R&D Update from the National Airport Pavement Test Facility

Presented to: SWIFT 2009

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Airport Technology R&D Program

- Introduction
- Full Scale Testing
- Software
- Research Projects
- Facility Upgrades
- Up Coming Events

Acknowledgments

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Federal Aviation Administration
Airport Technology R&D Program

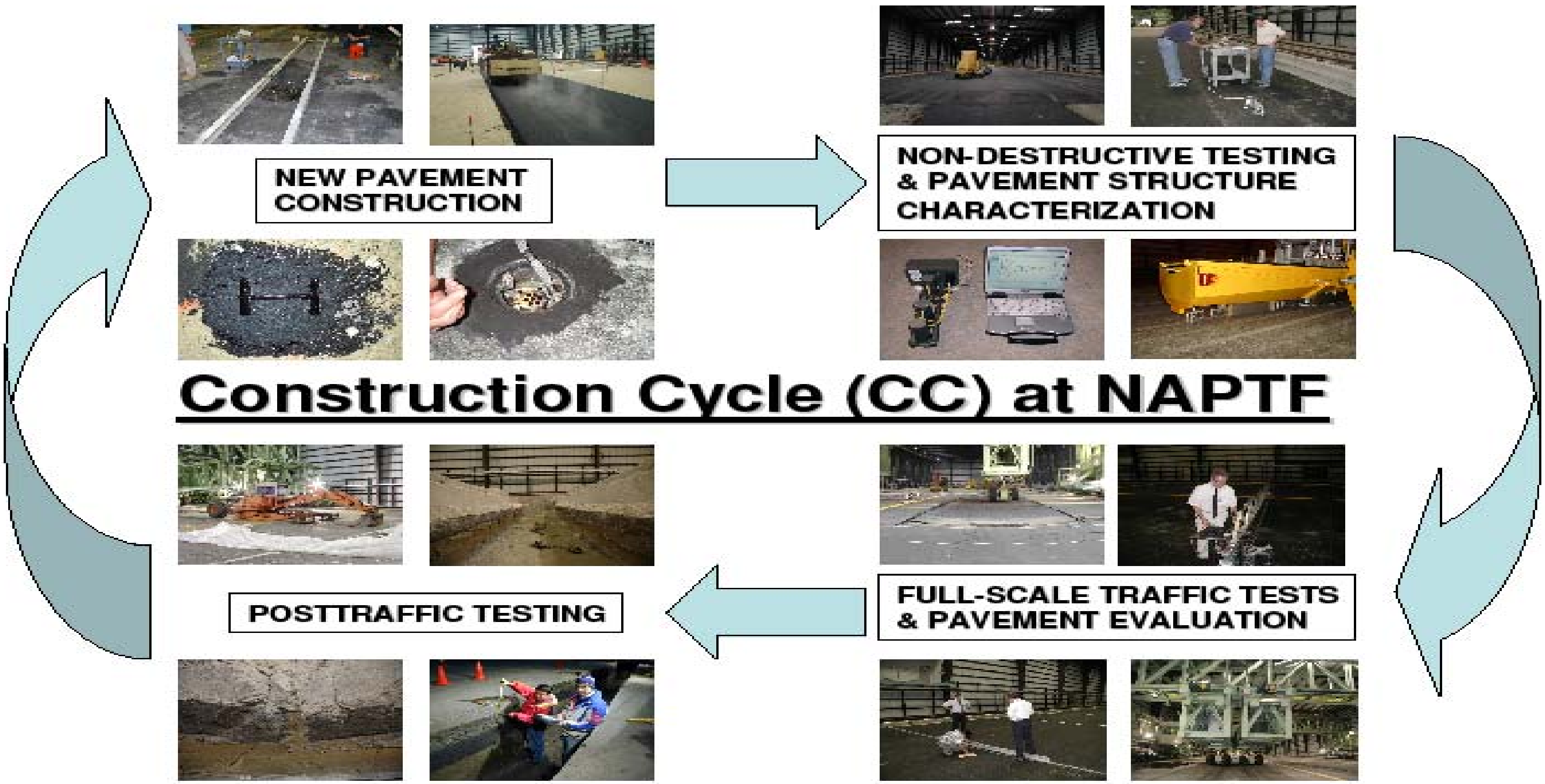
- **Research conducted at the FAA William J. Hughes Technical Center, Atlantic City, NJ, USA.**
- **Sponsor: FAA Office of Airport Safety and Standards (AAS100), Washington, DC.**
- **Provide support for development of FAA pavement standards (Advisory Circulars).**

National Airport Pavement Test Facility (NAPTF)

FACTS:

- **Fully enclosed facility for accelerated traffic testing of airport pavements.**
- **Full-scale pavement structures and landing gear loads with programmed wander.**
- **Opened in 1999.**
- **Total construction contract was $21M.**
  - $14M from FAA
  - $7M from Boeing Co. under FAA/Boeing CRDA.

NAPTF Construction Cycle (CC)



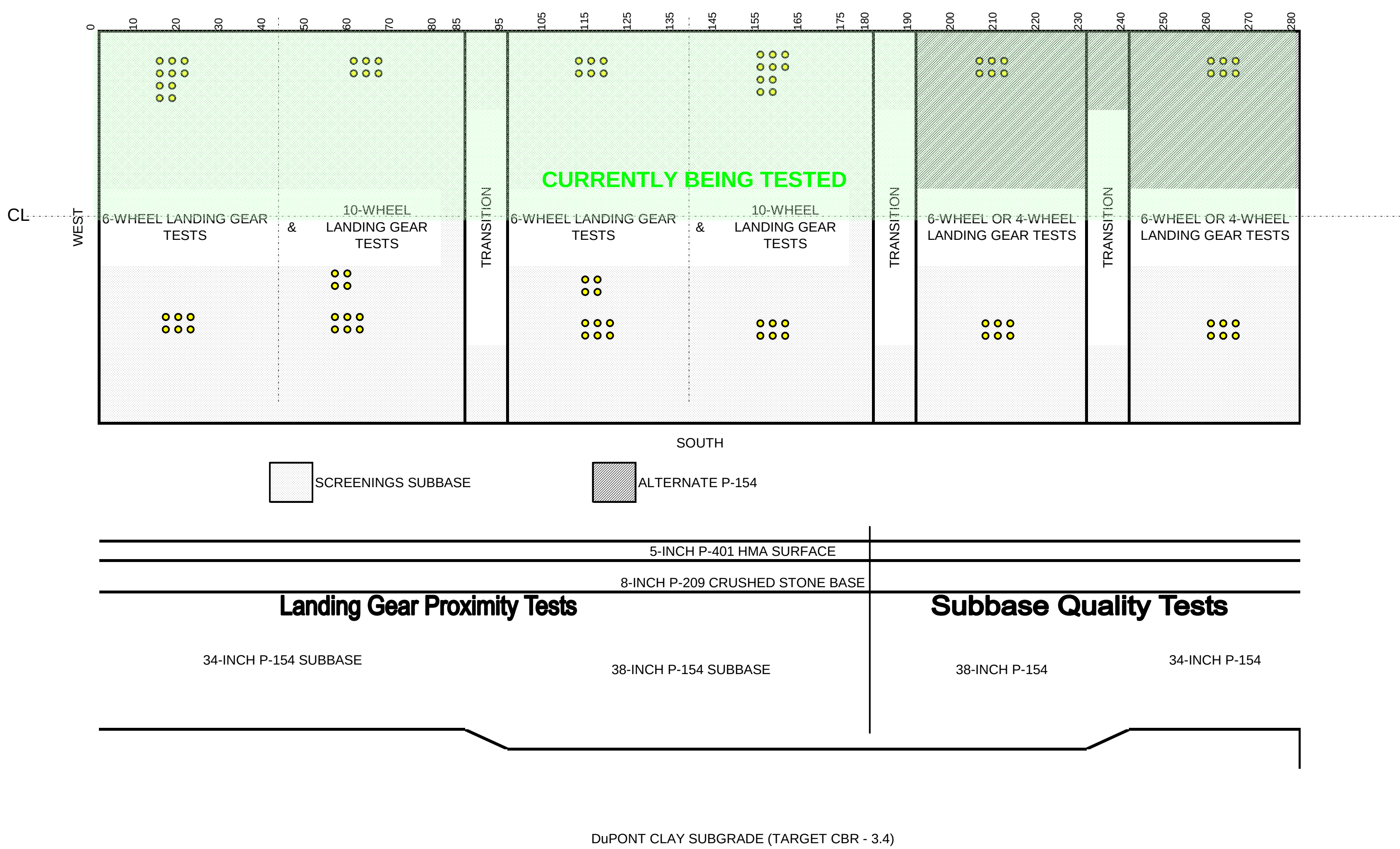
Full Scale Testing

Construction Cycle 5 (CC5) – Flexible Pavement

- **Objectives**
  - Determine the effect of gear interaction on low-strength subgrade flexible pavement life.
  - Study the Performance of different quality subbase materials.
- **History**
  - Construction Completed: July 14, 2008
  - Started Loading: August 14, 2008
  - Increased wheel load from 50k to 58k: October 7, 2008
  - Cold Weather Shut Down: November 12, 2008
  - 12,276 passes restart
  - Restarted testing on Sept 1st at 65k

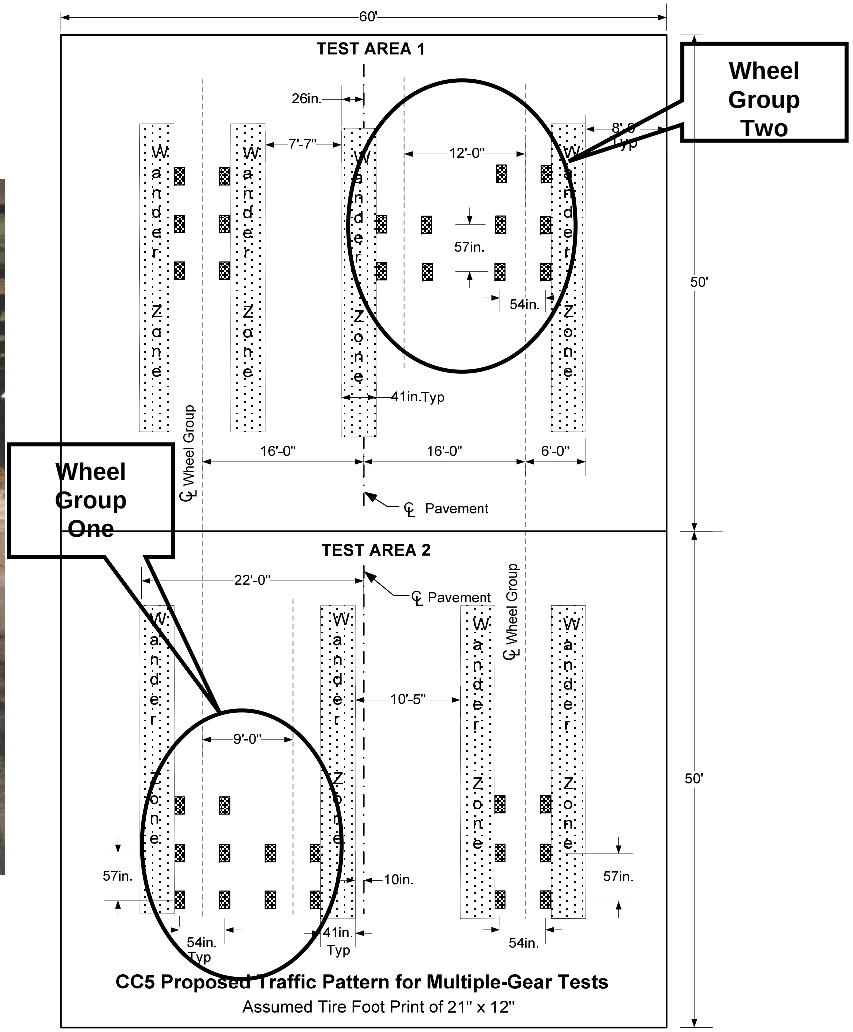
Full Scale Testing

CC5 Test Plan & Profile



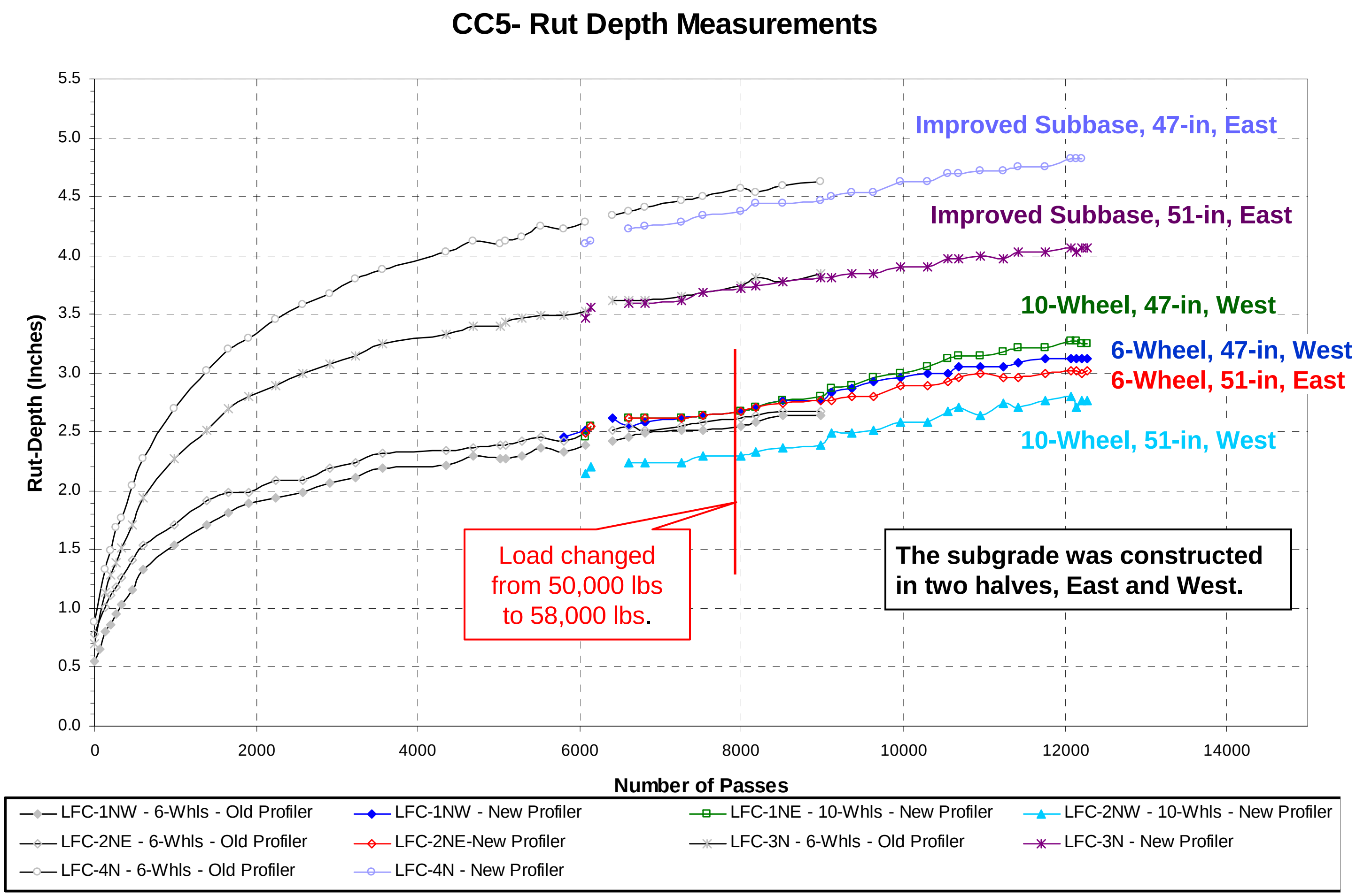
Full Scale Testing

CC5 Gear Configuration



Full Scale Testing

CC5 Rut Depth Measurements



Full Scale Testing

Construction Cycle 6 (CC6) – Rigid Pavement

- **Objectives**
  - Primary
    - The effect of concrete modulus of elasticity (*E*) on rigid pavement structural life
  - Secondary
    - Perform side-by-side comparison of Cement and Asphalt stabilized bases.
    - Perform side-by-side comparison of thickened edge isolation joint and reinforced isolation joint.
    - Develop a standard procedure for using PSPA on rigid pavement.
    - Study the required compaction requirements under rigid pavements.

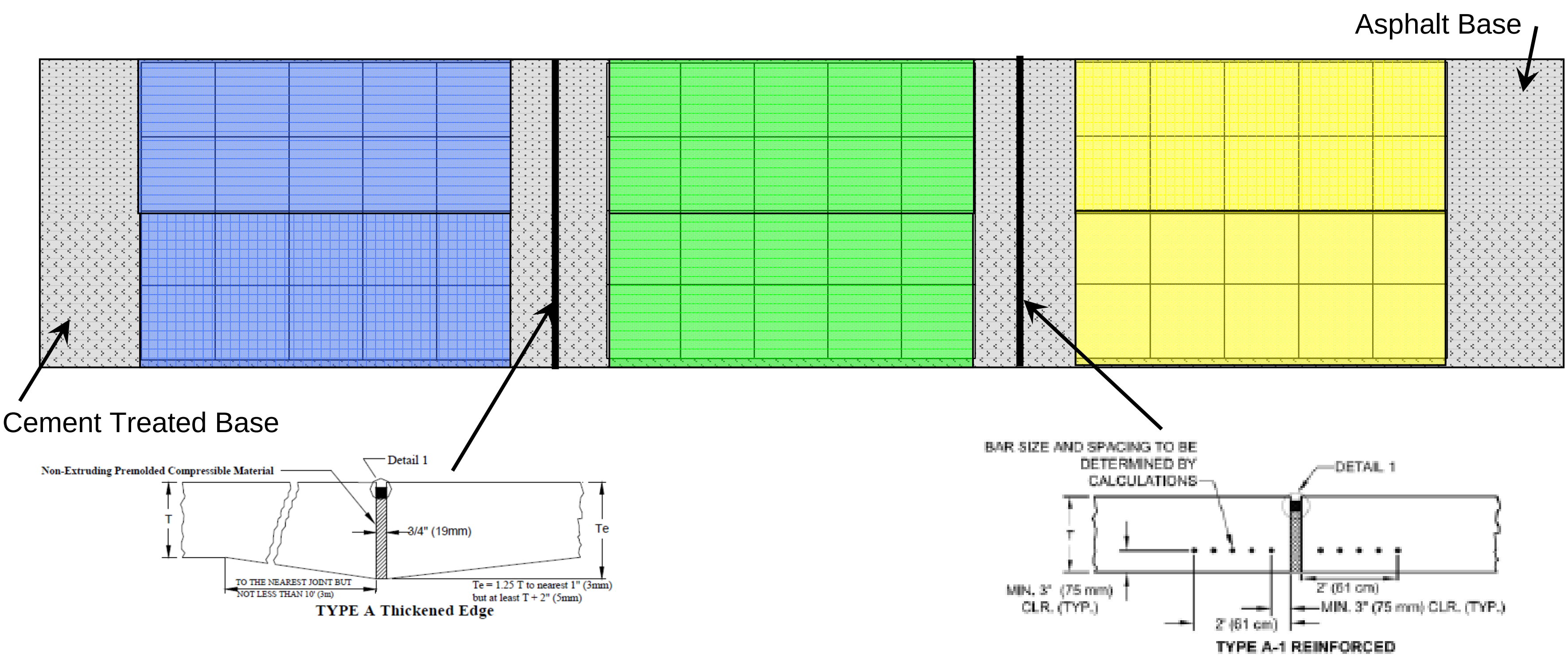
Full Scale Testing

CC6 Layout and Details

- High Modulus Concrete

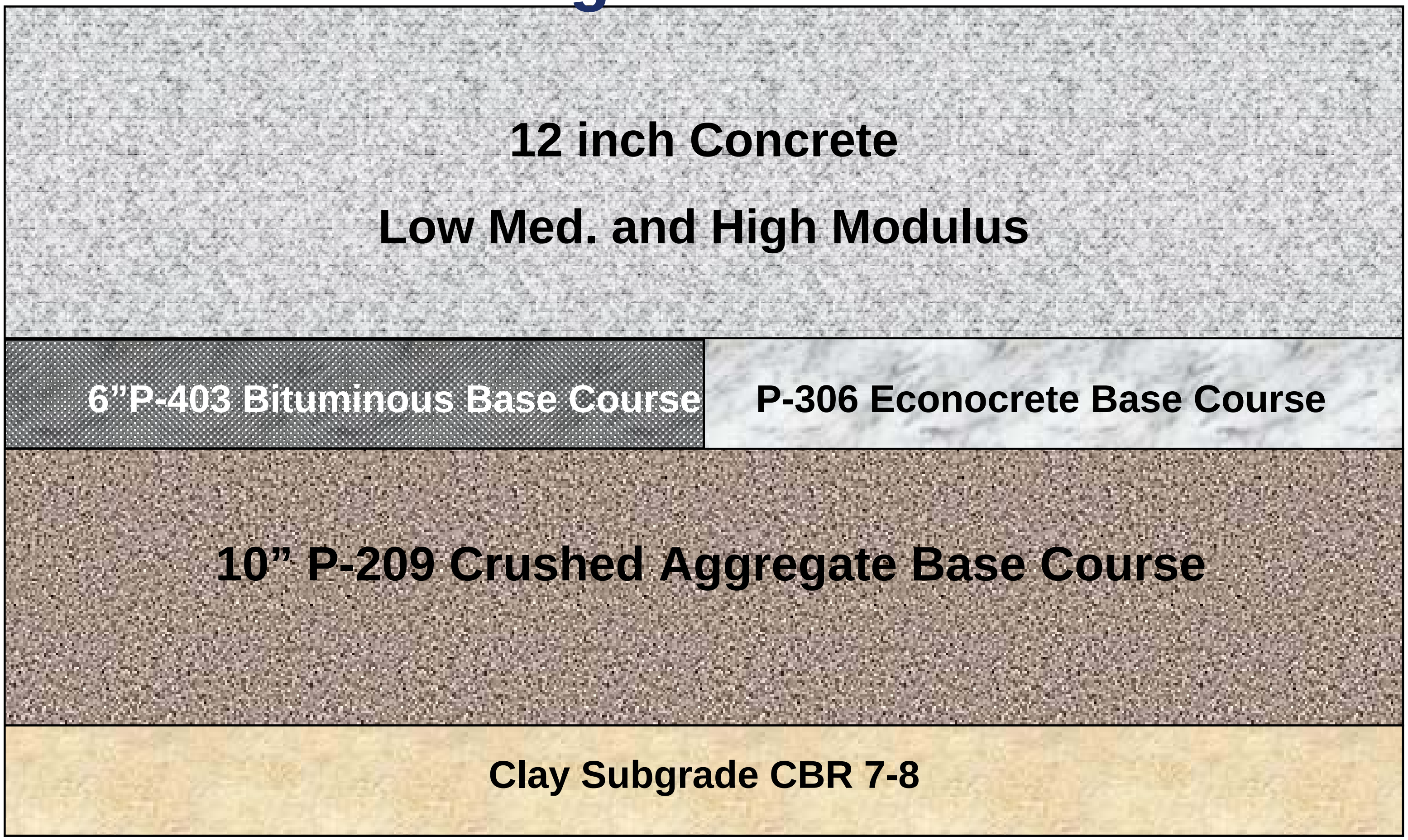
- Med. Modulus Concrete

- Low Modulus Concrete



Full Scale Testing

CC6 Pavement Design



Full Scale Testing
Construction Cycle 6

Started on June 24, 2009

Full Scale Testing
High Tire Pressure Tests

- **Issues**
  - As airplane weights have increased, so have wheel loads and tire pressures.
  - ICAO tire pressure limits under the ACN-PCN system are fixed.
  - Tire pressures are now crossing the ICAO limit and in the future some aircraft may not be allowed to operate at full load on some pavements.
  - A340-500/-600, 747-400ER, A380-800F, 777-300ER and new 787, A350 and 747-8 all exceed category X upper limit.

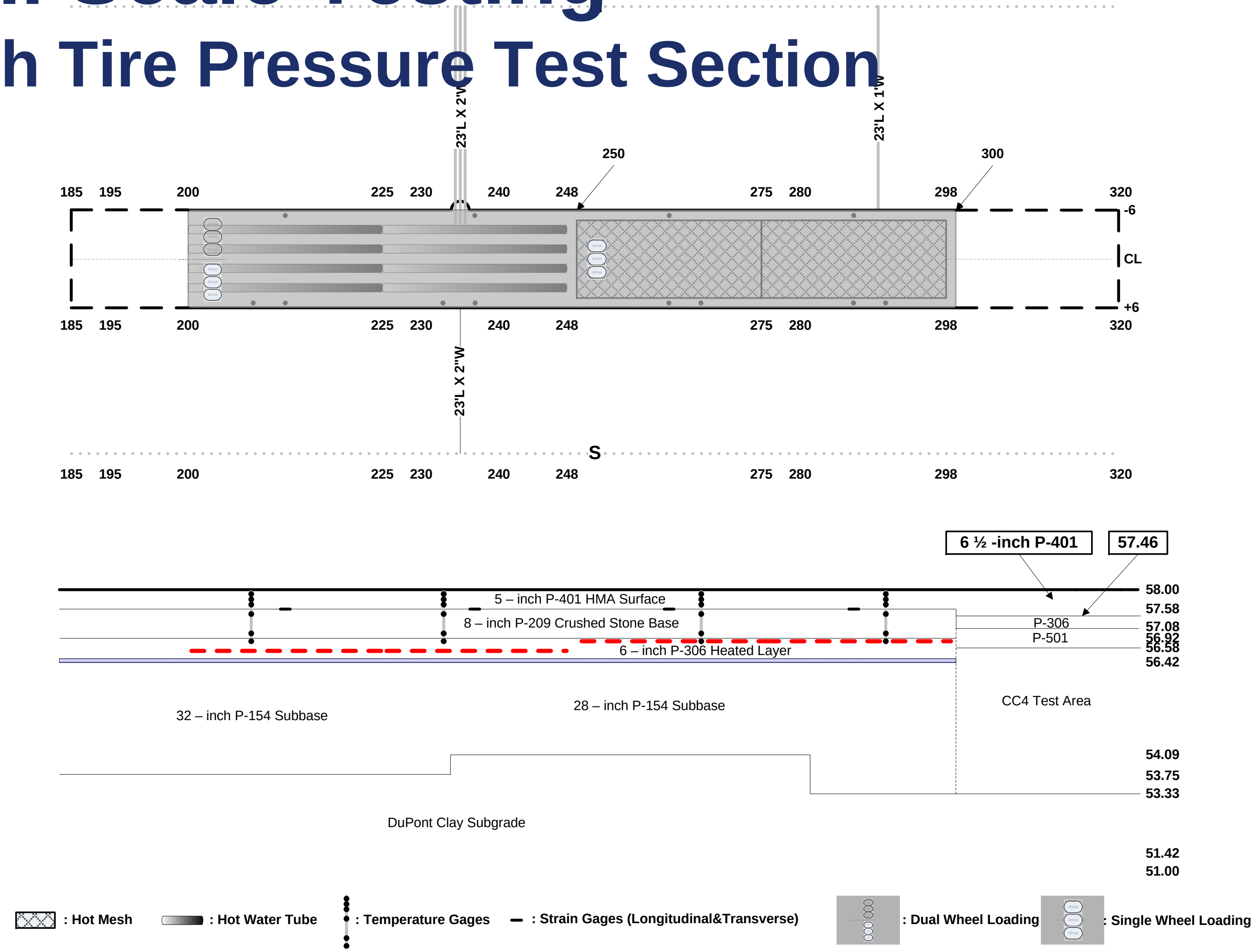
Full Scale Testing
High Tire Pressure Tests

- **Objectives**
  - To control and increase pavement temperatures of a HMA layer
  - Compare rutting @ tire pressures of 218 and 240 psi with single wheel loads of 60-65 K
  - Propose Changes to ICAO Tire Pressure Categories

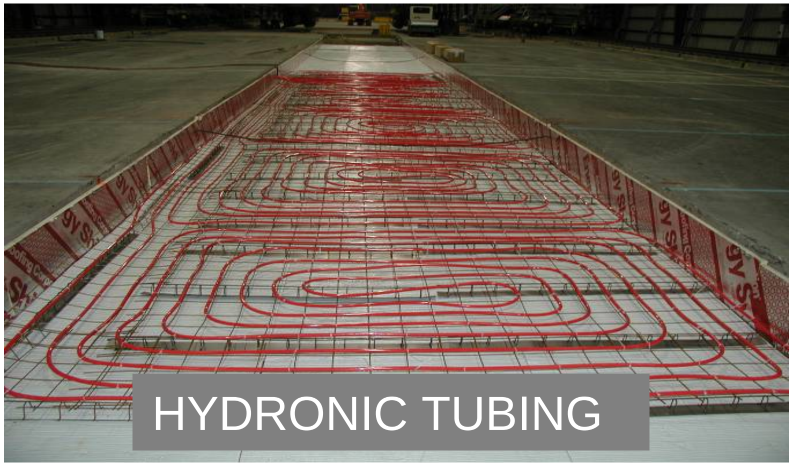
Tire Pressure Category	Current ICAO Limits Psi (MPa)	Proposed New ICAO Limits Psi (MPa)
W	Unlimited	Unlimited
X	217 (1.50)	240 (1.65)
Y	145 (1.0)	181 (1.25)
Z	72 (.50)	72 (.50)

Full Scale Testing

High Tire Pressure Test Section



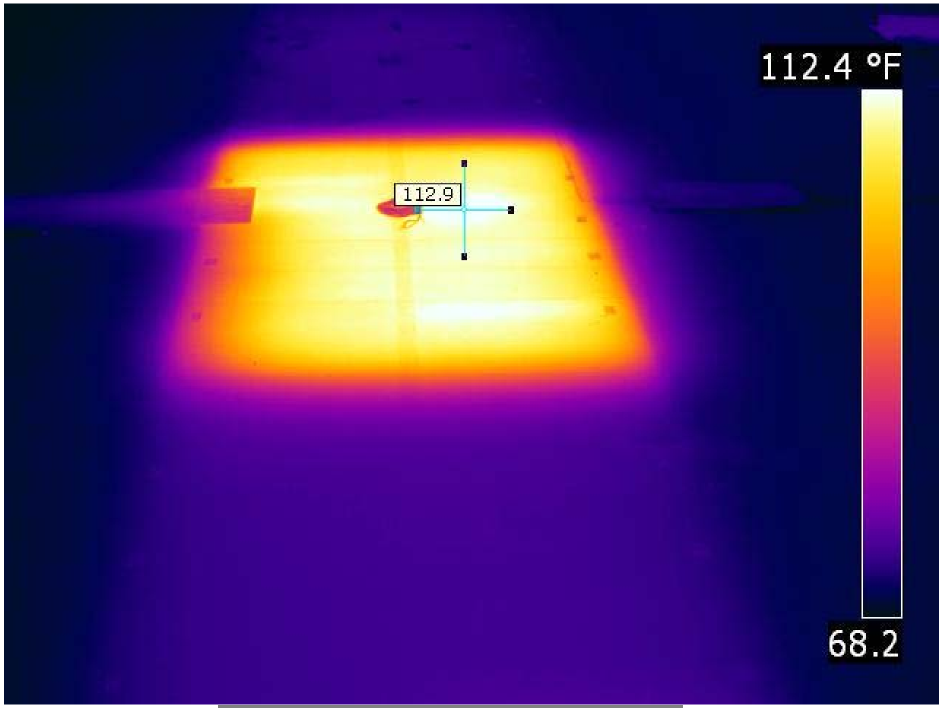
Full Scale Testing
High Tire Pressure Tests



Full Scale Testing
High Tire Pressure Tests

Full Scale Testing
High Tire Pressure Tests

TEST SECTION



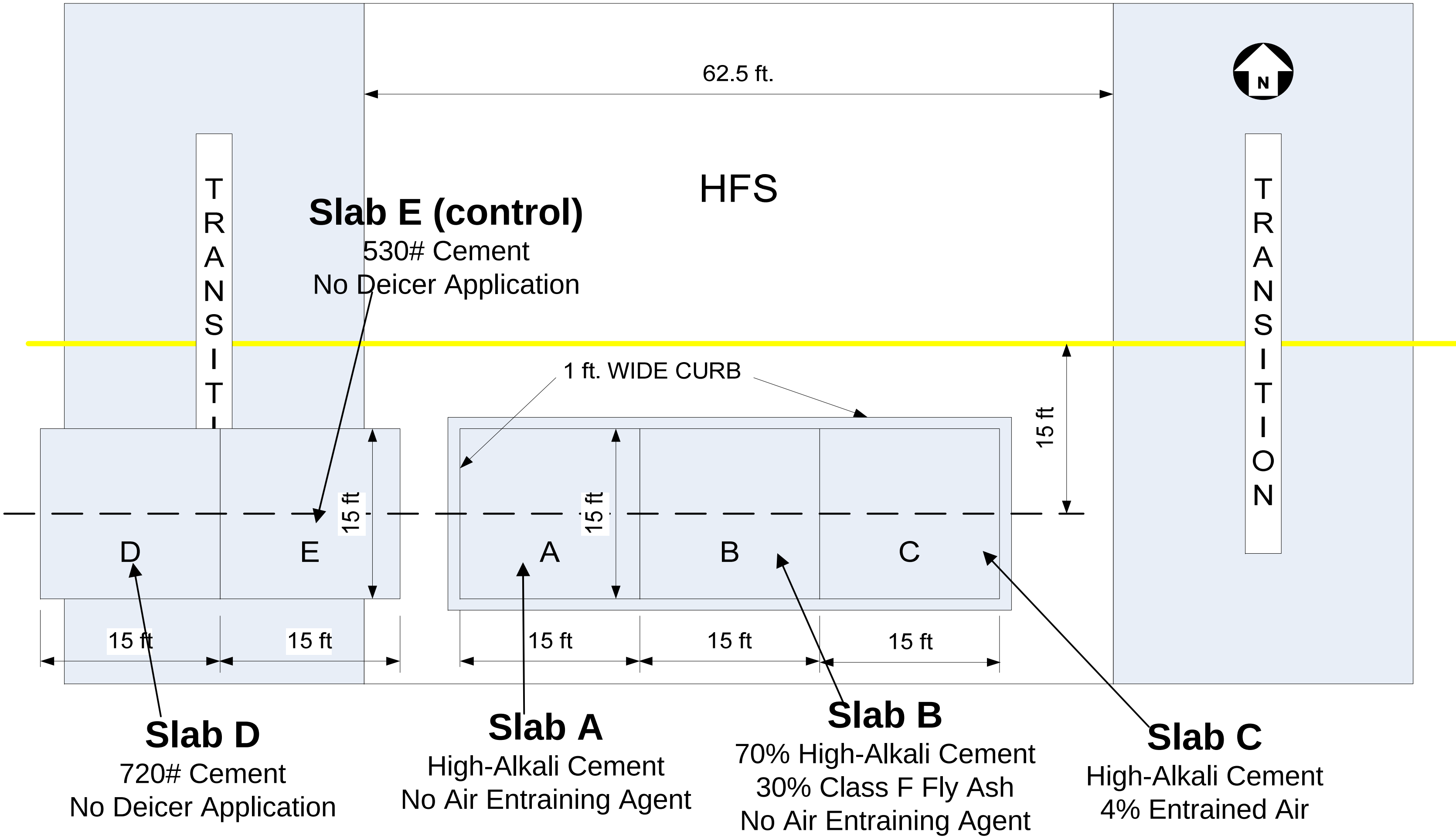
PAVEMENT TEMPERATURE

Full Scale Testing
Alkali-Silica Reactive (ASR) Slabs

- **Objectives**
  - Study the feasibility of conducting large scale accelerated Alkali Silica Reactivity in concrete slabs.
    - Develop methods to accelerate the ASR reaction.
  - Investigate the effects of ASR on the structural capacity of concrete slabs.
    - Develop plans to apply loads to the ASR affected slabs.
    - Monitor deterioration of slabs both with and without loading.

Full Scale Testing

Alkali-Silica Reactive (ASR) Slabs



Full Scale Testing

Alkali-Silica Reactive (ASR) Slabs

Data	Interior Slabs			Exterior Slabs		
	A	B	C	A	B	C
Size	15 × 15 ft.					
Thickness	12 in.					
Concrete Mix	Reactive Aggregates; High-Alkali Cement (min. 0.82% Na_2O_{eq}); 0.55 w/c					
Air Entrainment*	No admixture 1.2%	No admixture 0.9%	4% 5.4%	No admixture 1.2%	No admixture 1.0%	4% 5.2%
Fly Ash*	0	30% Cl. F	0	0	30% Cl. F	0
Deicer	Potassium Acetate					

*Both air entrainment and fly ash replacement will reduce susceptibility to ASR in concrete mixtures.

As-Built Test Results

Full Scale Testing

Alkali-Silica Reactive (ASR) Slabs

Exterior

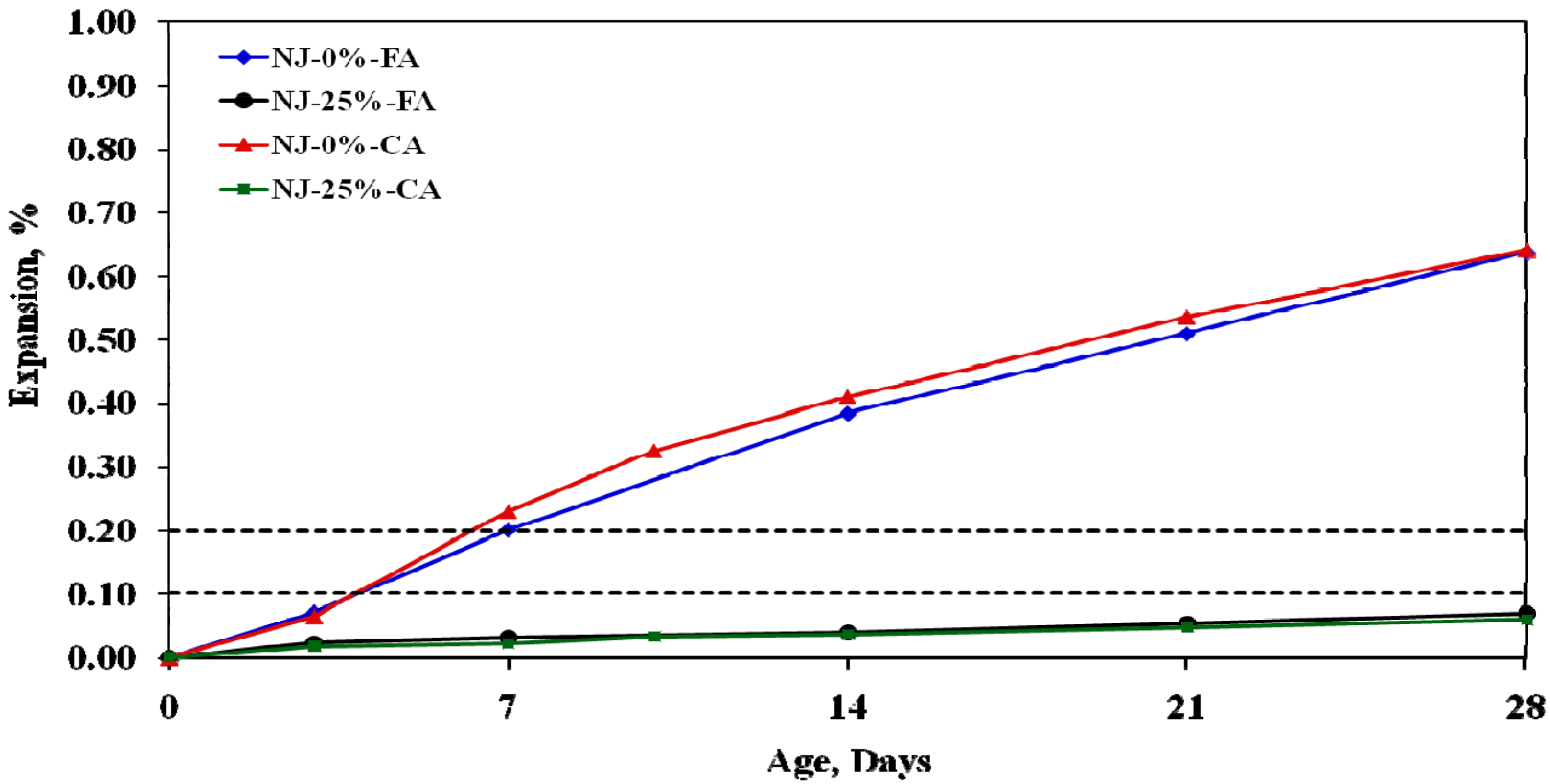
Interior

Full Scale Testing
Alkali-Silica Reactive (ASR) Slabs

- **Macro Changes**
  - Physical Expansion (install survey pins to measure gross length change).
  - Modulus of Elasticity (PSPA, GPR, HWD, etc.).
  - Joint gage monitoring.
- **Micro Structural Changes**
  - Presence and location of ASR cracks.
  - Presence and location of ASR gel.
  - Alteration of paste chemistry.
- **Petrography**
  - Cores at 12, 18 and 24 months will be sent to Clemson University for evaluation.

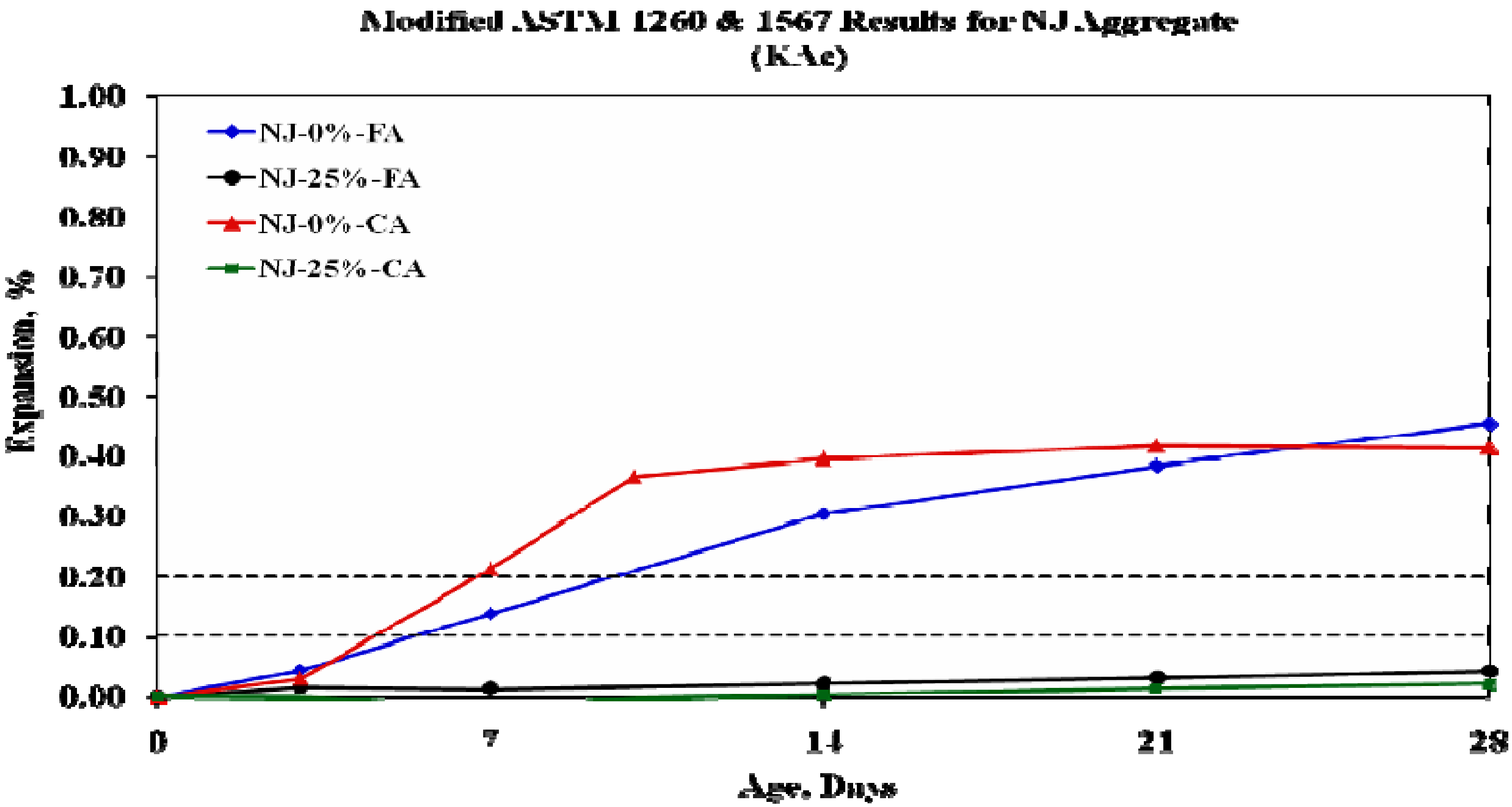
Full Scale Testing
Alkali-Silica Reactive (ASR) Slabs

Standard ASTM 1260 & 1567 Results for NJ Aggregate



Full Scale Testing

Alkali-Silica Reactive (ASR) Slabs



Software

FAARFIELD

F	**Federal**
A	**Aviation**
A	**Administration**
R	**Rigid and**
F	**Flexible**
I	**Iterative**
E	**Elastic**
L	**Layered**
D	**Design**

- **Computer program for desktop PCs.**
- **Program preserves the "look and feel" of LEDFAA 1.3.**
- **Major changes are internal.**
- **Incorporates advanced structural models:**
  - 3-D finite element analysis for rigid pavements and overlays.
    - NIKE3D (3D finite element analysis)
    - INGRID (3D mesh generation)
  - Layered elastic analysis (LEAF) for flexible pavements and overlays.

Software
FAARFIELD

- **Key Differences from LEDFAA 1.3**
  - Rigid Pavements/Overlays
    - Slab edge stresses are now computed directly using 3D-FEM.
    - Completely revised rigid pavement failure model.
    - Rewrote and improved rigid overlay design procedures.
    - Supports PCC overlay design on rubblized base.
  - Flexible Pavements/Overlays
    - Automatic base thickness design.
    - Supports HMA overlay design on rubblized base.

Software
FAARFIELD

- **Key Differences from LEDFAA 1.3**
  - General
    - Upgrade to MS Visual Basic.NET programming environment.
    - Aircraft library updated.
    - New function allows user to export design data to XML.
    - All user options collected on one “Options” screen.
    - External aircraft library in XML format.
    - Displays CDF values graphically.
    - Enhanced Airplane Data window now displays gear coordinates.
    - Design is now computed for constant tire contact area.

Software
COMFAA 3.0

COMFAA

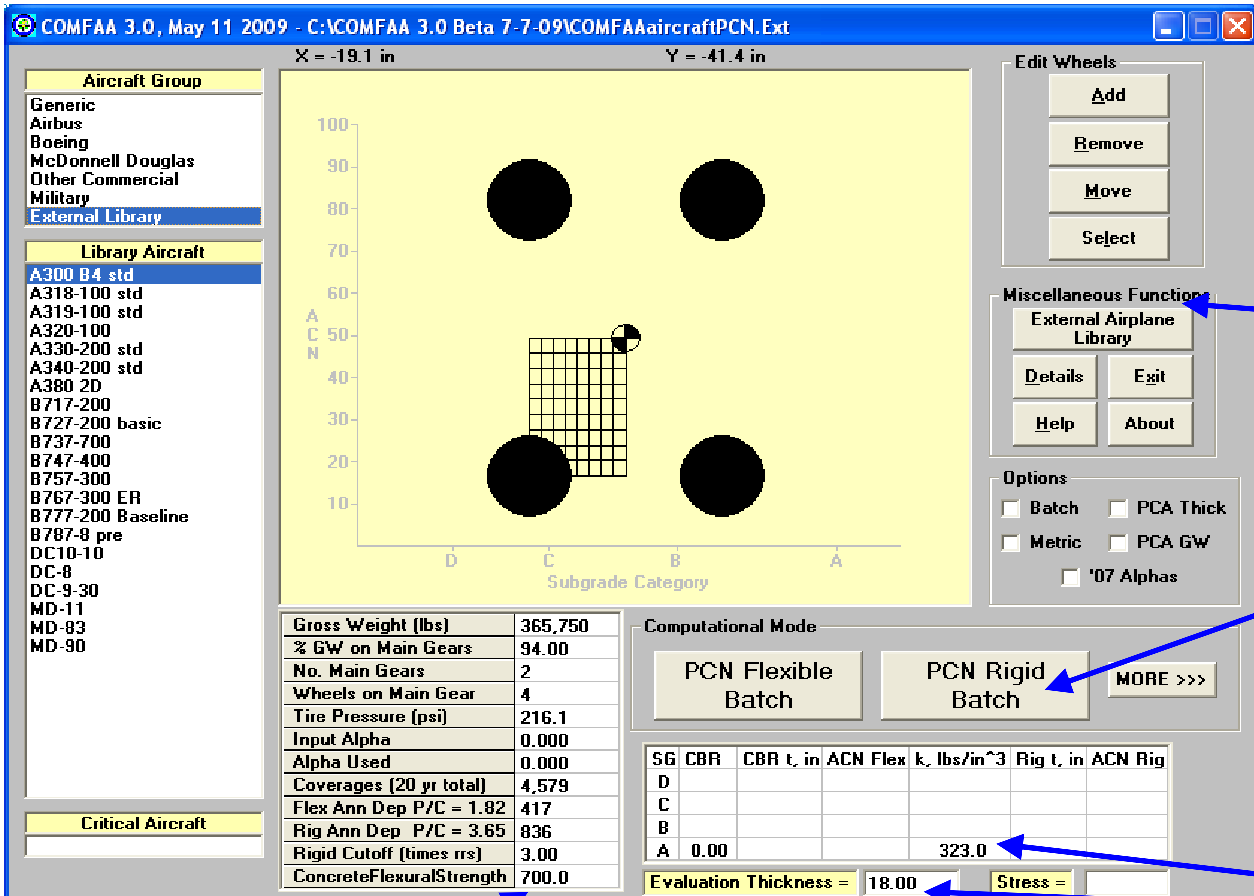
<u>Com</u>putation of ACN/PCN <u>F</u>ederal <u>A</u>viation <u>A</u>dministration

- **The new PCN methodology will use the CDF concept**

- **Incorporated in a new advisory circular AC 150/5335-5B "Standardized Method of Reporting Airport Pavement Strength – PCN," replacing AC 150/5335-5A.**

Software

COMFAA 3.0



1. Select External Library

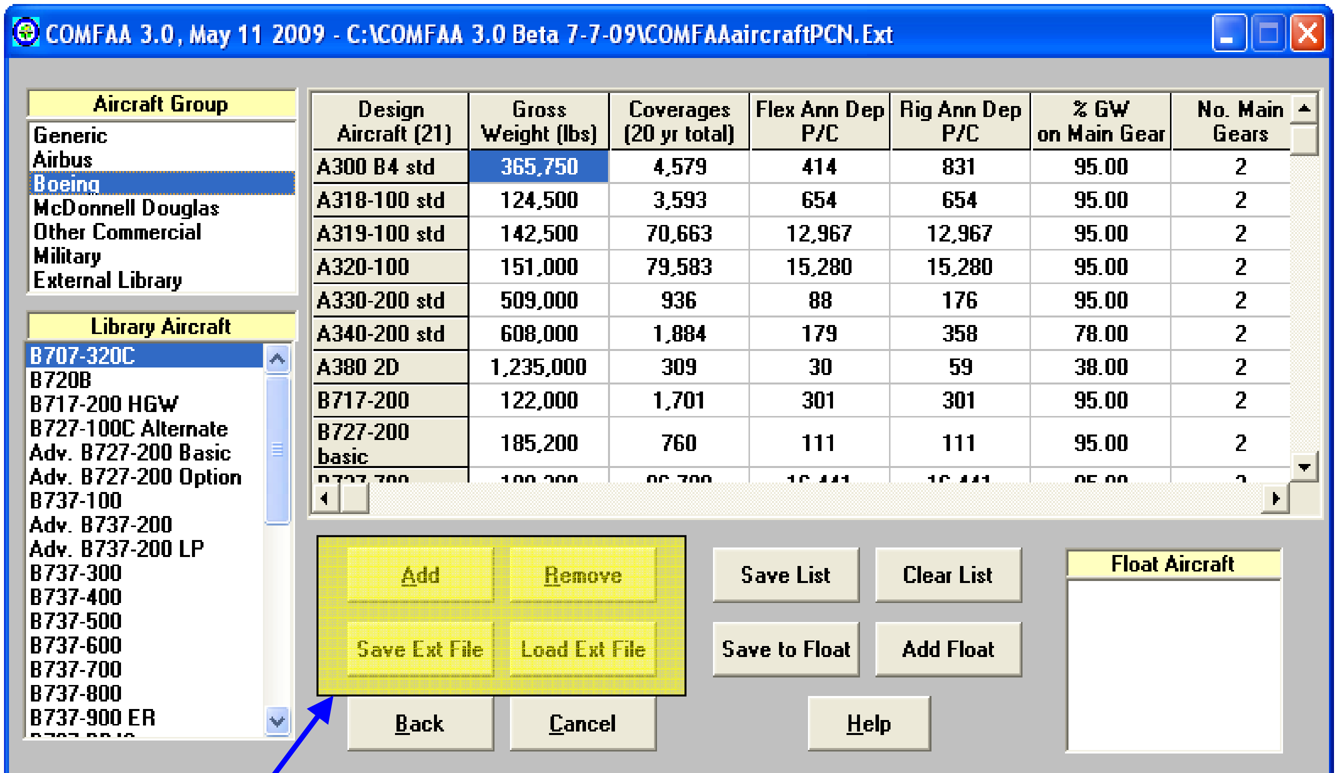
3. Select for automated PCN calculation

2. Input k and Design Thickness

2. Input Concrete Strength

Software

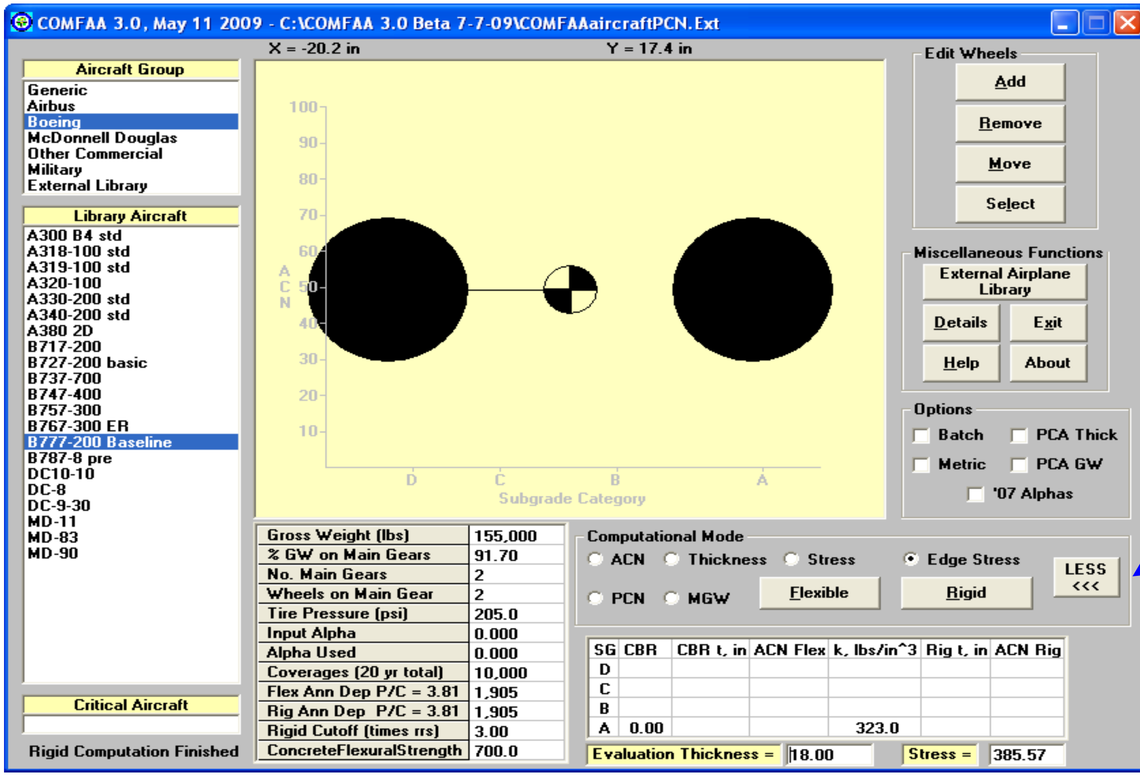
COMFAA 3.0



Traffic mix can be created by adding or removing airplanes from existing Aircraft Group library or by loading an Ext text file

Software

COMFAA 3.0 – Additional Analysis



Select More/Less to bring up additional options

Additional options allow edge stress and PCA center case stress calculations.

ACN mode of existing COMFAA program still available

Software

COMFAA 3.0 – Results Page

Results Rigid 7-9-2009.txt - Notepad

File Edit Format View Help

```
This file name = Results Rigid 7-9-2009.txt
Library file name = C:\COMFAA 3.0 Beta 7-7-09\COMFAAaircraftPCN.Ext

Evaluation pavement type is rigid
Equivalent coverages computed with the AC 150/5320-6C/D method.
Maximum gross weight computed with the AC 150/5320-6C/D method.

                        k Value = 323.0 lbs/in^3
              flexural strength = 700.0 psi
   Evaluation pavement thickness = 18.00 in
```

Aircraft Name	Gross Weight	Percent Gross Wt	Tire Press	Annual Deps	20-yr Coverages	6D Thick
A300 B4 std	365,750	94.00	216.1	836	4,579	11.64
A318-100 std	124,500	90.40	147.9	670	3,593	9.67
A319-100 std	142,500	92.60	172.6	13,143	70,663	12.90
A320-100	151,000	94.00	200.1	15,360	79,583	13.82
A330-200 std	509,000	94.80	205.9	88	936	11.71
A340-200 std	608,000	79.58	206.0	177	1,884	11.99
A380 2D	1,235,000	38.05	218.0	59	309	11.50
B717-200	122,000	94.42	164.0	302	1,701	10.33
B727-200 basic	185,200	96.00	148.0	111	760	11.84
B737-700	188,200	91.70	205.0	16,731	96,709	15.76
B747-400	877,000	93.32	200.0	761	4,358	12.06
B757-300	271,000	92.62	195.0	10,208	51,555	11.69
B767-300 ER	413,000	92.40	200.0	2,556	14,006	12.50
B777-200 Baseline	537,000	95.42	185.0	1,092	5,153	9.63
B787-8 pre	478,000	93.80	220.0	32	169	11.45
DC10-10	458,000	93.32	195.0	119	622	10.90
DC-8	358,000	96.12	196.0	79	472	11.19
DC-9-30	109,000	92.40	155.0	8	44	8.49
MD-11	633,000	77.54	206.0	44	240	11.58
MD-83	161,000	94.76	195.0	739	4,322	12.54
MD-90	168,500	93.96	193.0	214	1,283	12.29

Aircraft Name	Critical Aircraft Total Equiv. Covs.	Max. Allowable Gross Weight	PCN at Indicated Strength A(552)	B(295)	C(147)	D(74)
A300 B4 std	1,365,963	434,944.4	62.1	73.5	85.1	95.2
A318-100 std	>10,000,000	148,189.5	33.6	36.3	[illegible]	40.9
A319-100 std	6,366,010	174,640.1	44.4	47.4	50.1	52.3
A320-100	1,474,734	186,268.9	51.2	54.1	56.7	58.9
A330-200 std	400,263	639,943.1	70.8	[illegible]	99.7	115.8
A340-200 std	388,029	764,511.7	71.0	83.7	100.1	116.3
A380 2D	267,332	1,514,318.0	73.7	87.5	103.8	119.0
B717-200	>10,000,000	147,214.7	43.6	45.8	47.7	49.2
B727-200 basic	274,674	233,290.4	65.5	69.7	73.4	76.3

PCN Results-
B subgrade

Software
FAA PAVEAIR

- **Background**
  - A joint initiative between the FAA and the National Association of State Aviation Officials (NASAO) to develop a system for sharing information to optimize the expenditure of funds.
  - An Internet (Web) based system was deemed to be the best option considering the mature status of web-based applications.
  - The FAA also has a need for system-wide dissemination and analysis of the performance of FAA sponsored pavement projects.
  - A collection of airport pavement design and evaluation computer programs has also been developed and a dedicated PMS software application would tie these programs together.

Software
FAA PAVEAIR

- **Program Requirements**
  - Web-based application that provides a system for easy dissemination of information for airport pavement construction, maintenance, and management.
  - Data for multiple airports available on a single server connected to the web
  - Make the complete application available for free download:
    - As a set of installation files.
    - Full source code.
    - Documentation for installation and operation.
  - Suitable for installation and use on:
    - Single PC
    - Private network
    - Intranet or Internet.

Software
FAA PAVEAIR

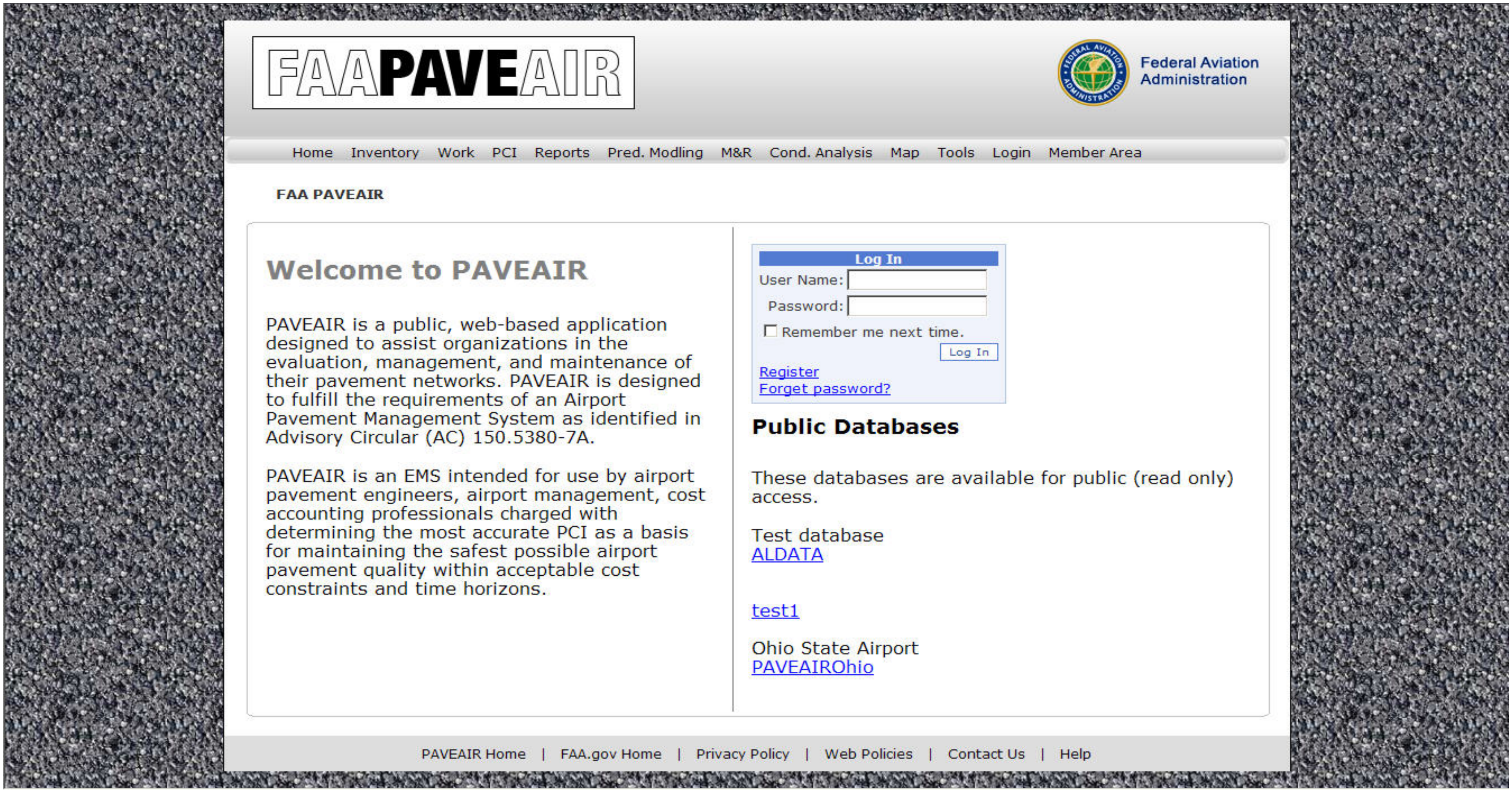
- **Current Status– Subject to Testing and Reviews**
  - The development phase of alpha version should be complete by September 2009
  - Testing is anticipated to continue for approximately one year
  - The release of a beta version should take place prior to September 2010
  - The first release of FAA PAVEAIR will have the same functionality of MicroPAVER version 5.3.
  - *Tentative first deployment – September 2010*.

Software
FAA PAVEAIR

- **Possible Implementations**
  - By the FAA for AIP projects.
  - By FAA regions for small airports.
  - By state DOT's for GA airports (NASAO interest).
  - By consulting and engineering services companies for private or customer only access.
- **Will continue support and development after initial deployment; for example include functions to comply with existing FAA GIS Standards.**

Software

FAA PAVEAIR – Home Page



Software
FAA PAVEAIR – Work Page

FAA PAVEAIR

Federal Aviation Administration

PAVEAIR Home Profile Password Data Management Logout qjia

FAA PAVEAIR : Member Area : Work

Network	1	Pike County Commissioners	test	
Branch	202	Apron		
Section	562	C	APRON B	AIRPORT ROAD
Work History	848	9/13/2003	New Construction - AC	

WorkTrackingID	848
SectionID	562
DateTime	9/13/2003 12:00:00 AM
Work	New Construction - AC
Type	NC-AC
Project	FAA AIR 21
Phase	
Quantity	0
Thickness	38.1000000001524
ThicknessUnit	mm
Cost	0
MaterialType	Asphalt Concrete
Material	ODOT 448
Comment	ODOT 448
WorkCompleted	True
MajorMR	True
BackCalculated	
WorkAreaUnit	m²
WorkLinearUnit	m
WorkThicknessUnit	in
WorkQuantityUnit	m²
QuantityUnit	SqFt

Update Cancel

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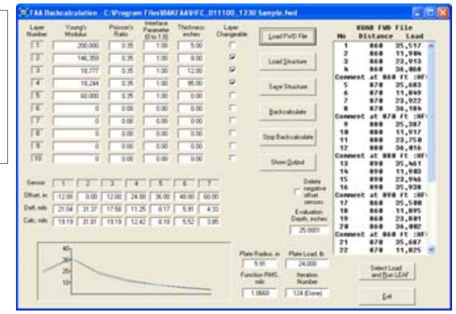
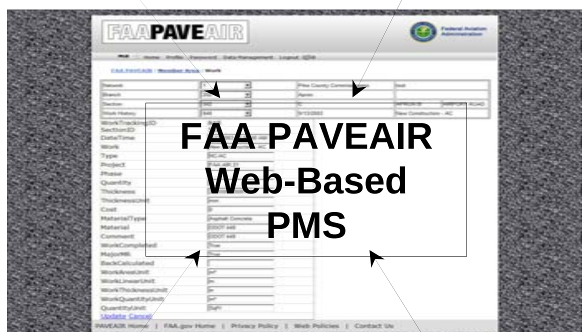
Software

FAA PAVEAIR – Integration

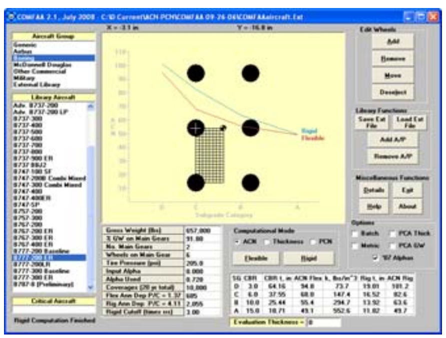
FAARFIELD Thickness Design

BAKFAA Strength Evaluation



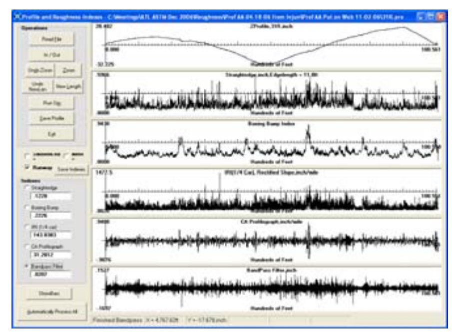


FAA PAVEAIR Web-Based PMS



COMFAA PCN Load Rating

ProFAA Roughness Condition Evaluation



Research Projects
Gyratory Mix Design

- **Objectives**
  - Establish N_{design} for P- 401, Plant Mix Bituminous Pavement.
  - Revise P-401 Specifications using the Superpave Gyratory Compactor.
  - Run verification testing on a variety of well performing HMA mixes.
  - In parallel with and complimentary to an FAA sponsored study being performed by ERDC at WES.

Research Projects
Gyratory Mix Design

- **Phase 1:**
  - Determine N-design equivalent to 75-blow Marshall
- **Phase 2:**
  - Validate N-design with performance tests
  - Finalize N-design
- **Phase 3:**
  - Draft Superpave specification (New P-401)

Research Projects

Gyratory Mix Design

- **Well performing Mixes**

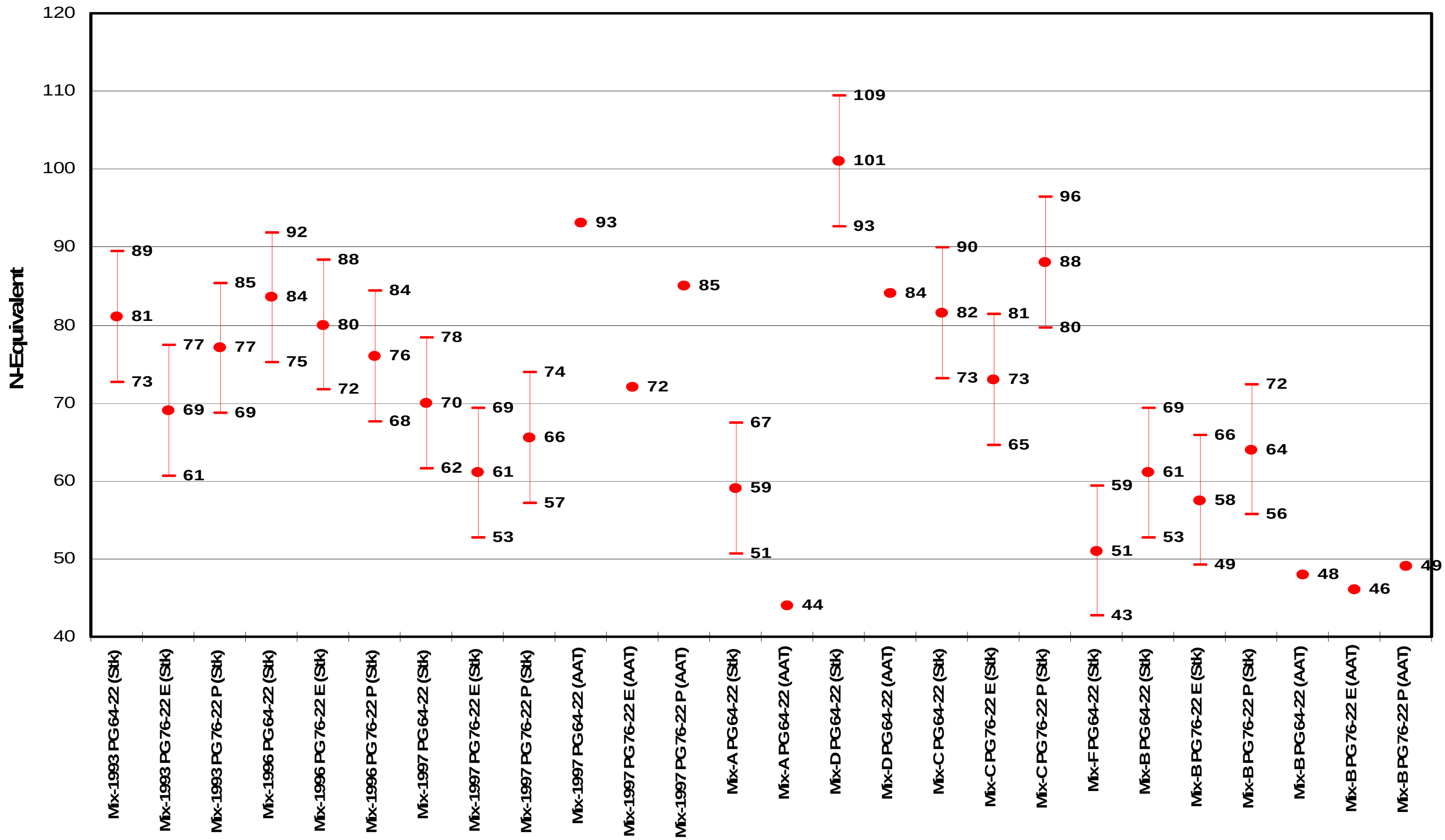
Mix Code	Aggregate Type	Nominal Maximum Aggregate Size	Binder Grade		
			PG 64-22	PG 76-22 SBS Modified	PG 76-22 PE-Modified
Mix–E1993	Gneiss	12.5 mm	X	X	X
Mix–E1996	Dolomite/granite	19 mm	X	X	X
Mix–E1997	Dolomite	25 mm	X	X	X
Mix-A	Basalt	19 mm	X		
Mix-D	Limestone	19 mm	X		
Mix-C	Crushed Gravel	19 mm	X	X	X
Mix-F	Argillite	12.5 mm	X		
Mix-B	Diabase	19 mm	X	X	X

Research Projects
Gyratory Mix Design

N_{design} Summary

	FAA
Minimum	44
Maximum	104
Mean	72
Std. Dev.	15
COV, %	21.0

Research Projects
Gyratory Mix Design



Research Projects
Gyratory Mix Design

- **Phase 2: Performance Evaluation**
  - Evaluate effect of N_{des} on performance with respect to:
    - Asphalt content and/or gradation changes
    - Rut resistance: AMPT flow number & APA
    - Compatibility: compaction curve
    - Durability: film thickness & binder content

Research Projects

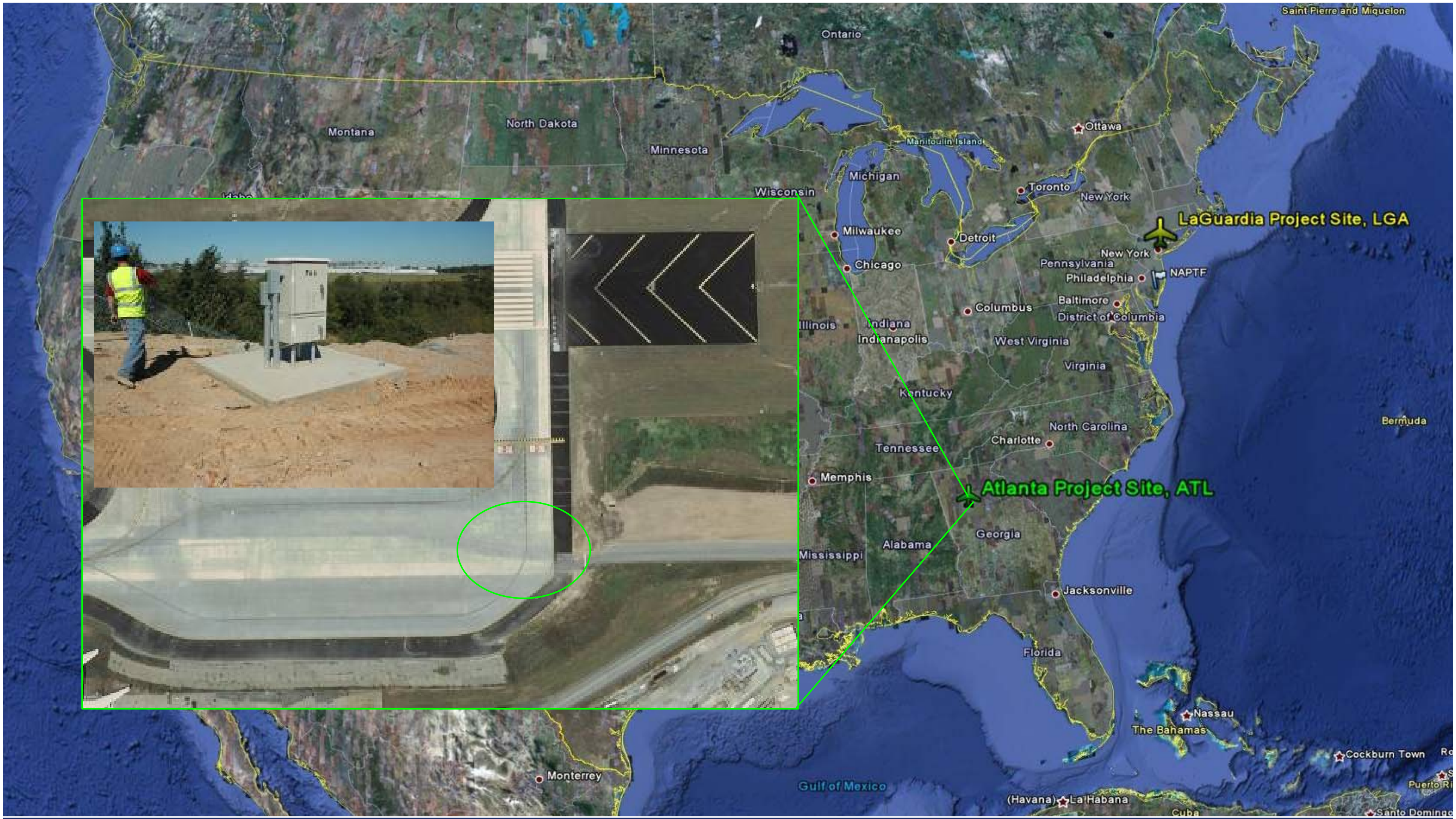
Gyratory Mix Design

Phase 2 Mix Designs

Mix Name	Aggregate	NMAS	Binder Grade
Airport E/1993	Gneiss	12.5 mm	AC 20
Airport E/1997	Dolomite	25 mm	PG 82-22 PG 64-22
Airport A	Basalt	19 mm	PG 64-22
Airport D	Limestone	19 mm	PG 70-22
Airport C	Crushed gravel	19 mm	PG 64-28
Airport F	Argillite	12.5 mm	PG 64-22
Airport B	Diabase	19 mm	PG 64-22
Oceana*	Granite	19 mm	PG 70-22

* New Mix – poor performer

Research Projects
Field Instrumentation - ATL



Research Projects
Field Instrumentation - ATL

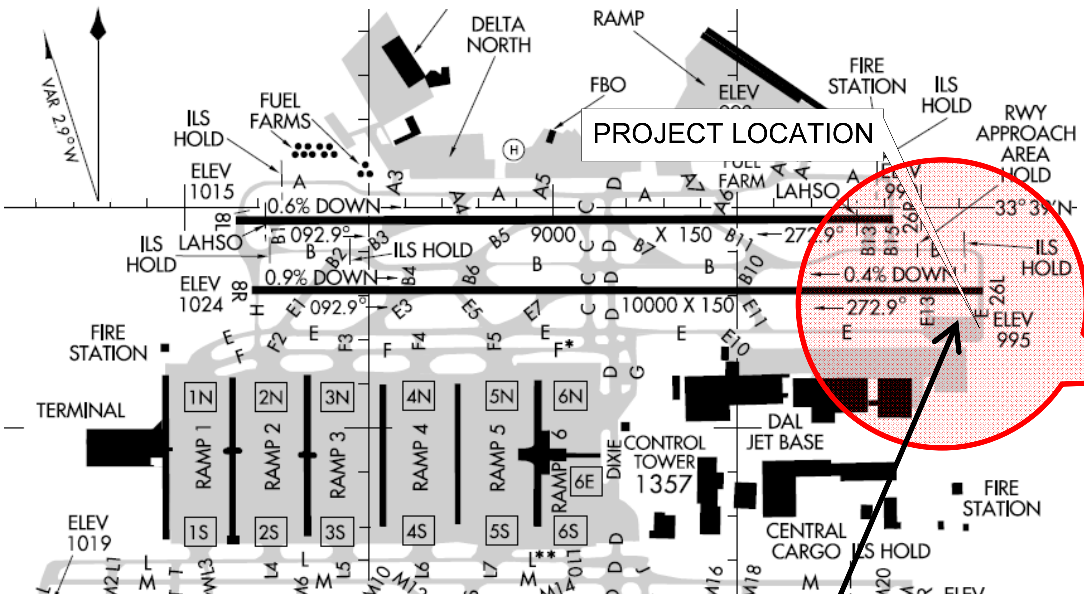
- **Why**
  - – Current FAA design method does not consider slab curling or top-down cracking modes for rigid slabs.
- **Objectives**
  - – Obtain in-situ data on vertical slab movements
  - – Monitor slab data over an extended period.

Research Projects
Field Instrumentation - ATL

- **History**
  - Oct 2006:
    - Construction Completed with 64 Sensors installed
    - Initial data collected using portable data system
  - Mar 2007:
    - Permanent data collection and power generation system installed
  - Aug 2007:
    - Lightning Strike to System
  - Aug 2008:
    - Reinstalled Data Acquisition System & installed lightening suppression system
  - Jan 2009:
    - Installed New Data Acquisition System

Research Projects

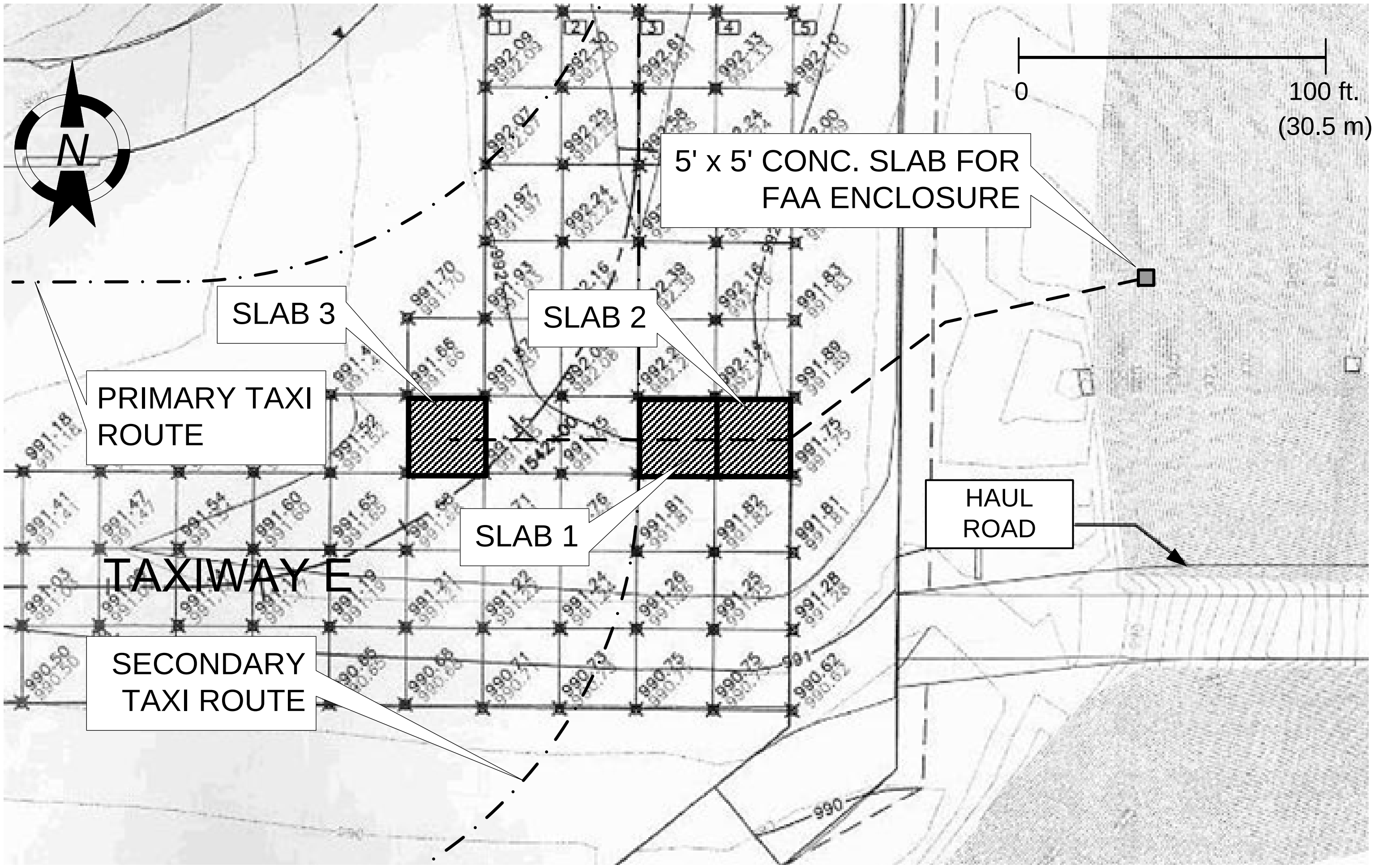
Field Instrumentation - ATL



RUNWAY 26L

Project Location – Taxiway E

Research Projects
Field Instrumentation - ATL



Research Projects
Field Instrumentation - ATL

Research Projects

Field Instrumentation - LGA

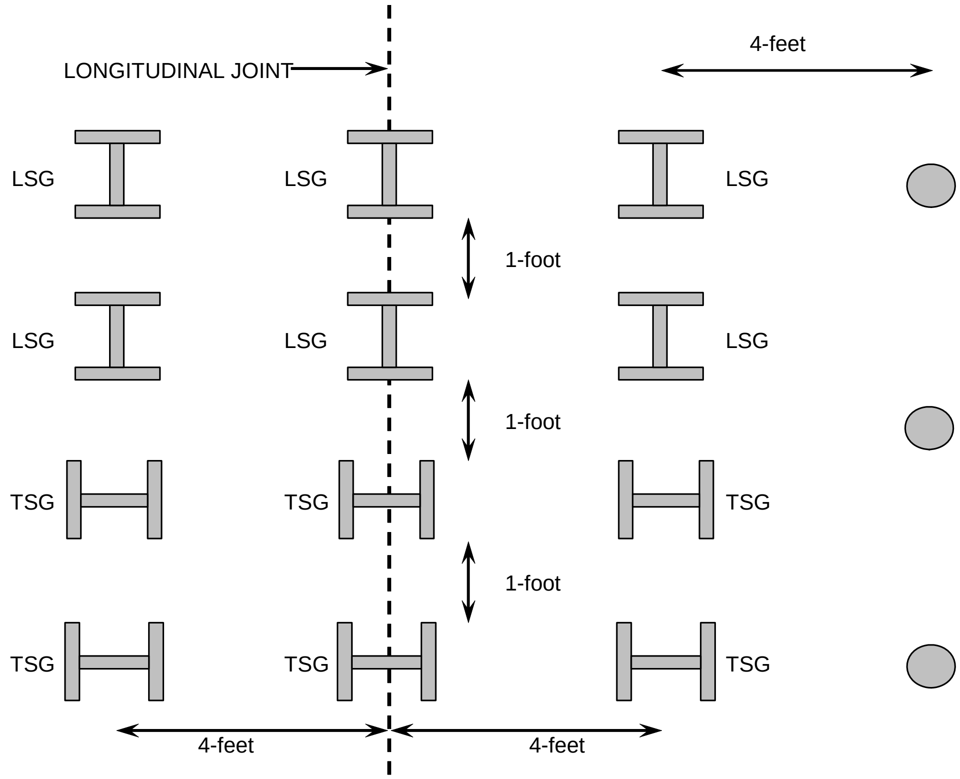
Research Projects
Field Instrumentation - LGA

- **Why**
  - Very little research has been performed on asphalt longitudinal construction joints even though they are a known maintenance issue
  - No one has instrumented the joints to evaluate the causes of cracking after construction
- **Objectives**
  - To measure the strains and movement of these joints to better understand the failure/cracking mode
  - Evaluate movement of joint due to environmental effects

Research Projects
Field Instrumentation - LGA

Research Projects
Field Instrumentation - LGA

- **Instrumentation**
  - H Bar Asphalt Strain Gages



Research Projects
Field Instrumentation - LGA

- **Instrumentation Plan Submitted to Port Authority**
  - Port Authority awarded the bid. Bid included:
    - Installation of FAA data collection cabinet
    - Installation of all FAA underground conduit
    - All saw cutting and coring required for gage installation
- **Components**
  - Similar to ATL
  - Campbell Scientific Data Acquisition System
  - Have direct power / no solar panels
  - Remote Access / no phone line
- **Installed gauges on Aug. 17th**

Research Projects
Field Instrumentation - LGA





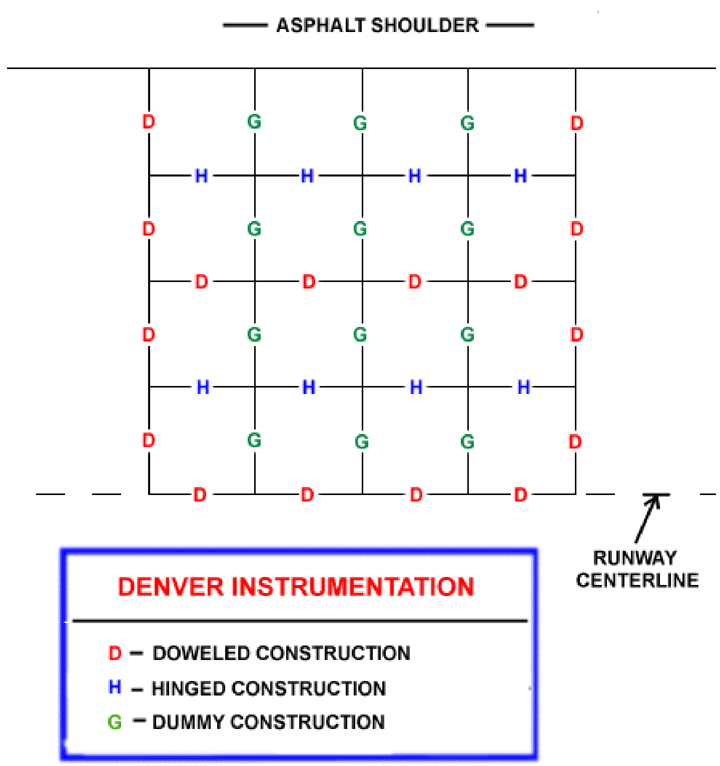

Research Projects
Field Instrumentation - DIA

Research Projects
Field Instrumentation - DIA

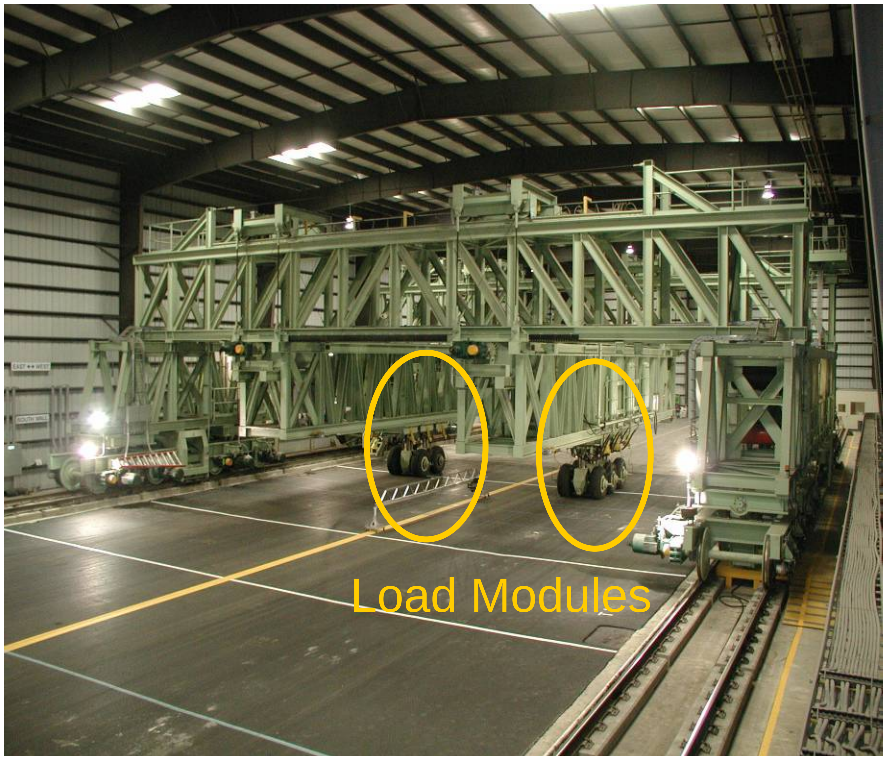
- **History**
  - Work Started in 1992
  - 460 sensors installed
  - Remote access est. 1994
  - Automatic Data Collection and Periodic Site Visits from 1995 to 1999
    - Pavement Response under aircraft loads
    - Environmental parameters
    - Weather Conditions
    - Visual Pavement Inspections
    - Falling-Weight Deflectometer (FWD) Testing
    - Elevation Surveys

Research Projects
Field Instrumentation - DIA

- **Instrumentation**
  - – Strain Gauges
  - – Vertical Displacements
  - – Aircraft Position, Speed and Acceleration
  - – Environmental data



Facilities Upgrade
Pavement Testing Machine



- Commissioned 1999
- Vehicle Weight = 1,200,000 lbs
- Max Tire Load = 75,000 lb (Per Tire)
- 16 Electric Motors - 48 HP Each
- Top Speed – 15 MPH
- Fully Programmable Load Control
- Fully Programmable Position Control
- Laser Data Communication System*
- 8 Camera Closed Circuit Video System*

Facilities Upgrade
Pavement Testing Machine

- **Purpose:**
  - Modify the NAPTF Test Vehicle to accommodate 8- and 10-wheel landing gear configurations.
  - Allow the FAA to conduct full-scale testing of future landing gear designs.
- **New Capabilities:**
  - +/- 5 degrees of steering.
  - Larger rims with redesign for tire removal/installation without bearing removal.
  - Radial tires with greater load capacity than current bias ply tires 66,500 versus 55,700 lb.

Facilities Upgrade
Pavement Testing Machine



Disconnecting Existing Modules

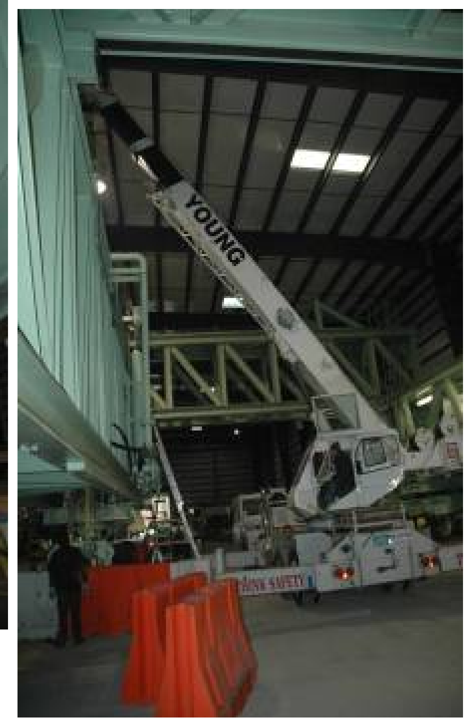
Facilities Upgrade

Pavement Testing Machine

Relocating Existing Modules

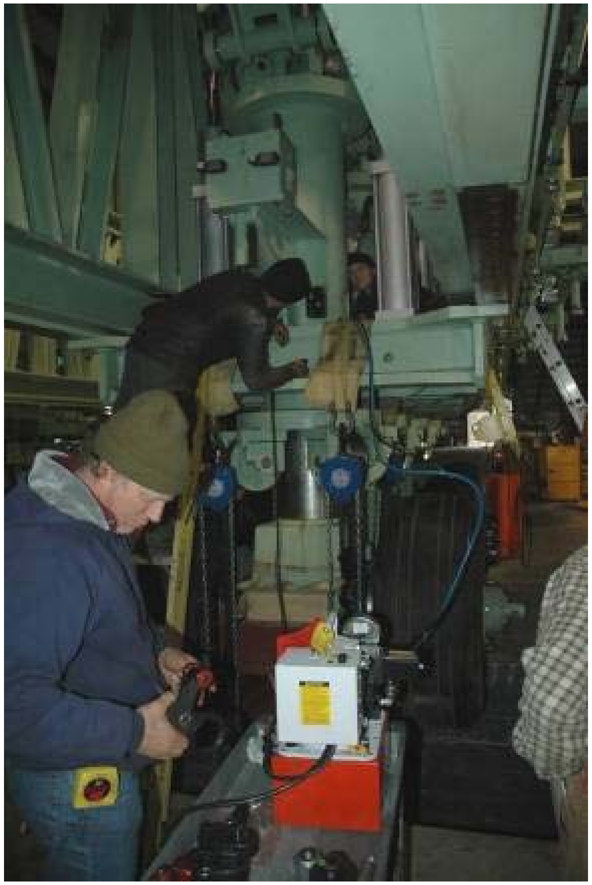
Facilities Upgrade
Pavement Testing Machine





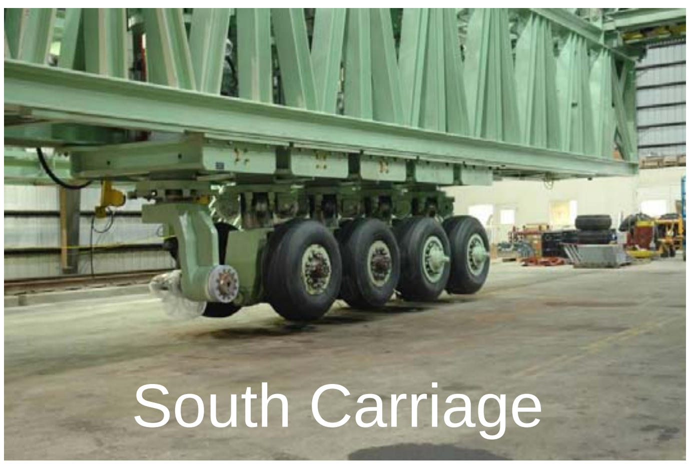
Installing New Modules – Upper Section

Facilities Upgrade
Pavement Testing Machine



Installing New Modules – Lower Section

Facilities Upgrade
Pavement Testing Machine



New Module Installation Completed

December 2008

Facilities Upgrade

Pavement Testing Machine

Electrical Work

Hydraulic Work

Facilities Upgrade
Pavement Testing Machine

Existing Control Cab

Facilities Upgrade
Pavement Testing Machine

New Control Cab

Facilities Upgrade

Pavement Testing Machine

- **Replace Bias Ply Tires and Manufacture New Rims on Existing Load Modules (12 Sets Required).**

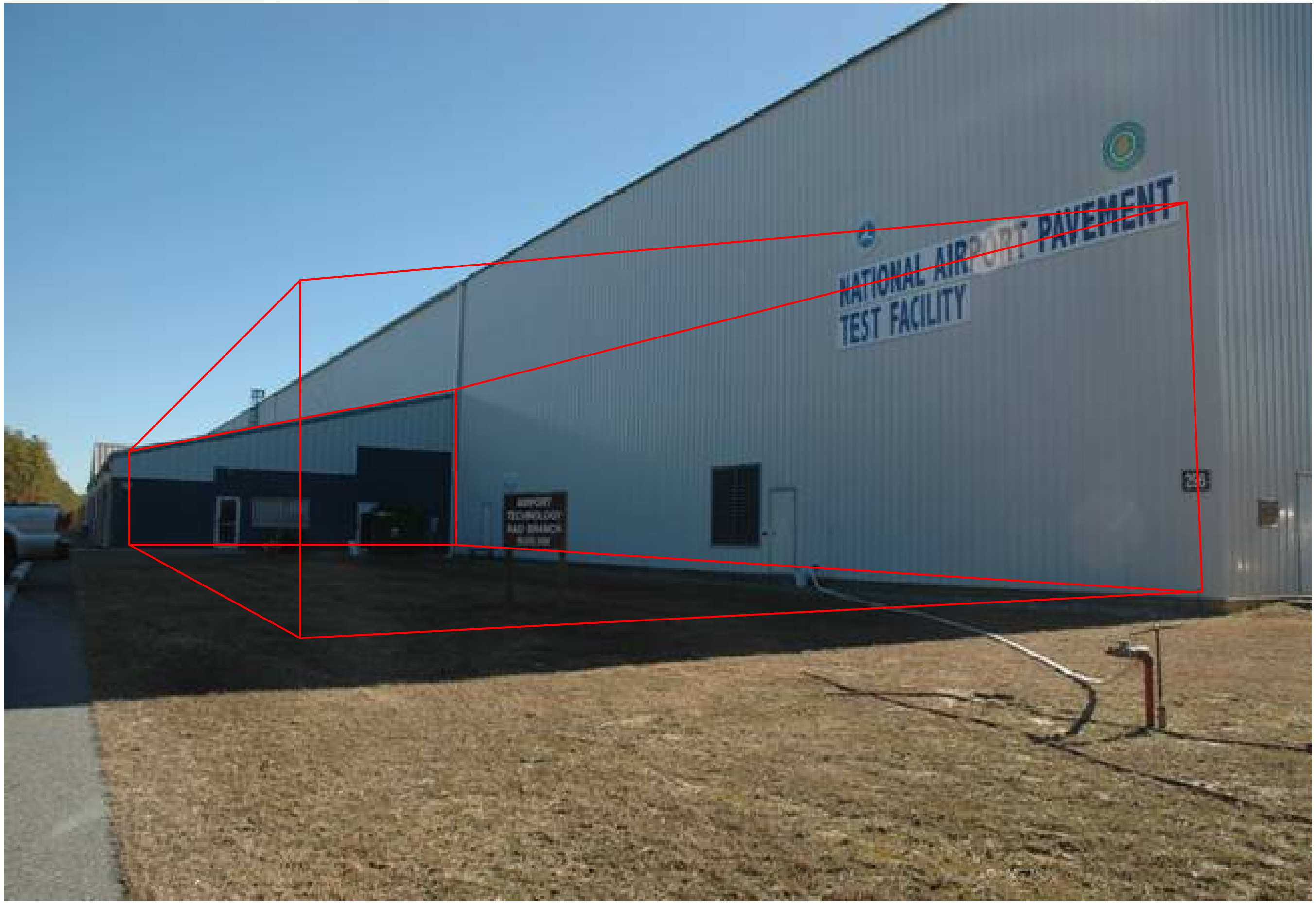
Facilities Upgrade
Materials Testing Lab

- **Design Started – August 2006**
- **Bid Documents Completed – August 2008**
- **100% design review preformed by Philadelphia District Army Corps of Engineers**
- **USACE to administer the construction contract**
  - $1.1 million estimated construction cost
- **FAA to provide construction oversight**
- **Projected contract award <u>February 2009</u>**

Facilities Upgrade
Materials Testing Lab

- **120 x 48 ft building (~5500 sq ft)**
- **Designed for Soils, Aggregates Concrete and Asphalt testing**
- **AMRL Certified**
- **CCRL Certified**
- **Material Testing for others**

Facilities Upgrade
Materials Testing Lab

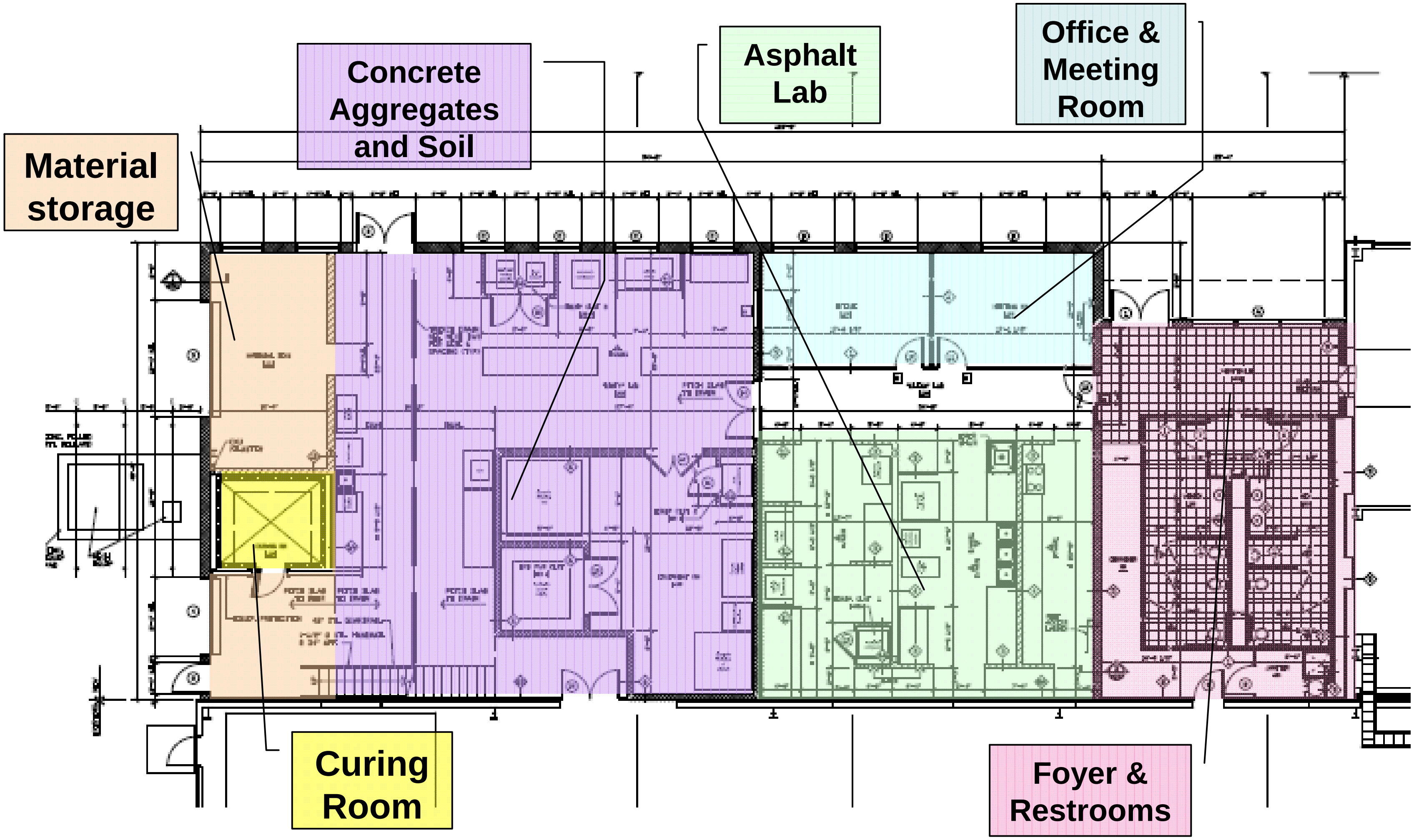


Facilities Upgrade
Materials Testing Lab

Facilities Upgrade
Materials Testing Lab

Facilities Upgrade

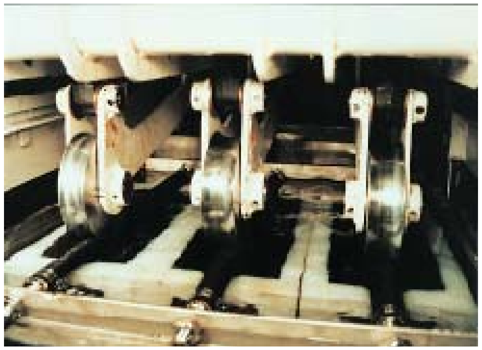
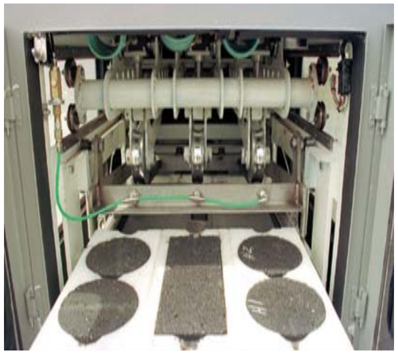
Materials Testing Lab



Facilities Upgrade
Materials Testing Lab

- **Asphalt Pavement Analyzer (APA)**
- **Contact Pressure**
  - through rubber hose
    - Up to 250-psi
    - 100-psi (standard APA)
  - through aluminum wheels
    - Up to 500-psi
    - 200-psi (standard APA)
- **Variable rate of loading**




Facilities Upgrade
Heavy Vehicle Simulator

- **Proposed Research Using HVS**
  - ✈High Tire Pressure Testing
  - ✈Warm Mix Asphalt
  - ✈Stone Matrix Asphalt
  - ✈Asphalt Overlays of PCC
  - ✈Recycled Asphalt Pavement
  - ✈Polymer Modified Binders
  - ✈Shear failure of HMA

FEDERAL AVIATION ADMINSITRATION

F/HWD ROUND-UP 2010

MAY 2010

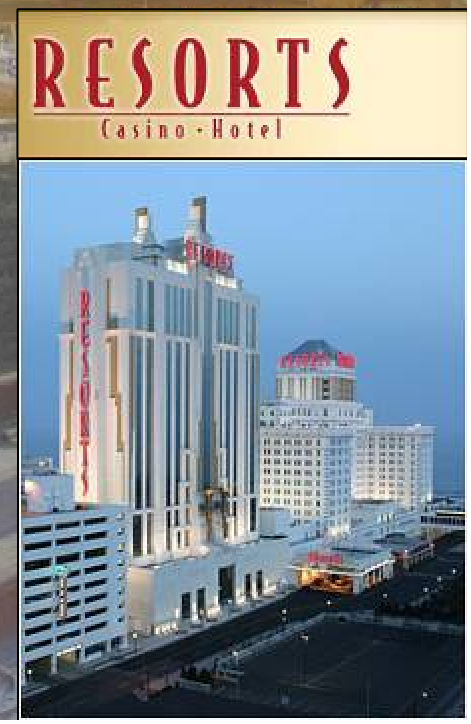
NAPTF - Atlantic City, New Jersey

2010 FAA WORLDWIDE AIRPORT TECHNOLOGY TRANSFER CONFERENCE

"NEXT GENERATION OF AIRPORT TECHNOLOGY"

April 20 - 22, 2010

Atlantic City, New Jersey



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THANK YOU

QUESTIONS

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