ICAO AERODROME PAVEMENT WORKSHOP

ACR/PCR Discussion Topics

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Federal Aviation Administration

ACR/PCR Discussion Topics

- Criteria for occasional overloads
- Tire pressure limitations
- Overlay structures
- Determining layer properties for PCR
- Open Discussion

Criteria for Occasional Overloads

Occasional Overloads

- **The PCR should not be considered as a “hard” limit, nor as the maximum absolute pavement bearing strength.**
- **Annex 14 allows overload operations when ACR>PCR:**
  - “ICAO allowance” is increased to 10% of the PCR for both flexible and rigid pavements
  - Overloads in excess of 10% may be allowed if justified through a technical analysis of the impact on pavement damage.

Annex 14 on Overloads

*20.1.1 … For those operations in which **magnitude of overload and/or the frequency of use do not justify a detailed analysis**, the following criteria are **suggested**:*

*a) **for flexible and rigid pavements**, occasional movements by aircraft with **ACR not exceeding 10 per cent above the reported PCR** should not adversely affect the pavement;*

*b) **the annual number of overload movements should not exceed approximately 5 per cent of the total annual movements, excluding light aircraft**.*

20.1.2 Such overload movements should not normally be permitted on pavement exhibiting signs of distress or failure. Furthermore, overloading should be avoided during any periods of thaw following frost penetration, or when the strength of the pavement or its subgrade could be weakened by water. Where overload operations are conducted, the appropriate authority should review the relevant pavement condition regularly, and should also review the criteria for overload operations periodically since excessive repetition of overloads can cause severe shortening of pavement life or require major rehabilitation of pavement.

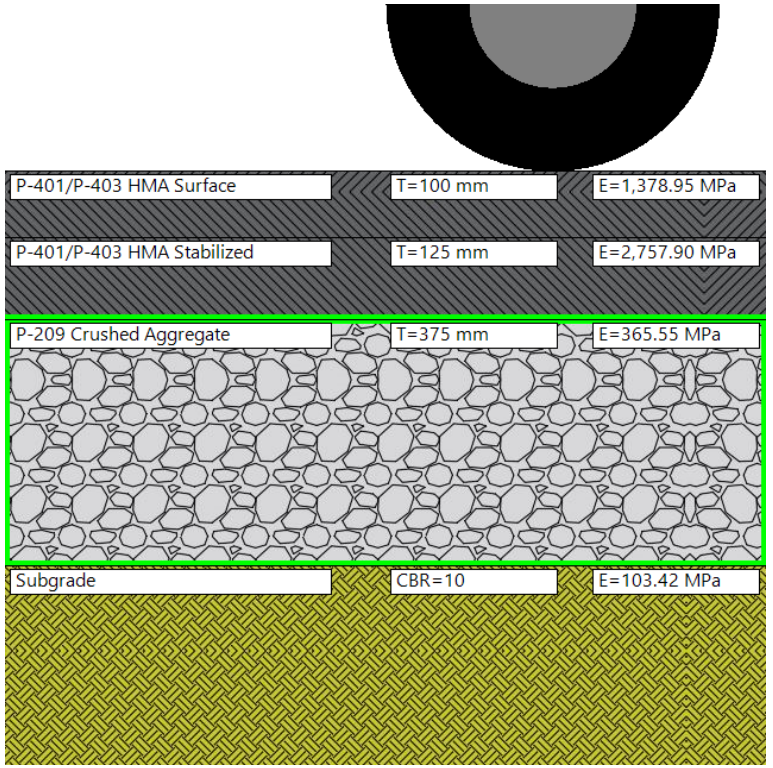
Overloads – Key Points

- **ICAO Annex 14 criteria are suggested. State criteria can and do deviate from these in practice.**
- **Allows technical analysis in lieu of default criteria.**
- **Amendment 15 increased allowable overload for rigid pavements from 5% to 10% (ACR over reported PCR).**
  - Provides parity with flexible pavements.
  - Based on R&D performed at FAA Technical Center.
- **Allowable annual overload movements set at approximately 5% of total movements.**
  - Total excludes “light” aircraft that do not contribute significantly to CDF.
  - “Light aircraft” not defined.

Overload Example

- **Consider a flexible pavement section.**
- **Existing Traffic:**

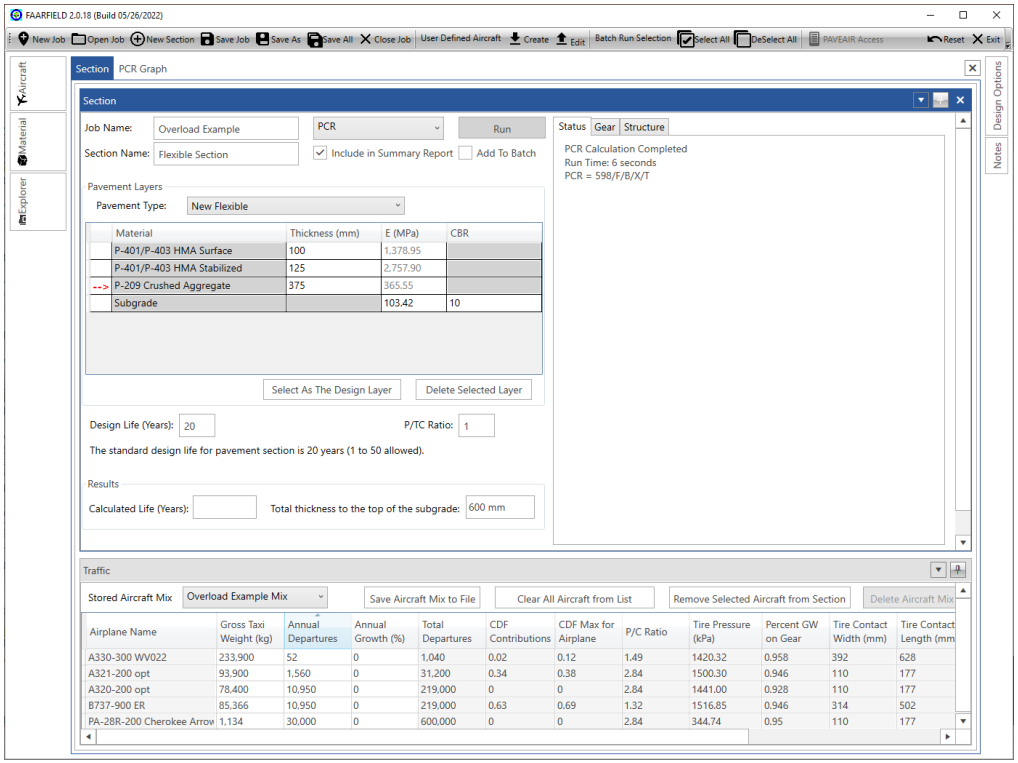
No.	Aircraft	Gross Wt., kg	Annual Departures
1	A330-300 WV 022	233,900	52
2	A321-200 opt	93,900	1,560
3	A320-200 opt	78,400	10,950
4	B737-900 ER	85,366	10,950
5	PA-28-R-200 Cherokee Arrow	1,134	30,000



- **Q: Can airport operate 52 annual departures of B777-300 ER?**

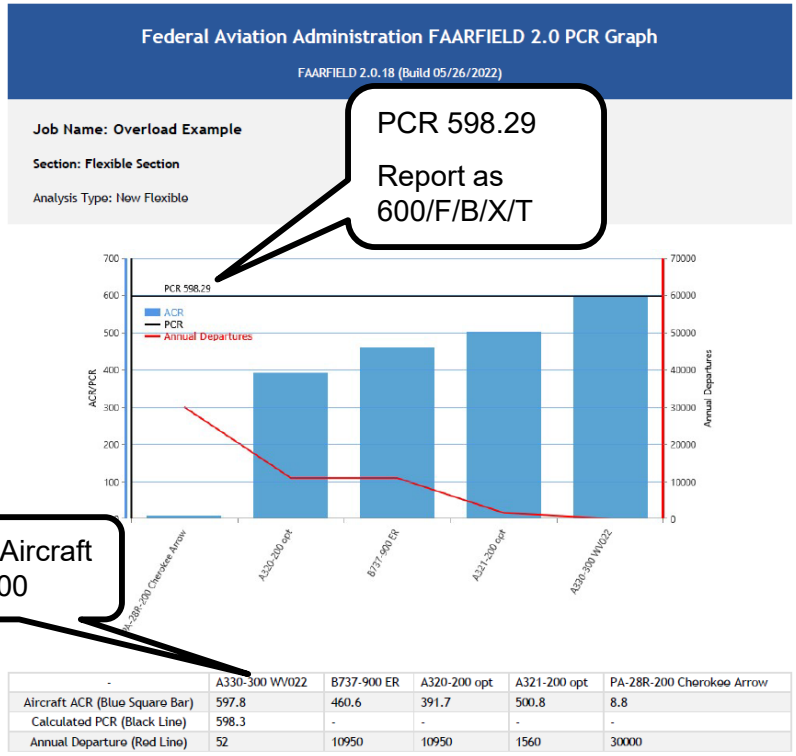
Overload Example

- **For existing traffic, FAARFIELD gives PCR 598/F/B/X/T.**
  - No restrictions on existing traffic.
  - A330-300 is the critical aircraft.
  - Report as **600/F/B/X/T**.
- **Allowable ACR for overloads is 1.1 × 600 = 660/F/B.**
- **Allowable number of overload operations = 0.05 × 23,512 = 1,176 (say 1200 ops per year).**
- **Disregard 30,000 annual departures of “light aircraft” Piper Cherokee.**



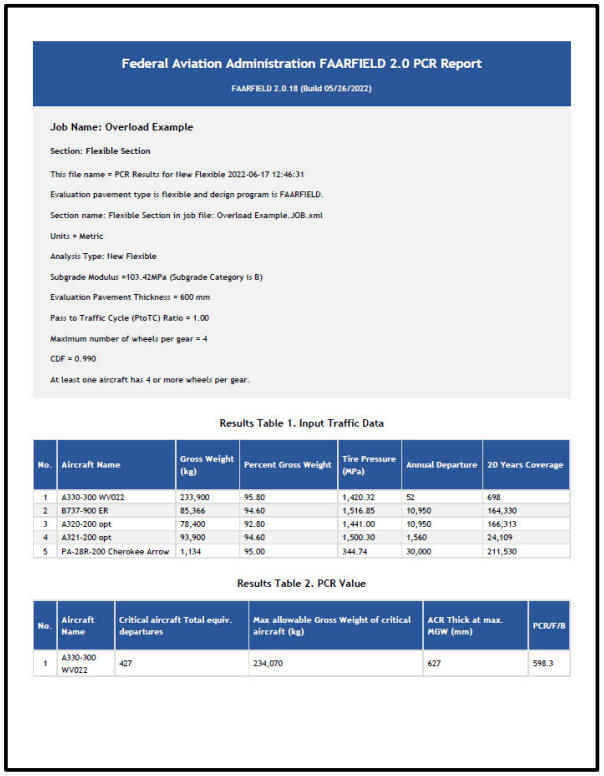
Overload Example (continued)

PCR GRAPH



-	A330-300 WV022	B737-900 ER	A320-200 opt	A321-200 opt	PA-28R-200 Cherokee Arrow
Aircraft ACR (Blue Square Bar)	597.8	460.6	391.7	500.8	8.8
Calculated PCR (Black Line)	598.3	-	-	-	-
Annual Departure (Red Line)	52	10950	10950	1560	30000

PCR REPORT



Federal Aviation Administration FAARFIELD 2.0 PCR Report

FAARFIELD 2.0.18 (Build 05/26/2022)

Job Name: Overload Example

Section: Flexible Section

This file name = PCR Results for New Flexible 2022-06-17 12:46:31

Evaluation pavement type is flexible and design program is FAARFIELD.

Section name: Flexible Section in job file: Overload Example.JOB.xml

Units = Metric

Analysis Type: New Flexible

Subgrade Modulus =103.42MPa (Subgrade Category is B)

Evaluation Pavement Thickness = 600 mm

Pass to Traffic Cycle (PtoTC) Ratio = 1.00

Maximum number of wheels per gear = 4

CDF = 0.990

At least one aircraft has 4 or more wheels per gear.

Results Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight (kg)	Percent Gross Weight	Tire Pressure (MPa)	Annual Departure	20 Years Coverage
1	A330-300 WV022	233,900	95.80	1,420.32	52	698
2	B737-900 ER	85,366	94.60	1,516.85	10,950	164,330
3	A320-200 opt	78,400	92.80	1,441.00	10,950	166,313
4	A321-200 opt	93,900	94.60	1,500.30	1,560	24,109
5	PA-28R-200 Cherokee Arrow	1,134	95.00	344.74	30,000	211,530

Results Table 2. PCR Value

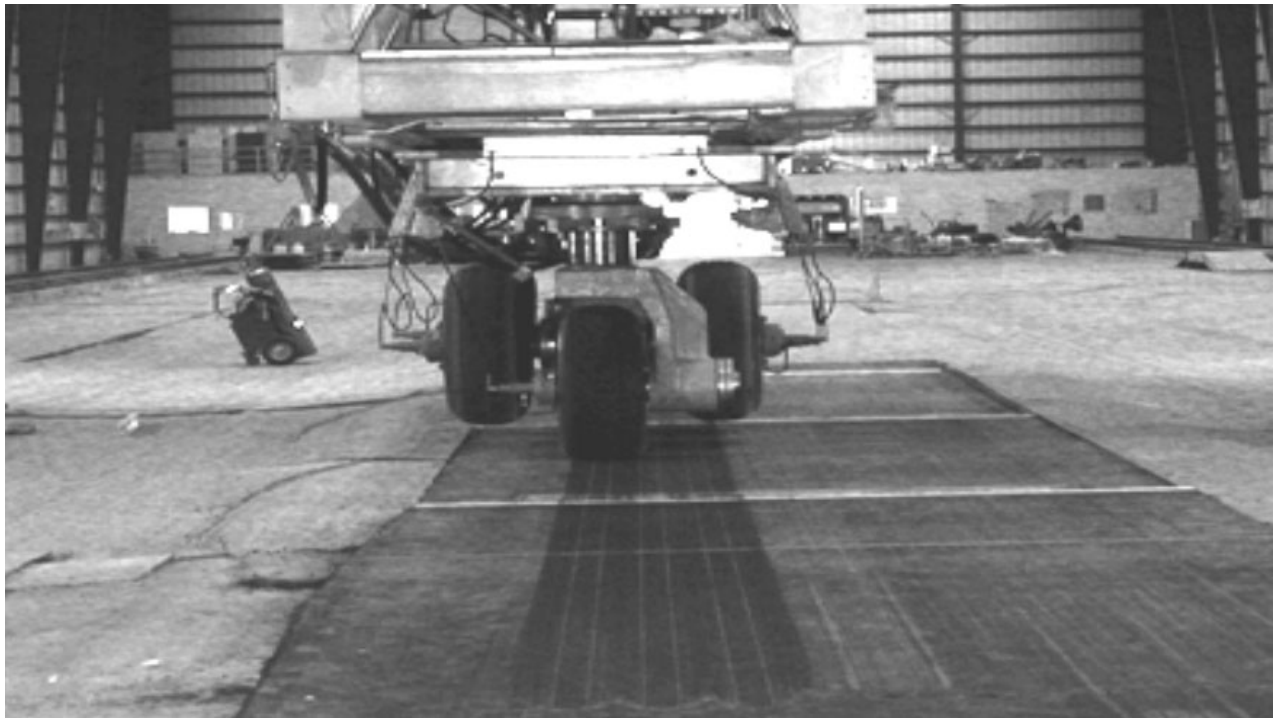
No.	Aircraft Name	Critical aircraft Total equiv. departures	Max allowable Gross Weight of critical aircraft (kg)	ACR Thick at max. MGW (mm)	PCR/F/B
1	A330-300 WV022	427	234,070	627	598.3

Overload Example (continued)

Results Table 3. New Flexible ACR at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight (kg)	Percent Gross Weight on Main Gear	Tire Pressure (MPa)	ACR Thick (mm) (B)	ACR/F/B
1	A330-300 WV022	233,900	95.8	1,420.32	627	597.8
2	B737-900 ER	85,366	94.6	1,516.85	561	460.6
3	A320-200 opt	78,400	92.8	1,441.00	526	391.7
4	A321-200 opt	93,900	94.6	1,500.30	579	500.8
5	PA-28R-200 Cherokee Arrow	1,134	95	344.74	117	8.8
6	B777-300 ER	352,441	92.4	1,503.06	638	628.8

- **In FAARFIELD 2.0, compute ACR of B777-300 ER at operating weight 352,441 kg = 628.8/F/B**
- **Since ACR 629 < 660, overload operations are allowed.**
- **The proposed number of annual overload operations (52) is less than the limit of 1200.**
- **The airport should nevertheless inspect the pavement for damage after each overload op.**



Tire Pressure Limitations

ACR-PCR Tire Pressure Categories

OLD ACN/PCN Tire Pressure Categories (Modified by ICAO State Letter in 2011)

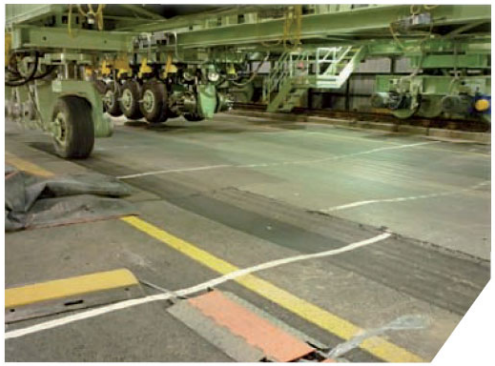
Category	Code	Range
Unlimited	W	No limit
High	X	< 1.50 MPa
Medium	Y	< 1.00 MPa
Low	Z	< 0.5 MPa

NEW Tire Pressure Categories (No Change in ACR/PCR System)

Category	Code	Range
Unlimited	W	No limit
High	X	< 1.75 MPa
Medium	Y	< 1.25 MPa
Low	Z	< 0.5 MPa

High Tire Pressure Full-Scale Testing Program

- **Arose from concerns among aircraft manufacturers that:**
  "The four tire pressure categories assigned to the PCN rating, which may have been representative of the aircraft existing at its inception, are no longer representative of the current fleet of large wide bodied aircraft operating with higher wheel loads and higher tire pressures."
  M.J. Roginski, Effects of Aircraft Tire Pressures on Flexible Pavements, PIARC 2007,
  https://proceedings-paris2007.piarc.org/ressources/files/3/AP01-ROGINSKI-E.pdf
- **High Tire Pressure tests conducted at FAA NAPTF, 2007 and 2009 (heated).**
- **Pavement Experimental Programme (PEP) tests by Airbus at Toulouse (2009 – 2010)**



High Tire Pressure Full Scale Tests

- **Test results from NAPTF HTP tests concluded that:**
  "*Increasing tire pressure from 210 psi (1.45 MPa) to 245 psi (1.66 MPa) had an insignificant effect on the amount of rutting caused by trafficking at two different wheel loads on two different asphalt mixes, one straight asphalt and the other polymer modified.*"
  I. Song, "Full-Scale High Tire Pressure Tests on Heated Pavement," Report to ICAO AOSWG, 2010.
- **Airbus PEP came to a similar conclusion.**
- **Annex 14 amendment revising tire pressure code limits was applicable in November 2012.**

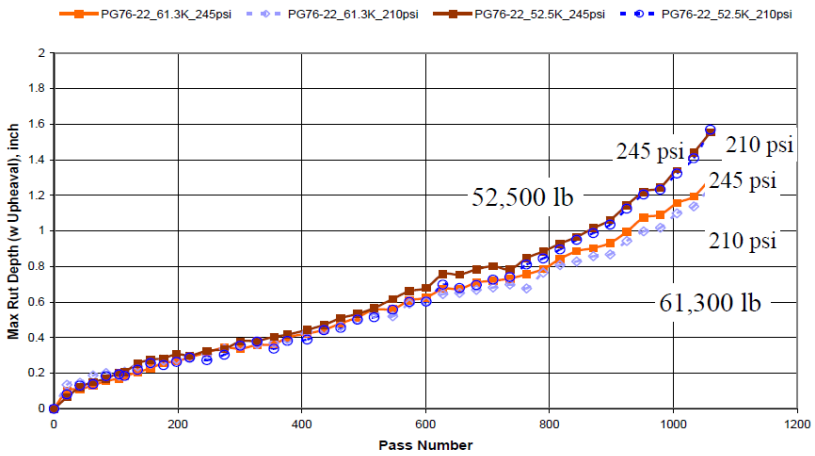


Figure 9. Rut depth changes with different tire pressures and load magnitudes in the PG 76-22 test items.

Australian State Practice

- **Australian State Practice is to publish the numerical tire pressure limit as part of the PCN, rather than the letter category. This practice will be carried over to the PCR.**
- **PCN data are published in the ERSA (En Route Supplement Australia) entries for airports.**

PHYSICAL CHARACTERISTICS

12/30	118	55a	PCN 12 /F /C /1050 (152PSI) /T	WID 30	RWS 90
17/35	168	108a	PCN 62 /F /B /1500 (218PSI) /T Grooved. 7.5M shoulders sealed.	WID 45	RWS 300

Additional TKOF length AVBL for RWY 35. Refer ERSA Runway Distance Supplement (RDS) for further details.

Example of ERSA entry for Canberra Airport, showing PCN reported following Australian State practice.

Overlay PCR Example

Overlay PCR Example

- **Like ACN/PCN, the ACR/PCR system does not recognize "composite" or overlay pavements for reporting purposes.**
- **Pavements are categorized as either flexible (F) or rigid (R).**
- **The general rule is, report the type that most accurately reflects the structural behavior of the pavement.**
  - Pavement type does not necessarily correspond to the wearing surface material.
  - FAARFIELD will consider a rigid pavement overlaid with asphalt to be type "R" if the overlay thickness < the PCC thickness.
  - If the overlay thickness matches or excess the PCC thickness, FAARFIELD determines the correct type (R or F) based on life computation.

Overlay PCR Example

- **Medium-hub airport in the U.S.**
- **Runway 9-27 is 2,896 m (9,500 ft.) long and 46 m (150 ft.) wide.**
  - The surface is HMA, except for a 1352-m (155-foot) length at the intersection with a crossing runway, which is PCC.
  - Runway was constructed in 1968 as a PCC pavement. At the time of initial construction, the PCC section was 25.4 cm (10 in.), except for 152-m (500-ft.) long sections at each runway end, where the PCC thickness was increased to 30.5 m (12 in.).
  - Subsequent overlays in 1981, 1997 and 2012 increased the total HMA thickness to approximately 25,4 m (10 inches).
- **The PCN for this composite pavement is reported on the AMR as 65/F/D/W/T.**

01L/19R | 01R/19L | 09/27

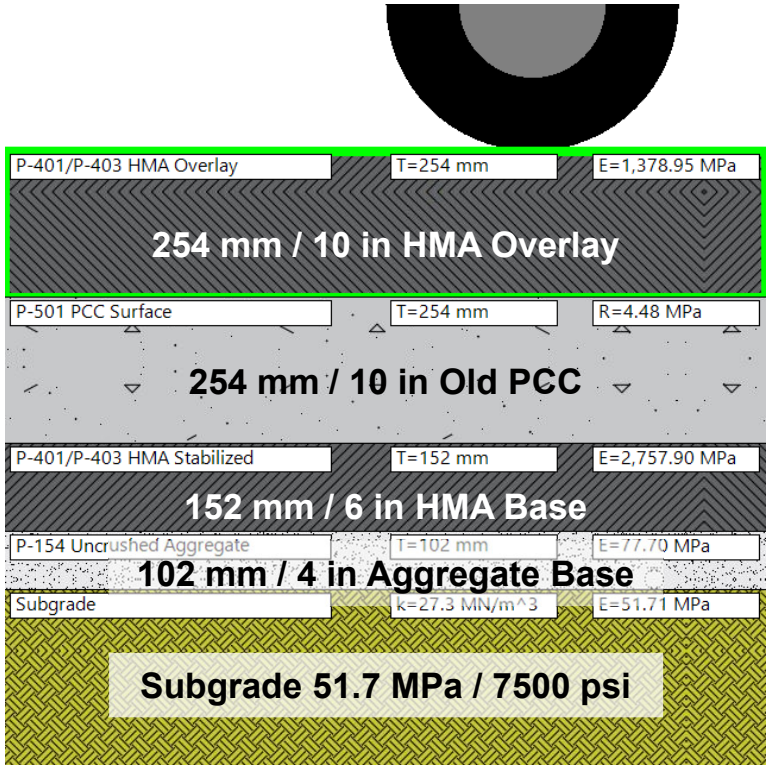
Runway Data		Obstruction Data	
Runway Identification	09/27	FAR 77 Category	PIR/PIR
Length	9,501	Displaced Threshold	/
Width	150	Controlling Obstruction	/
Surface Type-Condition	ASPH-G	Obstruction Marked/Lighted	/
Surface Treatment	GRVD	Height Above Runway End	/
Gross Weight (In Thousands)		Distance From Runway End	/
Single Wheel (S)	75.0	Centerline Offset & Direction	/
Dual Wheel (D)	125.0	Obstruction Clearance Slope	50/50
2 Dual Wheels in Tandem (2D)	180.0	Close-In Obstruction	N/N
2 Dual Wheels in Tandem/ 2 Dual Wheels in Double Tandem (2D/2D2)	260.0		
Pavement Classification Number (PCN)	65 /F/D/W/T		

Overlay PCR Example – Input Data

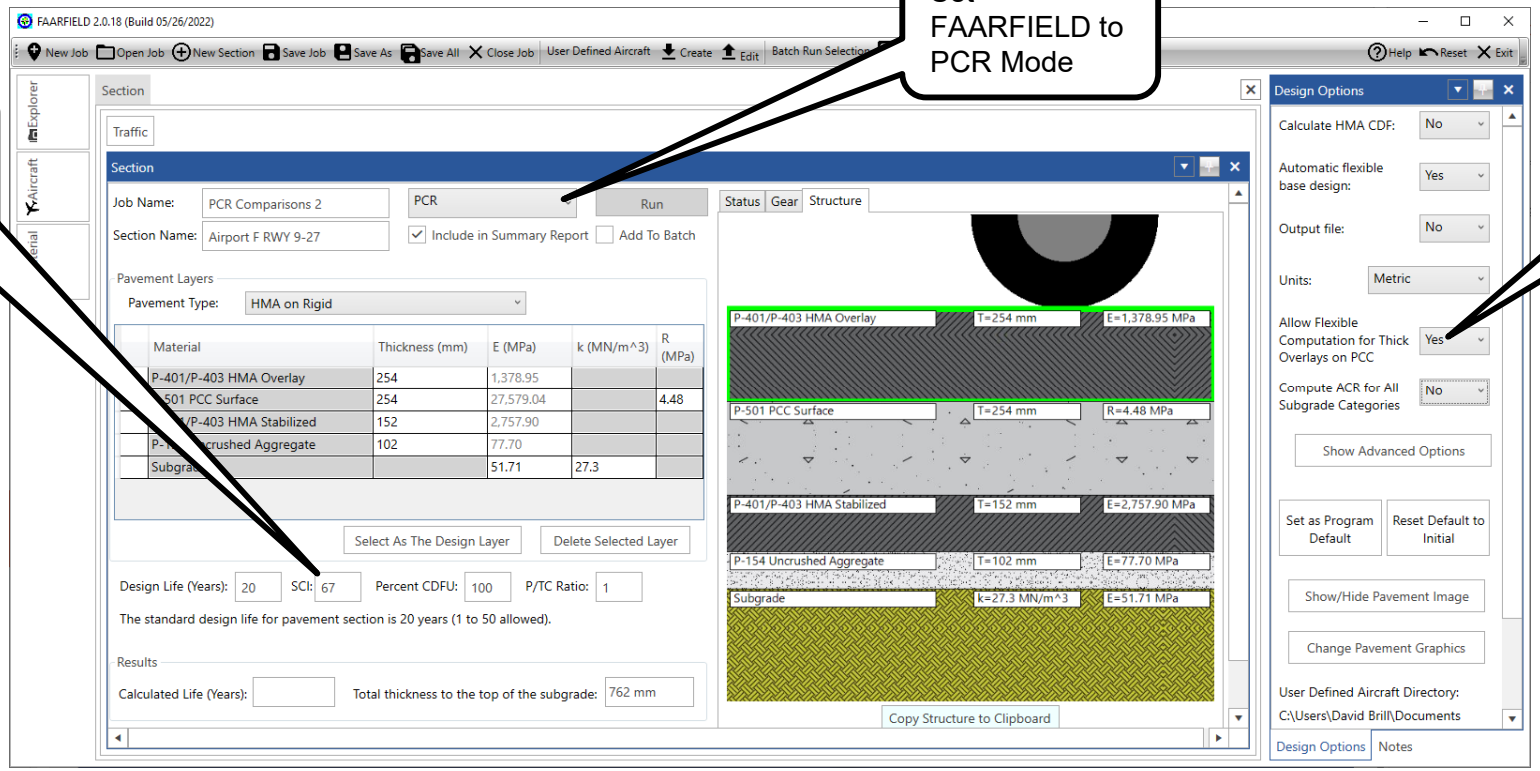
Design Aircraft Traffic

No.	Aircraft	Gross Wt., lbs.	Annual Departures
1	A300-600 Std Bogie	380,518	18
2	A318-100 opt	141,978	553
3	A320-200 std	150,796	170
4	A321-100 std	183,866	28
5	B717-200 HGW	122,000	111
6	B727-200 Advanced Basic	185,200	5
7	B737-300	140,000	651
8	B737-700	155,000	2000
9	B737-800	174,700	235
10	B737-900 ER	188,200	53
11	B757-200	256,000	137
12	B767-400 ER	451,000	4
13	B787-9	555,000	4
14	CRJ100/200	47,450	102
15	CRJ700	72,500	473
16	DC/MD-10-10/10F	458,000	10
17	DC9-32	109,000	9
18	Q400/Dash 8 Series 400	64,700	122
19	ERJ-145 ER	45,635	143
20	ERJ-145 XR	53,352	187
21	EMB-170 STD	79,697	864
22	EMB-190 STD	105,712	11
23	MD-11	633,000	17
24	MD-83	161,000	209
25	MD-90-30 ER	168,500	235

FAARFIELD Representation of Evaluation Structure

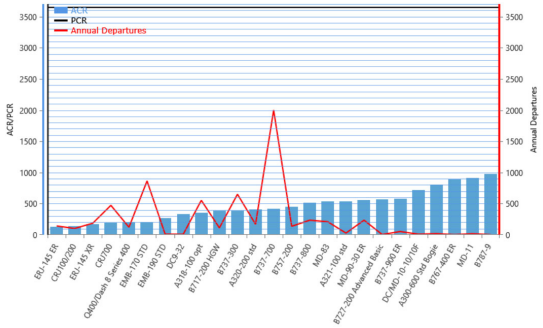


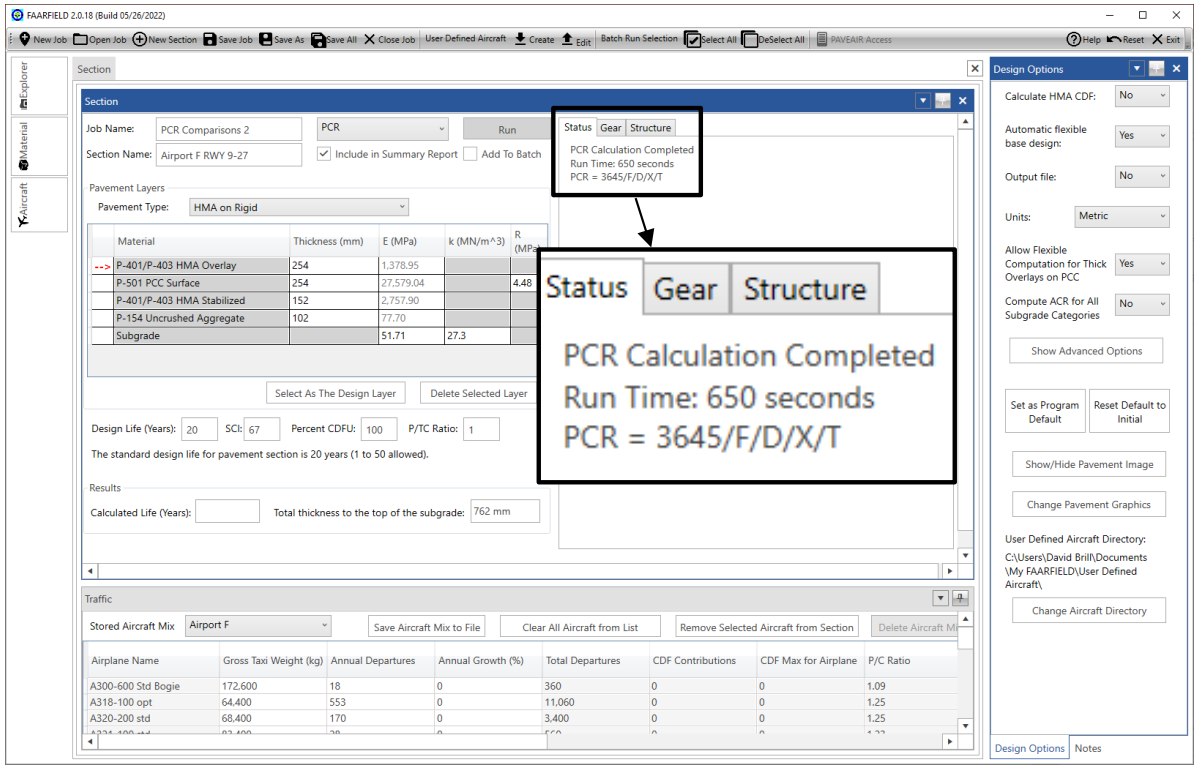
Overlay PCR Example – FAARFIELD 2.0



Overlay PCR Example – FAARFIELD 2.0

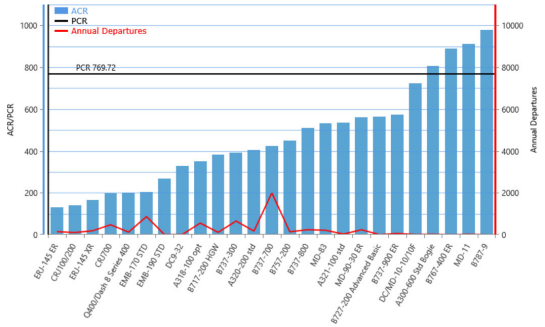
- **FAARFIELD computes PCR <u>3650/F/D</u>.**
- **No operating weight restrictions**
- **Since the overlay thickness matches that of the existing PCC, FAARFIELD can compute flexible PCR, by converting the PCC to a high-stiffness user-defined layer.**

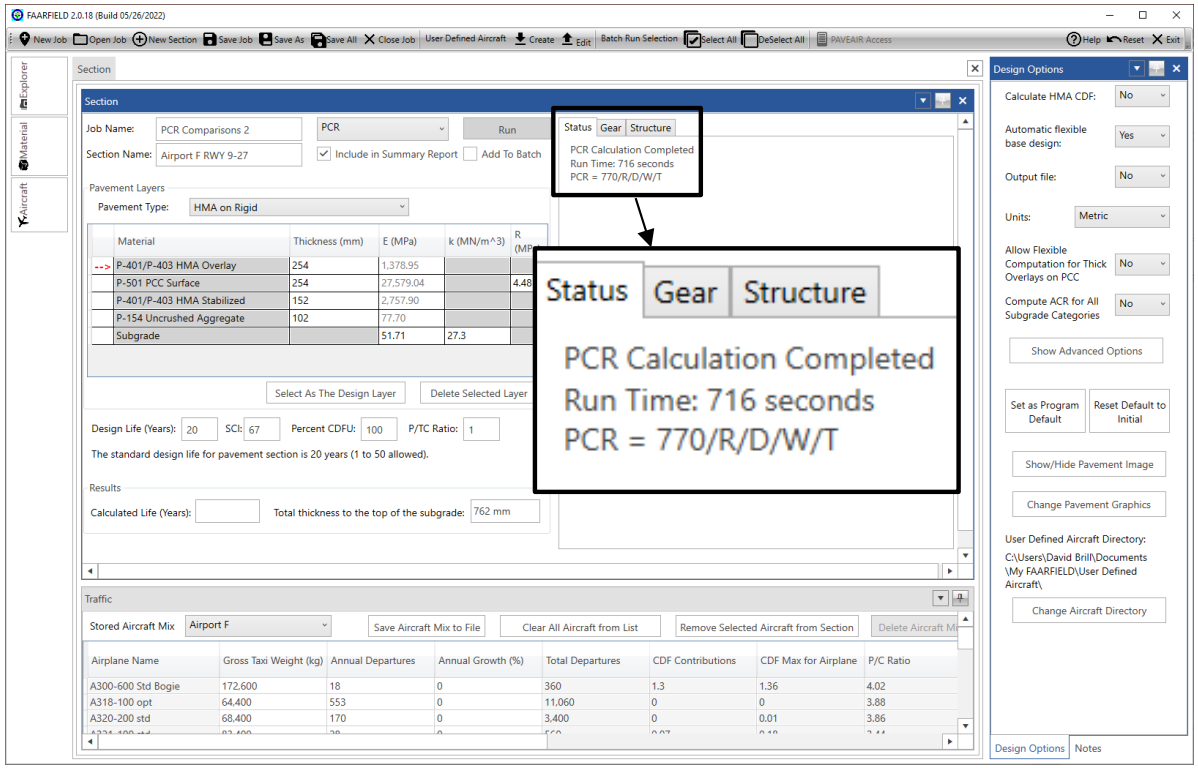




Overlay PCR Example – FAARFIELD 2.0

- **Alternatively, if the flexible option is disabled, then FAARFIELD computes PCR 770/R/D.**
- **Does not take advantage of the available strength by treating pavement as a flexible structure.**
- **Much lower rigid PCR would require operating weight restrictions on several mix aircraft.**





Determining Layer Properties for PCR Evaluation

Pavement Evaluation Process

Flexible Pavement –

- Layer thicknesses
- Subgrade CBR
- Layer Properties

Rigid Pavement –

- Layer thicknesses
- Concrete Flexural Strength
- Subgrade modulus
- Layer properties

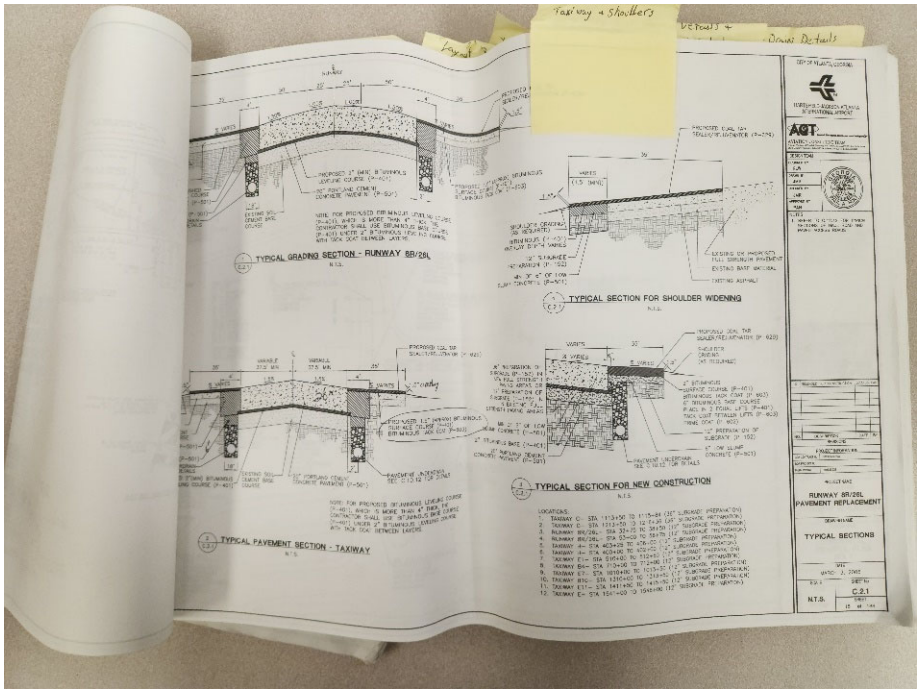
Pavement Evaluation Process

- **Methodical Step-by-Step Process**
  - Records Research
  - Site Inspection
  - Sampling & Testing
    - Direct Sampling Procedures
    - Nondestructive Testing
      - Falling Weight Deflectometer
      - Ground Penetrating Radar
      - Infrared Thermography
  - Pavement Condition Index
  - Roughness
  - Skid Resistance
- **Evaluation Report**

Credit: https://www.wannapik.com/

Pavement Evaluation Process

- **Records research**
  - Design drawings and reports
  - As-built drawings
  - Maintenance history/logs
  - Weather records
  - Traffic history



Pavement Evaluation Process

- **Site Inspection**
  - Visual inspection for general condition
  - Drainage Survey (Pavement)
    - Pumping
    - Joint/crack seal condition
    - Standing or ponded water
    - Weed growth
    - Moisture in joints/cracks
    - Shoulder condition
    - Pavement slopes

Pavement Evaluation Process

- **Site Inspection**
  - Drainage Survey (Structures)
    - Clogged inlet grates
    - Catch basins/pipes
    - Settlement
    - Outfall ditch stoppage
    - Erosion around structures
    - Structural damage

Pavement Evaluation Process

- **Sampling & Testing**
  - Direct Sampling Procedures
    - Coring
    - Borings
    - Material sampling
  - Determination
    - Pavement layer thicknesses
    - Pavement layer material types
    - Pavement layer material properties and conditions

Pavement Evaluation Process

- **Sampling & Testing**
  - Subgrade
    - Dynamic Cone penetrometer
    - Soil classification
    - Field CBR
    - Modulus of subgrade reaction
  - Unbound base and subbase
    - Visual material classification
    - Field CBR
    - Resilient modulus

Pavement Evaluation Process

- **Sampling & Testing**
  - Asphalt Concrete
    - Resilient modulus
    - Split tensile
    - Stripping
    - Aggregate gradation
    - Asphalt extraction
      - Asphalt content
      - Penetration
      - Softening point
  - Portland Cement Concrete
    - Indirect tensile
    - Flexural strength
    - Compressive strength

Pavement Evaluation – NDT and Minimally Destructive Testing

- **NDT can be used for structural evaluation**
  - Evaluate load-carrying capacity.
  - Provide material properties of pavement layers.
  - Compare parts of pavement system.
  - Provide structural performance data to supplement PCI.
- **Limitations to NDT**
  - Quantitative results obtained from NDT data are model-dependent.
  - Testing at different times of the year may give different results.
- **Types of NDT and Minimally DT**
  - FWD
  - Ground Penetrating Radar
  - DCP
  - PSPA

Questions?

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