

FAA Airport Pavement Design Procedure - History



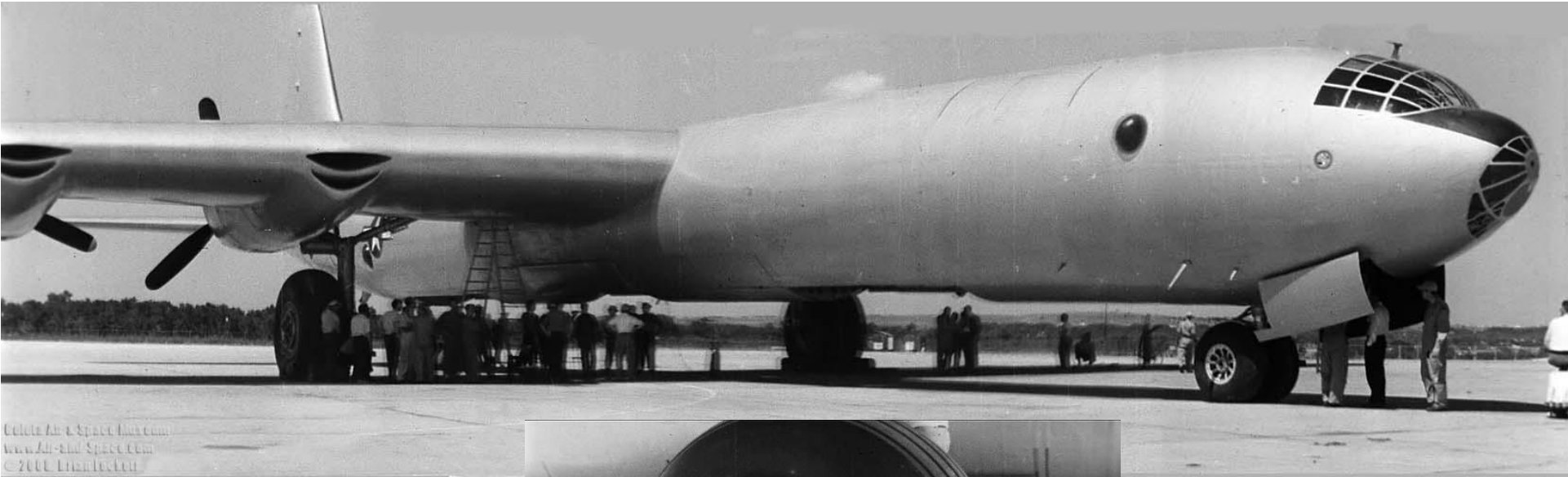
Presented to: ASCE T&DI 2026 International Airfield & Highway
Pavements Conference

Detroit, MI, USA

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FAA Airport Technology R&D

Date: June 28, 2026

1940's through 1970's: B-36 & B-29



Wheel Load
(100,000 – 200,000 lbs)

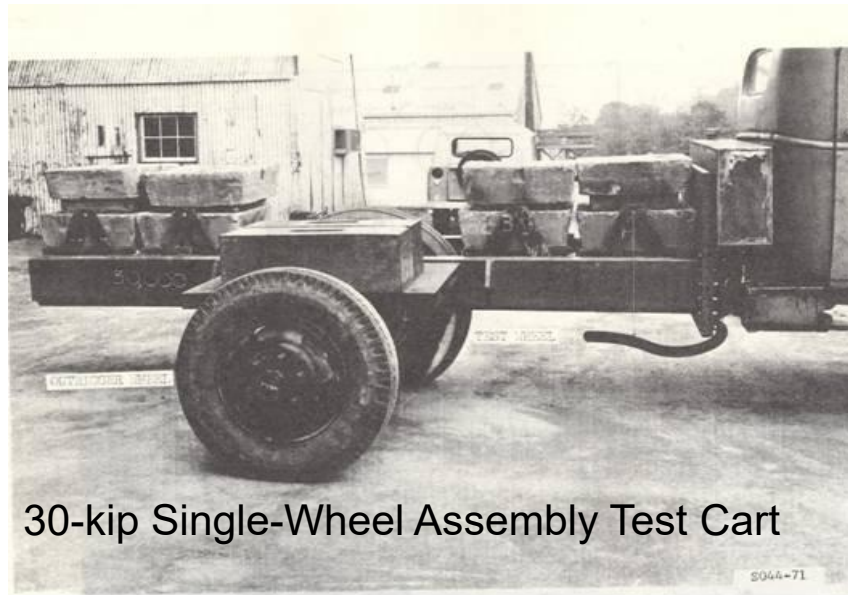




12-Wheel Assembly Test Cart



240-kip Twin-Tandem Test Cart



30-kip Single-Wheel Assembly Test Cart



50-kip Single-Wheel Assembly Test Cart

History

- 30-year period beginning in the 1940s.
- Testing performed by USACE.
- Tests involved full-scale aircraft loading on both flexible and rigid pavements, and overlays.
- Performance data obtained from these tests form the basis of rigid and flexible pavement design and evaluation models incorporated in both Federal Aviation Agency and Tri-Services manuals.

Evolution of FAA Design Procedures

- 1963: Federal Aviation Agency, Advisory Circular 150/5320-8
- “Airport Paving Design Curves Based on Gross Aircraft Weight”
- Precursor to AC 150/5320-6
- No attempt to consider number of departures. (That came later.)

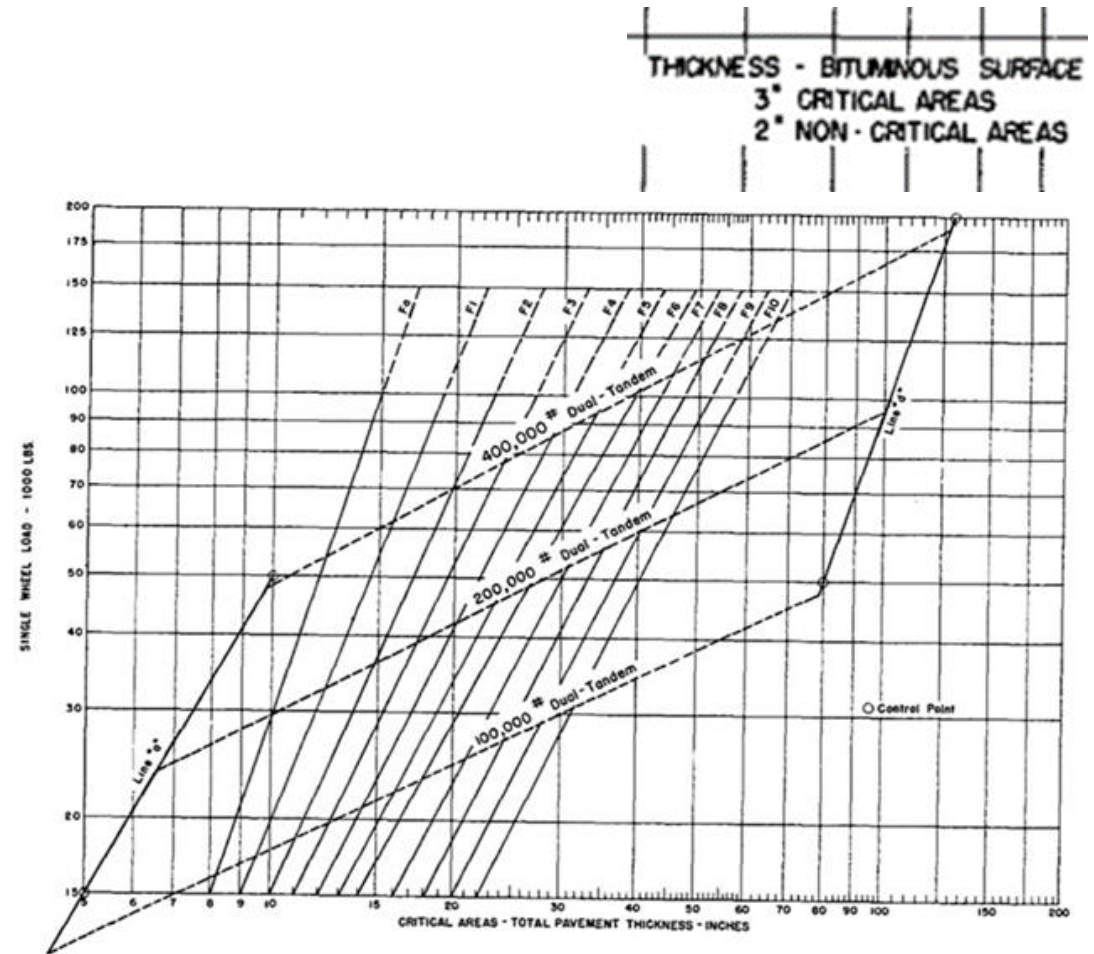
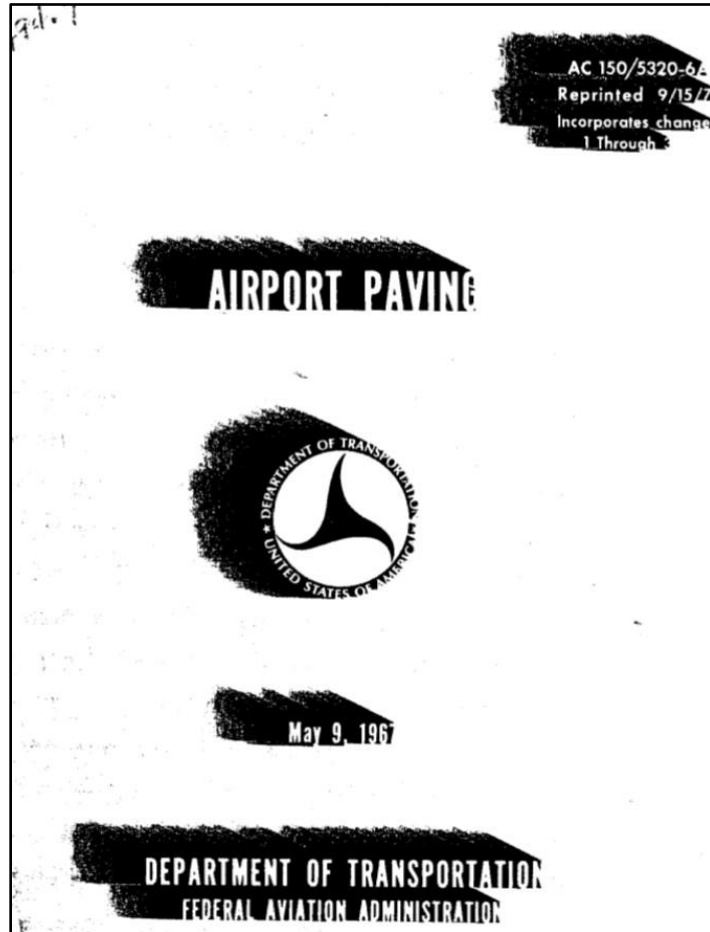


FIGURE 4 DEVELOPMENT OF FLEXIBLE PAVEMENT CURVES - DUAL-TANDEM GEAR

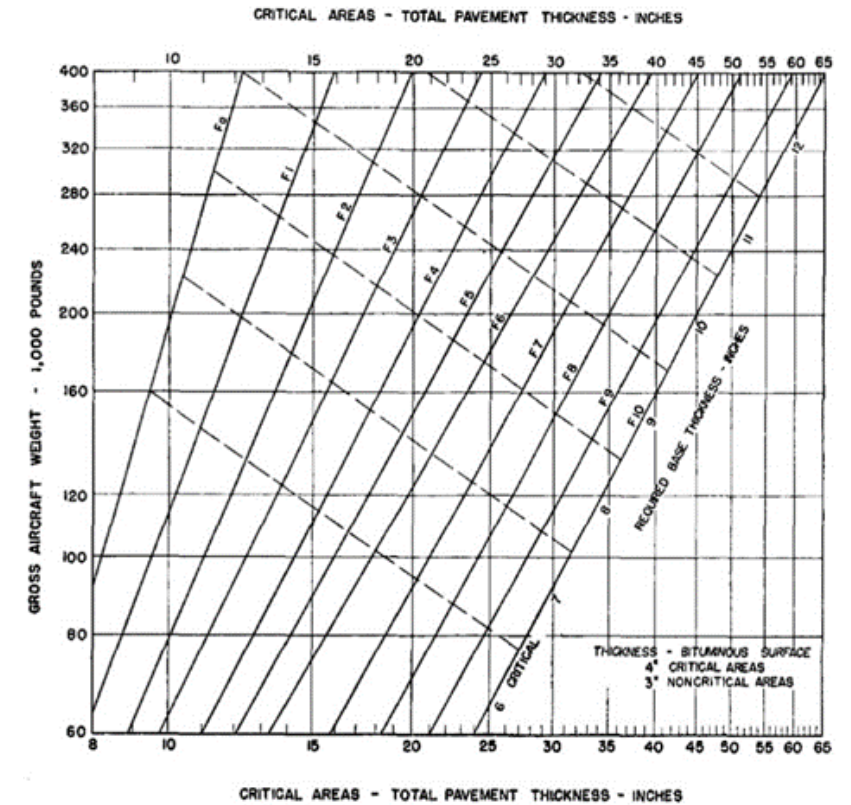
Evolution of FAA Design Procedures



Design Nomograph for Dual-Tandem Gear

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

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Design Charts – FAA AC 150/5320-6D

- Airport Pavement Design and Evaluation (1995)
- Contained nomographs for single-wheel, dual, dual-tandem and specific large aircraft (including B747).
- Design for B777 covered by AC 150/5320-16 (LEDFAA).
- Change 3 (2004) cancelled AC 150/5320-16 and made LEDFAA an alternate procedure for all thickness designs.

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

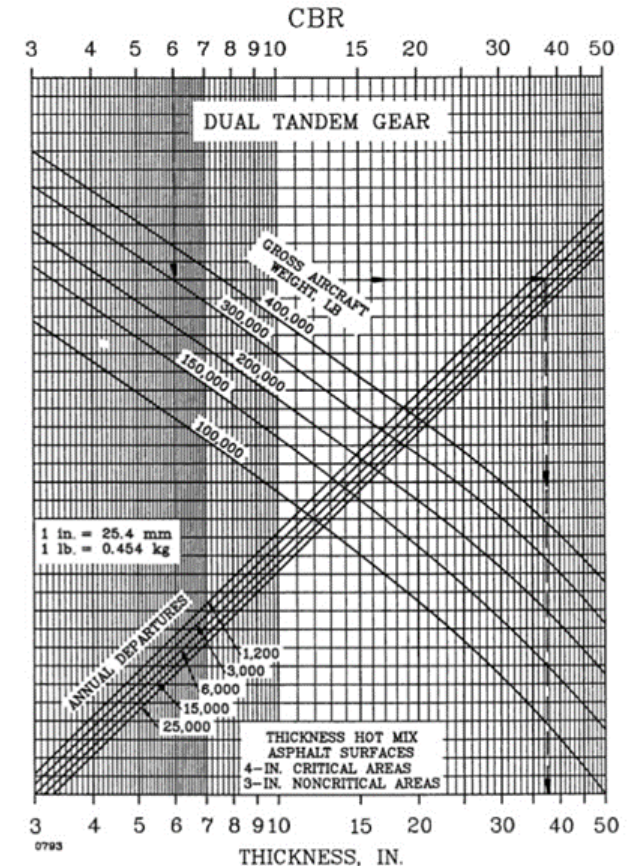


FIGURE 3-4 FLEXIBLE PAVEMENT DESIGN CURVES, DUAL TANDEM GEAR

Design Charts – FAA AC 150/5320-6D

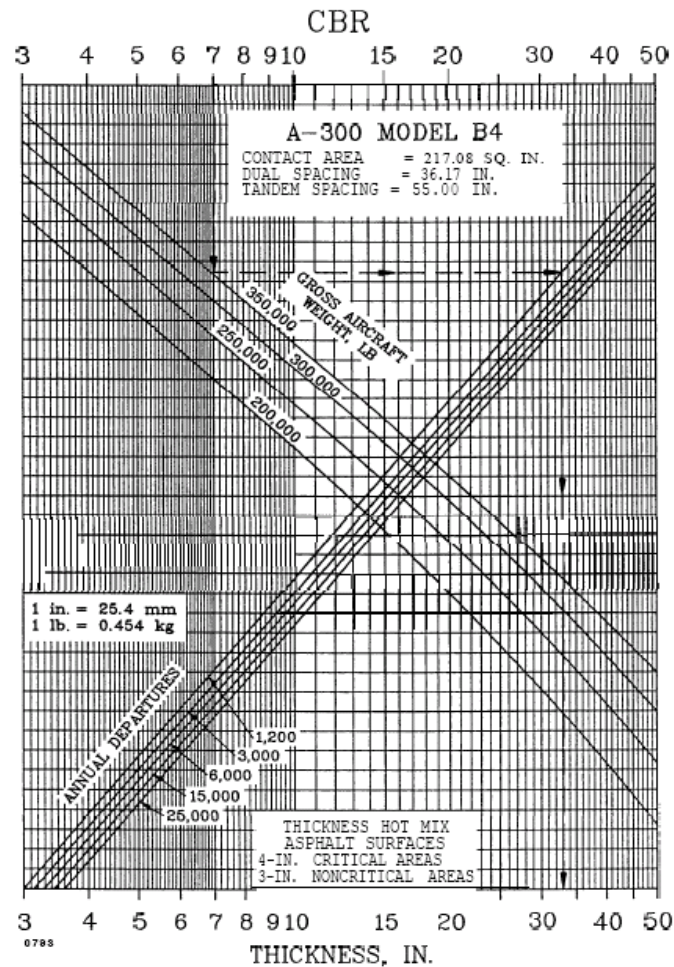


FIGURE 3-6 FLEXIBLE PAVEMENT DESIGN CURVES, A-300 MODEL B4

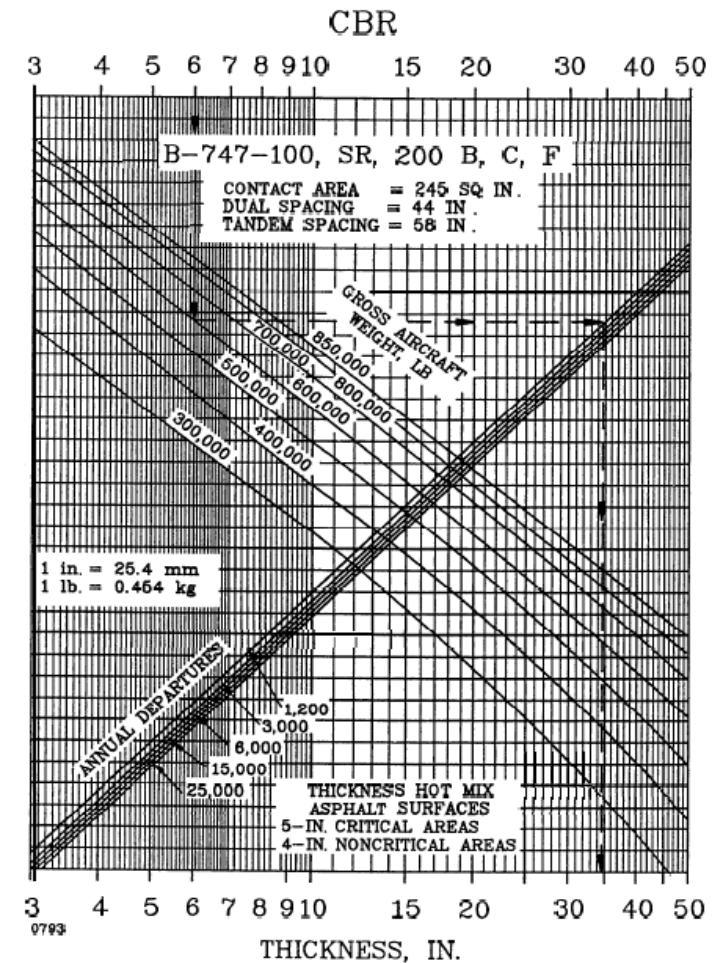
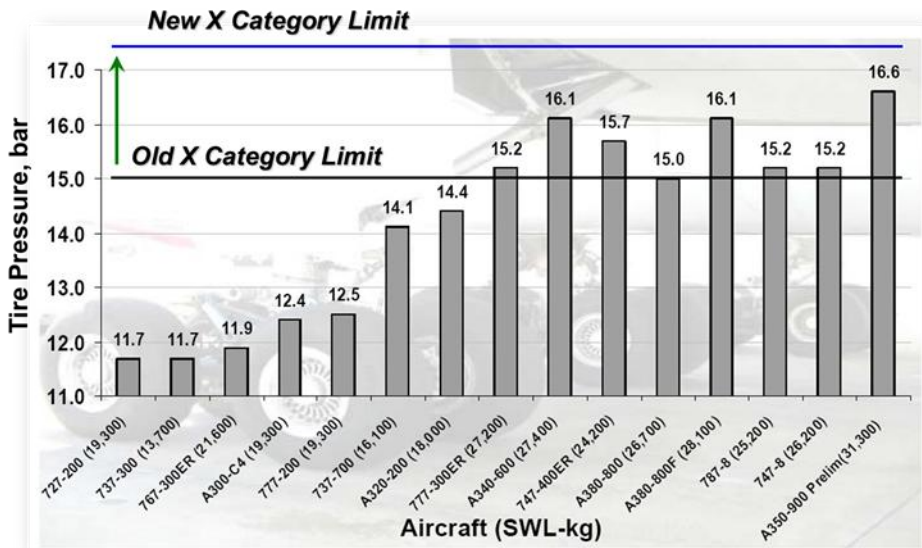
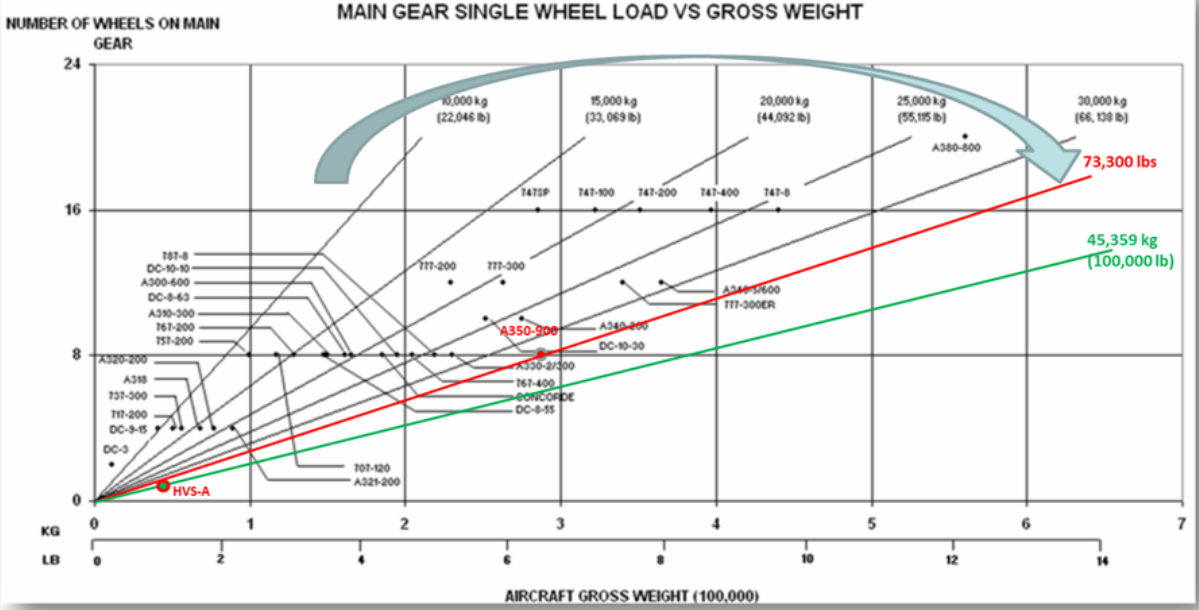


FIGURE 3-7 FLEXIBLE PAVEMENT DESIGN CURVES, B-747-100, SR, 200 B, C, F

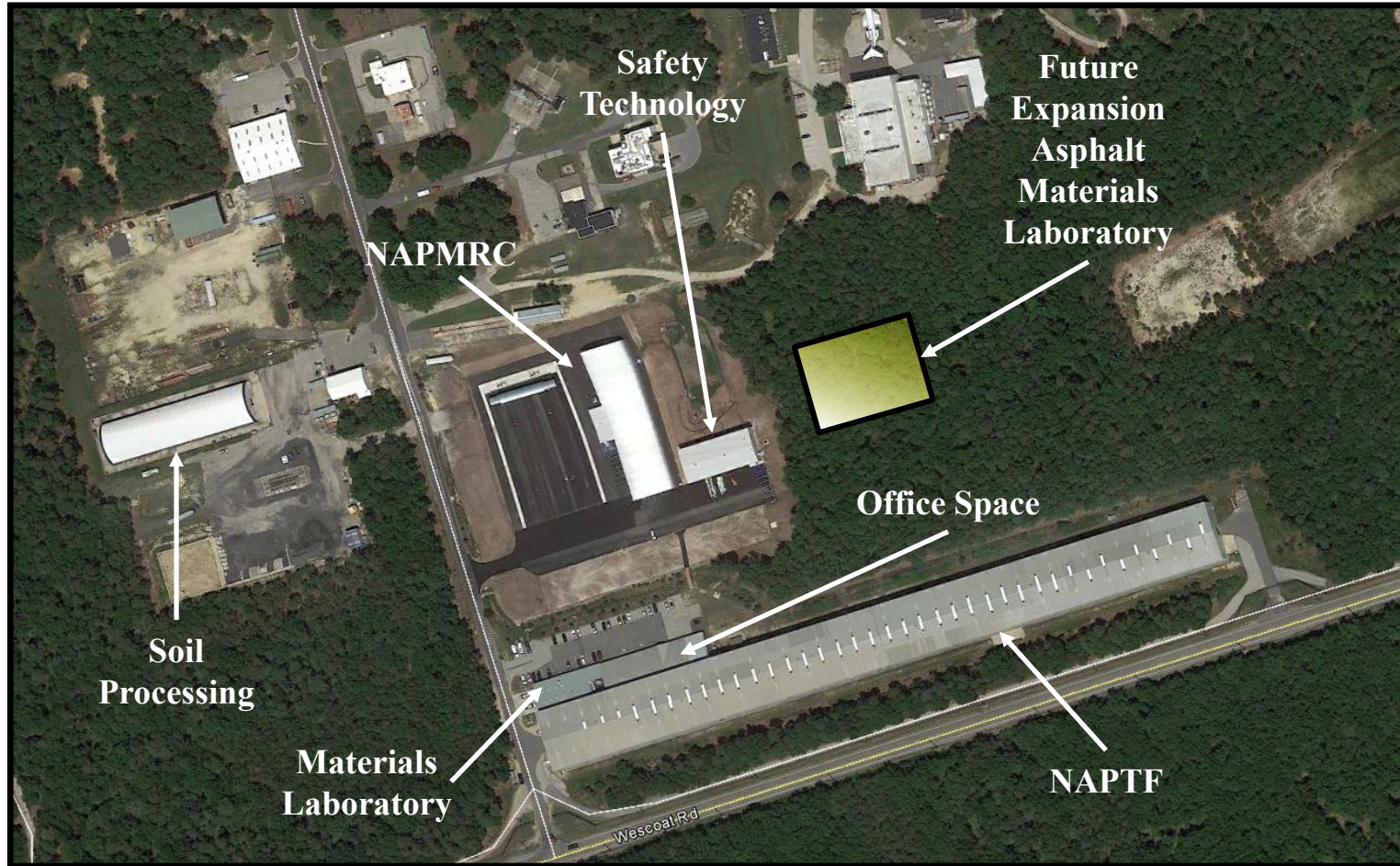


FAA Airport Technology R&D Program

- 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).



Airport Pavement R&D Program - Facility Layout



National Airport Pavement Test Facility (NAPTF)

Facility Facts:

- FAA / Boeing (CRDA) Partnership
- 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)

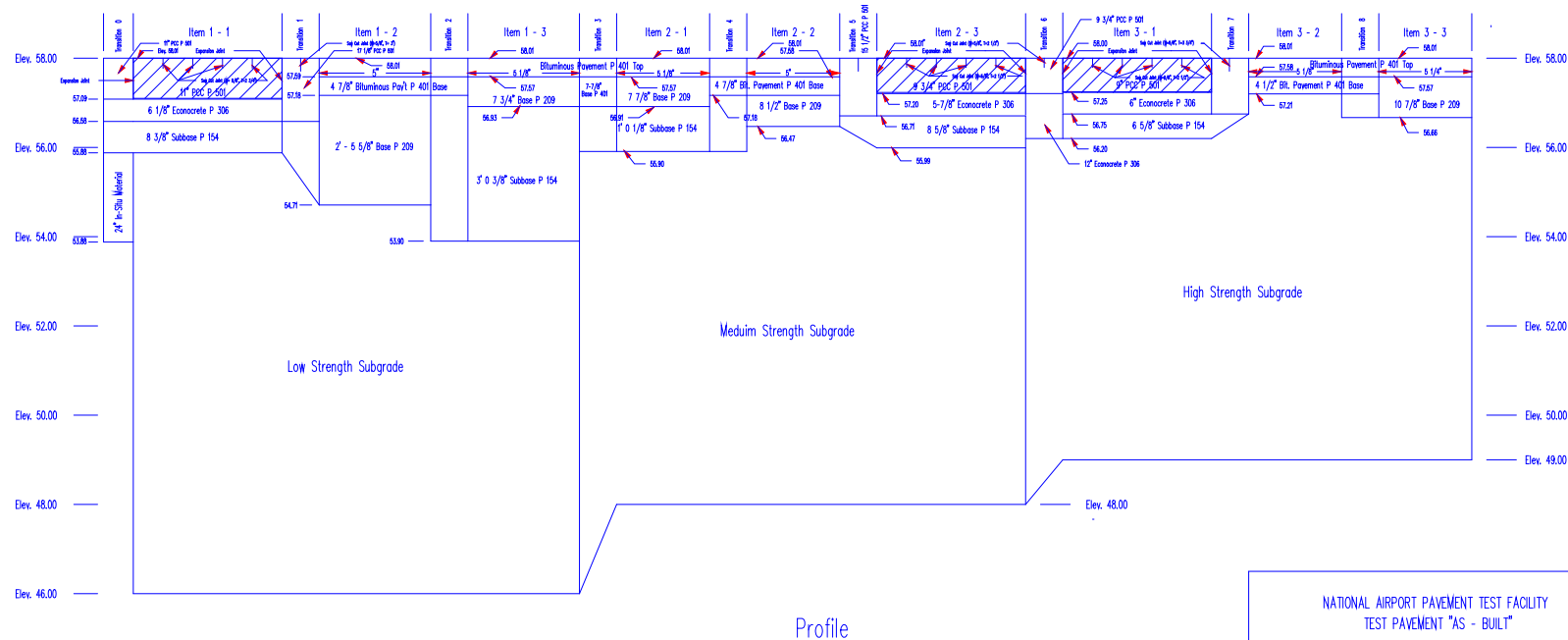
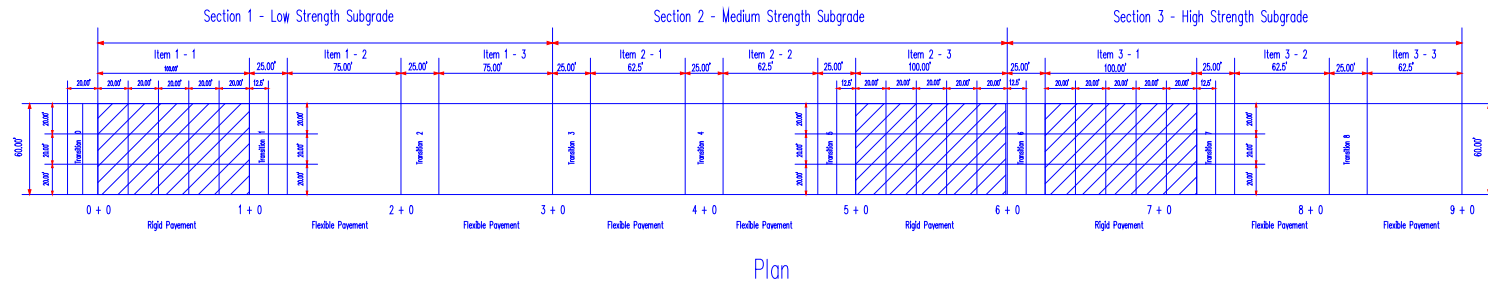
Facility Facts:

- 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 48°F (9°C) to 150°F (67°C) at a depth of 2-inches (5 cm) below pavement surface.
- 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)

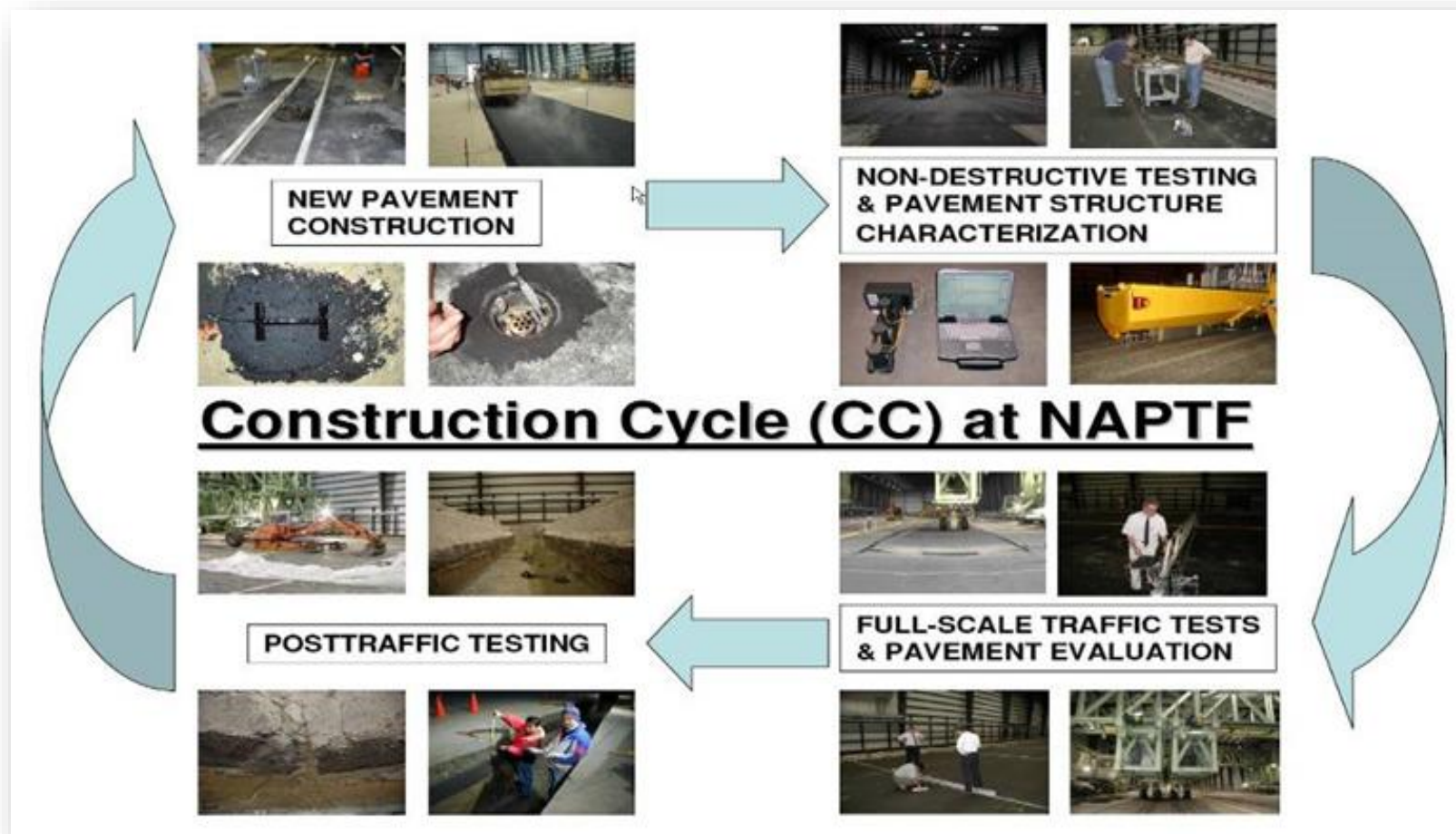




1. 900 feet long 60 feet wide test area
2. Three different subgrade Types – CBR 4, 8, 16

NATIONAL AIRPORT PAVEMENT TEST FACILITY TEST PAVEMENT "AS - BUILT"			
PLAN & PROFILE			
SUPERSED BY: 001	DRAWN BY: 001	SCALE: 1" = 30' - 0"	DATE: 6/1/99

Construction Cycle (CC) at NAPTF



Testing at NAPTF

- CC1:
 - 1999-2001
 - 6 flexible pavements, 3 rigid pavements
 - Low (CBR $\approx$ 4), medium (CBR $\approx$ 8), and high (CBR $\approx$ 20) strength subgrade
- CC3:
 - 2002
 - 4 flexible pavements over low strength (CBR $\approx$ 4) subgrade
- CC2
 - 2004
 - Test Strip and a free-standing test slab
 - 3 rigid pavements over medium strength (CBR $\approx$ 8) subgrade
 - Three different support conditions

Testing at NAPTF

- CC2-OL:
 - 2005
 - Rubblized CC2 pavements (after completion of CC2 Testing)
 - 5-inch thick HMA overlay
- CC4:
 - 2007 Phase-I
 - 2008 Phase-II
 - IPRF project (unbonded concrete overlays)
- CC5
 - 2008
 - Test strip
 - 4 flexible pavements over low strength (CBR $\approx$ 4) subgrade
 - Effect of landing gear spacing on pavement performance
 - Effect of subbase quality on pavement performance.

Testing at NAPTF

- CC6
 - 2010
 - Investigate the relative effect of concrete strength on test item performance.
 - Investigate the effect of subbase material (cement stabilized vs. asphalt stabilized) on performance.
 - CC6 test items give 6 combinations of concrete strength and subbase type.
- CC7
 - 2013
 - Verify/refine HMA fatigue model incorporated in FAARFIELD.
 - Perpetual Pavements.
 - Overload Study.
 - Asphalt treated drainable base.

Testing at NAPTF

- CC8
 - 2015
 - Obtain slab strength (rupture strength) for full-scale slabs under a monotonically increasing aircraft gear load.
 - Evaluate the fatigue performance of slabs under full-scale, non-wandered loading.
 - Evaluate the effect of higher strength/thinner slabs vs. lower strength/thicker slabs on rigid pavement fatigue performance, and compare the results to FAARFIELD's rigid failure model.
- CC9
 - 2019
 - Verify, refine, or modify the FAARFIELD HMA fatigue cracking model with full-scale test data.
 - Compare the sensitivity of crushed aggregate base course thickness in FAARFIELD with full-scale testing.
 - Evaluate the effects of geosynthetics on airport pavement performance
 - Evaluate performance of Cement-Treated Permeable Base (CTPB)
 - Overload test area is a follow-up to previous overload tests conducted on CC7

LEDFAA 1.3 (2004)

“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.”

The screenshot shows the LEDFAA software window titled "LEDFAA - Modify and Design Section NewFlexible in Job Samples". On the left, a "Section Names" list includes ACAggregate, AConFlex, AConRigid, NewFlexible (highlighted), NewRigid, PCConFlex, and PCConRigid. Below this is a "Status" field and an "Aircraft" button. At the bottom are buttons for "Back", "Help", "Life", "Modify Structure", "Design Structure", and "Save Structure". The main design area on the right shows a cross-section of a pavement structure with the following layers and properties:

Layer Material	Thickness (in)	Modulus or R (psi)
P-401 AC Surface	5.00	200,000
P-401 St (flex)	8.00	400,000
P-209 Cr Ag	10.00	75,000
Subgrade	CBR = 10.0	15,000

Below the table, it states: "Total thickness to the top of the subgrade, t = 23.00 in". A "Des. Life = 20" field is located at the top right of the design area.

FAA Legacy Design Procedures vs LEDFAA 1.3 (2004)

	AC 150/5320-6D (Chapters 3 - 4)	LEDFAA 1.3
Traffic Model	All traffic converted to equivalent departures of design aircraft	CDF (Cumulative Damage Factor) accounts for mixed traffic
Structural Response Models	•Westergaard's solution for rigid pavements •Boussinesq model used to compute ESWL for flexible	•Layered elastic analysis (LEAF) for flexible and rigid
Thickness Design Method	•CBR equation with alpha factor (flexible) •Apply percent of thickness to basic design for 5000 coverages (rigid)	Failure model relates coverages to structural failure to a suitable response: subgrade strain (flexible) or concrete stress (rigid).
Implementation	Design nomographs (spreadsheet implementation also available)	Desktop computer program

FAARFIELD 1.3 (2009) / 1.4 (2017)

- First released along with AC 150/5320-6E (30-Sep-2009).
- Replaced LEDFAA 1.3 and all paper design charts.
- Similar in look-and-feel to LEDFAA 1.3, but:
 - Real-time 3D finite element for rigid pavement design.
 - Implemented new failure models from NAPTF full-scale tests.
 - Updated overlay design method.
 - Updated aircraft library.

FAARFIELD v 1.42 - Modify and Design Section NewFlex10R in Job AirportB

Section Names
NewFlex10LX
NewFlex10R
NewFlexible

AirportB NewFlex10R Des. Life = 20

Layer Material	Thickness (in)	Modulus or R (psi)
P-401/ P-403 HMA Surface	5.00	200,000
P-401/ P-403 St (flex)	11.00	400,000
P-209 Cr Ag	12.00	38,575
Subgrade	CBR = 7.0	10,500

Total thickness to the top of the subgrade, t = 28.00 in

Status

Airplane

Back Help Life Modify Structure Design Structure Save Structure

FAARFIELD – What Is It?

 **Federal**
 **Aviation**
 **Administration**
 **Rigid and**
 **Flexible**
 **Iterative**
 **Elastic**
 **Layered**
 **Design**

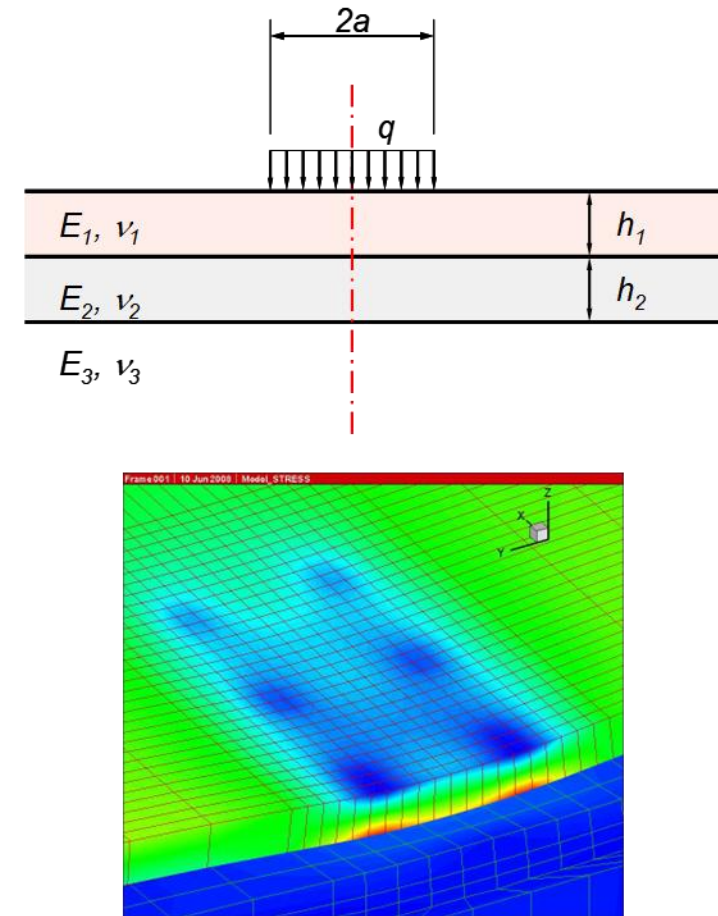
- FAARFIELD is the FAA airport pavement thickness design program.
- First released September 30, 2009.
- Periodic updates posted to web site
- Computer program for Windows operating systems.
- Main program drives three subprograms:
 - LEAF (layered elastic analysis)
 - NIKE3D (3D finite element analysis)
 - INGRID (3D mesh generation)
- NIKE3D and INGRID information:
 - Modified for FAARFIELD by the FAA
 - Distributed in compiled form under a software sharing agreement with Lawrence Livermore National Laboratory (LLNL)

FAA Legacy Design Procedures vs FAARFIELD

	AC 150/5320-6D (Chapters 3 - 4)	FAARFIELD 1.2
Traffic Model	All traffic converted to equivalent departures of design aircraft	CDF (Cumulative Damage Factor) accounts for mixed traffic
Structural Response Models	•Westergaard's solution for rigid pavements •Boussinesq model used to compute ESWL for flexible	•Layered elastic analysis (LEAF) for flexible. •3D finite element for rigid.
Thickness Design Method	•CBR equation with alpha factor (flexible) •Apply percent of thickness to basic design for 5000 coverages (rigid)	Failure model relates coverages to structural failure to a suitable response: subgrade strain (flexible) or concrete stress (rigid).
Implementation	Design nomographs (spreadsheet implementation also available)	Desktop computer program Visual Basic 2005

Structural Models in FAARFIELD

- Both layered elastic (LEAF) and 3D-FEM (NIKE3D) are used in FAARFIELD.
- Flexible pavement design
 - LEAF is used for all structural computations.
 - For flexible, no advantage to using 3D-FEM.
- Rigid pavement design
 - LEAF is used to generate a preliminary thickness.
 - Final iterations are done using a 3D finite element model (3D-FEM).

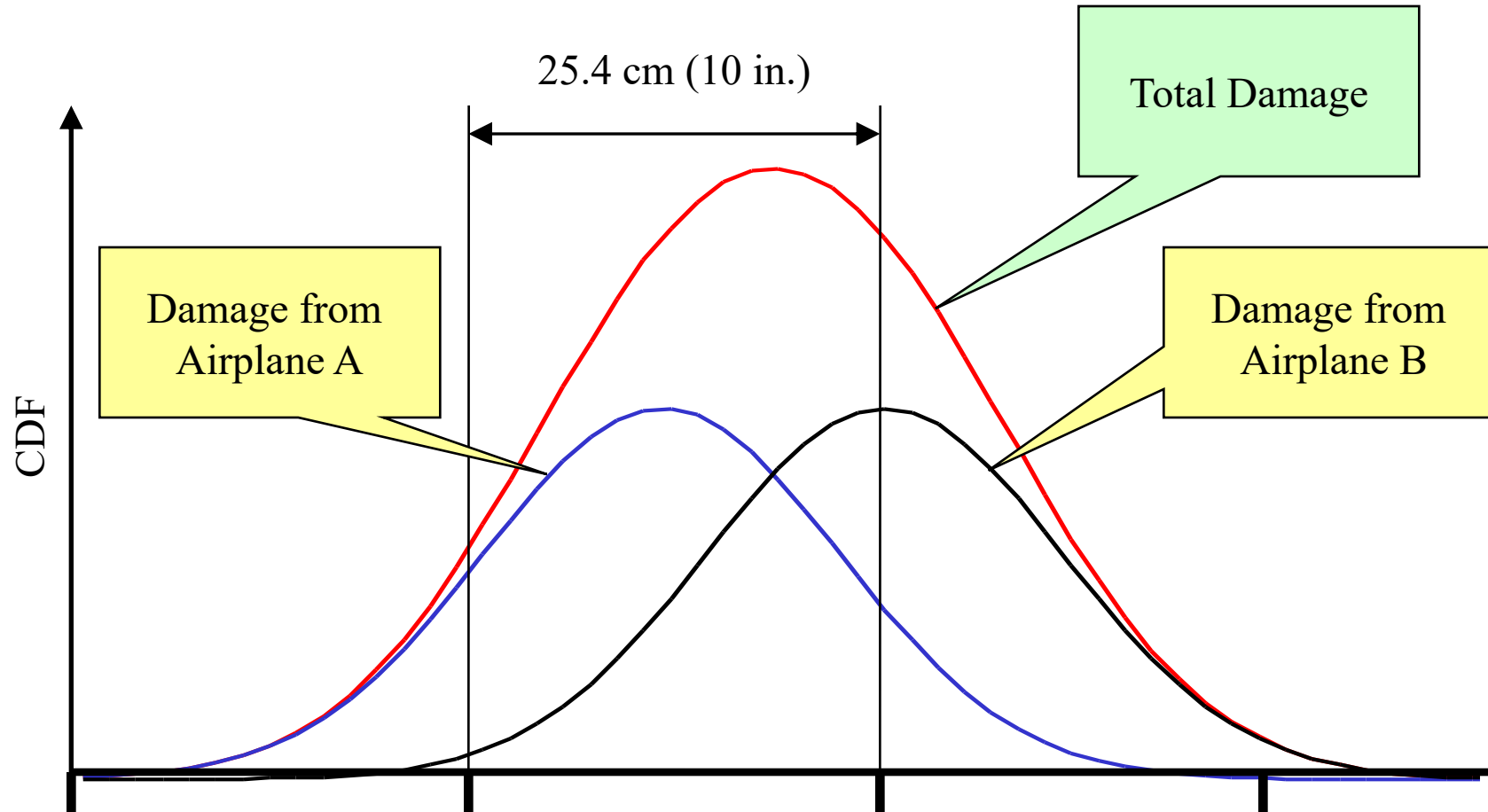


Cumulative Damage Factor (CDF)

- Sums the damage contributed from each aircraft - not from equivalent aircraft.
- $CDF = \sum (n_i / N_i)$, where:
 - n_i = actual passes of individual aircraft i
 - N_i = allowable passes of individual aircraft i
- When $CDF = 1$, design life is exhausted.
- In FAARFIELD (and LEDFAA 1.3):
 - The gear location and wander are considered separately for each aircraft in the total mix.
 - CDF is calculated for each 25.4 cm (10 inch) wide strip over a total 20.83 m (820 inch) width.
 - Miner's rule to sum damage for each strip.

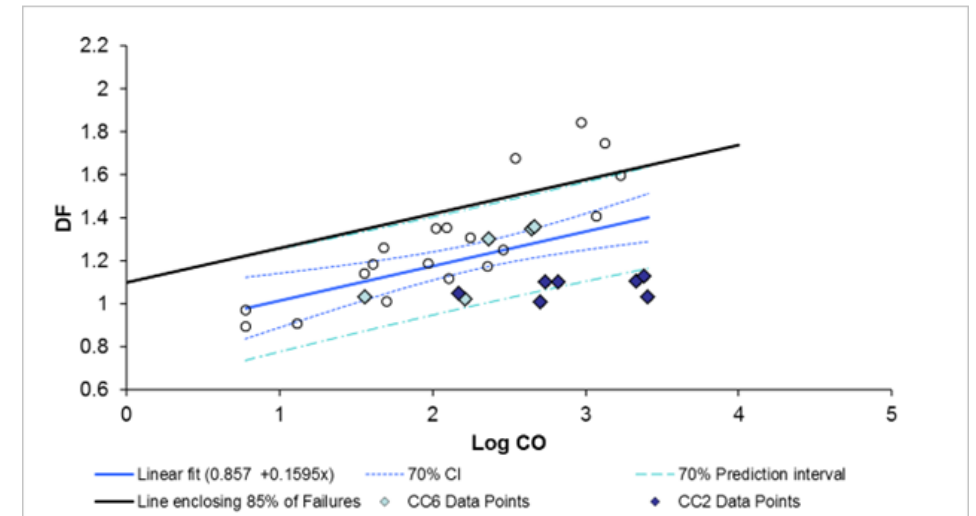
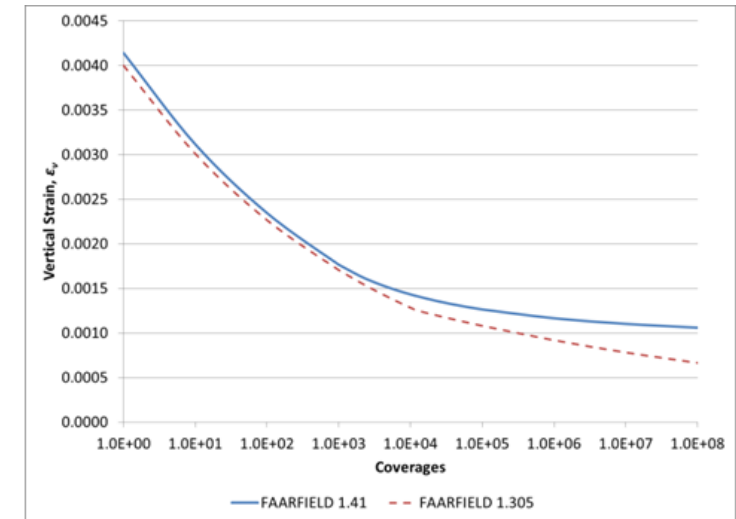
Must input the fleet mix, NOT equivalent departures of design aircraft.

Cumulative Damage Factor (CDF)



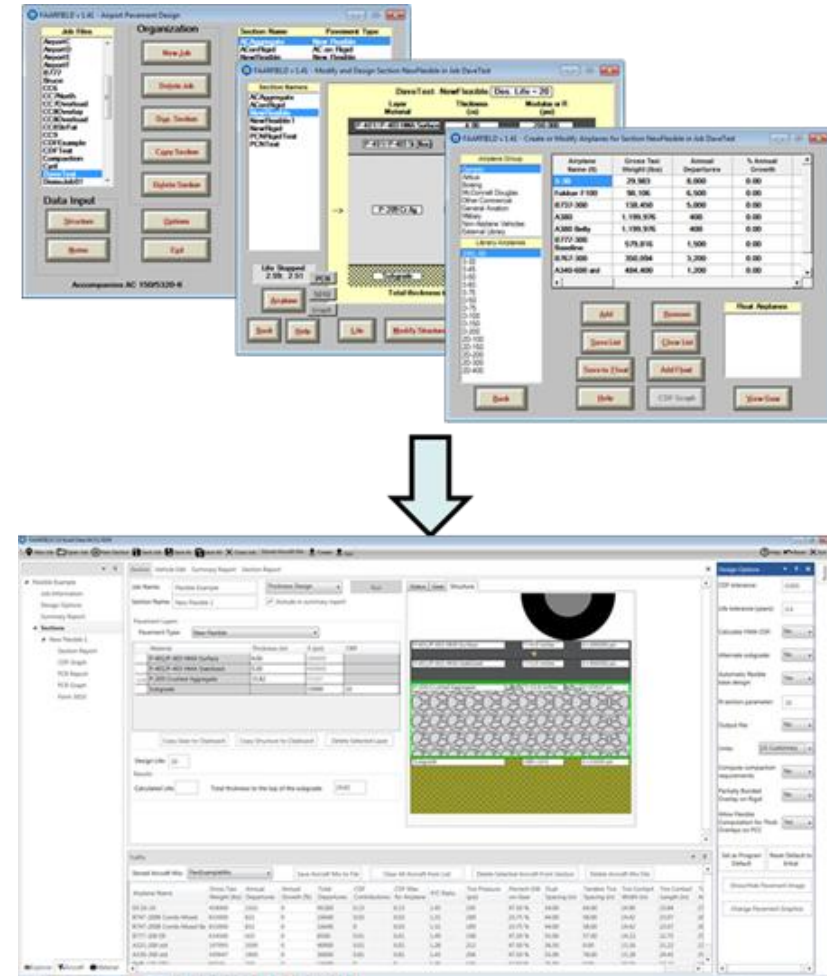
Failure Models in FAARFIELD

- This is the “empirical” part of mechanistic-empirical.
 - Derived from full-scale traffic tests at NAPTF and previous APT.
 - Relates strain or stress to allowable coverages (fatigue).
 - Tied to CDF through P/C ratio.
- Flexible:
 - Function of maximum vertical strain at the top of the subgrade.
- Rigid:
 - Function of maximum horizontal stress in concrete slab.
 - Design stress is the larger of:
 - 75% of computed free edge stress; or
 - 95% of computed center slab stress.



FAARFIELD 2.0 – Major Changes from version 1.4

- Modern Graphical User Interface (GUI) Features:
 - Easier job and section entry.
 - Explorer-based navigation.
 - Improved screen re-sizing and appearance.
 - Improved flow between screens.
 - Ability to store traffic mixes.
 - On-demand report generation.
- Supports the new ICAO ACR-PCR system.
- User-Defined Aircraft (UDA) editor.
- No change to thickness design requirements in this version.



FAARFIELD 2.0 – Technical Details

- Computer program for Windows operating systems.
- Main program drives four subprograms:
 - LEAF (layered elastic analysis).
 - FAAMesh (3D mesh Generation)
 - FAASR3D (3D finite element analysis)
 - ICAO-ACR (Aircraft Classification Rating)

FAARFIELD 2.0

The screenshot shows the FAARFIELD 2.0 software interface with the following components labeled:

- EXPLORER**: Points to the left sidebar containing a tree view of the project structure.
- TOOLBAR**: Points to the top menu bar with options like New Job, Open Job, New Section, Save Job, Save As, Save All, Close Job, Stored Aircraft Mix, Create, Edit, and Help.
- FUNCTION SELECTION**: Points to the 'Run' button in the top toolbar.
- PAVEMENT TYPE SELECTION**: Points to the 'Pavement Type' dropdown menu in the 'Section' panel.
- STRUCTURE TABLE**: Points to the table listing pavement layers with columns for Material, Thickness (in), E (psi), and CBR.
- STRUCTURE IMAGE**: Points to the visual representation of the pavement structure layers.
- TRAFFIC TABLE**: Points to the table listing aircraft data with columns for Airplane Name, Gross Taxi Weight (lbs), Annual Departures, Annual Growth (%), Total Departures, CDF Contributions, CDF Max for Airplane, P/C Ratio, Tire Pressure (psi), Percent GW on Gear, Dual Spacing (in), Tandem Tire Spacing (in), Tire Contact Width (in), and Tire Contact Length (in).
- MATERIAL LIBRARY TAB**: Points to the 'Material' tab at the bottom of the interface.
- AIRCRAFT LIBRARY TAB**: Points to the 'Aircraft' tab at the bottom of the interface.
- OPTIONS**: Points to the 'Design Options' panel on the right side of the interface.
- HELP**: Points to the 'Help' button in the top toolbar.

Section Panel Data:

Material	Thickness (in)	E (psi)	CBR
P-401/P-403 HMA Surface	4.0	200000	
P-401/P-403 HMA Stabilized	5.0	400000	
P-209 Crushed Aggregate	10.0	75000	
Subgrade		15000	10

Traffic Table Data:

Airplane Name	Gross Taxi Weight (lbs)	Annual Departures	Annual Growth (%)	Total Departures	CDF Contributions	CDF Max for Airplane	P/C Ratio	Tire Pressure (psi)	Percent GW on Gear	Dual Spacing (in)	Tandem Tire Spacing (in)	Tire Contact Width (in)	Tire Contact Length (in)
A319-100 std	141978	1200	0	24000	0	0	0	173	47.50%	36.5	0.0	12.5	19.9
B737-300	140000	12000	0	240000	0	0	0	201	47.50%	30.5	0.0	11.5	18.4
B747-400	877000	500	0	10000	0	0	0	200	23.75%	44.0	58.0	14.4	23.0
B747-400 Belly	877000	500	0	10000	0	0	0	200	23.75%	44.0	58.0	14.4	23.0
B787-8	503500	6500	0	130000	0	0	0	228	47.50%	51.0	57.5	14.4	23.1

FAARFIELD 2.0 - Material Properties



Advisory Circular

Subject: Standard Specifications for
Construction of Airports

Date: 12/21/2018
Initiated By: AAS-100

AC No: 150/5370-10H
Change:

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 ¹ /P-404 Asphalt Mixture	NA	200,000 (1,380) ²	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
	Variable stabilized rigid	250,000 to 700,000 (1,700 to 5,000)	NA	0.20
	Variable stabilized flexible	NA	150,000 to 400,000 (1,000 to 3,000)	0.35
Granular Base and Subbase	P-209 crushed aggregate	Internal calculation by FAARFIELD ⁴		0.35
	P-208, aggregate	Internal calculation by FAARFIELD ⁴		0.35
	P-219, Recycled concrete aggregate	Internal calculation by FAARFIELD ⁴		0.35
	P-211, Lime rock	Internal calculation by FAARFIELD ⁴		0.35
	P-207 Recycled Asphalt aggregate base ³	25,000-500,000		0.35
	P-154 uncrushed aggregate	Internal calculation by FAARFIELD ⁴		0.35
Subgrade ⁵	Subgrade	1,000 to 50,000 (7 to 350)		0.35
User-defined	User-defined layer	1,000 to 4,000,000 (7 to 30,000)		0.35



ATR Website:

<https://www.airporttech.tc.faa.gov>

Airport Technology Research Plans:

<https://www.airporttech.tc.faa.gov/Airport-R-D/Airport-Technology-Research-Plan>

ATR Research – Published Papers and Technical Notes:

<https://www.airporttech.tc.faa.gov/Products>

Acknowledgments:

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