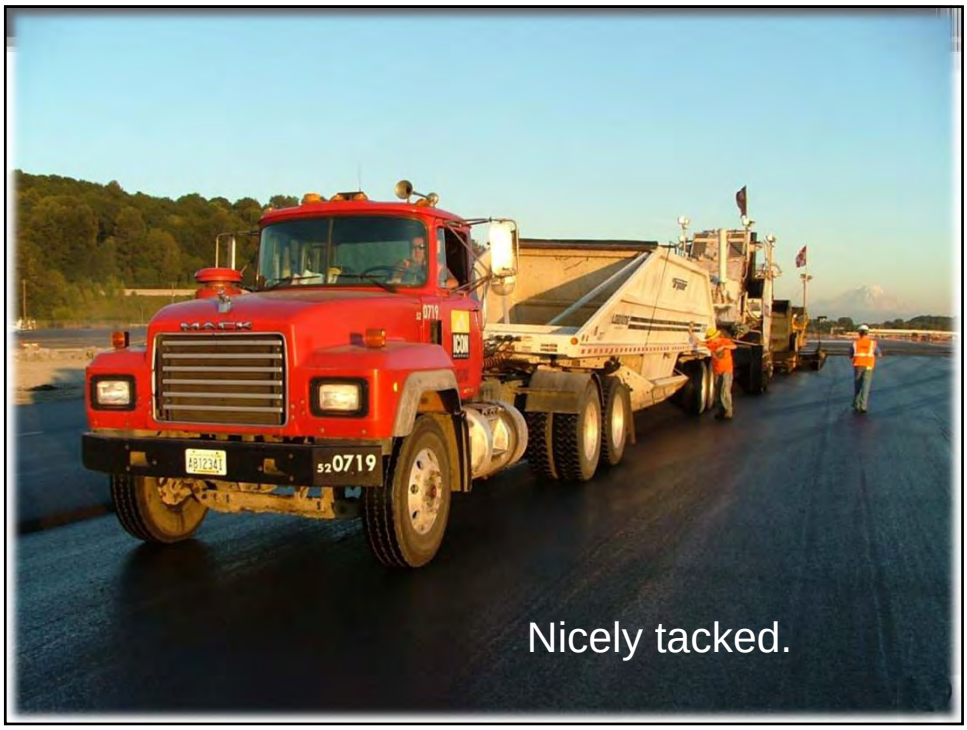
Tack Coat

- Why do we use tack coat?
- Promote bond between old and new pavement layers
- Prevent slippage between pavement layers

Slippage Cracks



Streaking


MACK
520719
Nicely tacked.

Segregation- Mechanical & Thermal

Most Agencies Confirm Segregation is the #1 Problem

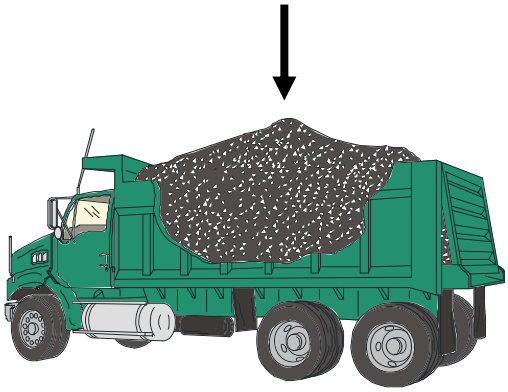
12 Areas where segregation occurs

- Mix design
- Stockpiles
- Cold bin loading
- Cold bin feeding
- Hot bins
- Drum mixer operations
- Pug mill gates
- Surge & storage bins
- Discharge systems
- Truck loading
- Truck unloading
- Paver operation

Source: "Asphalt Contractor May 1996"

If segregated from the plant it will be segregated on the mat

Single Dump Loading

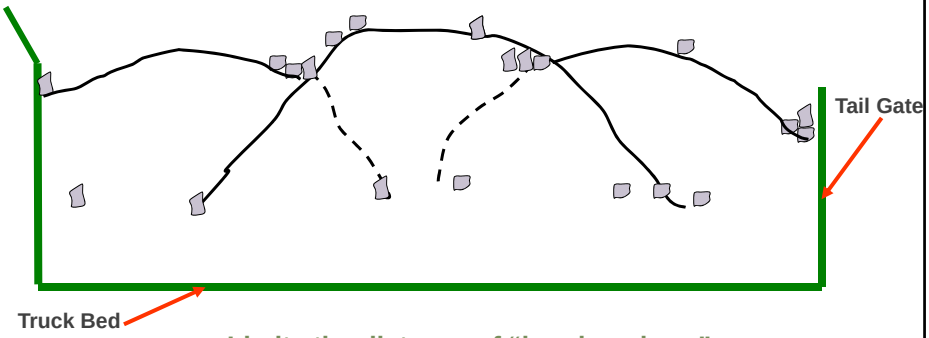


Segregation in the front, rear, & both sides

Mix "breaks & runs"

Correct Loading at the Plant

Minimizes the Segregation



Limits the distance of "break and run"

Multiple Dump Loading

Prevents HMA mix segregation and helps to retain temperatures

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Tarp Those Loads No Matter the Conditions

Prevents temperature loss and mix temperature differential

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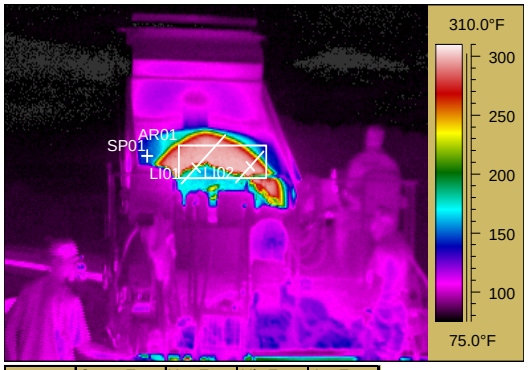
Temperature Differential in Hauling Process



	Cursor Temp	Max Temp	Min Temp	Avg Temp
LI01	196.0°F	300.9°F	171.8°F	244.1°F
LI02	298.6°F	302.2°F	141.0°F	233.9°F
AR01	-	302.6°F	129.9°F	256.2°F
SP01	146.1°F	-	-	-

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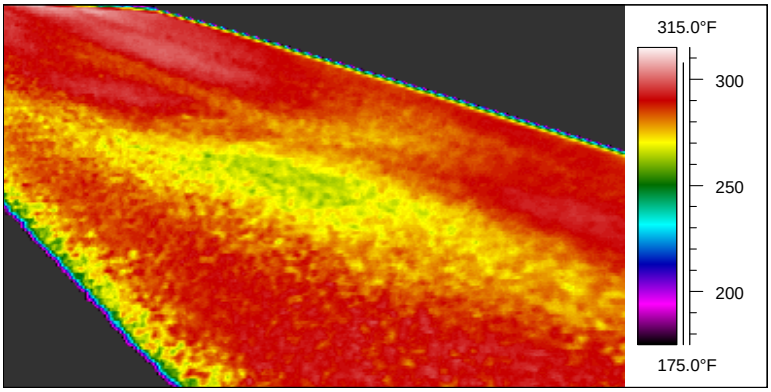
Inconsistent Temperature - Cold Slug of Material



Temperature Differential Will Cause Failure!

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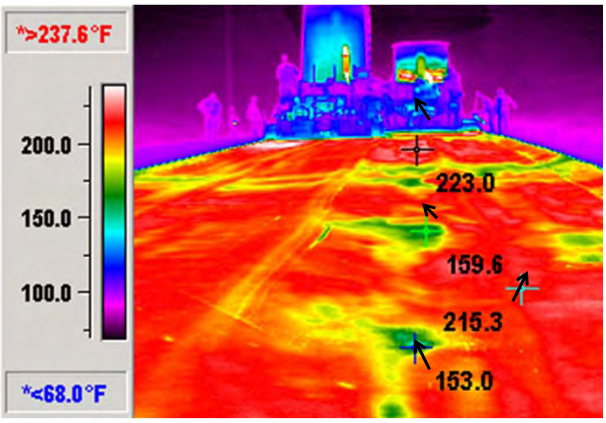
Thermal Segregation



Temperature differentials lead to compaction issues

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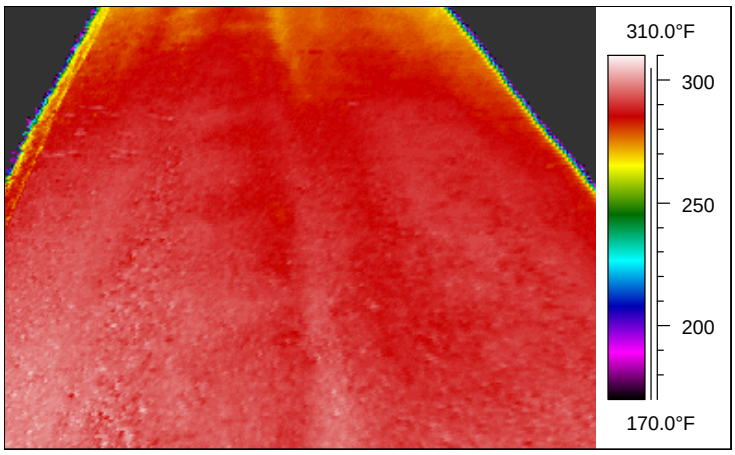
Top Quality Mat



Attainable with or without an MTV

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Weather Limitations

TABLE 4. BASE TEMPERATURE LIMITATIONS

Mat Thickness	Base Temperature (Minimum)
3 inches or greater	40 °F
Greater than 1 inch but less than 3 inches	42 °F
1 inch or less	50 °F

End of Load Segregation- Last Minute Dribbles

End of Load Segregation

Blemishes will likely fail!

Material Transfer Vehicles (MTV)

1. **Consistent paving speed**
2. **Balance production to laydown**
3. **Control segregation and temperature segregation**

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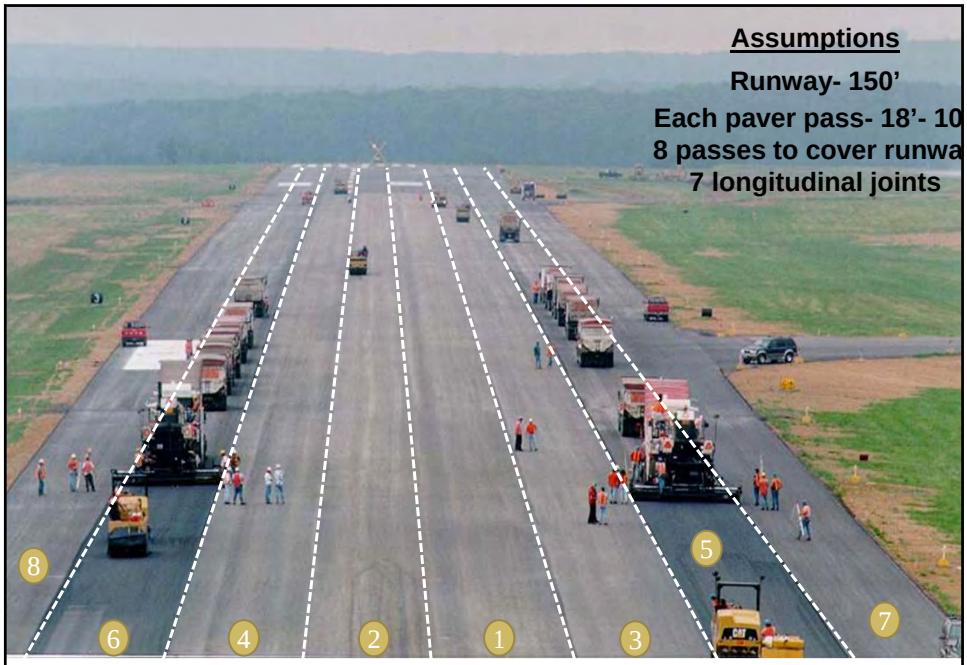

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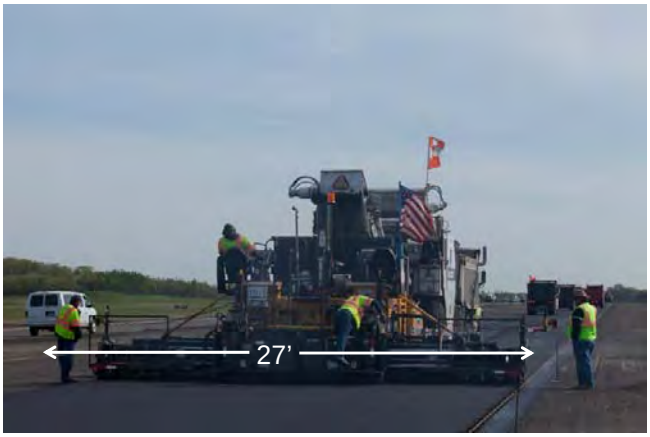
Airport Project- Hydraulic Extendible Screed



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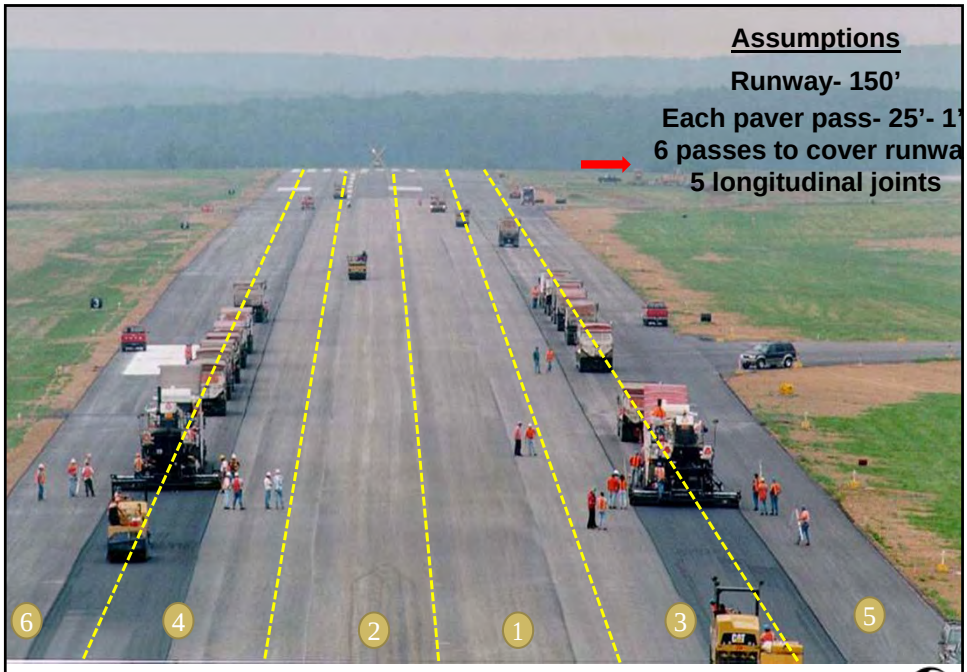

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Eliminating Longitudinal Joints- Echelon Paving

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Excessive Material At Joint & Removal

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Take the lute away from this guy!

Cold and segregated material

Maybe we should keep the lute man distracted !!

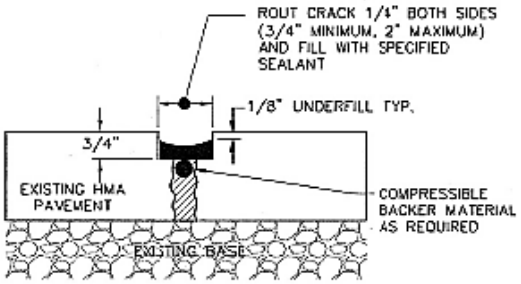
Slurry Seal application

Slurry Seal in Hangar area

INGERSOLL-RAND

Reclaminte spray application

AC 150/5380-6B
Appendix C



NOTE:

DEPENDENT ON SEALANT TYPE. USE MANUFACTURER'S RECOMMENDATIONS FOR BACKER MATERIAL TO FORM RESERVOIR FLOOR.

CRACK REPAIR DETAIL – CRACKS LESS THAN 1" WIDE AND GREATER THAN 1/8" WIDE USING ROUTER

NOT TO SCALE
FIGURE C-14

Summary

- Use the best materials available
- Use appropriate PG binder for the project
- Marshall Mix design / Gyratory Compaction soon
- Pay attention to preparation prior to paving
- Airfield deserve best construction practices
- No shortcuts in maintaining airfield pavements

Asphalt Airfield Pavements

Thank You!

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