Federal Aviation
Administration

FAA's Asphalt Pavements Research for Airport Pavements

Presented to: 2021 Annual Meeting of the NJ Asphalt Pavement Association

By: Navneet Garg, Ph.D.
NAPMRC Program Manager
Federal Aviation Administration (FAA)

Date: March 16, 2021

Outline

- **Introduction**
- **Research Facilities**
- **Research at**
  - NAPTF
  - NAPMRC
  - Field Instrumentation & Testing
- **New Research Initiatives**
- **Summary**

FAA Line Of business

The Office of Airports

- Sets airport standards, certifies air carrier airports and provides financial assistance to optimize safety, capacity and efficiency

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Standard Specifications for Construction of Airports
Date: 12/21/2018
Initiated By: AAS-100
AC No: 150/5370-10H
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.

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

ORDER 5100.38D, Change 1

National Policy

Effective date: February 26, 2019

SUBJ: Airport Improvement Program Handbook

1. PURPOSE.

This Handbook provides guidance and sets forth policy and procedures used in the administration of the Airport Improvement Program.

2. DISTRIBUTION.

This Handbook is located on the FAA Office of Airports website (see Appendix B for link) where it is available to all interested parties.

3. CANCELLATION.

This Handbook cancels the following order:

- FAA Order 5100.38D, Airport Improvement Program Handbook (dated September 30, 2014).

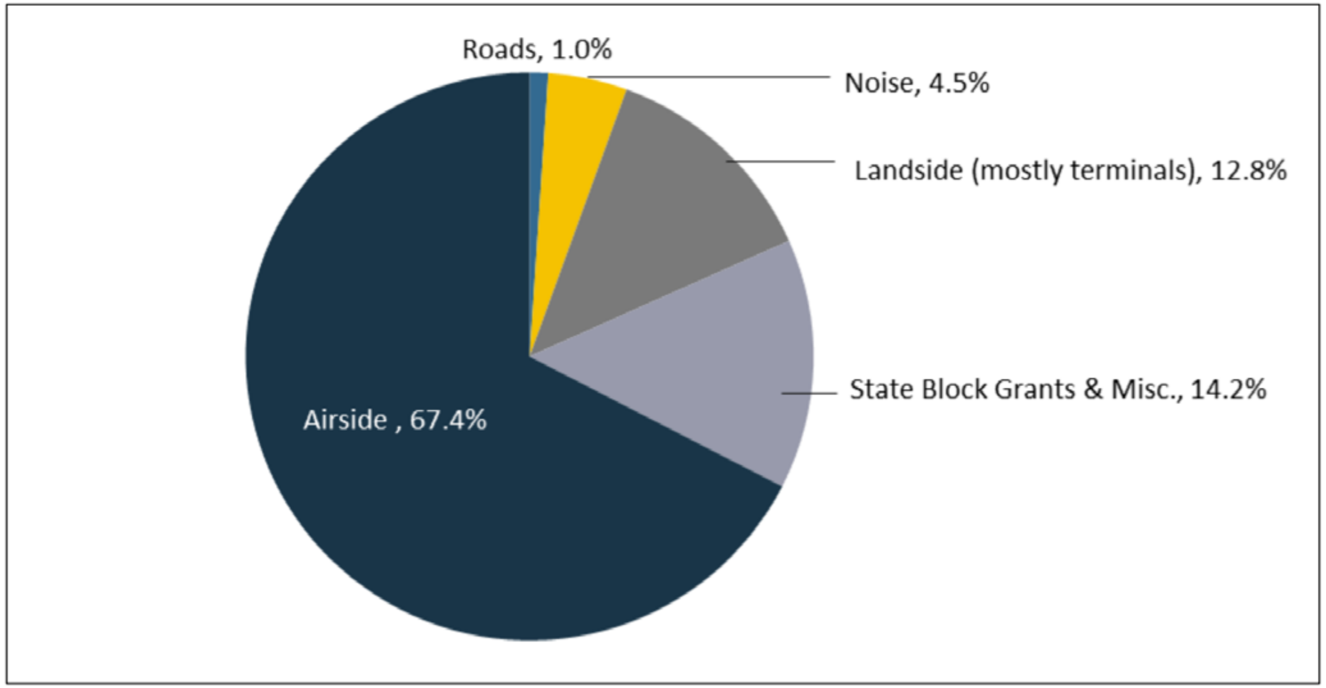
4. EXPLANATION OF CHANGES.

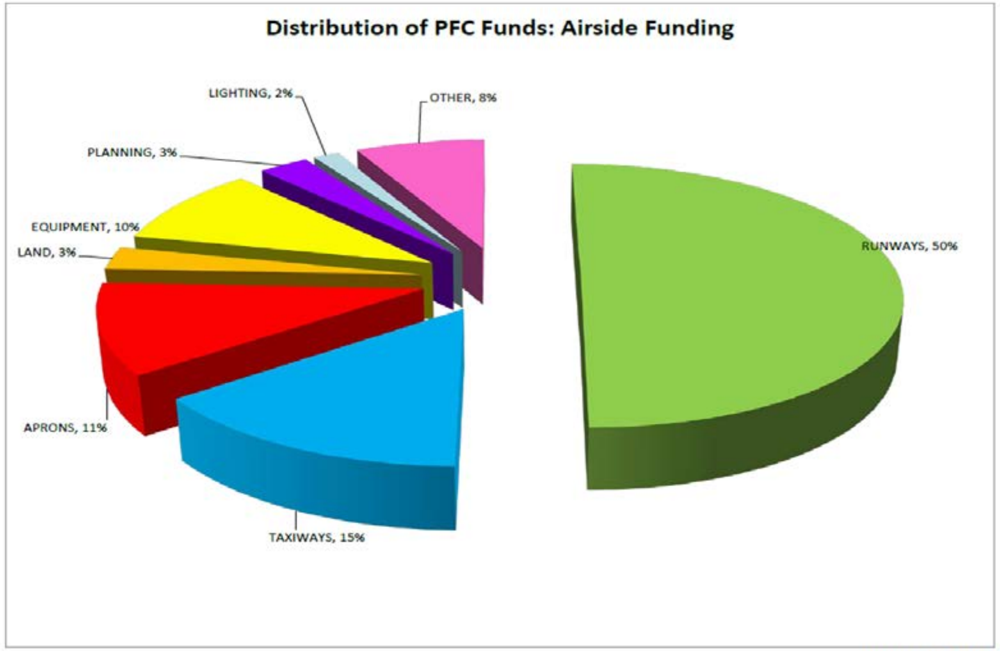
This Handbook replaces the above order with updated information that reflects current legislation and policy as of September 30, 2018, with the exception of Program Guidance Letter (PGL) 17-01. The changes in this Handbook reflect feedback from industry stakeholders over the last 4 years. It does not include changes in FAA Reauthorization Act of 2018 (Public Law 115-254), which will initially be addressed in the form of PGLs and then in a subsequent update of the AIP Handbook itself. The FAA Office of Airports has streamlined this Handbook and replaced guidance with references where there is a more appropriate source of guidance (such as in other orders or advisory circulars). This includes deleting guidance on airport planning, capital planning, labor rates, and civil rights. The references appear as the basic publication numbers without any suffix. The intent is for the reader to use the latest version of the referenced publications.

The Office of Airports is issuing Change 1 to this Handbook to:

- Incorporate PGLs issued up to, but not including PGL 17-01.
- Reflect the transition to 2 Code of Federal Regulations (CFR) part 200, which became effective on December 19, 2014.
- Incorporate legislation from the authorization extensions following the expiration of the FAA Modernization and Reform Act of 2012 (Public Law 112-95), which includes the following:

Figure 3. FY2018 AIP Grants Awarded by Project Type





SOURCE: FAA, PFC Branch
December 31, 2018

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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 (AAS100), Washington, DC.
- Provide support for development of FAA pavement standards (Advisory Circulars).

Airport Pavement R&D Program

Dr. Michel Hovan
Branch Manager Pavements & Safety

Jeff Gagnon – Pavements Branch Manager

- Dr. David Brill
- Dr. Navneet Garg
- Robert "Murphy" Flynn
- Qingge Jia
- Ryan Rutter
- Wilfredo Villafane
- Dr. Richard Ji
- Matthew Brynick
- Dr. Gabriel Bazi

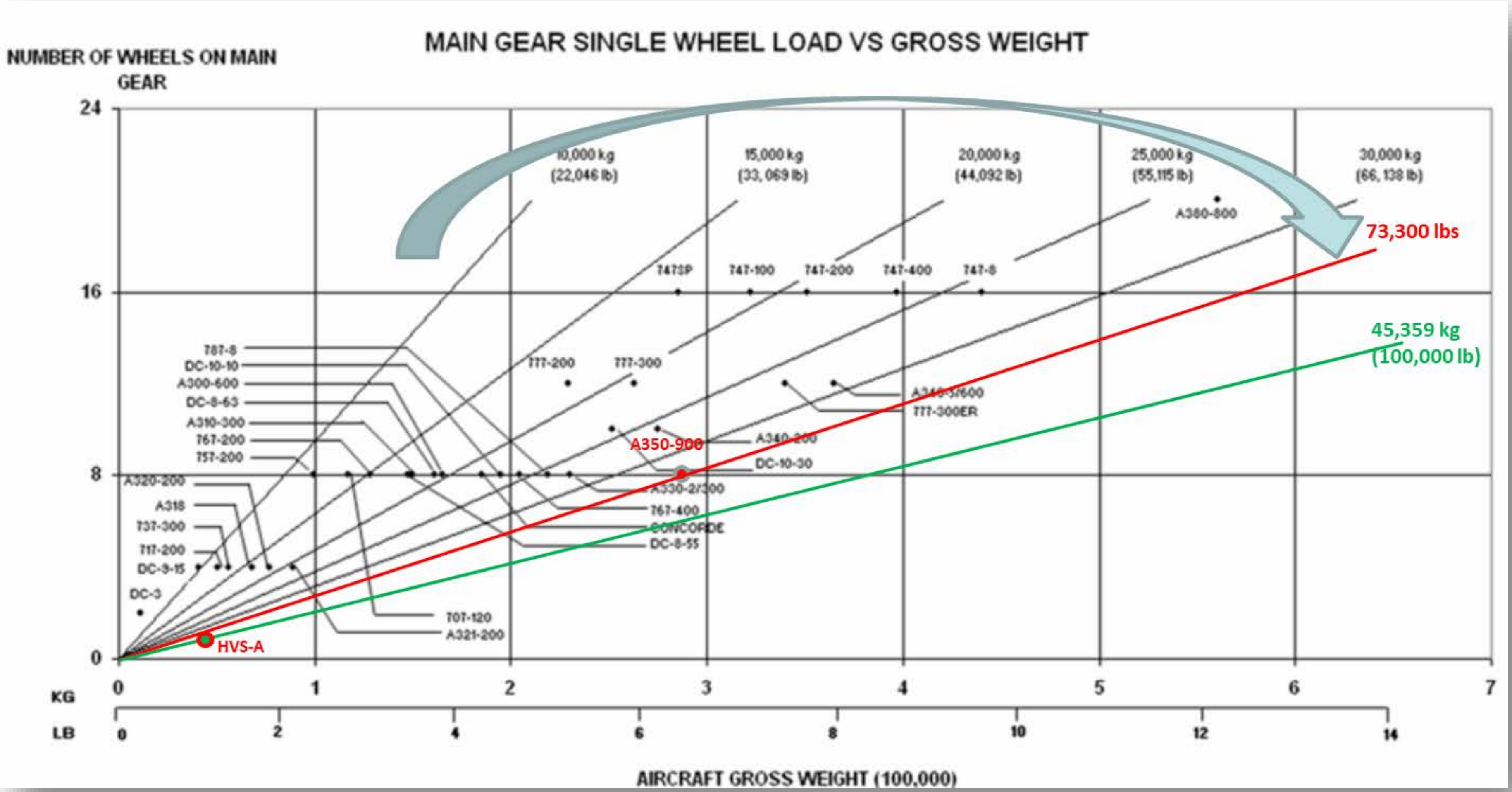
Support Contractor – GDIT
Consultants
Universities – Grants, BAA's, OTA's
ERDC – Interagency Agreements


AIRBUS A380


787

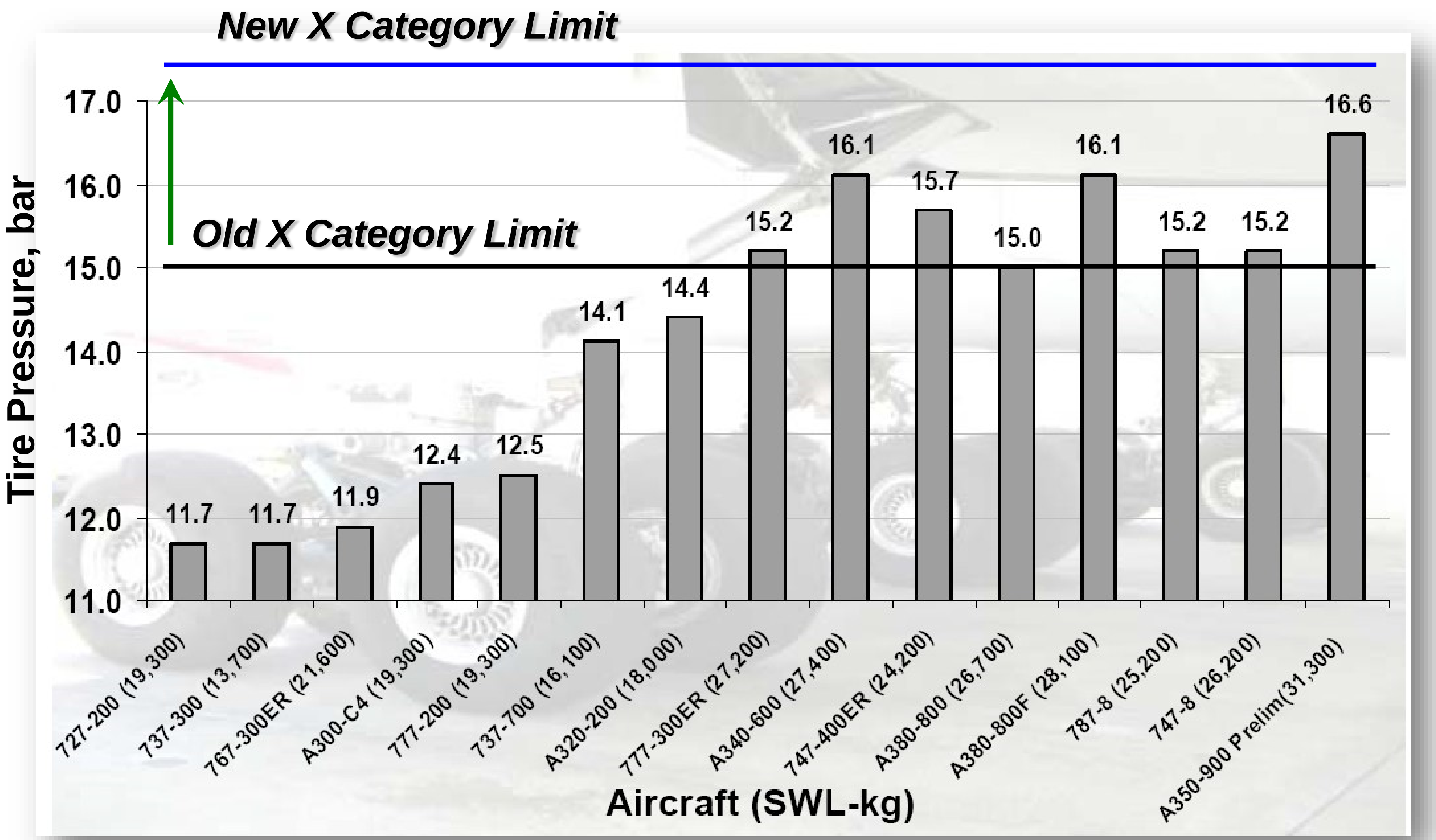

CATHAY PACIFIC

Aircraft Gross Weight Trends

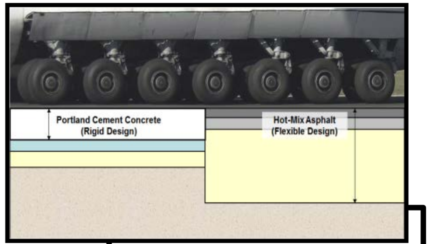


[Published by the International Industry Working Group (IIWG), 2010]

Aircraft Tire Pressure Trends

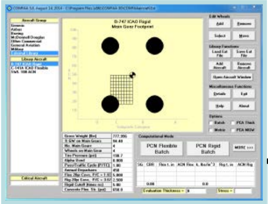


Airport Pavement R&D Program
Four Major Pavement Focal Areas



Pavement Thickness Design

- FAARFIELD 1.4
- Concrete or Asphalt
- Support Anticipated Aircraft Loads for Design Life (20 Year)
- Avoid Premature Failure
- Minimize Construction Cost



Aircraft / Airport Compatibility

- Support ICAO Compatibility Criteria (ACN-PCN Method)
- Improvements
  - New Alpha Factors
  - ICAO Tire Pressure Categories
  - Computer Program - COMFAA
- Changes Adopted by US and Worldwide

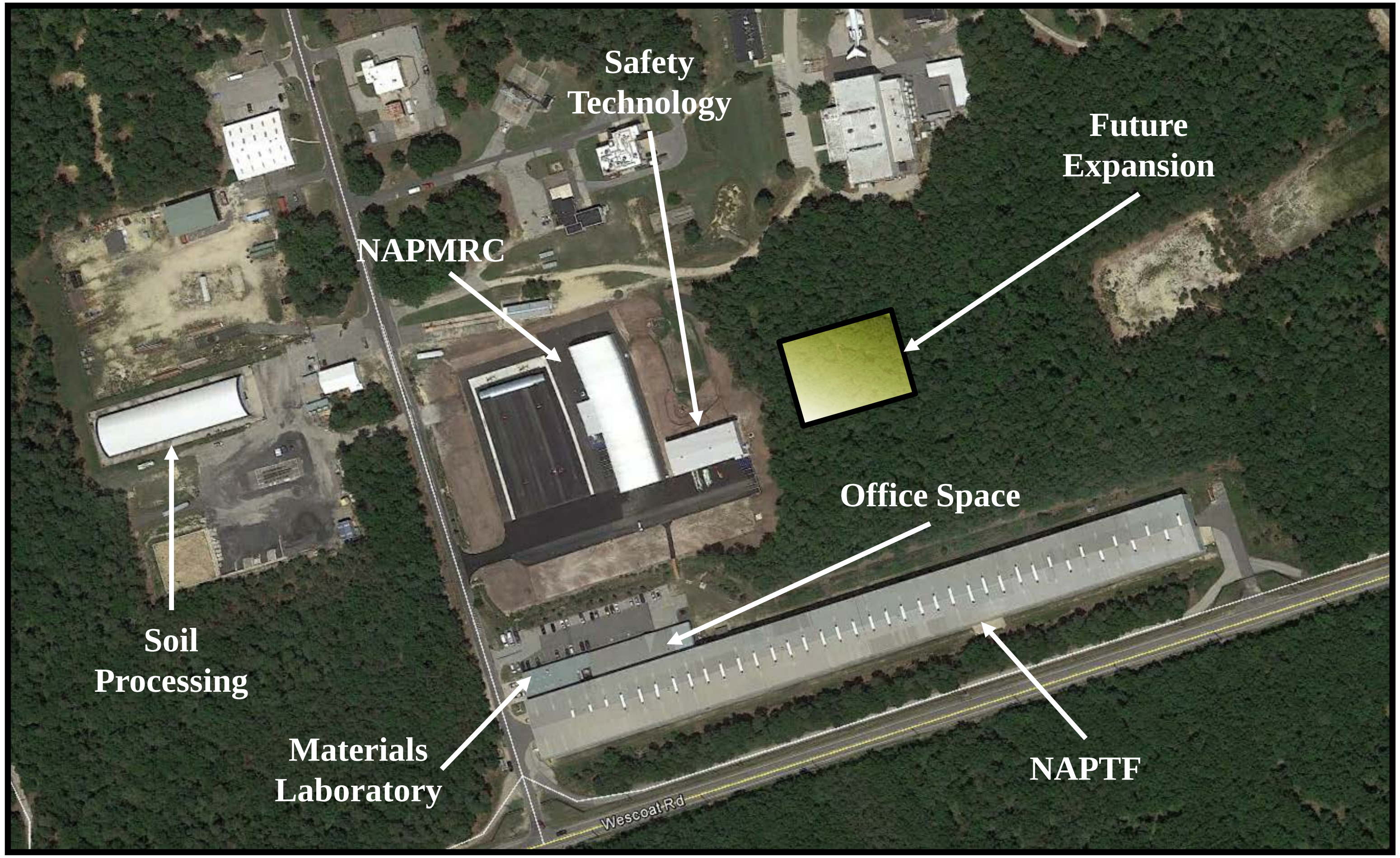
Airport Pavement Management

- FAA PAVEAIR Program
  - Free Web Based Management Software
  - Airports Manage Pavement Inventory
  - FAA to Monitor AIP Grants
- Nondestructive Testing and Evaluation
  - Roughness
  - Smoothness

Advanced Pavement Materials

- New Technologies
  - Reduce Construction Cost
  - Improve Durability
  - Environmental Benefit
- Active R&D
  - Warm Mix Asphalt
  - Establish standards for Gyratory Mix Design
  - Characterizing Subgrade Soil
  - Deicing Agents

Airport Pavement R&D Program - Facility Layout



National Airport Pavement Test Facility (NAPTF)

Facility Facts:

- FAA / Boeing (CRDA) Partnership at $21M
- Opened April 1999
- Fully Enclosed Facility
- Accelerated Traffic Testing
- 900 ft. x 65 ft. of Test Pavement Surface
- Full-scale Pavement Structures and Landing Gear Loads

Test Vehicle Facts:

- Fully Automated & Programmed Wander Patterns
- Up to 5-dual wheel configuration
- Roughly 1.3 Million lbs.
- Up to 75,000 lbs. per wheel

National Airport Pavement Materials Research Center (NAPMRC)

Facility Facts:

- Dedication Ceremony August 2015
- Indoor and Outdoor Testing Capability
- Accelerated Traffic Testing
- Outdoor: 150ft. x 300ft. & Indoor: 72ft. x 300ft.
- Accelerated resurfacing

HVS-A Facts:

- Wheel loads - 10,000 (44.48 kN) to 100,000 lbs (444.8 kN).
- Pavement temperatures up to 150°F (67°C)
- Test speeds - 0.17 to 5 mph (0.27 to 8 kmph)
- Single and Dual-Wheel configuration.
- Single wheel - radial aircraft tire size 52x21.0R22
- Dual wheel assembly (B-737-800)
- Wander Width – 6 feet (1.83 m)

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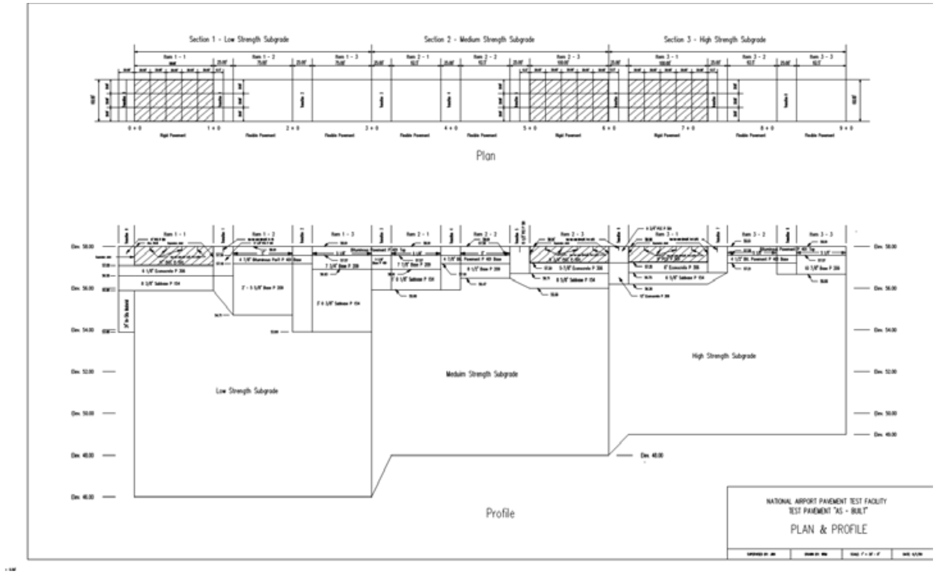
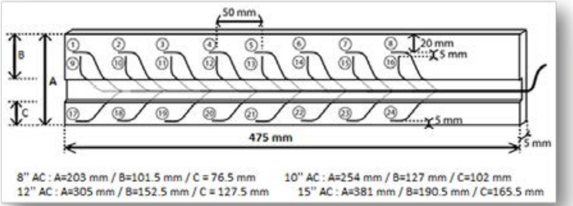
Testing at NAPTF

- CC-1: Flexible & Rigid Pavements
- CC-2, CC2-OL, CC-4, CC-6, CC-8: Rigid Pavements
- CC-3, CC-5, CC-7, CC-9: Flexible Pavements





CC7 - HMA Fatigue in FAARFIELD

- FAARFIELD is a computer program for airport pavement thickness design. FAA AC 150/5320-6F.

- Old HMA Fatigue Model: Heukelom & Klomp [1962]
  $\log_{10}(C) = 2.68 – 5 \times \log_{10}(\varepsilon_h) – 2.665 \times \log_{10}(E_A)$

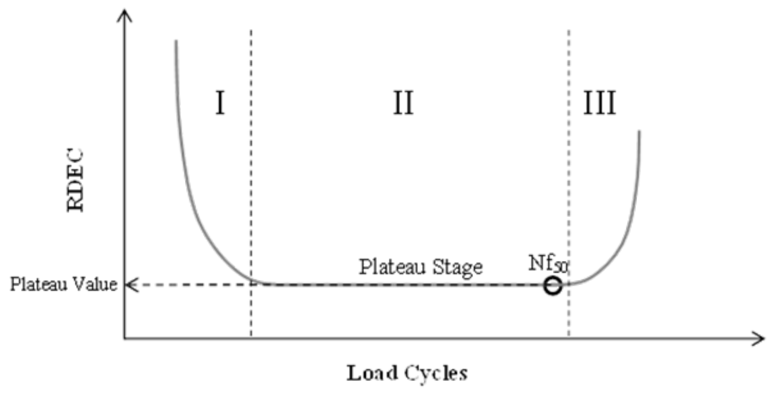
CC7 - HMA Fatigue in FAARFIELD

- New HMA Fatigue Model: Carpenter et.al. [1997, 2000, 2001, 2007]

$$N_f = 0.4801 \times PV^{-0.9007}$$

$$PV = 44.422 \times \varepsilon_h^{5.14} \times S^{2.993} \times VP^{1.85} \times GP^{-0.4063}$$

where PV is the estimated value of RDEC
plateau value (dimensionless),
S is HMA flexural stiffness (psi),
ε_h is horizontal strain at the bottom of the asphalt layer,
VP is the volumetric parameter, and
GP is gradation parameter.



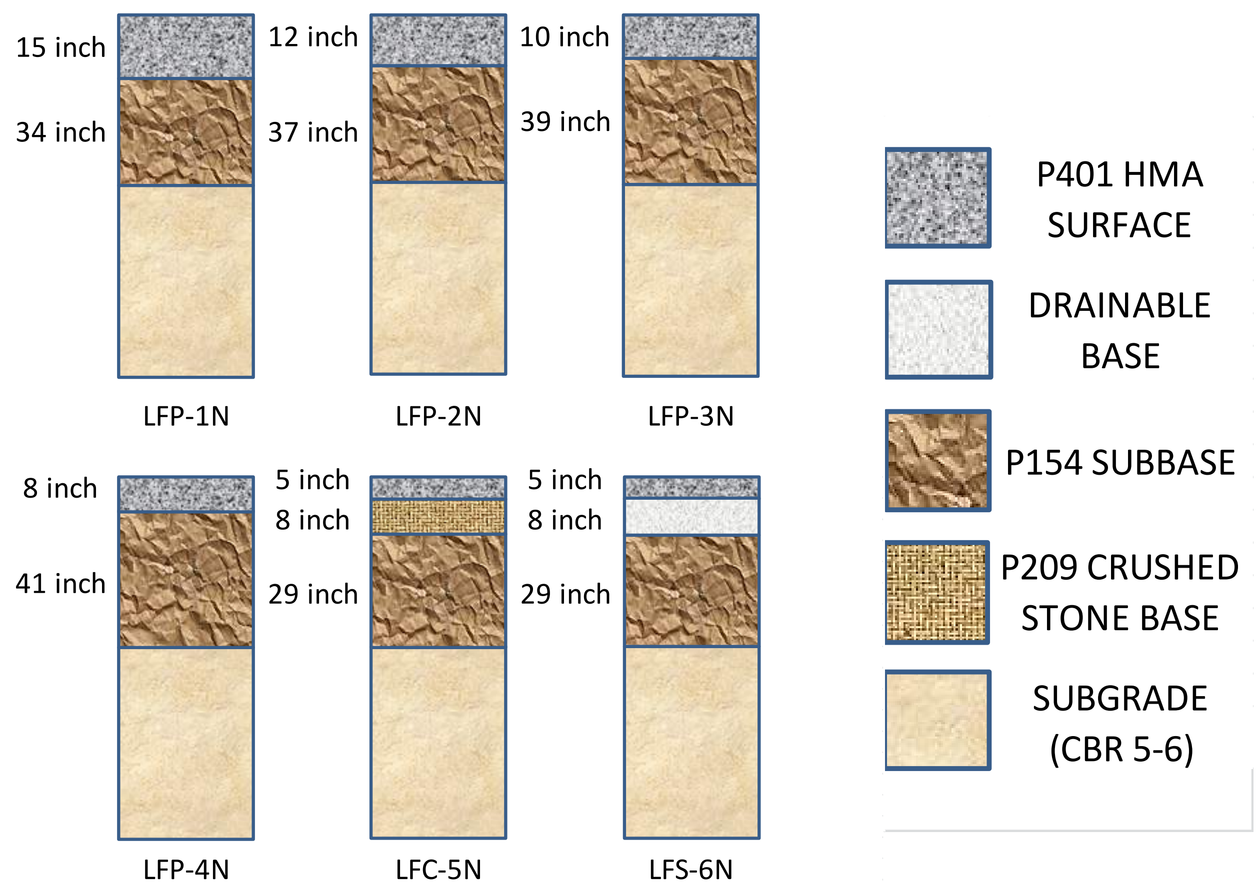
CC7 - HMA Fatigue in FAARFIELD

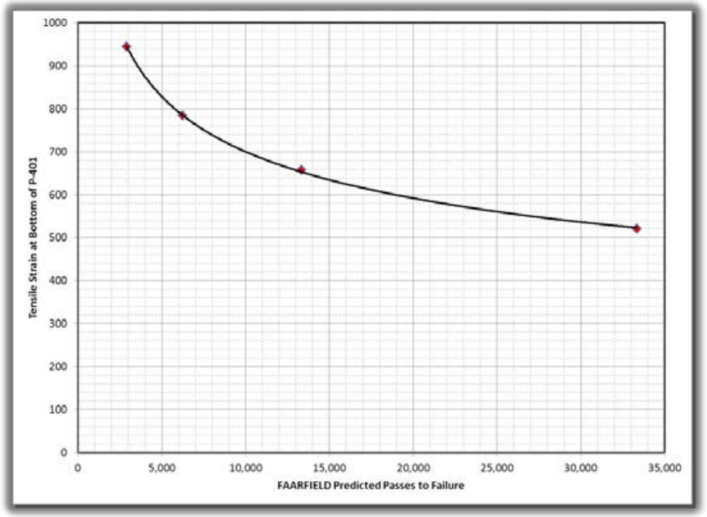
$$VP = V_a/(V_a+V_b)$$
$$GP = (P_{NMS}-P_{PCS})/P_{200}$$

where

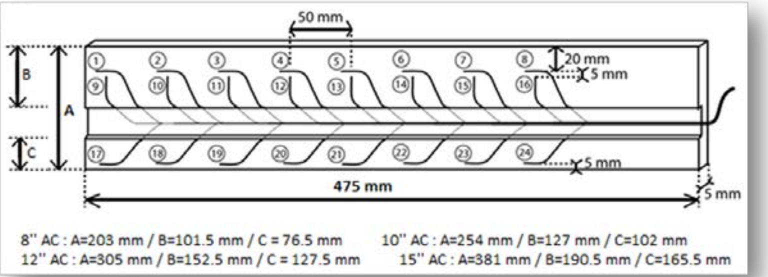
V_a is air voids,
V_b is asphalt content by volume,
P_{NMS} is the % of aggregate passing the nominal maximum size sieve,
P_{PCS} is the % of aggregate passing the primary control sieve, and
P_{200} is the % of aggregate passing the #200 (0.075 mm) sieve.

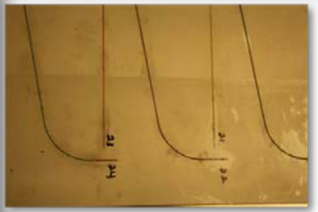
CC-7 Pavement Cross Sections





CC7 - Pavement Instrumentation



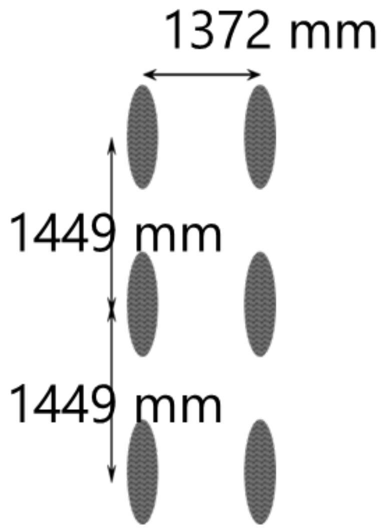


CC7 - Traffic Tests

- Standard NAPTF wander pattern.

			63 & 64	65 & 66	61 & 62			
		51 & 52	59 & 60	53 & 54	57 & 58	55 & 56		
	43 & 44	45 & 46	41 & 42	47 & 48	39 & 40	49 & 50	37 & 38	
19 & 20	35 & 36	21 & 22	33 & 34	23 & 24	31 & 32	25 & 26	29 & 30	27 &28
1 & 2	17 & 18	3 & 4	15 & 16	5 & 6	13 & 14	7 & 8	11 & 12	9 & 10
-4	-3	-2	-1	0	1	2	3	4

- 55 kips (245 kN) wheel load
- 6-wheel gear.

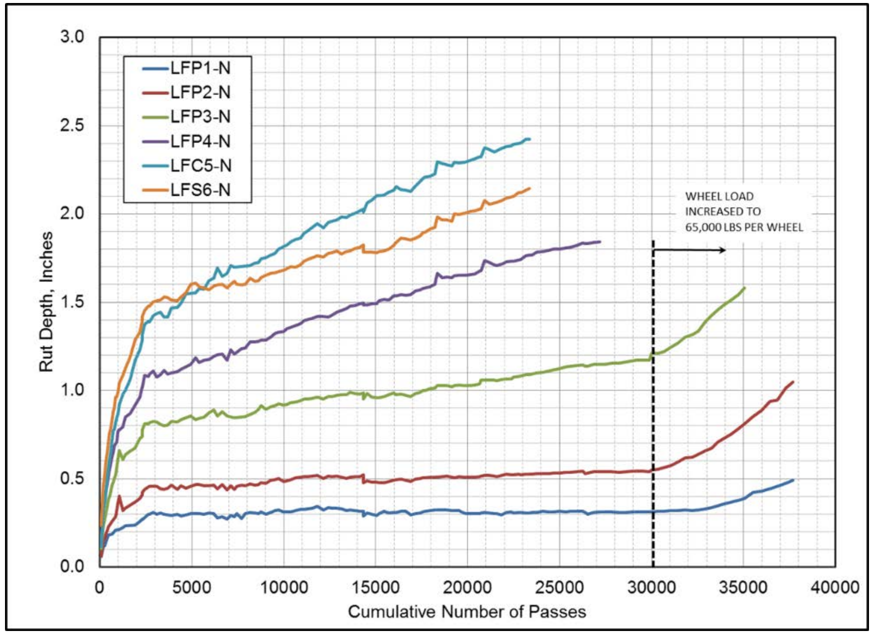


CC7 - Traffic Tests

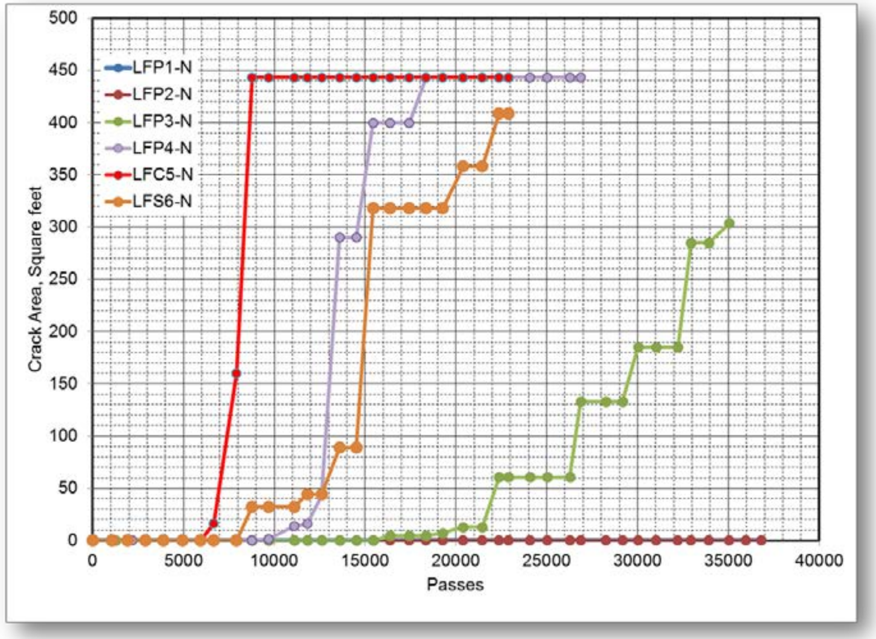
- Pavement Monitoring
  - Straight Edge Rut Depth Measurements
  - Surface profiles
  - Crack maps

CC7 – Pavement Performance

Straight Edge Rut Depth Measurements



Crack Monitoring



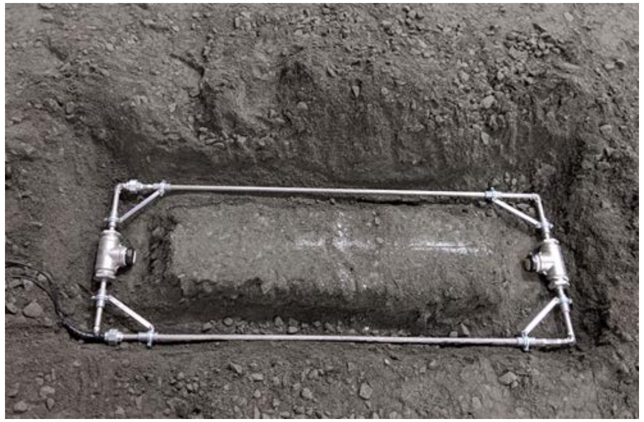
CC7 – Pavement Performance

PREDICTED & OBSERVED FATIGUE LIFE

Test Section	HMA Strain (from FAARFIELD)	PV	Pass to Coverage (P/C) Ratio	N_f from FAARFIELD		N_f from Full-Scale APT		Ratio ($N_{f\ APT}$/ $N_{f\ FAARFIELD}$)
				Passes	Coverages	Passes	Coverages	
PP-1	0.000524	2.14E-06	0.650	40000	61538	NO CRACKS OBSERVED		
PP-2	0.000657	6.86E-06	0.730	15385	21075			
PP-3	0.000781	1.67E-05	0.790	7407	9376	21450	27152	2.90
PP-4	0.000932	4.14E-05	0.860	3636	4228	11814	13737	3.25

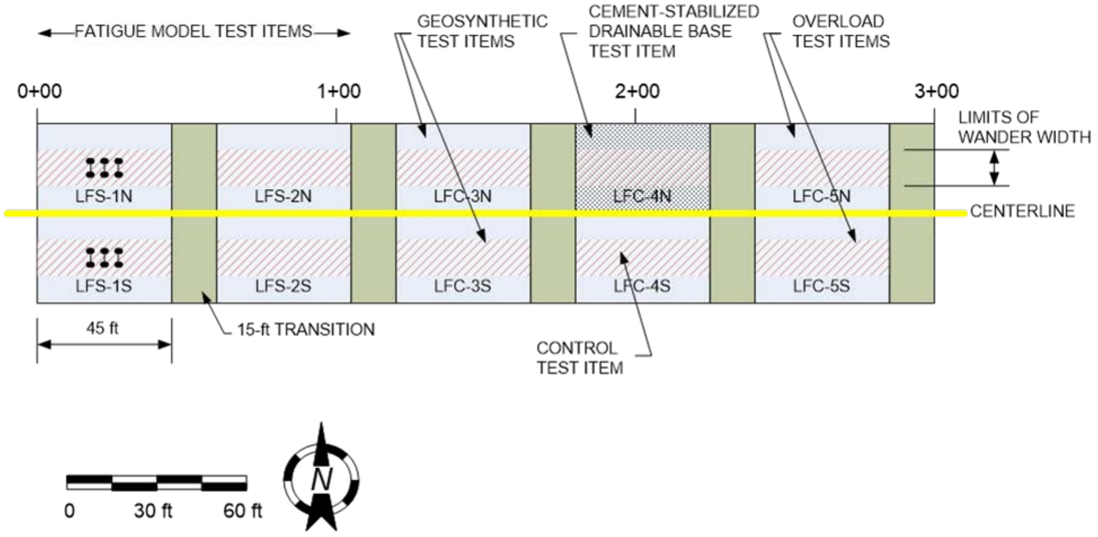
CC9 Objectives

- Verify/Refine/Modify fatigue model based on the ratio of dissipated energy change (RDEC)
- Effect of P-209 Layer Thickness on Pavement Life
- Effect of Geosynthetics use on Flexible Pavement Performance
- Cement Treated Permeable Base Performance
- Strain Criterion for Allowable Overload

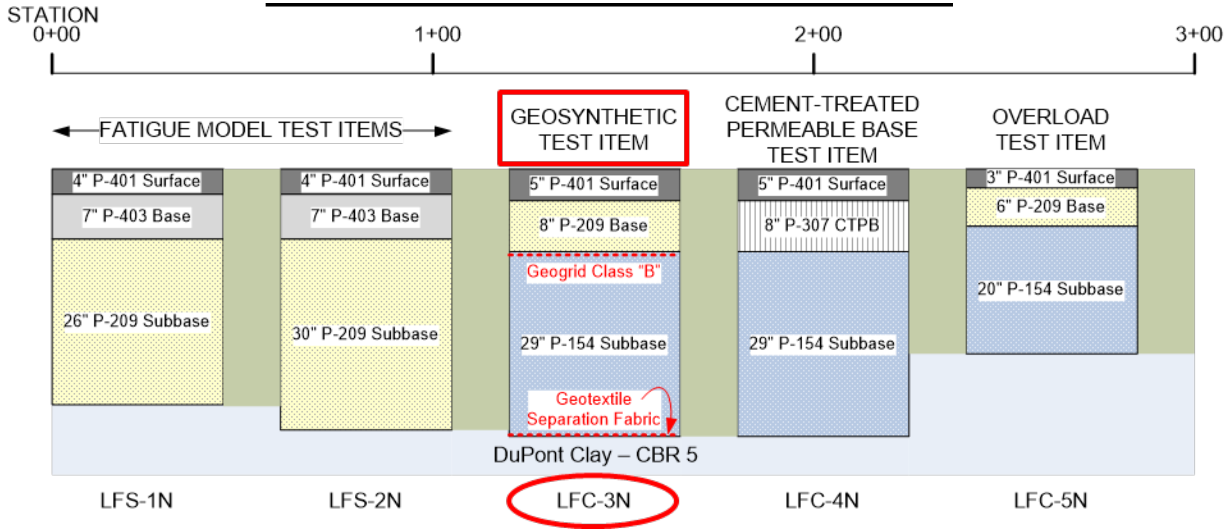


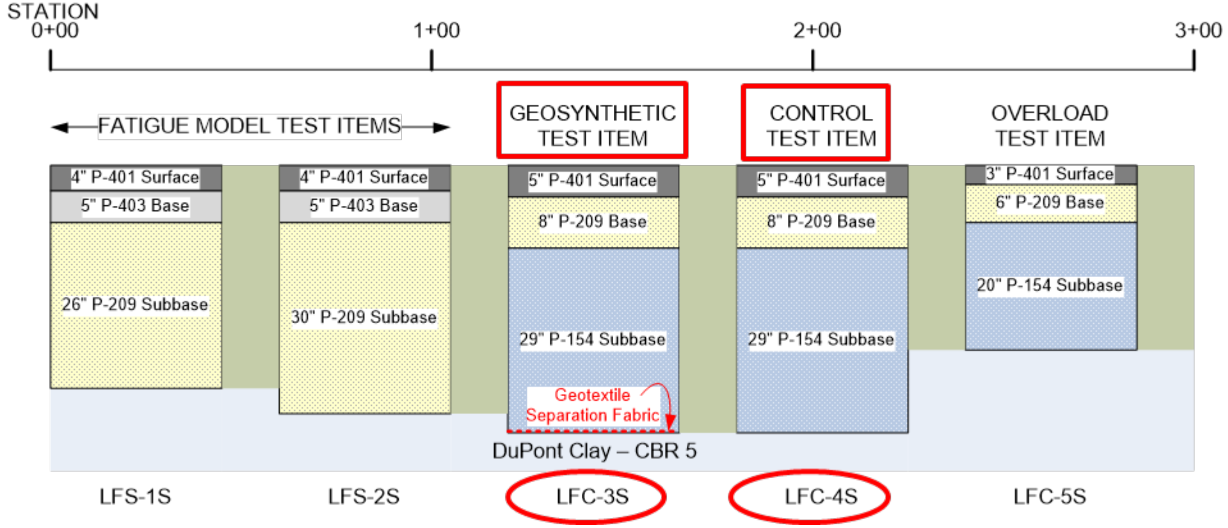
Bender Element Sensor developed by UIUC Team led by Dr. Erol Tutumluer

CC-9



Pavement Cross Section - North





Pavement Cross Section - South

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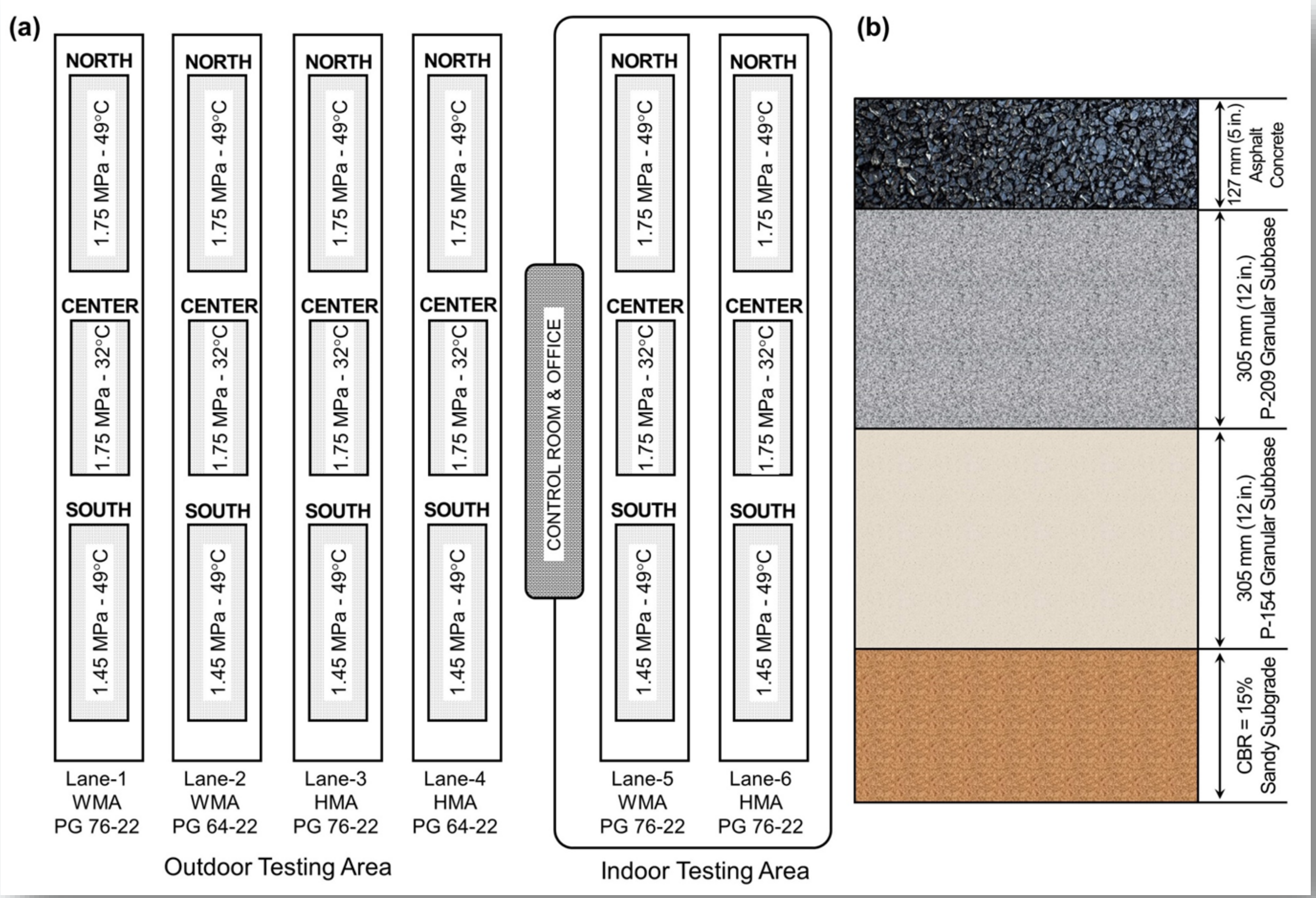
Test Cycle-1 (TC1)



- Pavement Temperature: 120°F (49°C) measured at a depth of 2-inch (50 mm) below pavement surface.
- Test Speed: 3-mph (4.8 kmph)
- Failure criteria: 1-inch (25 mm) surface rut

Test Area	Load Module	Wheel Load, lbs	Tire Pressure, psi	
South	Single Wheel	61,300	210	(1.45 MPa)
North	Single Wheel	61,300	254	(1.75 MPa)
		(27.8 metric ton)		

Test Cycle-1 (TC1)

Test Cycle-1 Completed

- Compare WMA performance with P401 HMA performance (rutting);

  Comparable Performance in rutting.

  Cracking performance need to be evaluated (TC2)

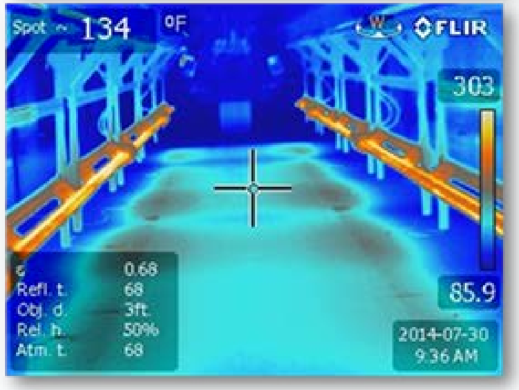
- Effect of polymer modified binder (PMA) on pavement rutting;

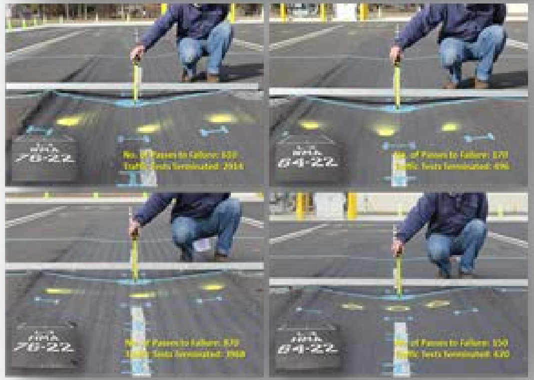
  Improves rutting performance significantly.

- Effect of temperature on pavement rutting.

  Rutting performance of HMA/WMA is more sensitive to temperature than tire pressure.







Test Cycle-2 (TC2) Objectives

- Compare WMA performance with P401 HMA performance (rutting);
- Compare WMA performance with P401 HMA performance (fatigue);
- Compare performance (rutting & fatigue) of different WMA additives;
- Evaluate performance of RAP+WMA

Test Cycle-2 (TC2)

- Construction May 2019
- Material
  - P-401 HMA
  - WMA (3)
  - RAP (2)
- Tire pressure 254 psi (1.75 MPa)
- Failure criterion:
  - fatigue cracking & rutting
- Testing in progress

OUTDOOR LANES

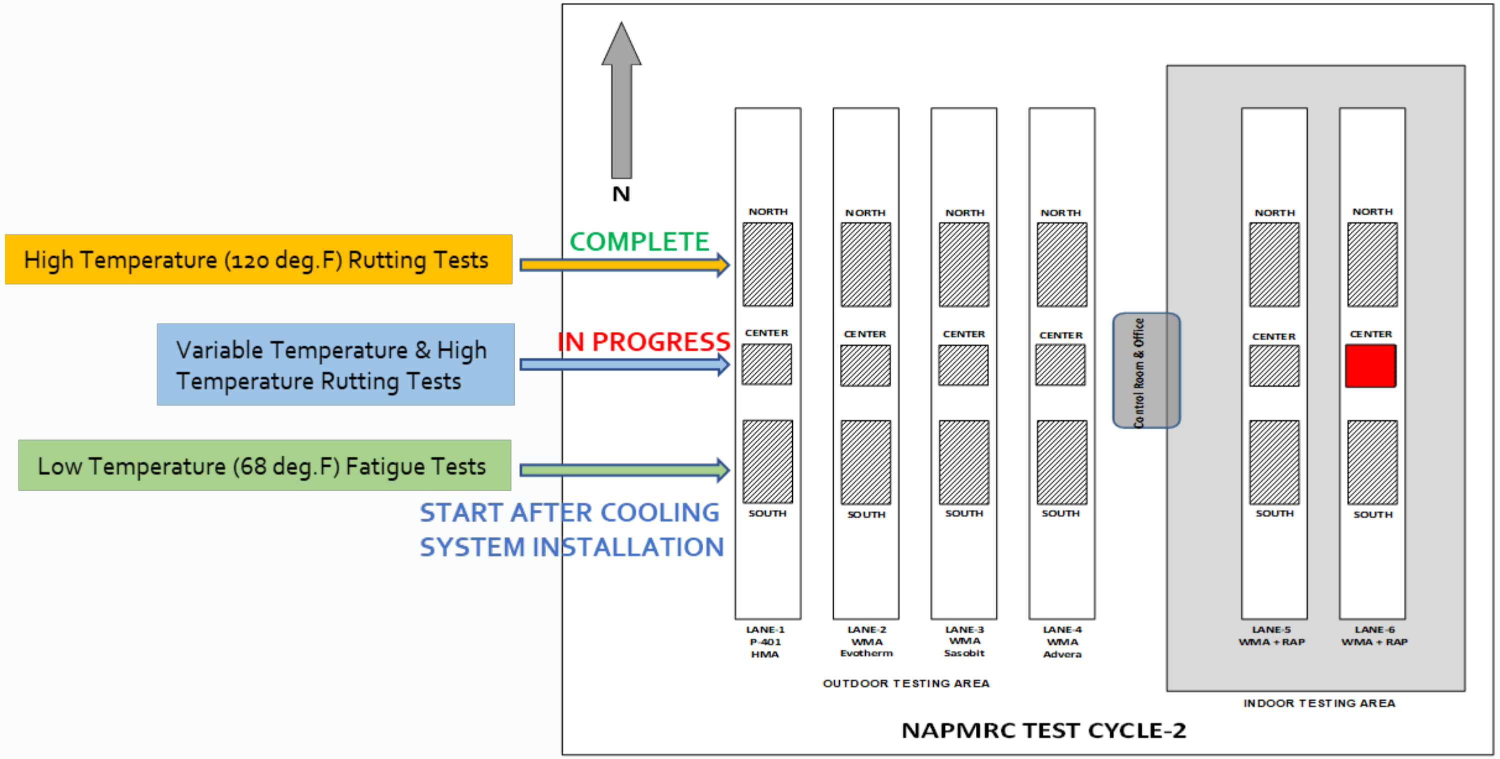
INDOOR LANES

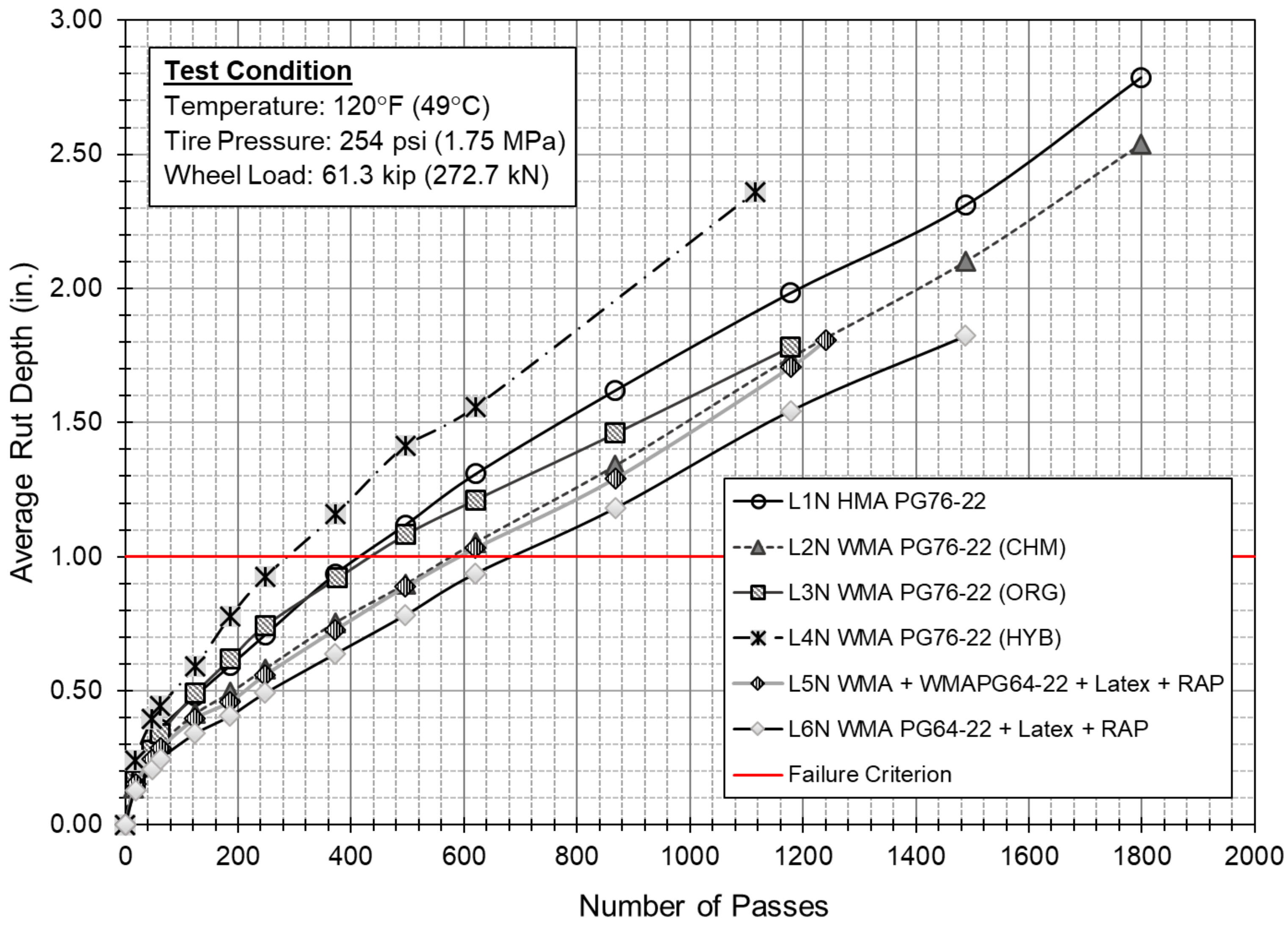
Lane-1 – HMA
Lane-2 – WMA Chemical
Lane-3 – WMA Organic
Lane-4 – WMA Hybrid

Lane-5
3-in WMA Organic
6-in WMA Organic + RAP

Lane-6
9-in WMA Organic + RAP

Test Cycle-2 (TC2) – Test Section Layout




Test Condition
Temperature: 120°F (49°C)
Tire Pressure: 254 psi (1.75 MPa)
Wheel Load: 61.3 kip (272.7 kN)
Average Rut Depth (in.)
Number of Passes
L1N HMA PG76-22
L2N WMA PG76-22 (CHM)
L3N WMA PG76-22 (ORG)
L4N WMA PG76-22 (HYB)
L5N WMA + WMAPG64-22 + Latex + RAP
L6N WMA PG64-22 + Latex + RAP
Failure Criterion
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
200
400
600
800
1000
1200
1400
1600
1800
2000

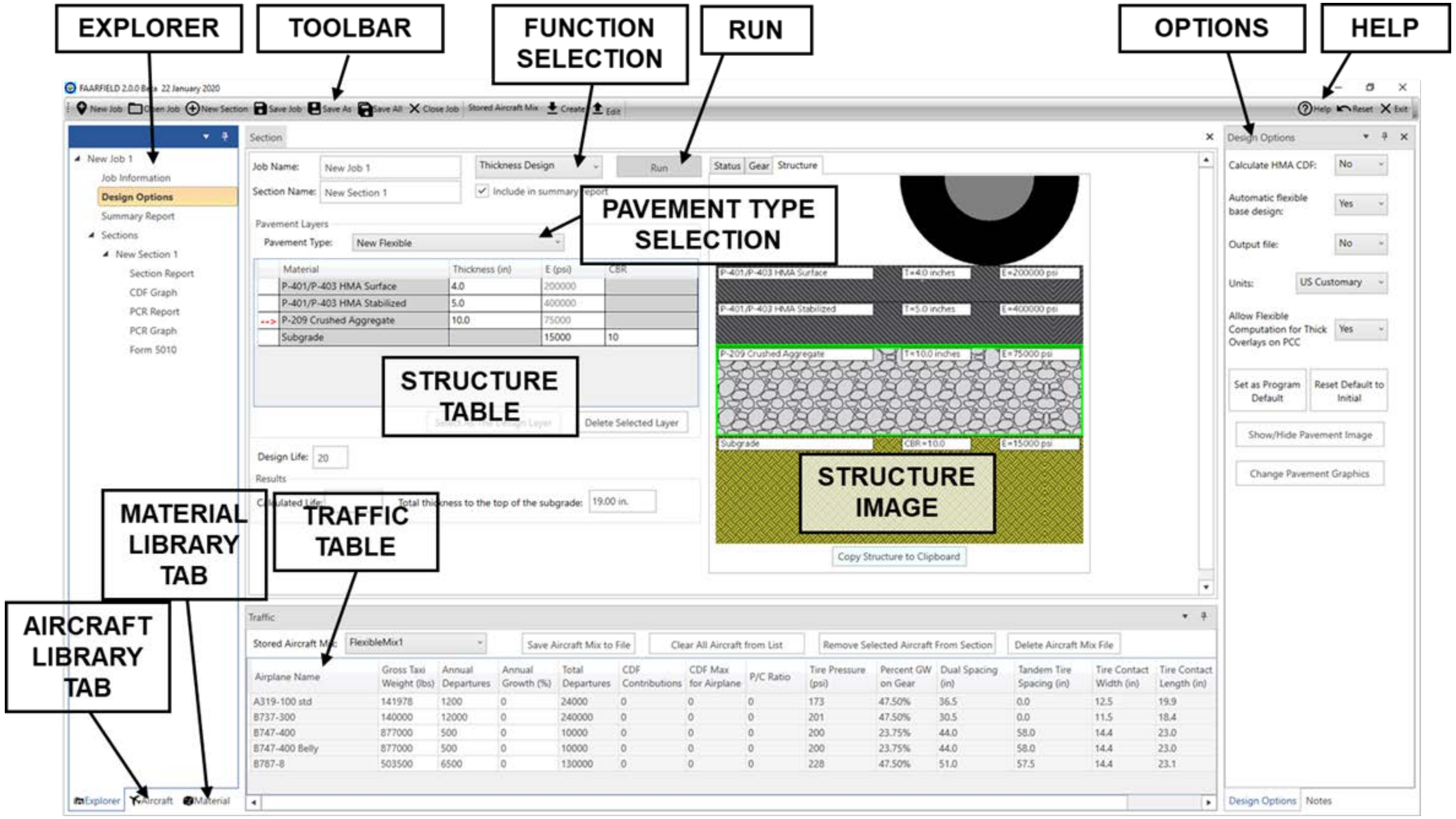
Fatigue Tests

AGING OF TEST AREA:

- Pavement Temperature: 120 deg. F measured at a depth of 2-inch below pavement surface.
- Test Lane will be subjected to these conditions for a period of 336 hours (14 days).
- After 336 hours of aging, heaters will be turned off and insulation panels removed.
- Wait till the pavement temperature stabilizes to ambient conditions.
- Place insulation panels back and prepare for Response Tests & Traffic Tests.
- Fatigue Test Pavement Temperature – 68 deg. F.

Testing at NAPTF

- Full-scale test data used to improve failure models in FAARFIELD, and FAA AC 150/5320-6.

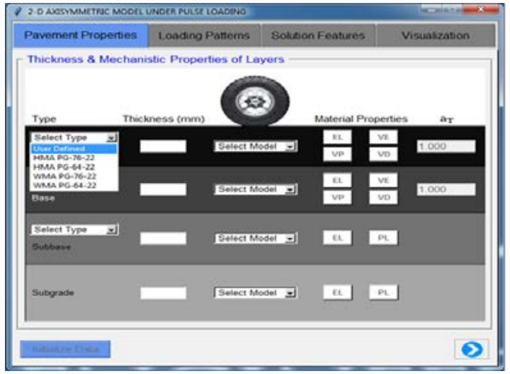


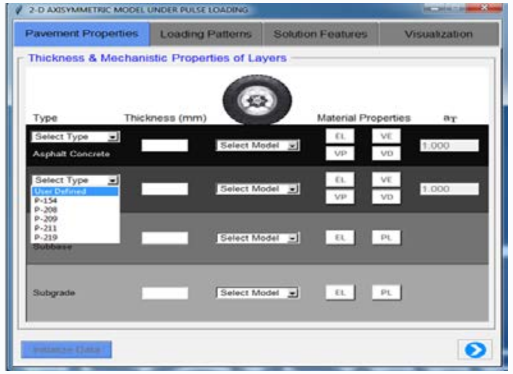
PANDA-AP

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

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, such as Abaqus and Ansys





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

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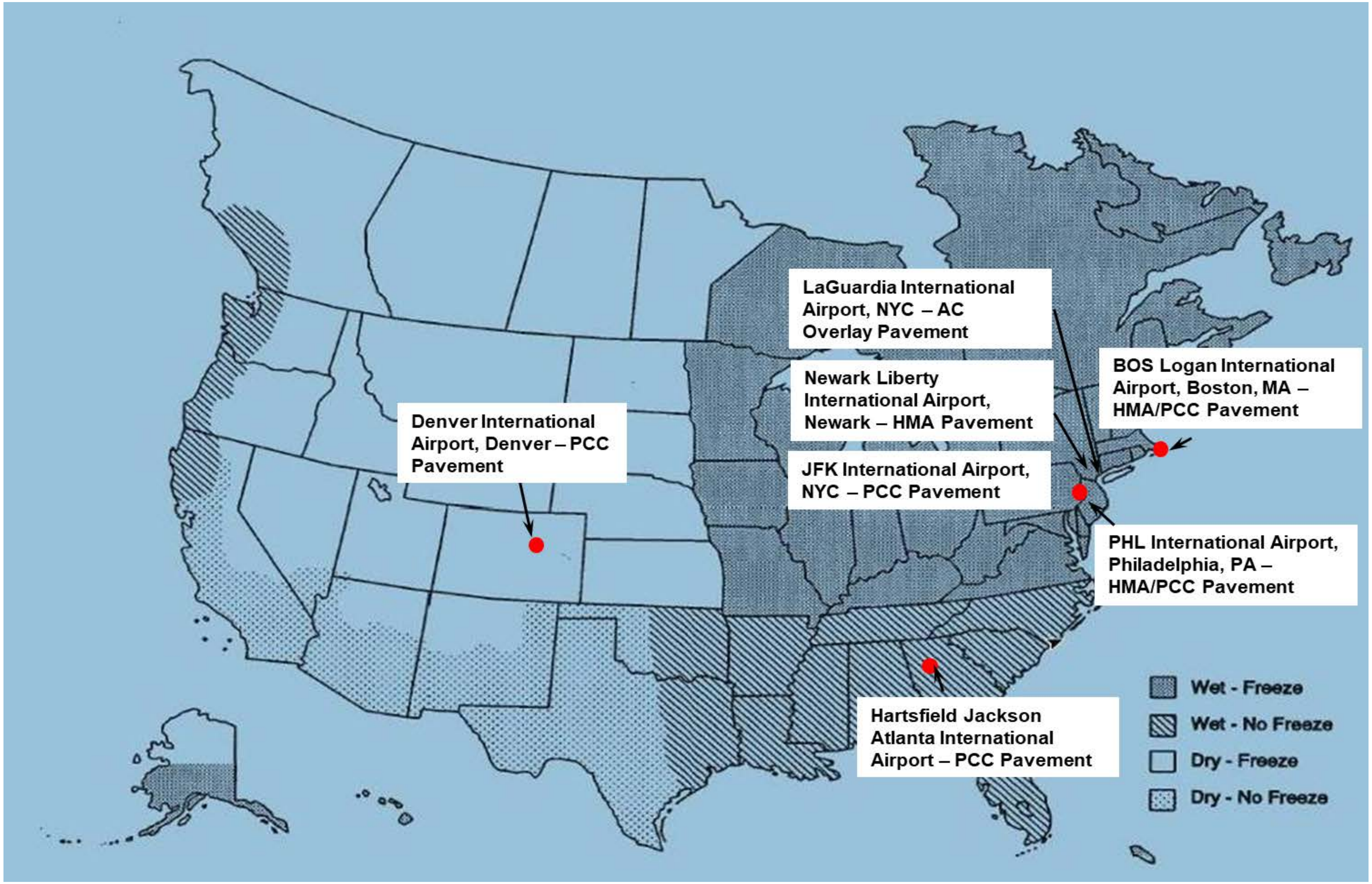
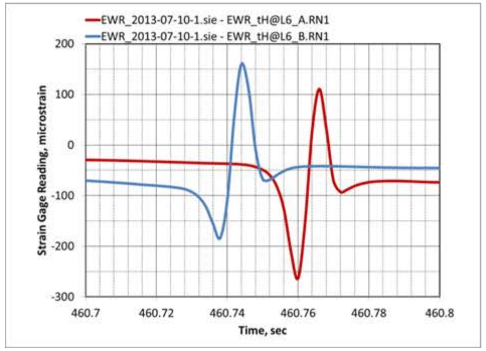
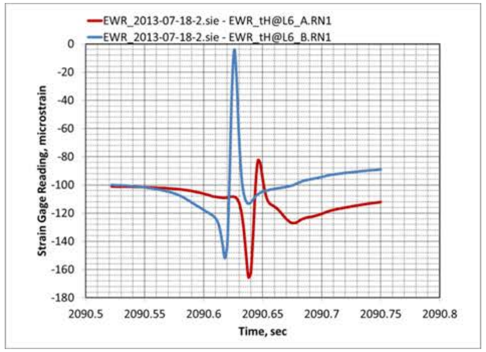
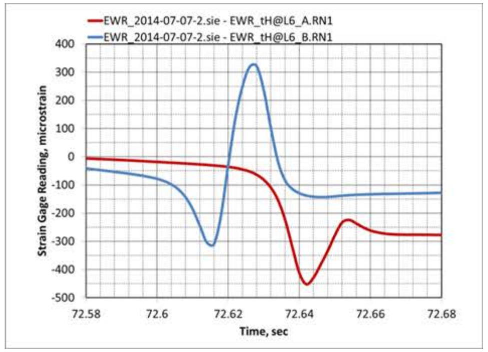

LaGuardia International Airport, NYC – AC Overlay Pavement
Newark Liberty International Airport, Newark – HMA Pavement
JFK International Airport, NYC – PCC Pavement
BOS Logan International Airport, Boston, MA – HMA/PCC Pavement
Denver International Airport, Denver – PCC Pavement
PHL International Airport, Philadelphia, PA – HMA/PCC Pavement
Hartsfield Jackson Atlanta International Airport – PCC Pavement
Wet - Freeze
Wet - No Freeze
Dry - Freeze
Dry - No Freeze



No Delamination

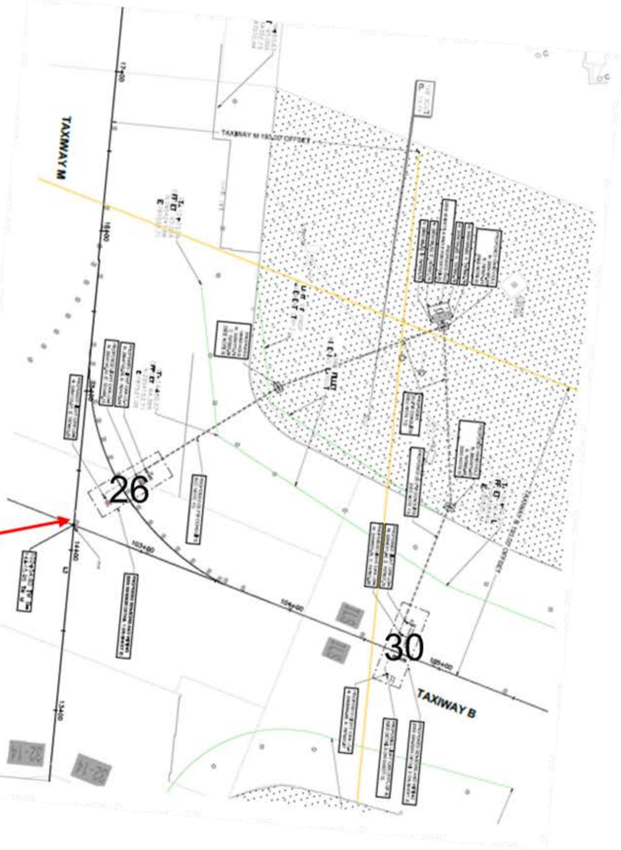


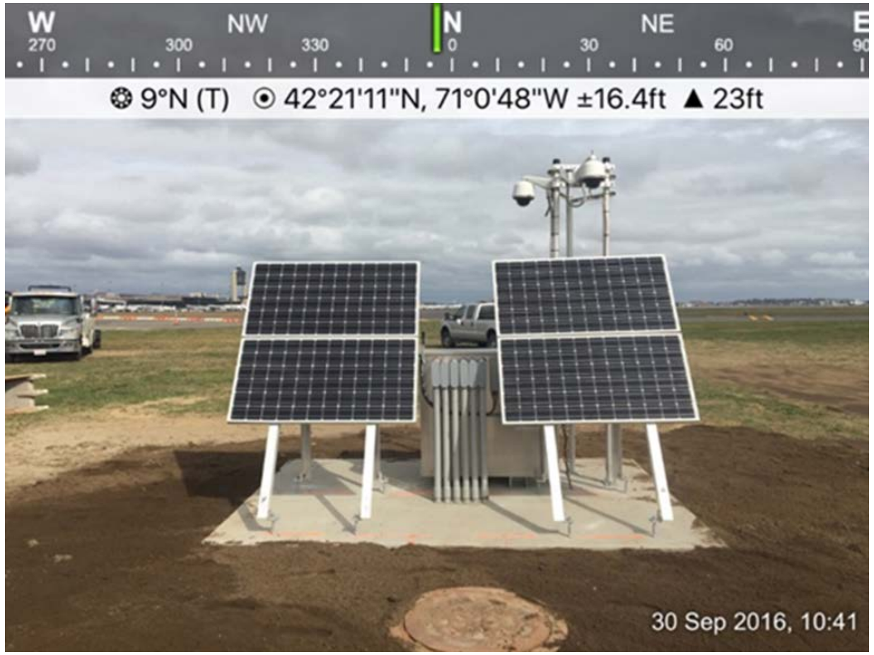
Early Indications



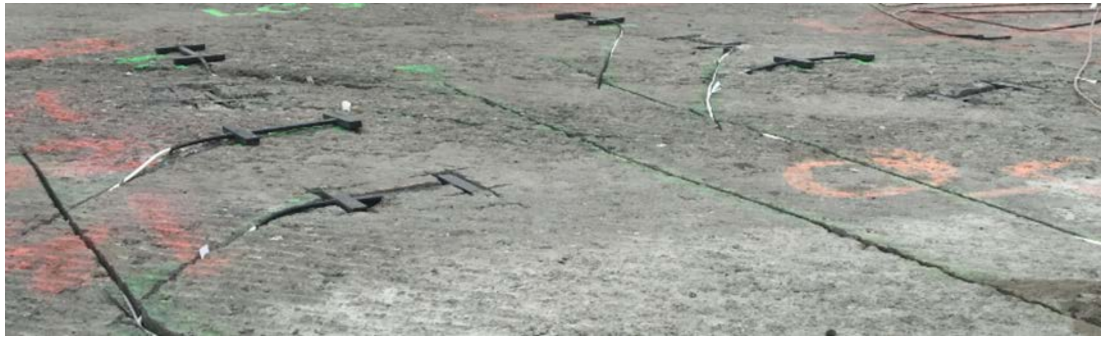
Delamination

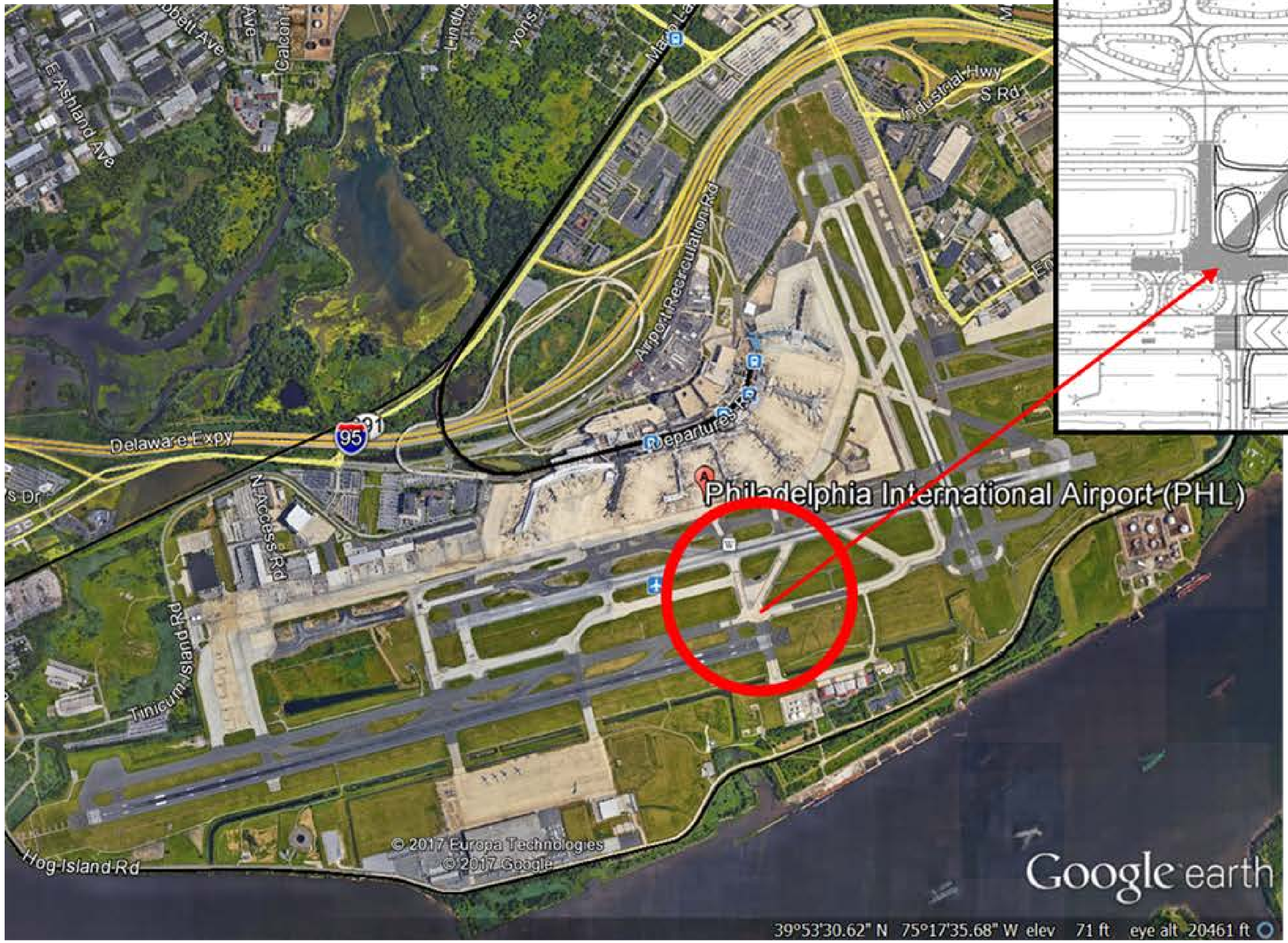

Boston Logan International Airport (BOS)
Prescott St
Airport Way
Harborside Dr
Waldemar Ave
Brookfield Rd
Bartlett Rd
Cottage Park Rd
Woodside Ave
Walden St
90
145
© 2017 Europa Technologies
© 2017 Google
Google earth
42°22'02.24" N 71°02'18.42" W elev 41 ft eye alt 16166 ft

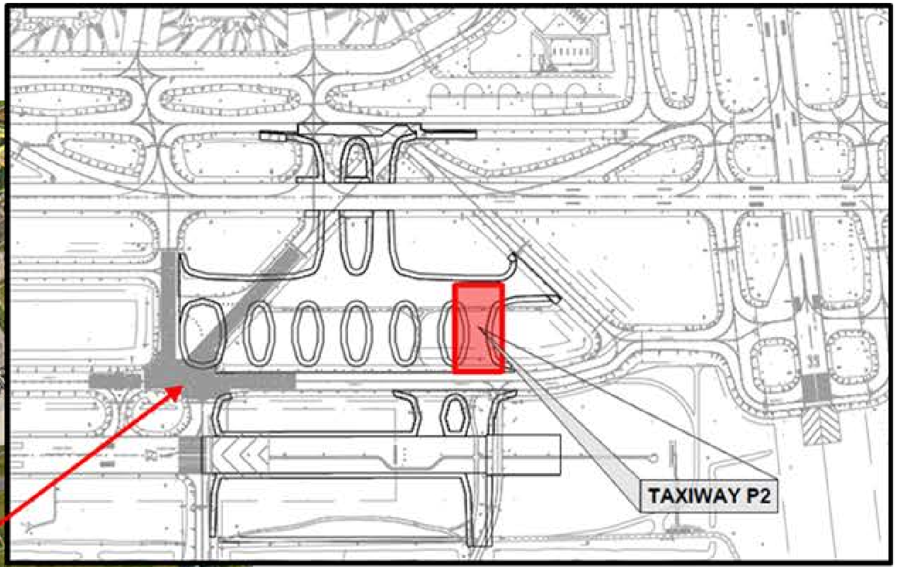

TAXIWAY M
26
30
TAXIWAY B


W
NW
N
NE
E
270
300
330
0
30
60
90
9°N (T)
42°21'11"N, 71°0'48"W ±16.4ft
23ft
30 Sep 2016, 10:41


JAPAN AIRLINES
Emirates
www.emirates.com





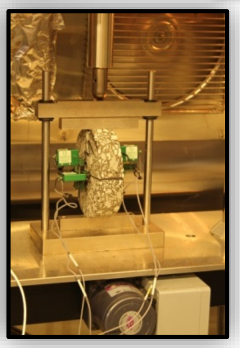


Runway 27L Extension and Associated Taxiways

New Construction on Taxiway P2:
- 18” P-501
- 17” P-401

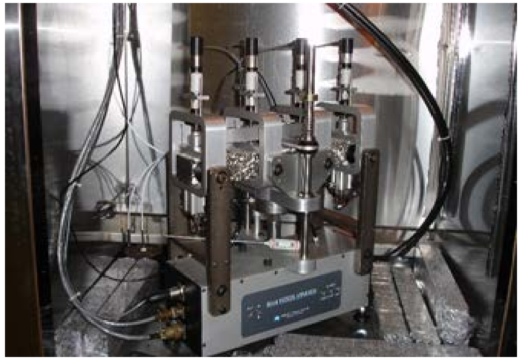
FAA NextGen Pavement Materials Lab

- **2010: Laboratory Opened**
- **2013: AASHTO Material Reference Laboratory (AMRL)**
- **2013: Cement and Concrete Reference Laboratory (CCRL)**
- **Full Test Capabilities: Asphalt, Concrete, Soils**
- **Advanced Test Capabilities:**
  - Asphalt Pavement Analyzer (APA)
  - Asphalt and Concrete beam fatigue
  - Semi-Circular Bending (SCB)
  - Disk-Shaped Compact Tension (DCT)
- **Benefits to the NAPTF & NAPMRC:**
  - Quality Control of Testing
  - Expedient Testing of Materials During Construction
  - Perform Advanced Materials Characterization On-site
  - Development of Performance Based Specification

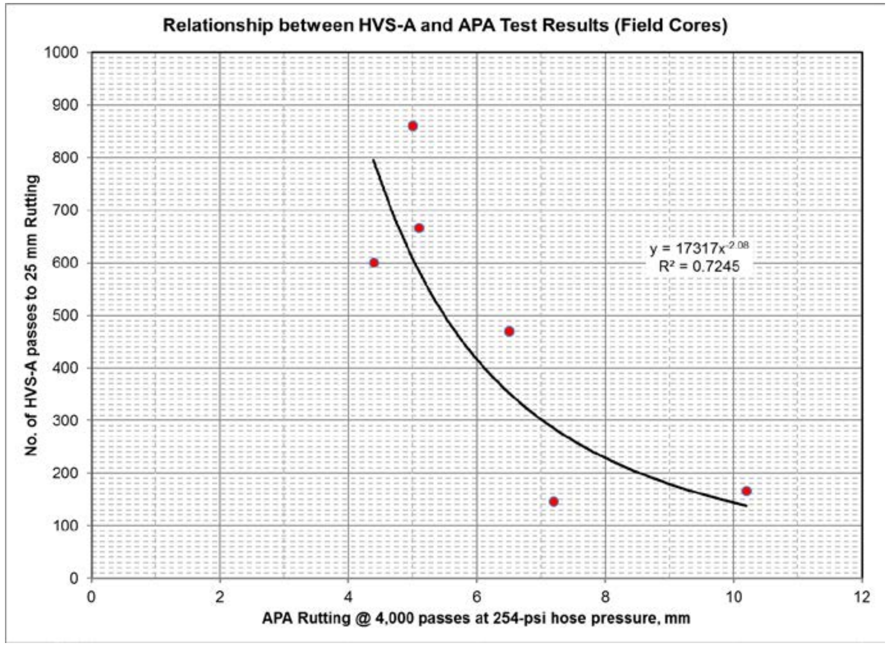


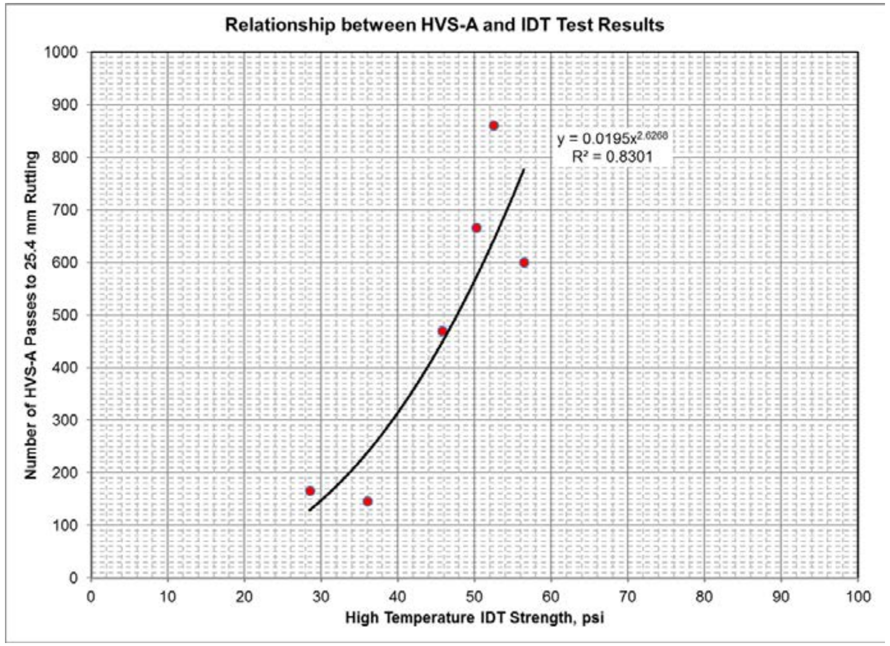
HMA Characterization

- **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)

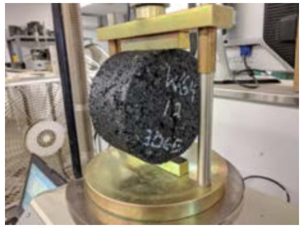


Relationship between HVS-A & APA Results







Outline

- Introduction
- Research Facilities
- Research at
  - NAPTF
  - NAPMRC
  - Field Instrumentation & Testing
- **New Research Initiatives**
- Summary

New Research Initiatives

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

- Concrete Pavements
  - Administered by the National Concrete Pavement Technology Center at Iowa State University

Directive Topics	Synopsis	Legislative Source	Deadline	LOB Responsible	Status	Comments
Airport technology research	Not less than $39,224,000 shall be available for Airport Technology Research	Conference Bill H.R. 1865 (p. 409)	N/A	ARP		
	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.	House Report 116-106 (p.28)				
	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.	Senate Report 116-109 (p.43)				

Other Research Projects

- In-Service Performance of Airport Pavements Constructed Following State Specifications for Highway Materials
- Stabilized Bases
- Surface Treatments
- Seasonal Frost and Permafrost
- Pavement Roughness
- Minimum material, construction, and acceptance recommendations for P401, P403, and P-404.

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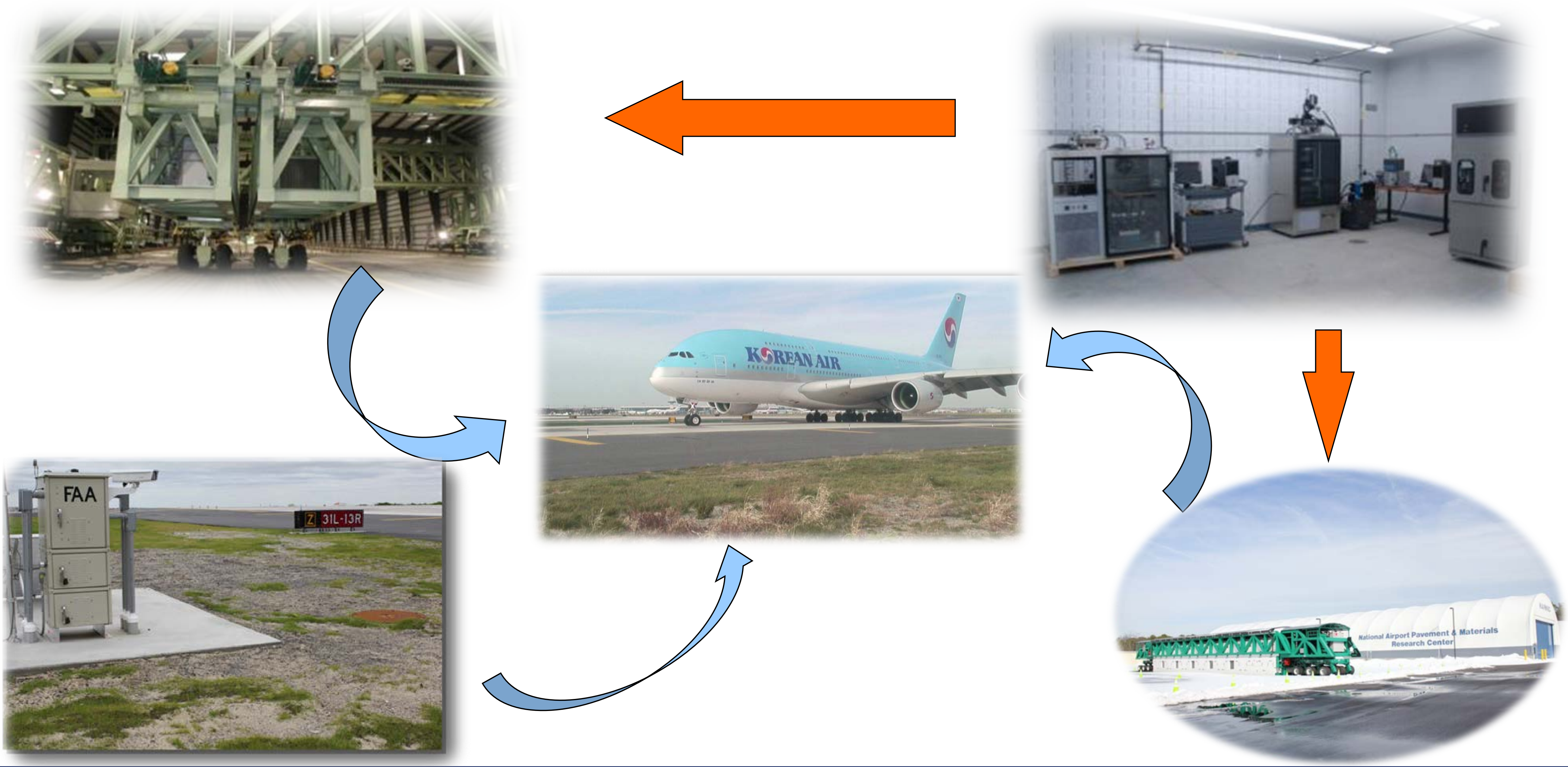
KOREAN AIR
FAA
Z 31L-13R
National Airport Pavement & Materials Research Center

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