

# HMA Mix Design and Characterization for Airport Pavements



Federal Aviation  
Administration



Presented to: 2025 SWIFT/CAPTG Conference and Workshop  
Niagara Falls, Canada

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Program Manager, NAPMRC  
Federal Aviation Administration (FAA)

Date: September 22, 2025

# Outline

- **Introduction**
- **Past**
  - HMA Mix Design - FAA Specifications for HMA Construction
  - HMA Characterization for Pavement Evaluation and Design
- **Present**
  - HMA Mix Design - FAA Specifications for HMA Construction
  - HMA Characterization for Pavement Evaluation and Design
- **Future**
  - HMA Mix Design - FAA Specifications for HMA Construction
  - HMA Characterization for Pavement Evaluation and Design



# FAA Airport Technology R&D Program

- Research conducted at the FAA William J. Hughes Technical Center, Atlantic City, NJ, USA.
- Sponsor: FAA Office of Airport Safety and Standards (AAS110), Washington, DC.
- Provide support for development of FAA pavement standards (Advisory Circulars).





# FAA Full-Scale Test Facilities

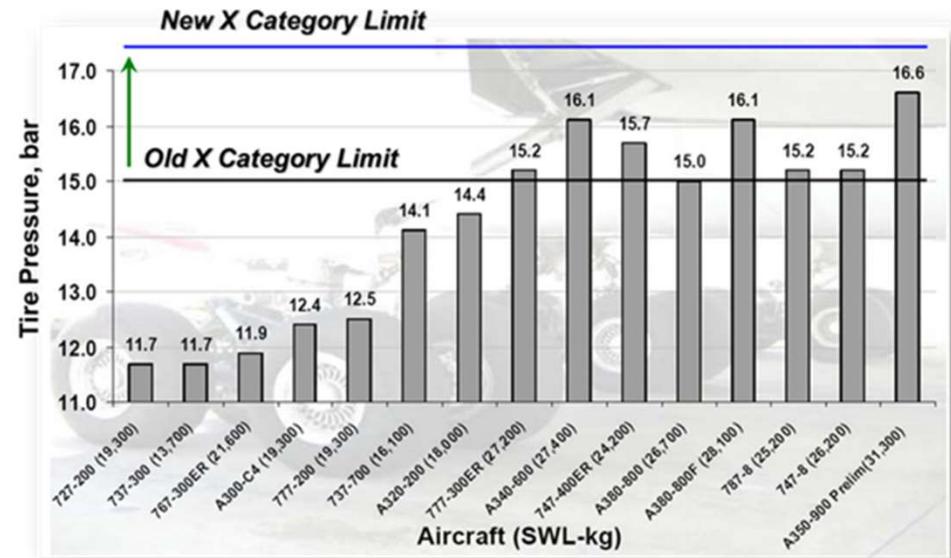
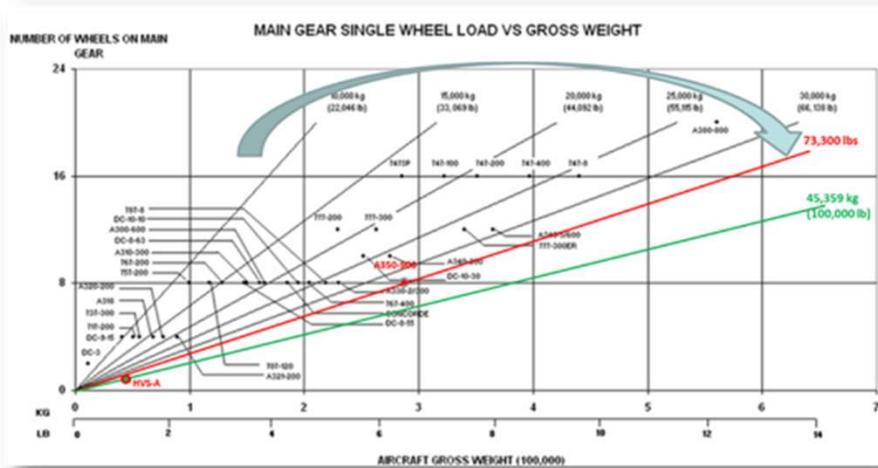


National Airport Pavement Test Facility (NAPTF)

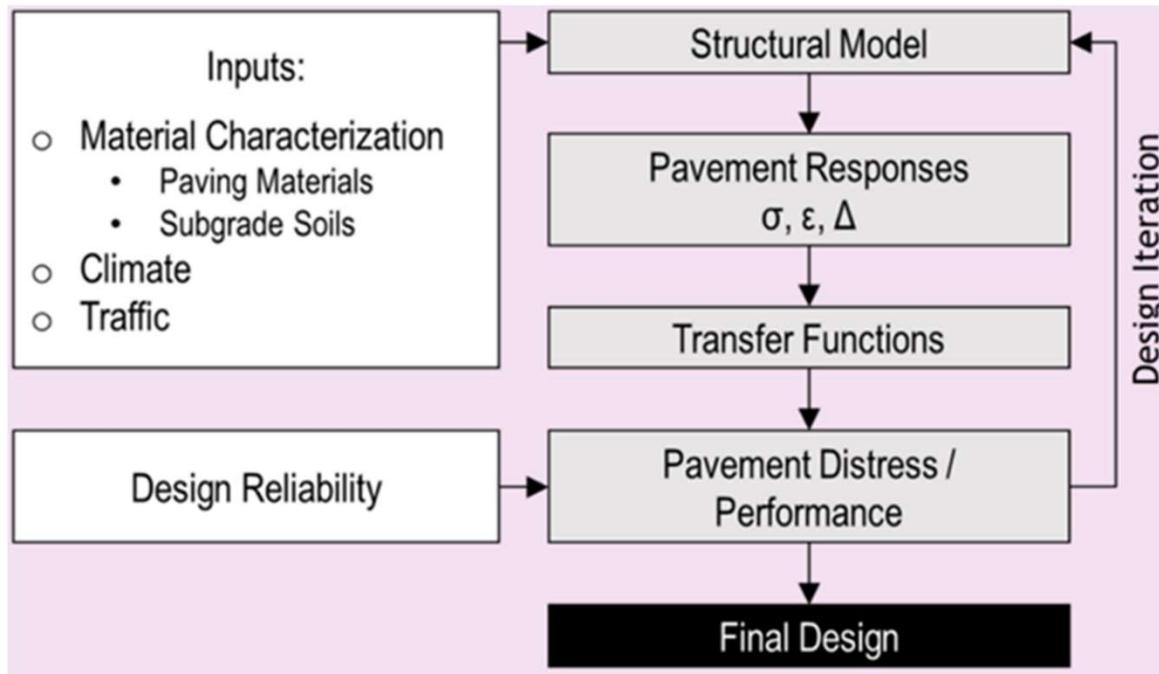


National Airport Pavement & Material Research Center (NAPMRC)

# Civil Aviation & Loading Characteristics

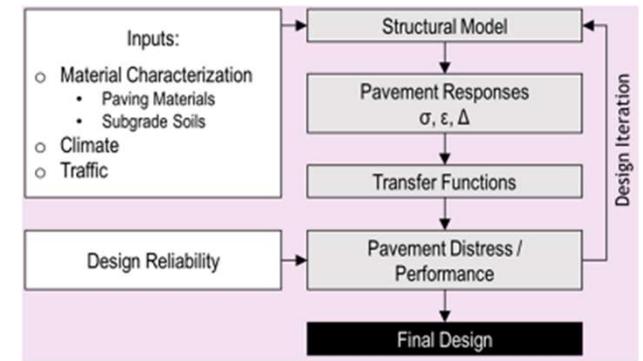


# Mechanistic-Empirical Design Procedure



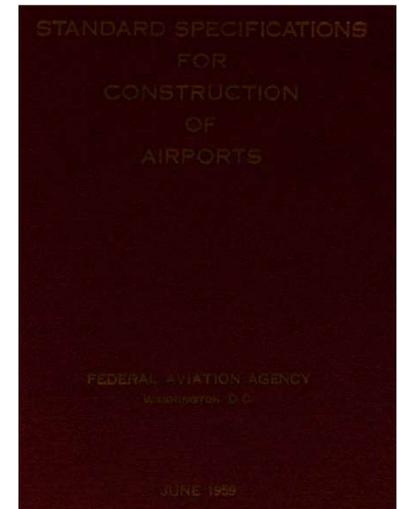
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# FAA Specification for HMA Mix Design

- **STANDARD SPECIFICATIONS FOR CONSTRUCTION OF AIRPORTS, JUNE 1959**
- **In the 1959 spec book,**
  - Gradations provided
  - Engineer was to select the amount of AC to use within the limits of the spec (4.5-7 for gravel and 6-9 for slag)
  - Requires 92% TMD, and
  - prescribed rolling with a 10T roller immediately and continue rolling until all roller marks eliminated.



Sufficient rollers of the designated types shall be furnished to adequately handle the output of the plant. Rolling shall continue until all roller marks are eliminated, until the surface is of uniform texture and true to grade and cross section, and until the density of at least 92 percent of the theoretical density is obtained. Field density tests shall be made at least twice daily.

The theoretical density shall be computed as follows:

$$\text{Density} = \frac{100}{\frac{\% \text{ mineral aggregate by weight}}{\text{Sp. gr. mineral aggregate}} + \frac{\% \text{ bitumen by weight}}{\text{Sp. gr. of bitumen}}}$$

## FAA Specification for HMA Mix Design

- 150/5370-10; 2/29/1984 Change-23: PWL added.
- EB59; 12/18/2001; Superpave
- 150/5370-10B; 4/25/2005 P403 Specification added.
- EB59A; 5/12/2006; Guidance on use of Superpave Mixes
- 150/5370-10G; 7/21/2014 Superpave Mix Design



# FAA Specification for HMA Mix Design

AC 150/5370-10G

7/21/2014

Table 1. Marshall Design Criteria

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 Blows	75	50
Stability, pounds (Newtons) minimum	2150 (9560)	1350 (6000)
Flow <sup>1</sup> , 0.01 inch. (0.25 mm)	10-16	10-18
Target Air Voids (percent)	3.5	3.5
Percent Voids in Mineral Aggregate (minimum)	See Table 2	See Table 2



<sup>1</sup> The flow requirement is not applicable for Polymer Modified Asphalts.

For Gyratory Method:

The Gyratory Design Criteria, applicable to the project shall be specified by the Engineer from the information shown below and inserted into Table 1 where asterisks (\*) denote insert points.

Table 1. Gyratory Design Criteria

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



# FAA Specification for Flexible Pavement Thickness Design

- 150/5320-8;  
4/5/1963  
Federal  
Aviation  
Agency

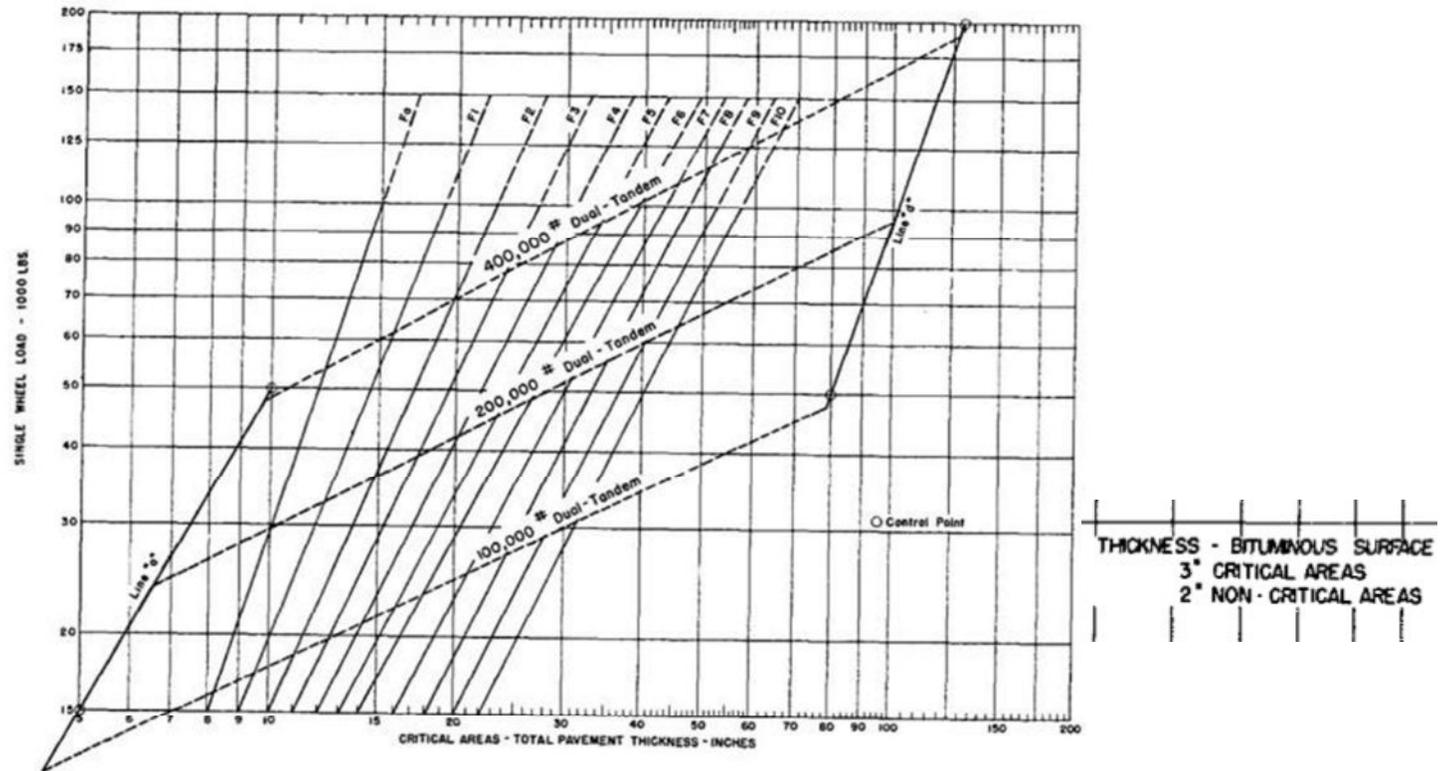


FIGURE 4 DEVELOPMENT OF FLEXIBLE PAVEMENT CURVES - DUAL-TANDEM GEAR

# FAA Specification for Flexible Pavement Thickness Design

AC 150/5320-6A CHG 3  
4/1/70

Page 31

3d-1

AC 150/5320-6A  
Reprinted 9/15/77  
Incorporates changes  
1 through

AIRPORT PAVING



May 9, 1967

DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION

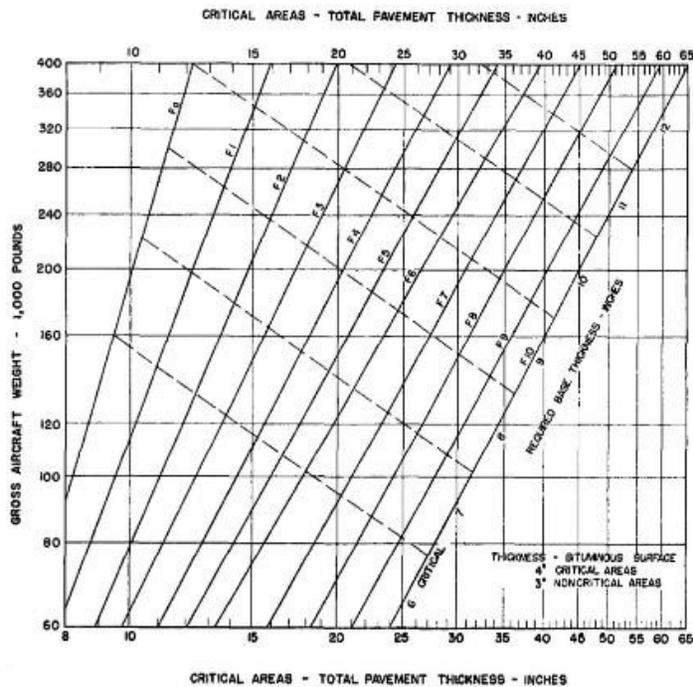


FIGURE 8. DESIGN CURVES - FLEXIBLE PAVEMENT - DUAL-TANDEM GEAR



# FAA Specification for Flexible Pavement Thickness Design

7/7/95 AC 150/5320-6D

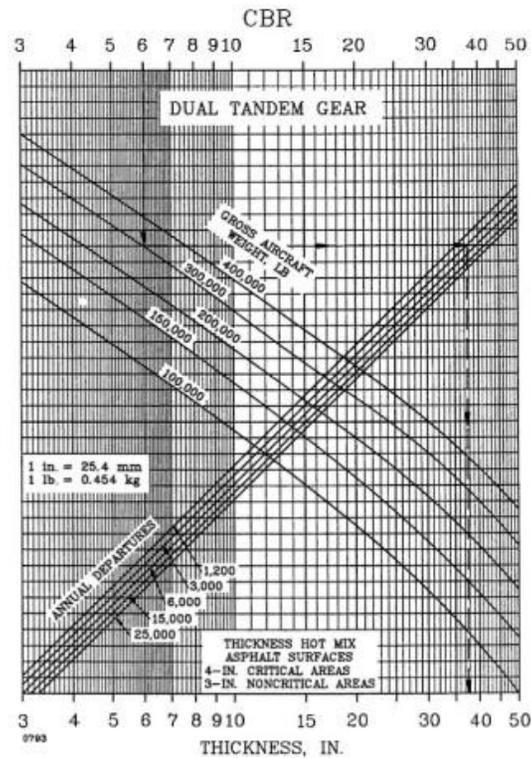
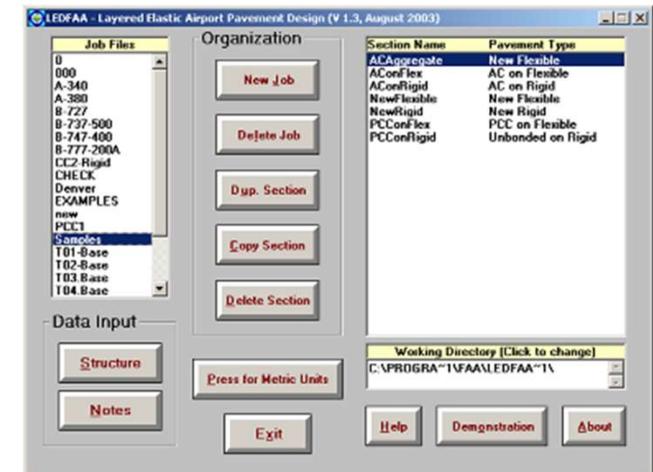


FIGURE 3-4 FLEXIBLE PAVEMENT DESIGN CURVES, DUAL TANDEM GEAR

# FAA Specification for Flexible Pavement Thickness Design

The pavement thickness design charts (nomographs) in [FAA Advisory Circular AC 150/5320-6D](#) have been used successfully for the past 30 years. These design charts were developed for many types of common aircraft gears, but they cannot accurately assess damage to airport pavement structures due to complex gear loads such as the B-777 and A380. To better predict wheel load interactions and to provide the airport community with a pavement design methodology addressing the needs of the B-777 aircraft, the FAA in 1995 introduced the design program called LEDFAA.

LEDFAA developed out of a 1993 FAA-sponsored feasibility study of Layered Elastic Design (LED) methods for airport pavements. The results of this feasibility study demonstrated that the LED procedure for flexible (asphalt) pavements produces pavement designs that are compatible with conventional FAA design procedures for existing aircraft types. At the same time, LED better predicts the wheel load interactions for the B-777 because the landing gear configurations and layered pavement structures can be modeled directly using the LED procedure. Therefore, the FAA decided to implement the LED procedure as a new standard for designing airport pavements intended to serve the B-777 airplane.



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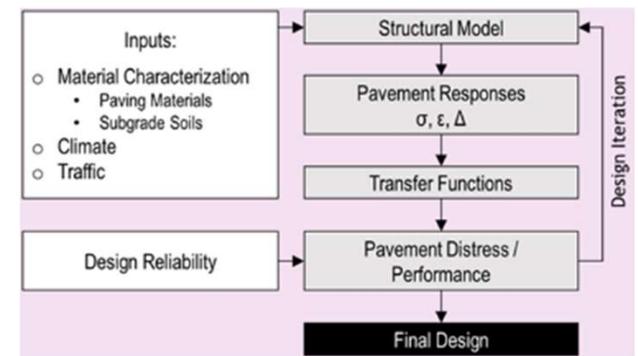
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# AC 150/5370-10H

- Standards for Specifying Construction of Airports.
- Most recent version – released **December 21, 2018**.
- 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/](http://www.faa.gov/airports/resources/advisory_circulars/)



## Advisory Circular

**Subject:** Standard Specifications for Construction of Airports

**Date:** 12/21/2018

**AC No:** 150/5370-10H

**Initiated By:** AAS-100

**Change:**

1 **Purpose.**

The standard specifications contained in this advisory circular (AC) relate to materials and methods used for construction on airports. Items covered in this AC include general provisions, earthwork, flexible base courses, rigid base courses, flexible surface courses, rigid pavement, fencing, drainage, turf, and lighting installation.

2 **Cancellation.**

This AC cancels AC 150/5370-10G, *Standards for Specifying Construction of Airports*, dated July 21, 2014.

3 **Application.**

The Federal Aviation Administration (FAA) recommends the guidelines and specifications in this AC for materials and methods used in airfield development for construction and rehabilitation projects on airports.

This AC does not constitute a regulation and is not mandatory, however the following applies:

- a. The standard specifications contained in this AC are practices that the FAA recommends for the construction of pavements and airport development serving aircraft greater than 30,000 pounds (13,600 kg).
- b. This AC contains methods and procedures for compliance with 14 CFR part 139 that are acceptable to the Administrator.
- c. The use of this AC is mandatory for all projects funded under Federal grant assistance programs, including the Airport Improvement Program (AIP). See Grant Assurance No. 34., *Policies, Standards, and Specifications*.
- d. This AC is mandatory, as required by regulation, for projects funded with the Passenger Facility Charge program. See PFC Assurance #9, *Standards and Specifications*.

For building construction, the General Contract Provisions are applicable, in addition applicable laws and local building codes shall serve as construction standards acceptable to the FAA.



# AC 150/5370-10H

## Required Grade Bump

Aircraft Gross Weight	High Temperature Adjustment to Asphalt binder Grade	
	All Pavement Types	Pavement area with slow or stationary aircraft
$\leq 12,500$ lbs (5670 kg)	--	1 Grade
$< 100,000$ lbs (45360 kg)	1 Grade	2 Grade
$\geq 100,000$ lbs (45360 kg)	2 Grade	3 Grade

# AC 150/5370-10H

Table 1. Asphalt Design Criteria

Test Property	Value	Test Method
Number of blows or gyrations	[ 75 ]	
Air voids (%)	3.5	ASTM D3203
Percent voids in mineral aggregate (VMA), minimum	See Table 2	ASTM D6995
Tensile Strength Ratio (TSR) <sup>1</sup>	not less than [ 80 ] at a saturation of 70-80%	ASTM D4867
Asphalt Pavement Analyzer (APA) <sup>2</sup>	Less than 10 mm @ 4000 passes	AASHTO T340 at 250 psi hose pressure at 64°C test temperature



- <sup>1</sup> Test specimens for TSR shall be compacted at  $7 \pm 1.0$  % air voids. In areas subject to freeze-thaw, use freeze-thaw conditioning in lieu of moisture conditioning per ASTM D4867.
- <sup>2</sup> AASHTO T340 at 100 psi hose pressure at 64°C test temperature may be used in the interim. If this method is used the required Value shall be less than 5 mm @ 8000 passes

# AC 150/5370-10H

\*\*\*\*\*

75 blows or gyrations shall be specified for airports serving aircraft greater than 60,000 pounds. 50 blows or gyrations may be specified for airports serving aircraft 60,000 pounds or less.

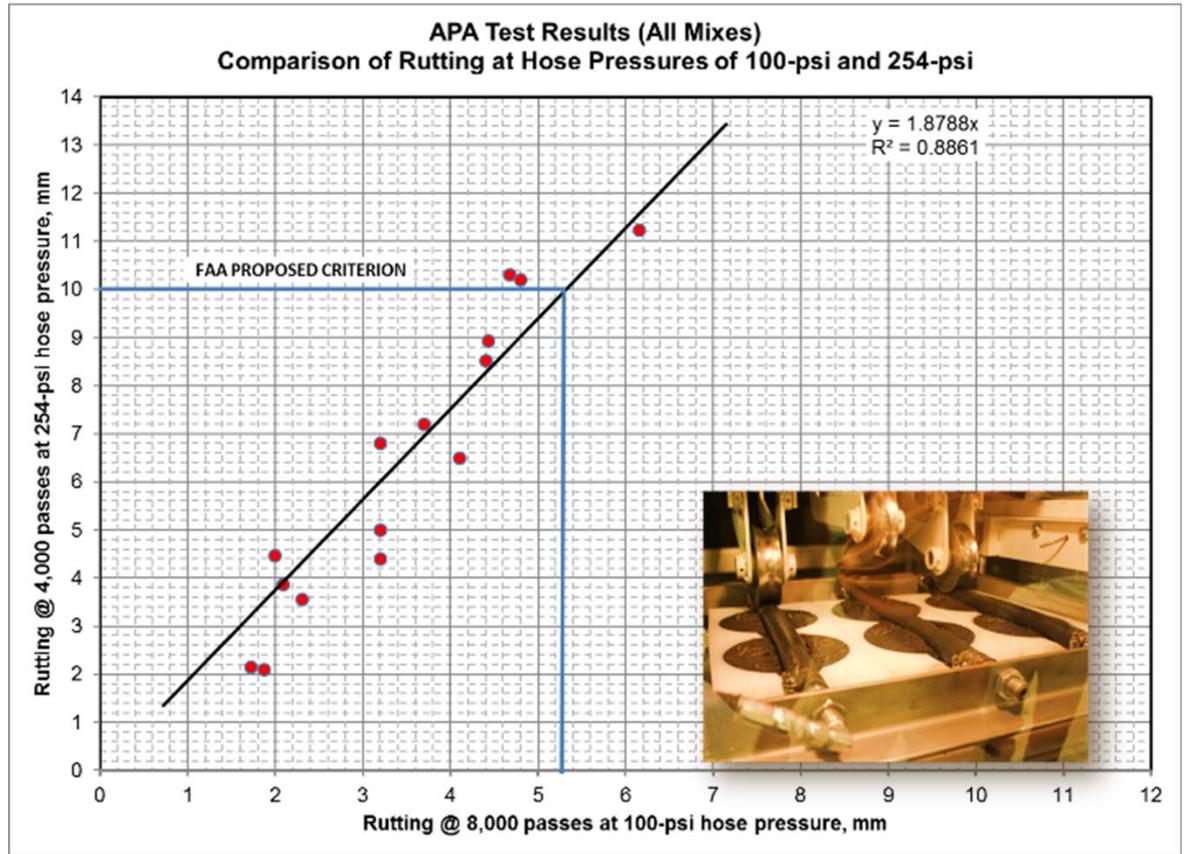
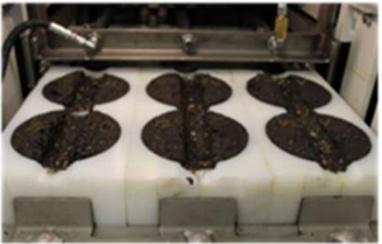
The APA procedure has shown that mixes that meet the requirements above perform well under aircraft loading. The APA is preferred on airport pavement projects serving aircraft greater than 60,000 pounds. **If APA is not available in an area, compacted mix design samples may be sent to a laboratory that has an APA or the Hamburg wheel test (AASHTO T 324) 10mm @ 20,000 passes may be used with FAA approval.**

Specify a TSR of not less than 85 in areas with aggregate that have a history of stripping.

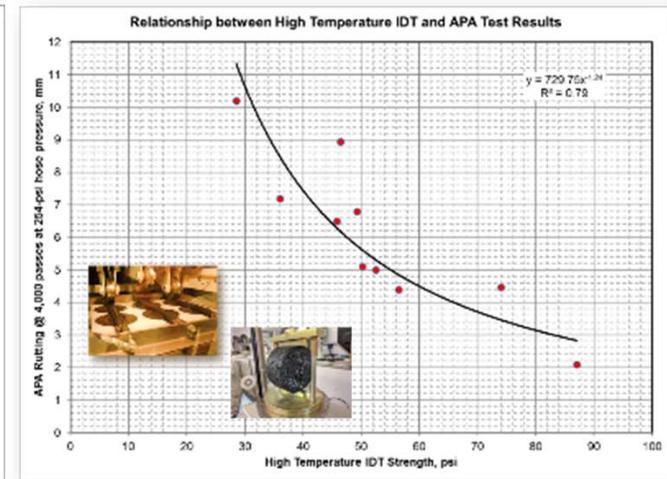
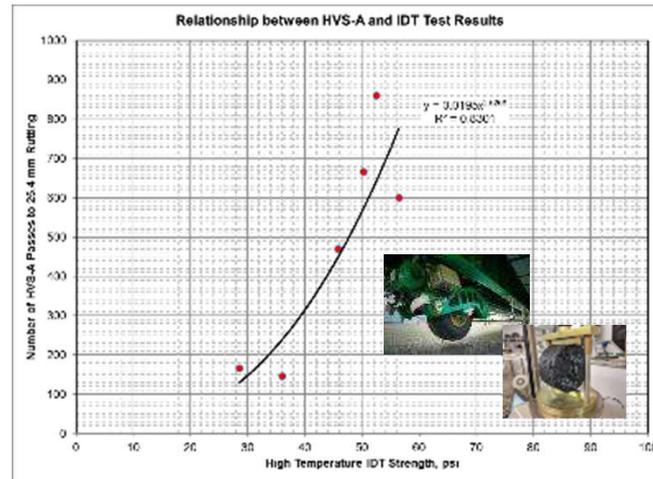
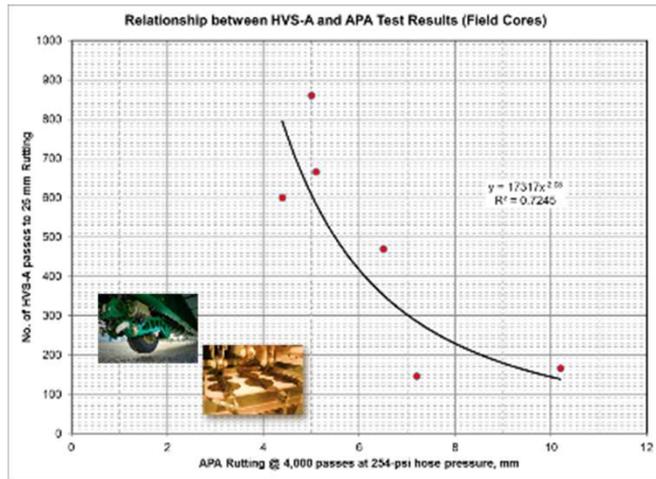
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# APA Test Results

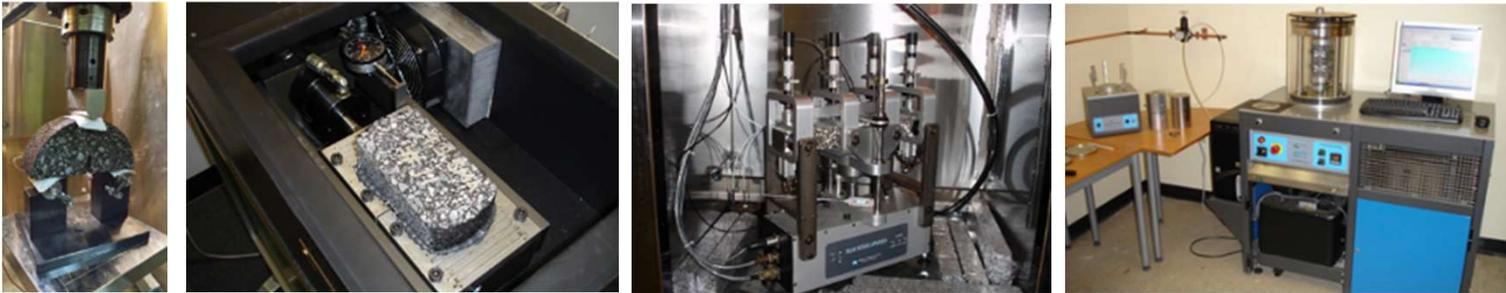


# Relationship between HVS-A, APA & IDT Results



# HMA/WMA Characterization

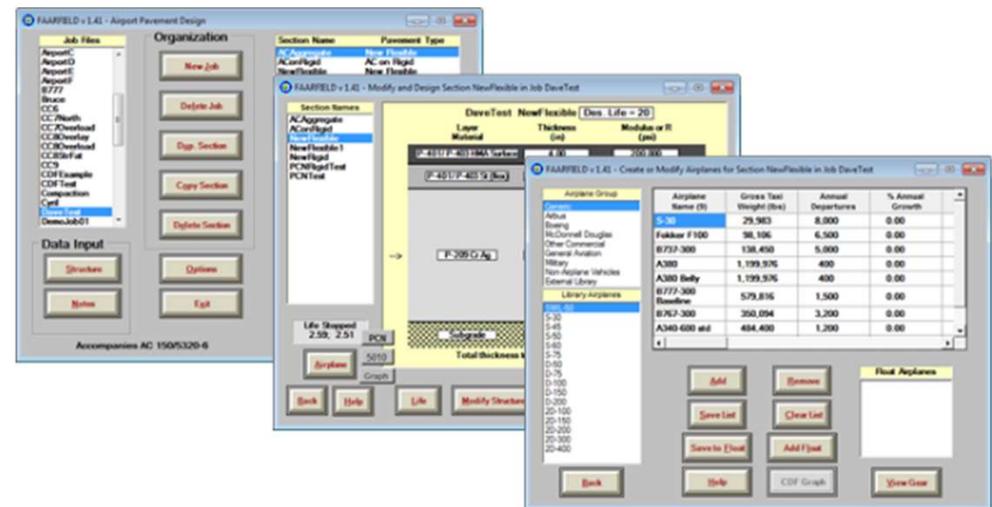
- **Performance Testing**
  - Mixture Stiffness (Dynamic Modulus)
  - Fatigue Cracking (Flexural Beam Fatigue, Overlay Tester, SCB Flexibility Index)
  - Rutting Resistance (AMPT Flow Number)
  - Asphalt Pavement Analyzer (APA)



# FAA Specification for Flexible Pavement Thickness Design

- 150/5320-6E; 9/30/2009  
150/5320-6F; 11/10/2016

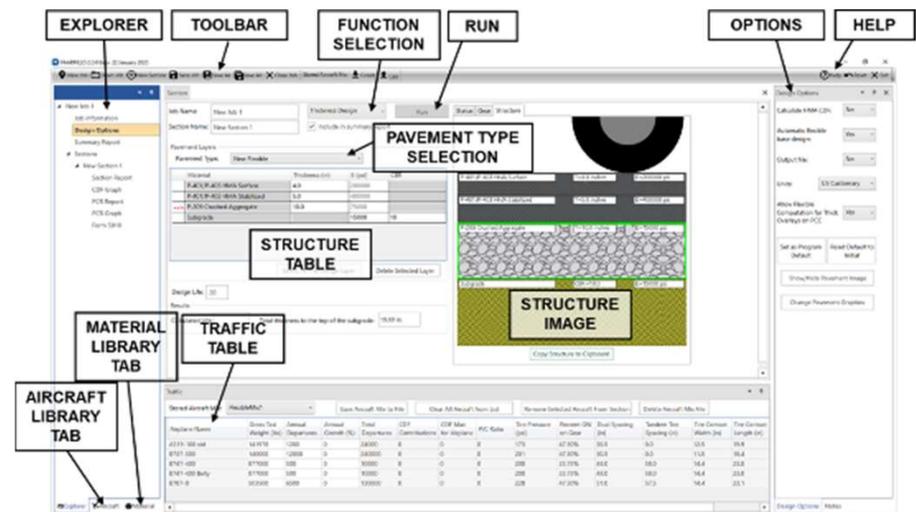
3.13.2.3 In FAARFIELD, the HMA surface or overlay types have the same properties, with modulus fixed at 200,000 psi (1,380 MPa) and Poisson's ratio fixed at 0.35. The HMA Overlay type can be placed over HMA or PCC surface types or User-Defined. Refer to [Table 3-2](#) for material properties used in FAARFIELD.



# FAA Specification for Flexible Pavement Thickness Design

- **AC 150/5320-6G, Airport Pavement Design and Evaluation.**
  - Released 6/7/2021
- **AC 150/5335-5D, Standardized Method of Reporting Airport Pavement Strength - PCR.**
  - Released April 29, 2022

Both ACs incorporate **FAARFIELD 2.0** for design & PCR computations.



# FAA Specification for Flexible Pavement Thickness Design

6/7/2021

AC 150/5320-6G

**Table 3-2. Allowable Modulus Values and Poisson’s Ratios Used in FAARFIELD**

Layer Type	FAA Specified Layer	Rigid Pavement psi (MPa)	Flexible Pavement psi (MPa)	Poisson’s Ratio
Surface	P-501 Cement Concrete	4,000,000 (30,000)	NA	0.15
	P-401/P-403 <sup>1</sup> /P-404 Asphalt Mixture	NA	200,000 (1,380) <sup>2</sup>	0.35
Stabilized Base and Subbase	P-401/P-403 Asphalt Mixture	400,000 (3,000)		0.35
	P-306 Lean Concrete	700,000 (5,000)		0.20
	P-304 cement treated aggregate base	500,000 (3,500)		0.20
	P-220 Cement treated soil base	250,000 (1,700)		0.20

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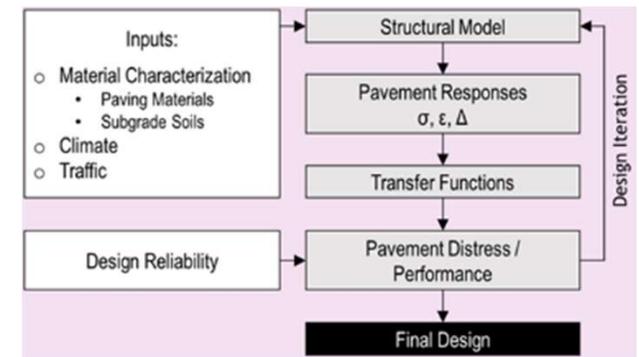
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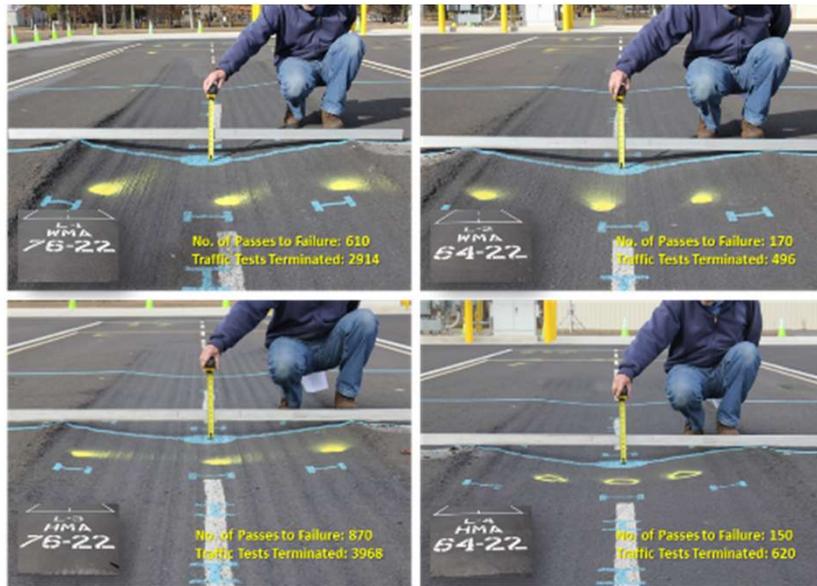


# Results of APT at NAPMRC

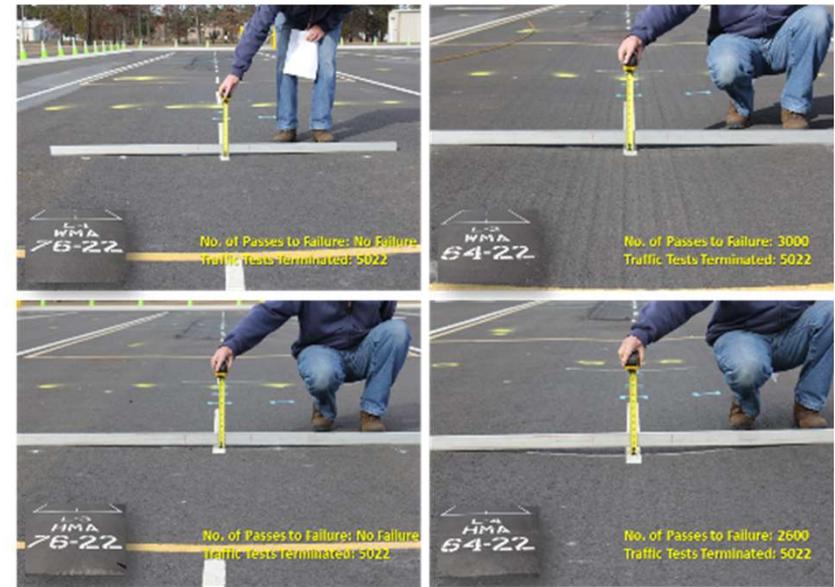


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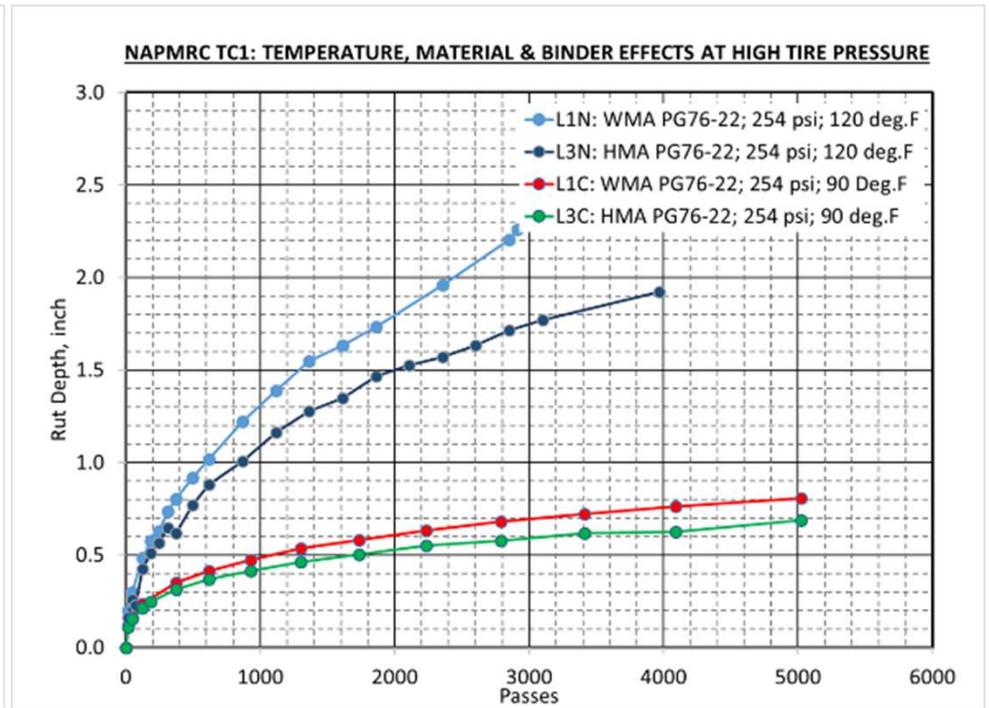
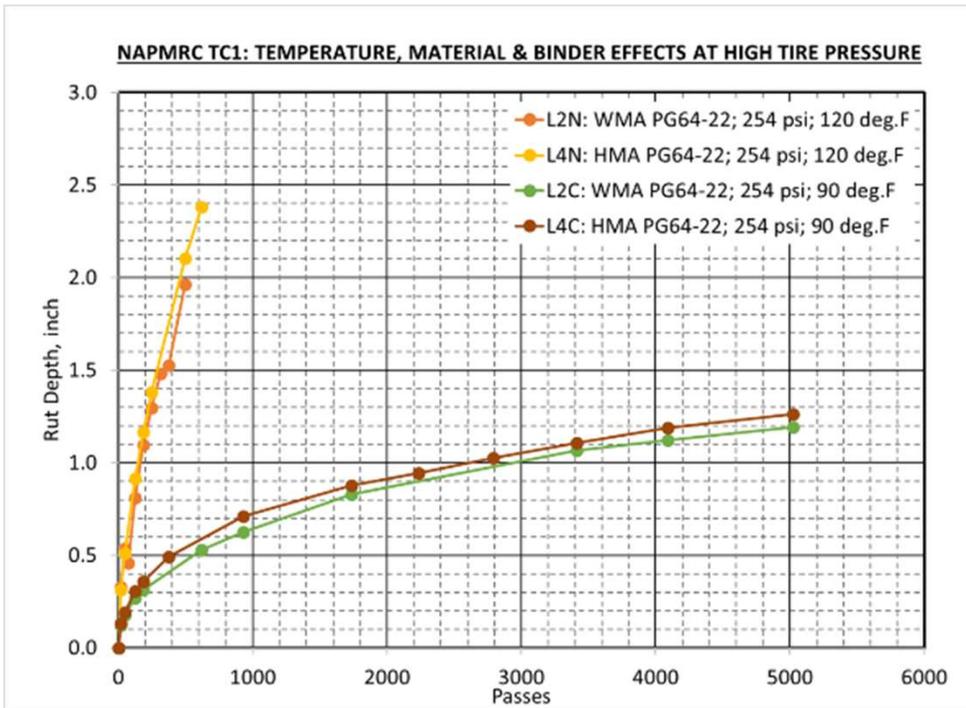
**NAPMRC-TC1 NORTH TEST AREA (254-psi; 120°F)**



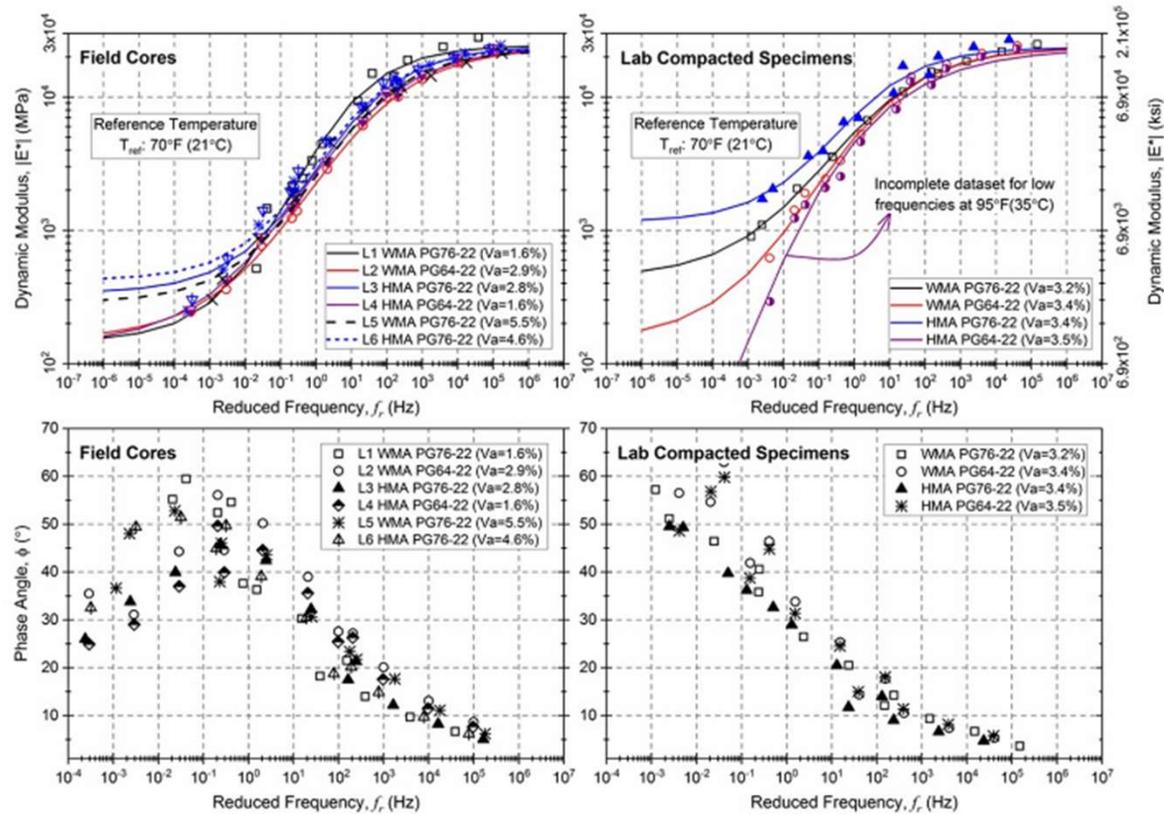
**NAPMRC-TC1 CENTER TEST AREA (254-psi; 90°F)**



# Results from APT at NAPMRC



# Results from APT at NAPMRC



# PANDA-AP

## Standalone PANDA-AP:

- Considers failure mechanisms
- Can be used as a *supplement* to FAARFIELD for refined analysis
- Allows for the definition of different gear configurations, loading type, and pavement structure
- User-friendly and customized for airfield pavements
- Will be free to public and independent of commercial FE software

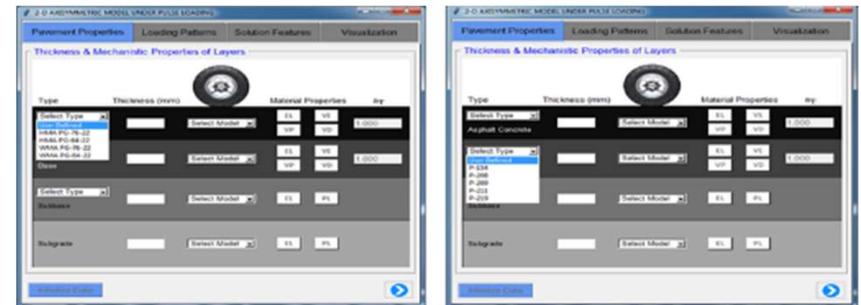


# PANDA-AP

Developing advanced pavement analysis tool PANDA-AP to use material characterization properties – improved pavement life prediction, compare two materials before being placed on airport.

To compare “green materials” and conventional materials:

- **In laboratory** – use lab test results and PANDA-AP analysis to predict pavement performance.
- **Verify performance** under accelerated pavement tests (APT) at NAPMRC & NAPTF.
- A **comparable performance** will lead to a **wider use of “green materials”** and lower carbon footprint.



**PANDA:** A Fortran code in which a number of sophisticated material models is implemented.

Includes Models for Performance Related Mechanisms

Includes Models for Environmental Effects

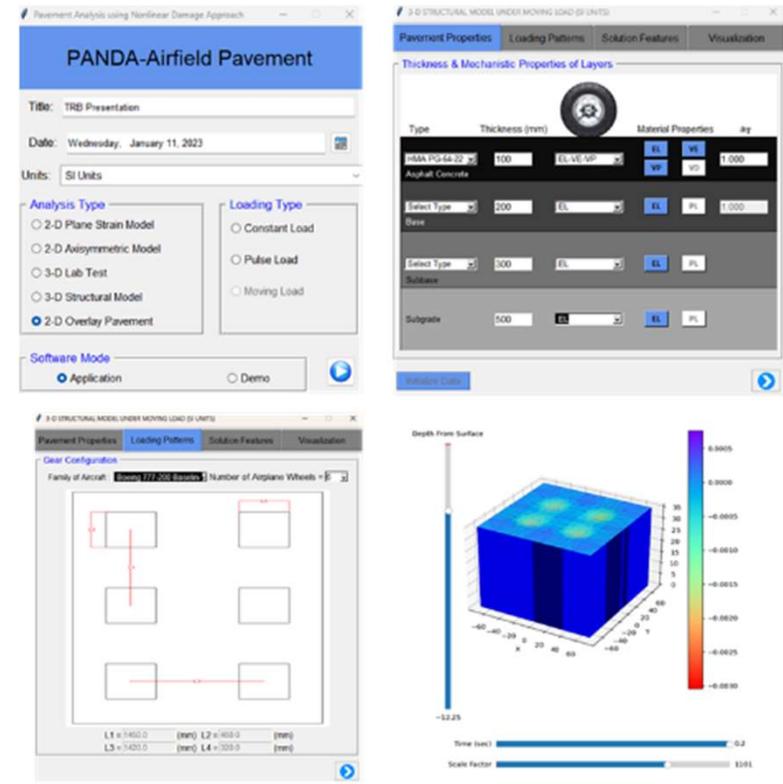
Models are Developed for General 3D Multi-Axial Stress States

Mechanical and Environmental Models are Coupled and Can Occur Concurrently

Flexible: Other models can be implemented to supplement/substitute current models in the future

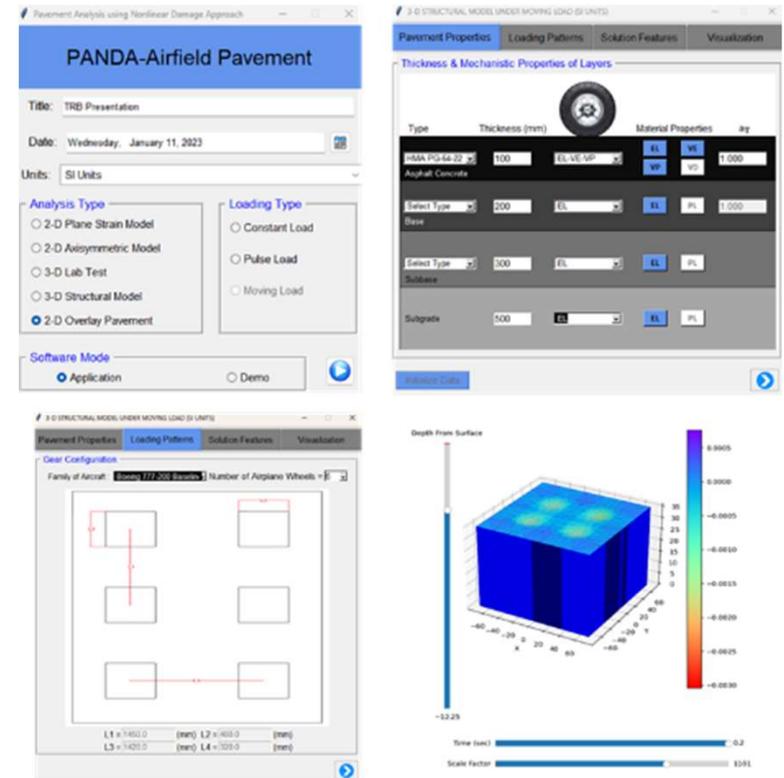
# PANDA-AP

- ❑ Beta version of PANDA-AP software that models asphalt concrete as visco-elastic/visco-plastic material has been delivered to FAA and is currently being tested.
- ❑ Implemented stress-dependent elastic models for all unbound layers, i.e., Unbound Aggregate Base/Subbase, and subgrade.
- ❑ Enhancements include post-processor to show the output results at critical locations in a user-friendly format, extend the aircraft database (completed) to be compatible with FAARFIELD.



# PANDA-AP

- ❑ Work on future enhancements will continue.
  - ❑ Make data exportable to third party software like Tecplot
  - ❑ Develop subroutines to calculate distress and permanent deformation using mechanistic-empirical (M-E) transfer functions.
  - ❑ Effect of oxidative aging of binder
  - ❑ Effect of moisture intrusion in asphalt



# PANDA-AP

2-D AXISYMMETRIC MODEL UNDER PULSE LOADING

Pavement Properties Loading Patterns Solution Features Visualization

Thickness & Mechanistic Properties of Layers



Type	Thickness (mm)		Material Properties		$a_T$
Select Type User Defined HMA PG-76-22 HMA PG-64-22 WMA PG-76-22 WMA PG-64-22	<input type="text"/>	Select Model	EL	VE	1.000
			VP	VD	
Base	<input type="text"/>	Select Model	EL	VE	1.000
			VP	VD	
Select Type	<input type="text"/>	Select Model	EL	PL	
Subbase	<input type="text"/>	Select Model	EL	PL	
Subgrade	<input type="text"/>	Select Model	EL	PL	

Initialize Data 

2-D AXISYMMETRIC MODEL UNDER PULSE LOADING

Pavement Properties Loading Patterns Solution Features Visualization

Thickness & Mechanistic Properties of Layers



Type	Thickness (mm)		Material Properties		$a_T$
Select Type Asphalt Concrete	<input type="text"/>	Select Model	EL	VE	1.000
			VP	VD	
Select Type User Defined P-154 P-208 P-209 P-211 P-219	<input type="text"/>	Select Model	EL	VE	1.000
			VP	VD	
Subbase	<input type="text"/>	Select Model	EL	PL	
Subgrade	<input type="text"/>	Select Model	EL	PL	

Initialize Data 

# New Research Initiatives

## AIRPORTS



AIRPORT ASPHALT PAVEMENT TECHNOLOGY PROGRAM (AATPTP)



The Cooperative Agreement effort between NAPA and the Federal Aviation Administration (FAA) advances multiple focus areas involving asphalt pavements and associated asphalt materials. The focus of this effort is not on inventing the next "big thing," but rather in advancing 21st century solutions for asphalt pavement design, construction, and materials deemed important to airfield reliability, efficiency, and safety with the overarching goal to keep America moving forward.

This Program includes developing and coordinating implementation plans; developing and conducting webinars, training, workshops, and conferences for the FAA; preparing new or updating existing written technical publications, compilations of findings, and presentation materials; and supporting stakeholder engagement. The program may include research needed to adapt technology for use in airport asphalt pavement mixtures or pavement applications. This effort will leverage the unique technology implementation capabilities of the NAPA with assistance of the FAA and industry, to advance deployment and adoption of innovative asphalt material technologies.

REQUESTS FOR PROPOSALS

CURRENT PROJECTS COMING SOON

UPCOMING WORK

PROJECT COORDINATION GROUP

<https://www.asphaltpavement.org/expertise/engineering/airports>

Directive Topics	Synopsis	Legislative Source	Deadline	LOB Responsible	Status	Comments
Airport technology research	<p>Not less than \$39,224,000 shall be available for Airport Technology Research</p> <p>The Committee recommendation includes a minimum of \$33,210,000 for the FAA's airport technology research program to conduct research on topics such as concrete and asphalt airport pavement in accordance with section 744 of the FAA Reauthorization Act (P.L. 115-254); airport marking and lighting; airport rescue and firefighting; airport planning and design; wildlife hazard mitigation; and visual guidance.</p> <p>The Committee recommends \$39,224,000 for Airport Technology Research. Of this amount, \$6,000,000 is for the airfield pavement technology program authorized under section 744 of Public Law 115-254, of which \$3,000,000 is for concrete pavement research and \$3,000,000 is for asphalt pavement research.</p>	<p>Conference Bill H.R. 1865 (p. 409)</p> <p>House Report 116-106 (p.28)</p> <p>Senate Report 116-109 (p.43)</p>	N/A	ARP		

- Asphalt Pavements
  - new Airport Asphalt Pavement Technology Program (AATPTP)
  - Administered by NAPA.



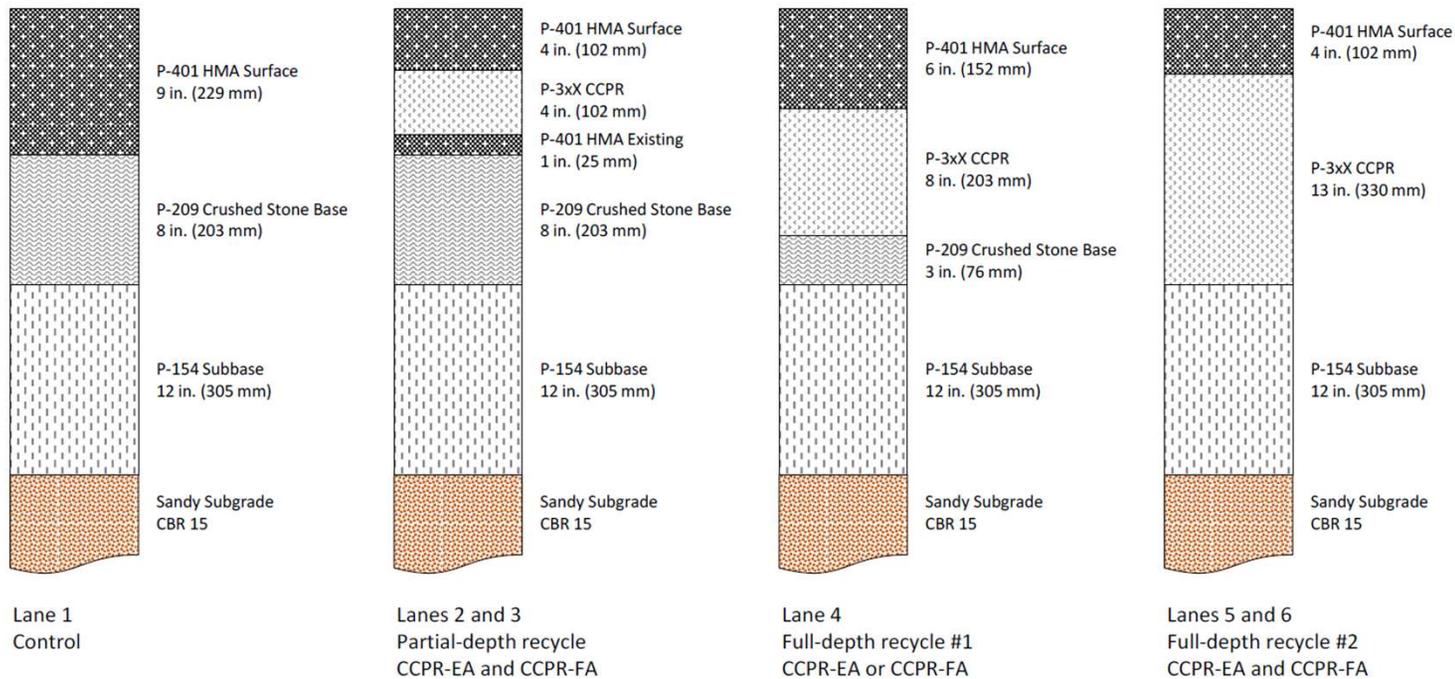
# New Research Initiatives - AAPT

1. FEASIBILITY OF COLD CENTRAL PLANT RECYCLING (CCPR) ASPHALT MIXTURES FOR AIRPORTS
2. MITIGATION OF PLASTIC FLOW AND DELAMINATION AT HIGH-SPEED EXITS
3. IMPROVING PERFORMANCE OF LONGITUDINAL JOINTS IN AIRFIELD ASPHALT PAVEMENTS
- 4. BALANCED MIX DESIGN: EVALUATION OF RUTTING TESTS FOR AIRFIELD PAVEMENTS**
- 5. BALANCED MIX DESIGN: EVALUATION OF CRACKING TESTS FOR AIRFIELD PAVEMENTS**
6. ASPHALT MIXTURES PAVING HANDBOOK REVISION
7. VALIDATION OF GYRATIONS FOR SUPERPAVE GYRATORY COMPACTOR FOR MIX DESIGN OF AIRPORT ASPHALT MIXTURES
8. P-401 MIXTURES: AGGREGATE GRADATION BANDS
9. SYNTHESIS OF STATE OF PRACTICE AND RESEARCH NEEDS FOR AIRFIELD ASPHALT PAVEMENT RESILIENCE
10. ASPHALT AIRFIELDS VIDEO SERIES
11. USE OF RAP IN P-401 MIXTURES



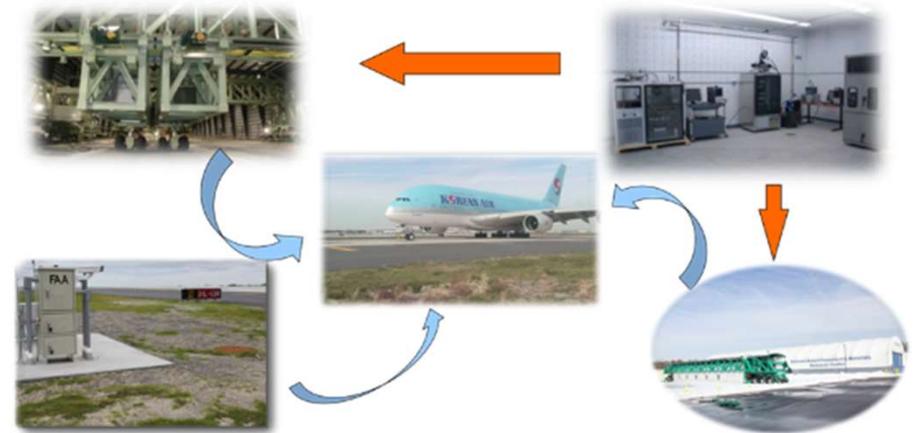
# NAPMRC Test Cycle-3 (TC-3): APTP Project

AAPT Project - Cold Central Plant Recycling (CCPR)  
 University of California, Davis – PI Dr. David Jones



# Summary

- Generate performance data using full-scale APT at NAPTF/NAPMRC
- Extensive laboratory tests to develop material properties database
- Airport projects
- Update failure models in FAARFIELD
- New pavement analysis tool (PANDA-AP)
- Sustainability – Web-based LCA Tool
- APTP & ACPTP program
- Collaboration with universities, research organizations (ERDC, FHWA), international agencies





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