ICAO AERODROME PAVEMENT WORKSHOP

FAARFIELD 2.1 for PCR

Presented to: ICAO Aerodrome Pavement Workshop
Bangkok, Thailand

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Date: 9 February 2024

Federal Aviation Administration

FAARFIELD 2.1 PCR Mode

- **Flexible Pavement PCR Example**
- **Understanding PCR Reports and Charts**
- **Rigid Pavement PCR Example**

Flexible Pavement PCR Example

FAARFIELD 2.0 PCR Example

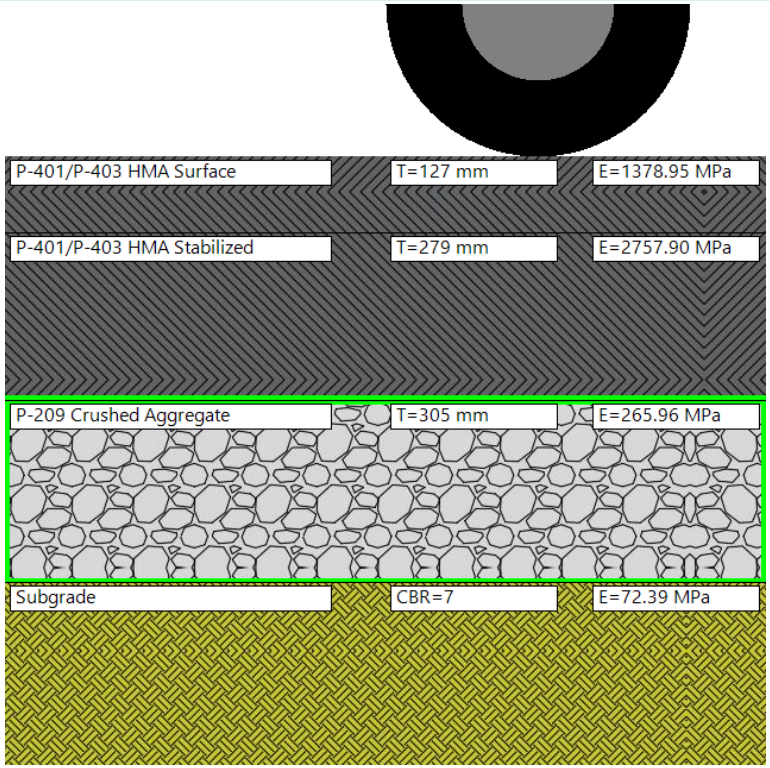
- **Airport B**
  - Medium-hub airport in the U.S.
  - Runway 10R-28L is a flexible runway constructed in 2013.
- **Design Section:**
  - 5 in. (127 mm) HMA surface (P-401)
  - 11 in. (279 mm) HMA base (P-401)
  - 12 in. (305 mm) crushed aggregate subbase (P-209)
  - 12 in. (305 mm) cement-stabilized subgrade (P-301)
- **Existing subgrade soils were of poor quality and potentially contaminated.**
  - Cement-stabilized soil layer was added to provide a higher CBR while minimizing disturbance of the existing subgrade.
  - Assumed CBR 7 at the top of the cement-stabilized subgrade.
- **Airport reported <u>PCN 77/F/C/W/T</u> using COMFAA 3.0.**

10L/28R | 10R/28L

Runway Data		Obstruction Data	
Runway Identification	10R/28L	FAR 77 Category	PIR/PIR
Length	10,114	Displaced Threshold	/
Width	150	Controlling Obstruction	/
Surface Type-Condition	ASPH-E	Obstruction Marked/Lighted	/
Surface Treatment	GRVD	Height Above Runway End	/
Gross Weight (In Thousands)		Distance From Runway End	/
Single Wheel (S)	120.0	Centerline Offset & Direction	/
Dual Wheel (D)	250.0	Obstruction Clearance Slope	50/50
2 Dual Wheels in Tandem (2D)	424.0	Close-In Obstruction	N/N
2 Dual Wheels in Tandem/ 2 Dual Wheels in Double Tandem (2D/2D2)			
Pavement Classification Number (PCN)	77 /F/C/W/T		

FAARFIELD 2.0 PCR - Data

Airport B - Runway 10R-28L



Traffic

Stored Aircraft Mix: Airport B 10R-28L

Save Aircraft Mix to File

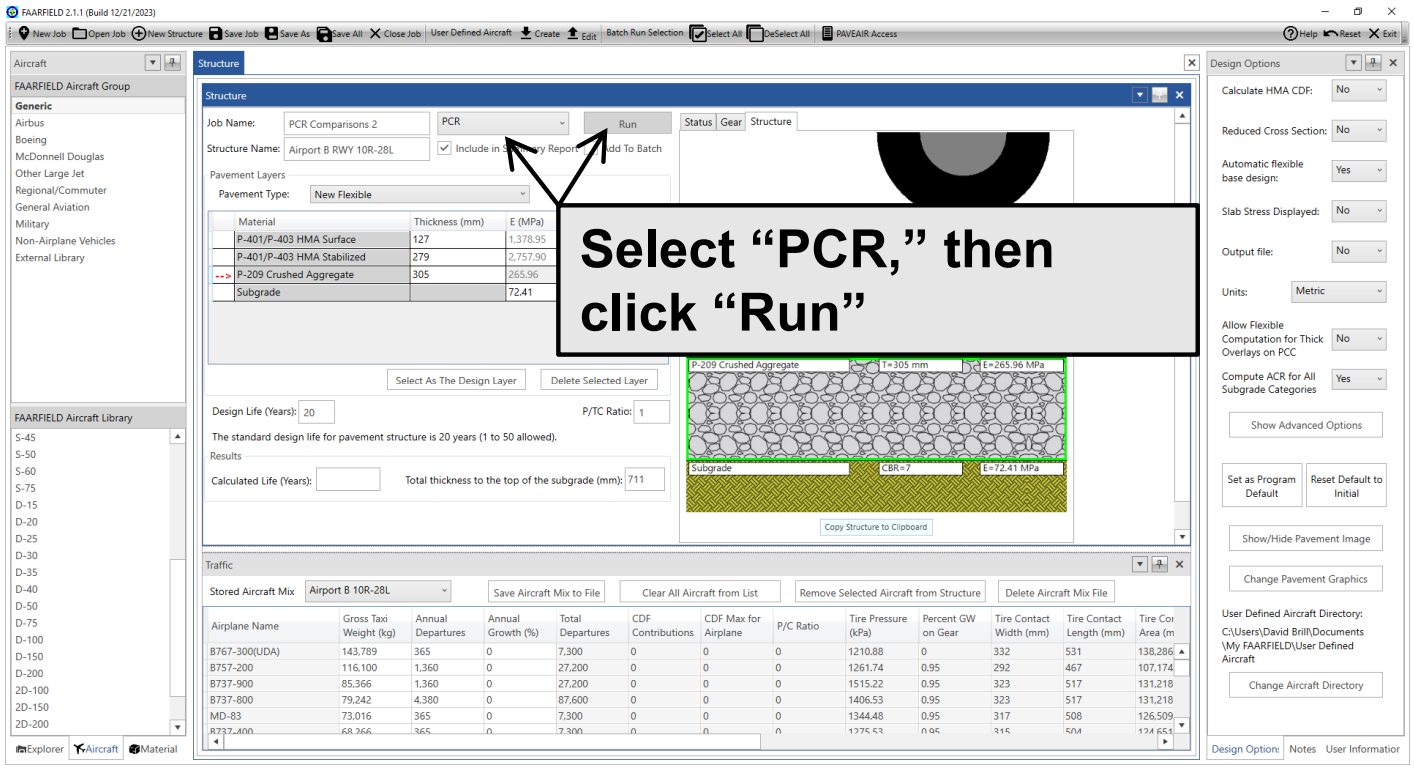
Airplane Name	Gross Taxi Weight (kg)	Annual Departures	Annual Growth (%)	Total Departures
B767-300(UDA)	143,789	365	0	7,300
B757-200	116,100	1,360	0	27,200
B737-900	85,366	1,360	0	27,200
B737-800	79,242	4,380	0	87,600
MD-83	73,016	365	0	7,300
B737-400	68,266	365	0	7,300
B737-300	63,503	17,885	0	357,700
B737-500	60,781	2,920	0	58,400
B717-200 HGW	55,338	3,531	0	706,200
CRJ900	38,329	6,570	0	131,400
CRJ700	34,019	18,615	0	372,300
ERJ-145 ER	21,999	32,405	0	648,100
S-10	3,969	550	0	11,000
S-3	1,043	600	0	12,000
D-30	13,608	6,525	0	130,500
S-10	4,536	15,225	0	304,500
D-50	22,680	40,400	0	808,000

One-Step PCR Procedure

- For PCR following design, the evaluation structure and traffic mix are already entered in FAARFIELD.
- No equivalent thickness calculation needed.
- In PCR mode, FAARFIELD automatically switches to standard CG and tire pressure conditions for ACR evaluation.
- FAARFIELD automatically determines the subgrade category from subgrade data.
- FAARFIELD automatically determines the critical aircraft from the traffic list.

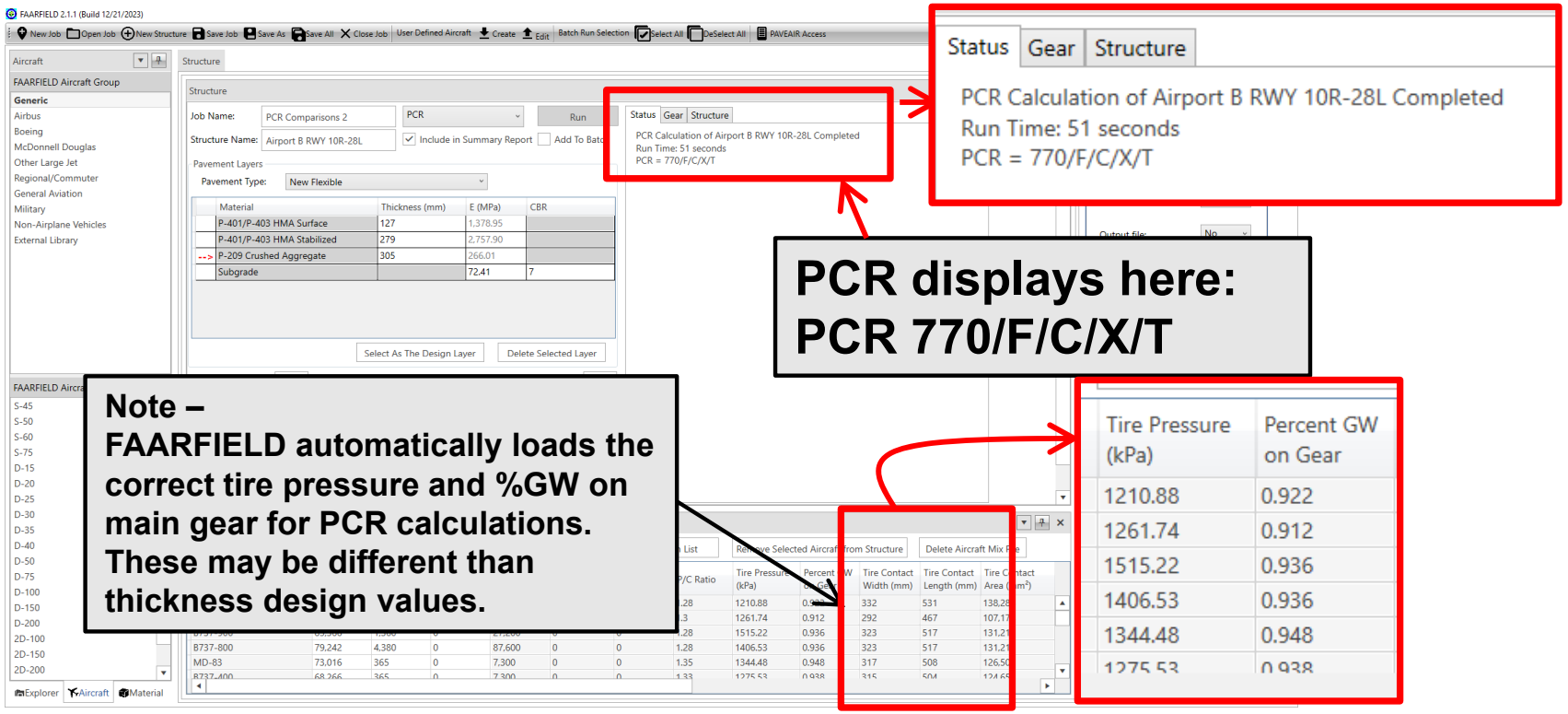
FAARFIELD 2.0 PCR Example

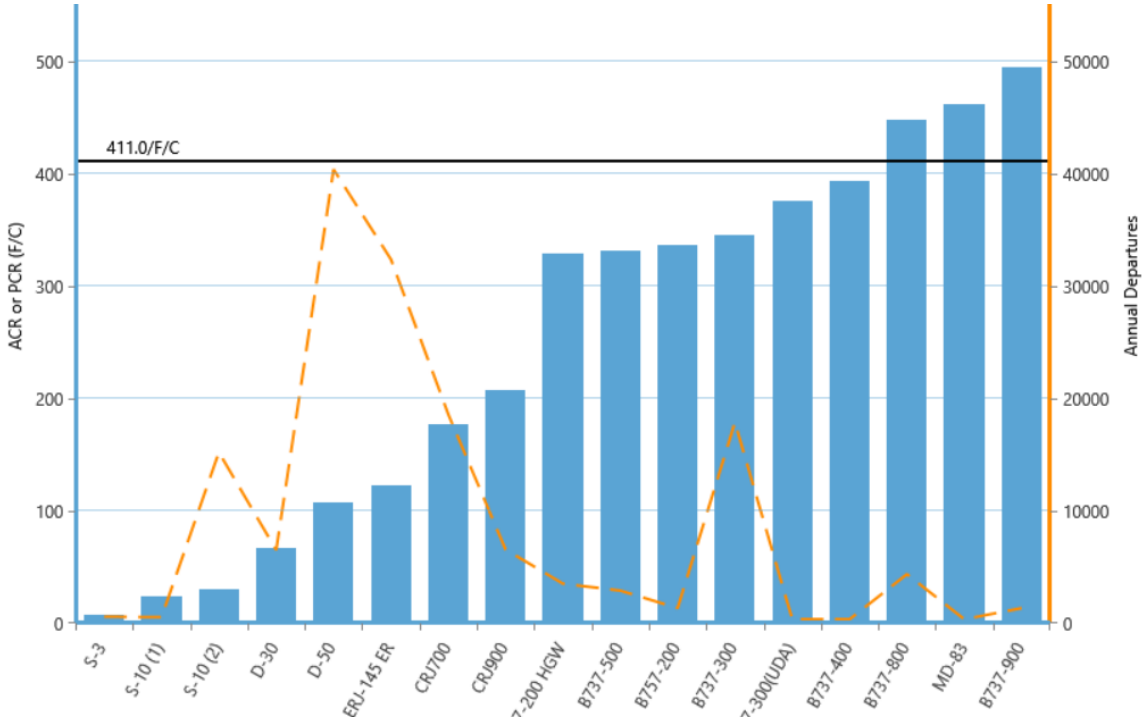
One-Step Procedure



FAARFIELD 2.0 PCR Example

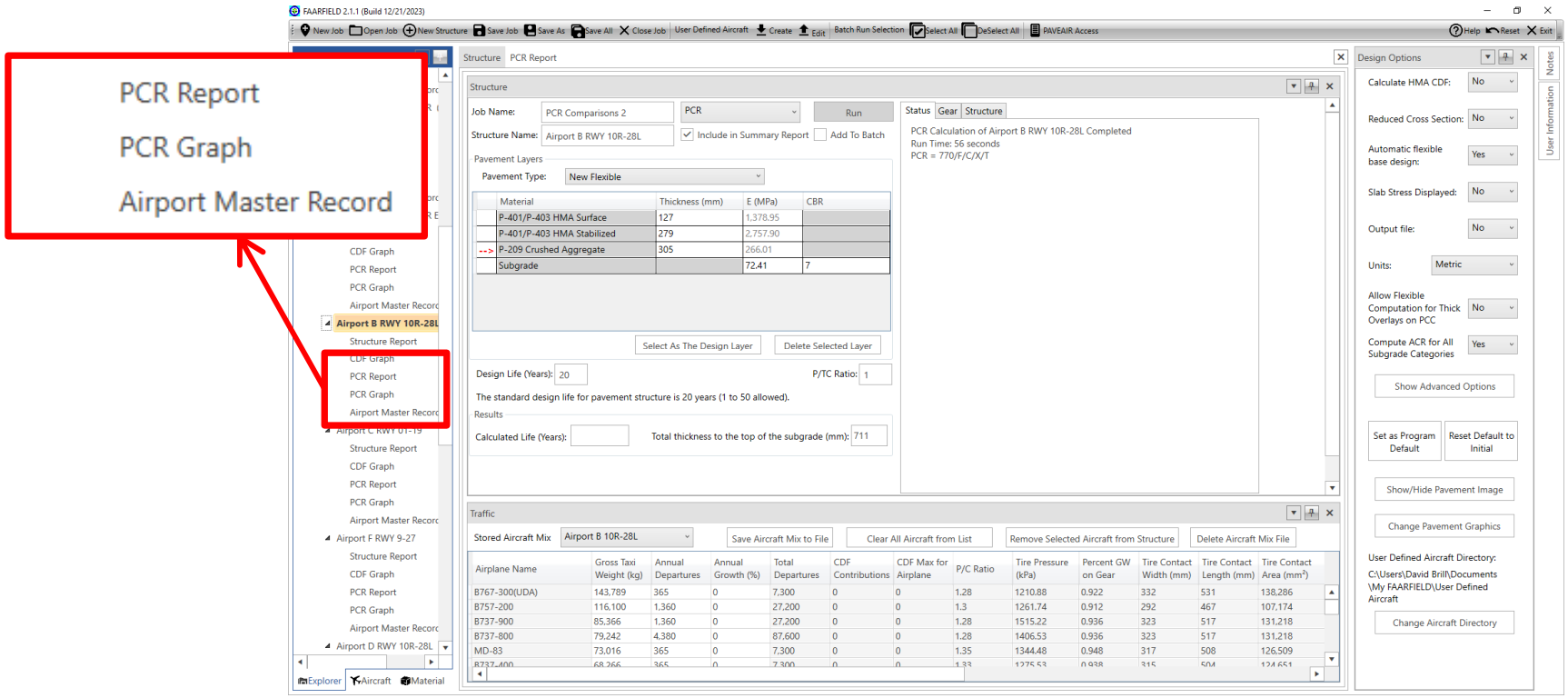
PCR = 770/F/C/X/T





Understanding PCR Reports and Charts

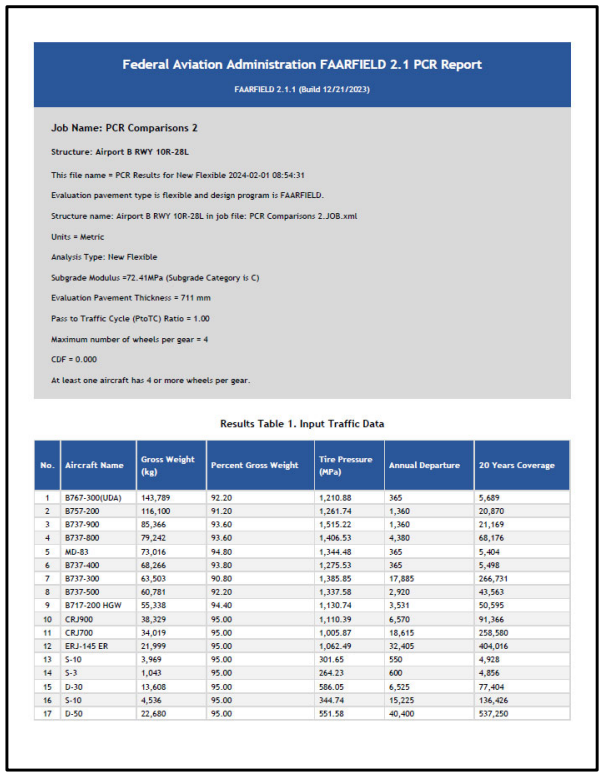
PCR Reports and Graphs



PCR Report

Summary Data

Results Table 1



Federal Aviation Administration FAARFIELD 2.1 PCR Report

FAARFIELD 2.1.1 (Build 12/21/2023)

Job Name: PCR Comparisons 2

Structure: Airport B RWY 10R-28L

This file name = PCR Results for New Flexible 2024-02-01 08:54:31

Evaluation pavement type is flexible and design program is FAARFIELD.

Structure name: Airport B RWY 10R-28L in job file: PCR Comparisons 2.JOB.xml

Units = Metric

Analysis Type: New Flexible

Subgrade Modulus =72.41MPa (Subgrade Category is C)

Evaluation Pavement Thickness = 711 mm

Pass to Traffic Cycle (PtoTC) Ratio = 1.00

Maximum number of wheels per gear = 4

CDF = 0.000

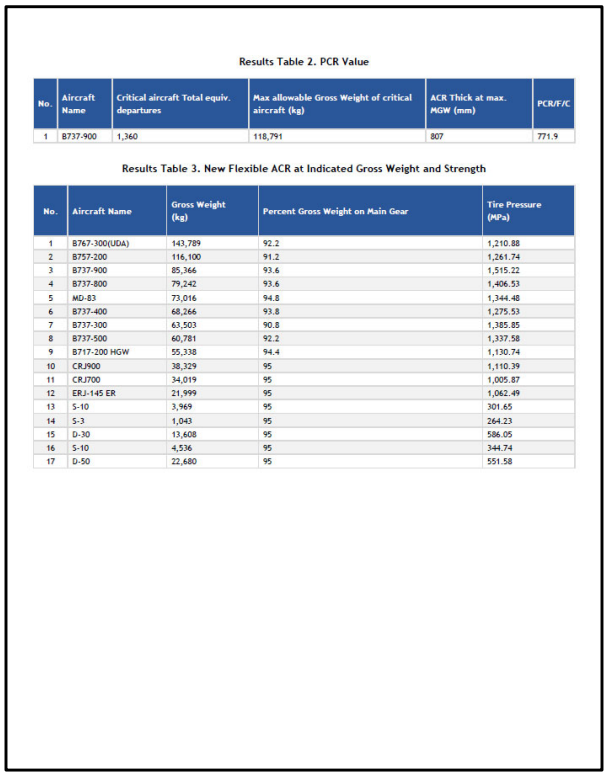
At least one aircraft has 4 or more wheels per gear.

Results Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight (kg)	Percent Gross Weight	Tire Pressure (MPa)	Annual Departure	20 Years Coverage
1	B767-300(UDA)	143,789	92.20	1,210.88	365	5,689
2	B757-200	116,100	91.20	1,261.74	1,360	20,870
3	B737-900	85,366	93.60	1,515.22	1,360	21,169
4	B737-800	79,242	93.60	1,406.53	4,380	68,176
5	MD-83	73,016	94.80	1,344.48	365	5,404
6	B737-400	68,266	93.80	1,275.53	365	5,498
7	B737-300	63,503	90.80	1,385.85	17,885	266,731
8	B737-500	60,781	92.20	1,337.58	2,920	43,563
9	B717-200 HGW	55,338	94.40	1,130.74	3,531	50,595
10	CRJ900	38,329	95.00	1,110.39	6,570	91,366
11	CRJ700	34,019	95.00	1,005.87	18,615	258,580
12	ERJ-145 ER	21,999	95.00	1,062.49	32,405	404,016
13	S-10	3,969	95.00	301.65	550	4,928
14	S-3	1,043	95.00	264.23	600	4,856
15	D-30	13,608	95.00	586.05	6,525	77,404
16	S-10	4,536	95.00	344.74	15,225	136,426
17	D-50	22,680	95.00	551.58	40,400	537,250

Results Table 2

Results Table 3



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/C
1	B737-900	1,360	118,791	807	771.9

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)
1	B767-300(UDA)	143,789	92.2	1,210.88
2	B757-200	116,100	91.2	1,261.74
3	B737-900	85,366	93.6	1,515.22
4	B737-800	79,242	93.6	1,406.53
5	MD-83	73,016	94.8	1,344.48
6	B737-400	68,266	93.8	1,275.53
7	B737-300	63,503	90.8	1,385.85
8	B737-500	60,781	92.2	1,337.58
9	B717-200 HGW	55,338	94.4	1,130.74
10	CRJ900	38,329	95	1,110.39
11	CRJ700	34,019	95	1,005.87
12	ERJ-145 ER	21,999	95	1,062.49
13	S-10	3,969	95	301.65
14	S-3	1,043	95	264.23
15	D-30	13,608	95	586.05
16	S-10	4,536	95	344.74
17	D-50	22,680	95	551.58

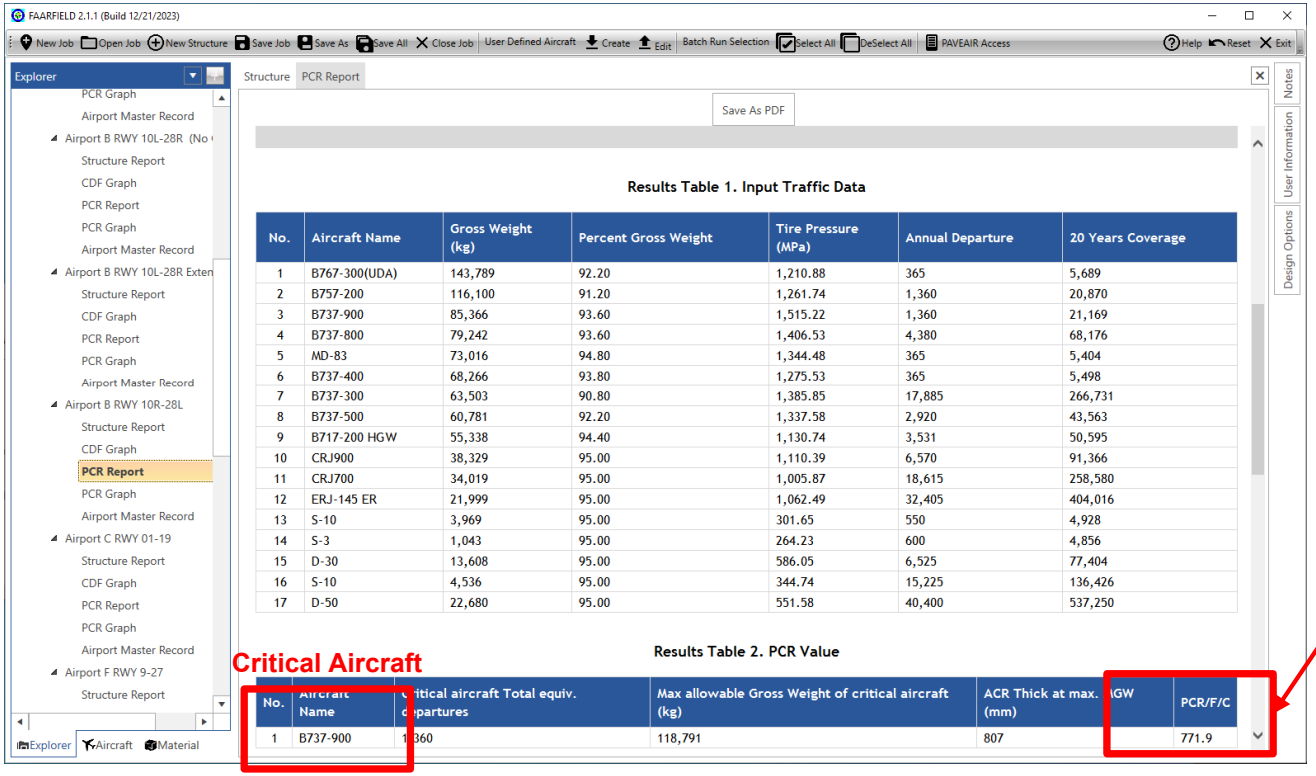
PCR Report

- **PCR report tables are similar to COMFAA results tables, but simpler.**
  - Results Table 1 – Input Traffic Data.
  - Results Table 2 displays PCR data for the critical (reference) aircraft only. PCR is defined as the ACR of the critical aircraft at the maximum allowable gross weight (MAGW).
  - Results Table 3 – ACR Data.
- **No cut-and-paste. The PCR graph is generated automatically.**

PCR Terminology

- **Critical aircraft: Aircraft taken to represent the whole traffic mix in the PCR computation. *It is not necessarily the aircraft with the highest ACR.***
- **Critical aircraft total equivalent departures = number of departures of the critical aircraft at the operating weight that results in the same CDF as the whole traffic mixture.**
- **Maximum allowable gross weight (MAGW) = gross weight of critical aircraft that results in CDF = 1 for the evaluation structure (at total equivalent departures).**
- **<u>PCR = ACR of critical aircraft computed at MAGW</u>.**

Results Tables 1 and 2



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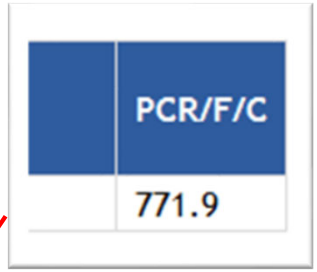
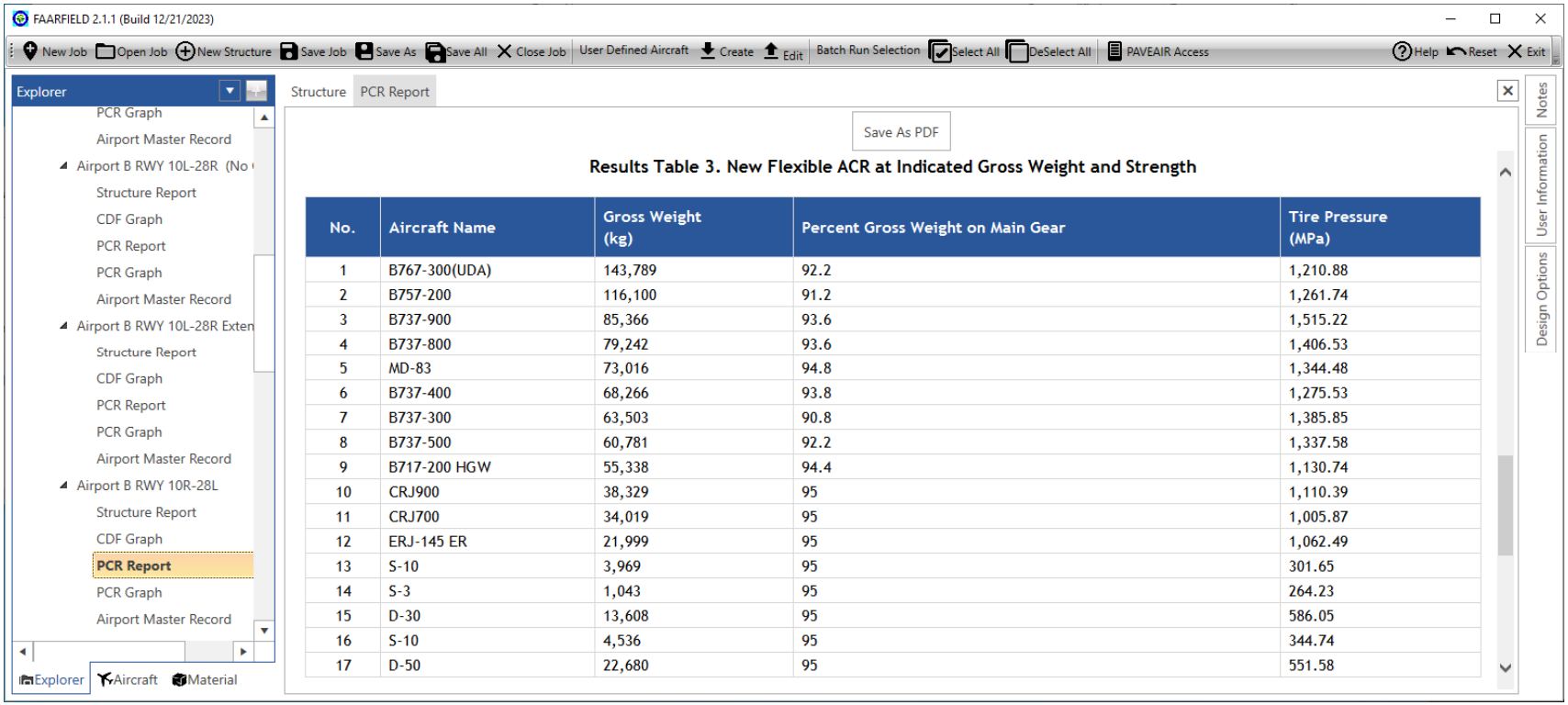
15	D-30	13,608	95.00	586.05	6,525	77,404
16	S-10	4,536	95.00	344.74	15,225	136,426
17	D-50	22,680	95.00	551.58	40,400	537,250

No.	Aircraft Name	Critical aircraft Total equiv. departures	Max allowable Gross Weight of critical aircraft (kg)	ACR Thick at max. MGW (mm)	PCR/F/C
1	B737-900	1360	118,791	807	771.9

- **Actual computed PCR = 771.9.**
- **Report PCR to nearest whole multiple of 10 (per ADM).**
- **Report PCR 770/F/C/X/T.**



Results Table 3



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

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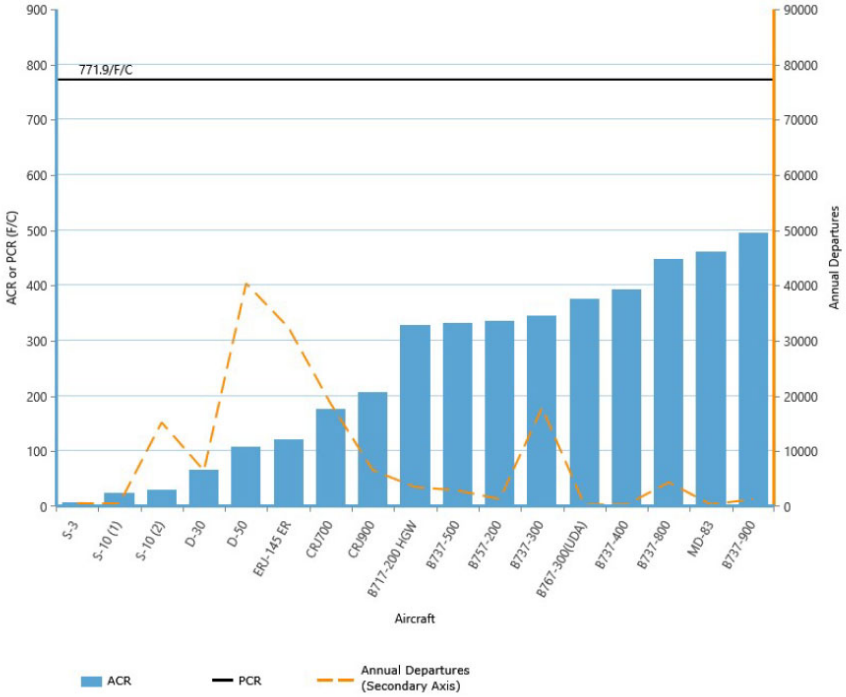
15	D-30	13,608	95	586.05
16	S-10	4,536	95	344.74
17	D-50	22,680	95	551.58

PCR Graph for Example

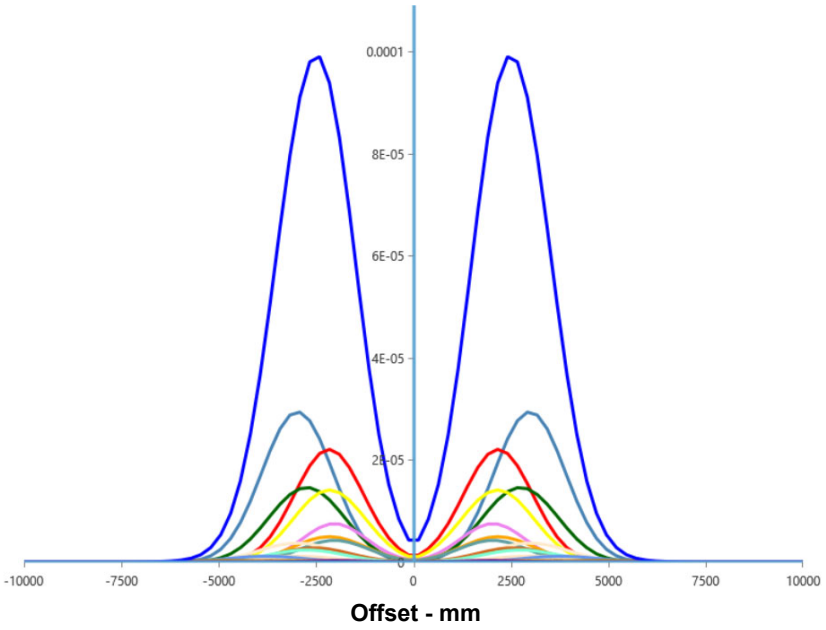
Critical aircraft: B737-900

No.	Aircraft Name	Aircraft ACR	Calculated PCR	Annual Departure
1	B737-900	495.4	771.9	1,360
2	MD-83	491.8	-	365
3	B737-800	447.9	-	4,380
4	B737-400	393.4	-	365
5	B767-300(UDA)	376	-	365
6	B737-300	345.6	-	17,885
7	B757-200	336.5	-	1,360
8	B737-500	331.6	-	2,920
9	B717-200 HGW	328.5	-	3,531
10	CRJ900	207.7	-	6,570
11	CRJ700	177.5	-	18,615
12	ERJ-145 ER	122.2	-	32,405
13	D-50	108	-	40,400
14	D-30	66.9	-	6,525
15	S-10	30.3	-	15,225
16	S-10	24.2	-	550
17	S-3	7.9	-	600

All design aircraft have ACR < PCR



CDF Graph

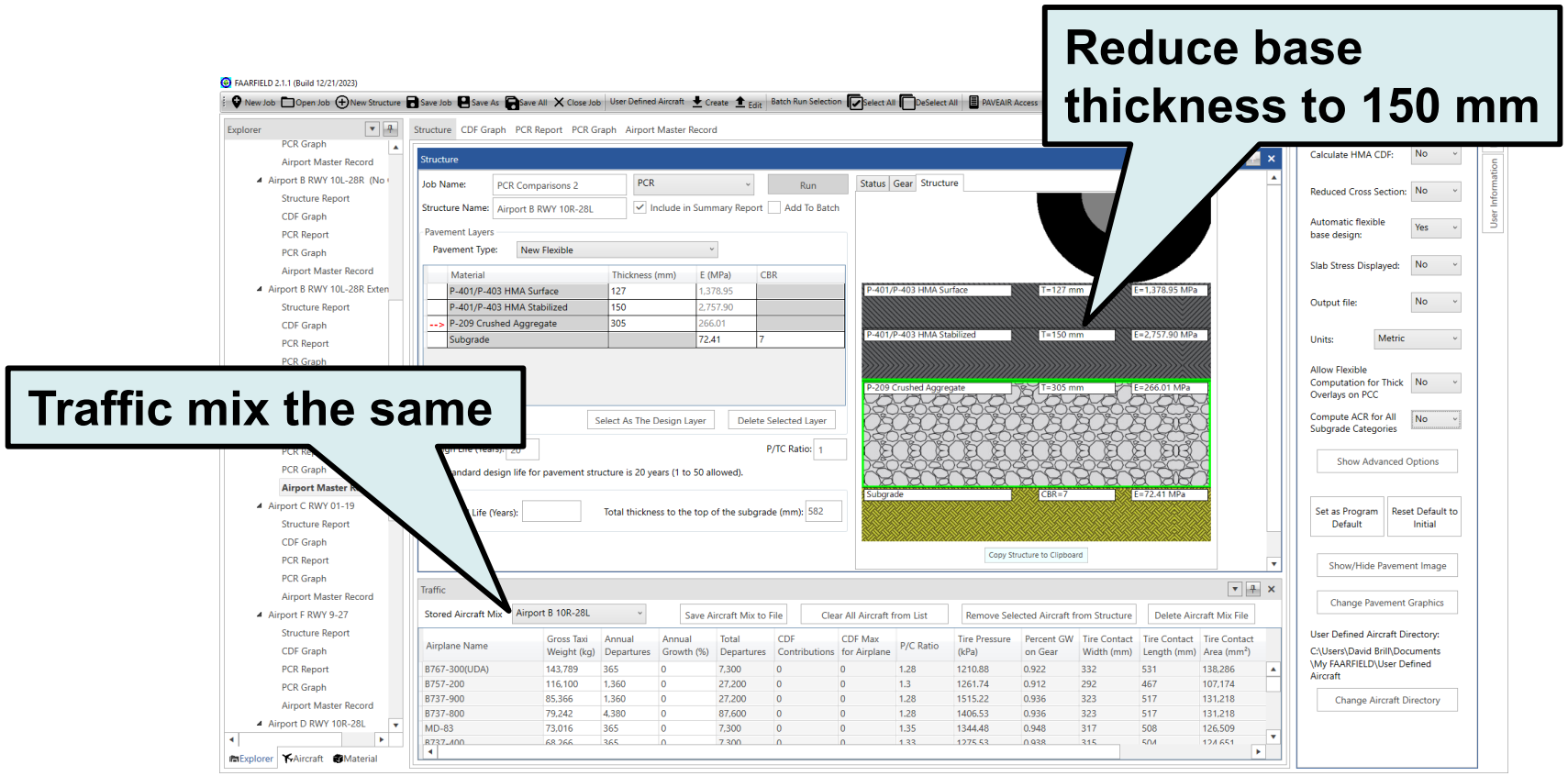


- **CDF for this example << 1**
  - Significant excess strength.
  - Consistent with no restrictions on using aircraft.
  - Aircraft generally bunched up around same offset.
- **Maximum CDF for PCR is usually less than CDF for design.**
  - Due to different gear characteristics used for PCR computation
  - For design, we assume 95% of gross weight on the main gear (conservative).
  - PCR assumes maximum ramp mass and actual corresponding aft c.g.

Airport Master Record (AMR) Data

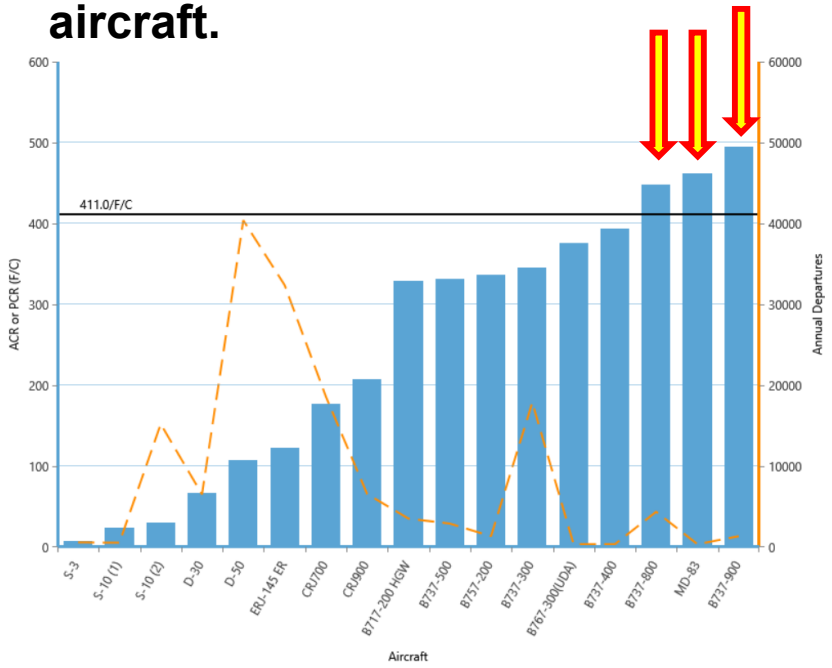
Use the information on this page to populate fields 35-39 in Airport Master Record (U.S. only).

What if we reduce the base thickness?

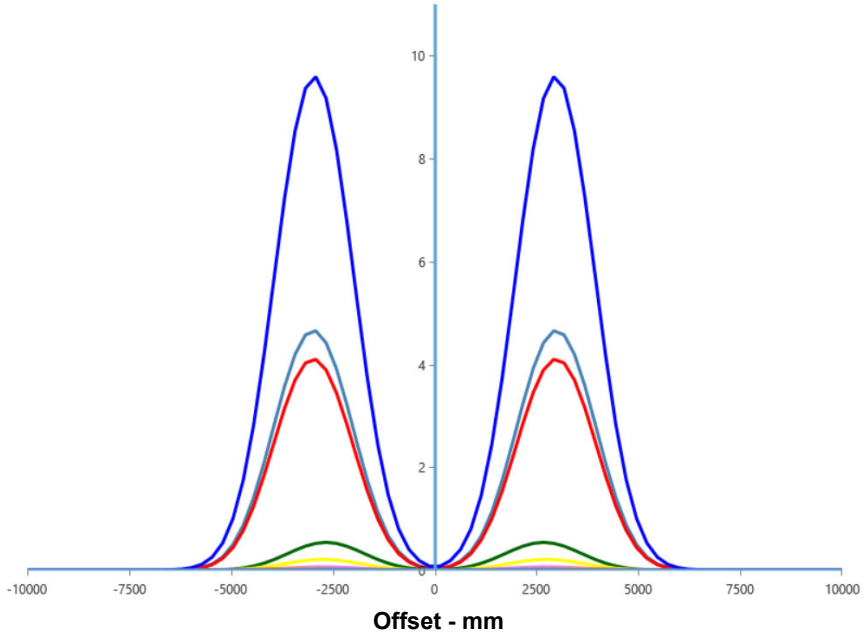


PCR for Reduced Based Thickness

- **PCR 410/F/C/X/T**
- **Requires exclusion or operating weight restrictions on 3 mix aircraft.**



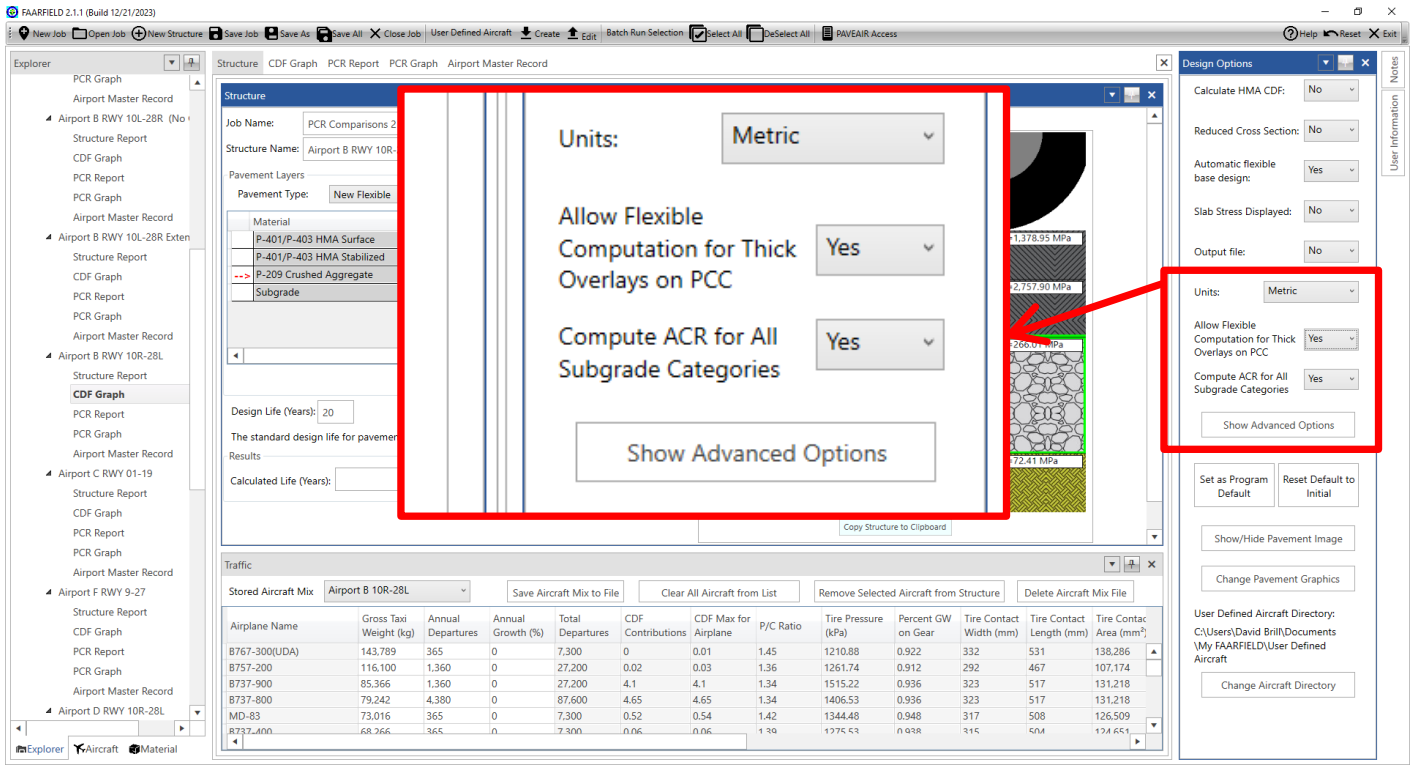
- **CDF > 1.0**
- **Consistent with need for weight restrictions.**



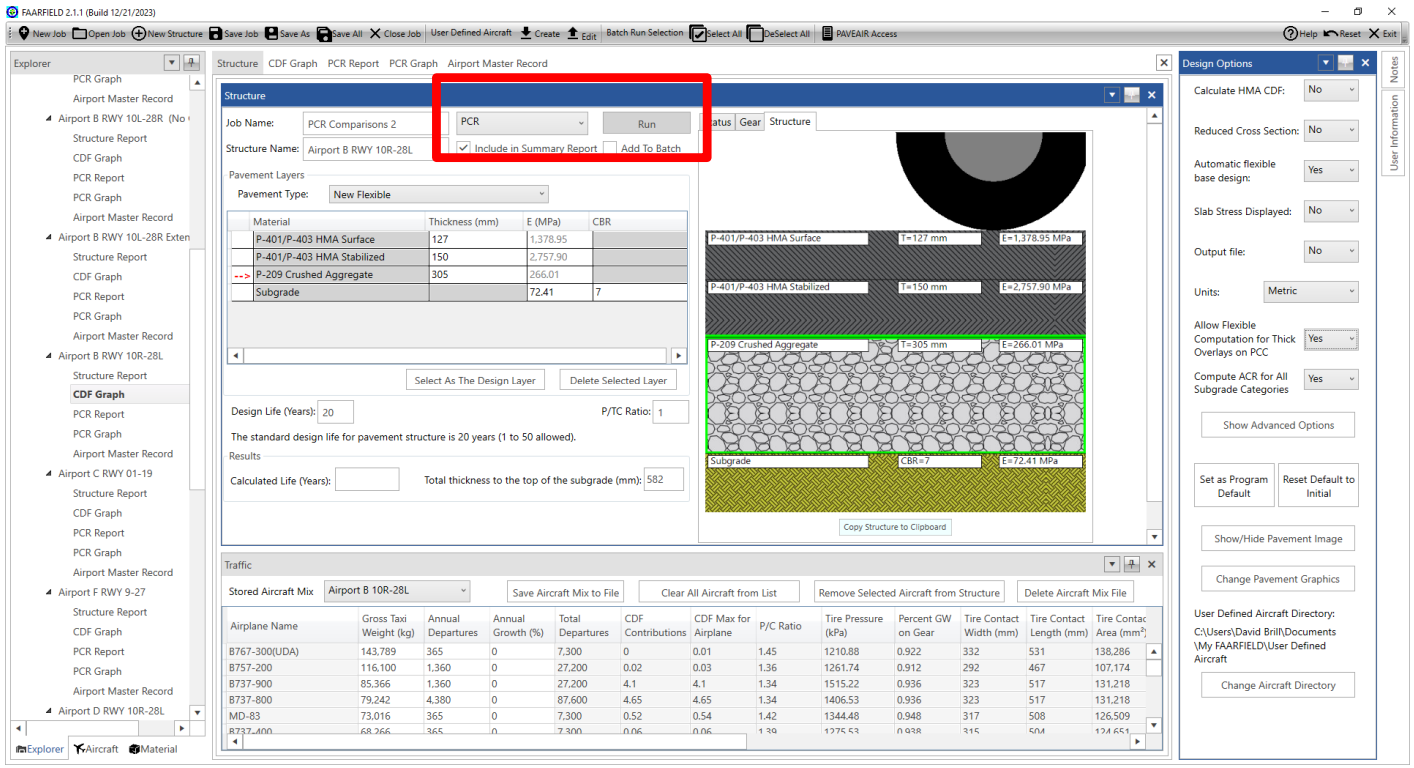
Use FAARFIELD to Compute ACR

- **By default, FAARFIELD computes ACR data for the subgrade strength category of the current pavement.**
- **Option to return ACR data for all subgrade categories.**
- **Convenient to compare ACR for various gear configurations.**

Use FAARFIELD to Compute ACR

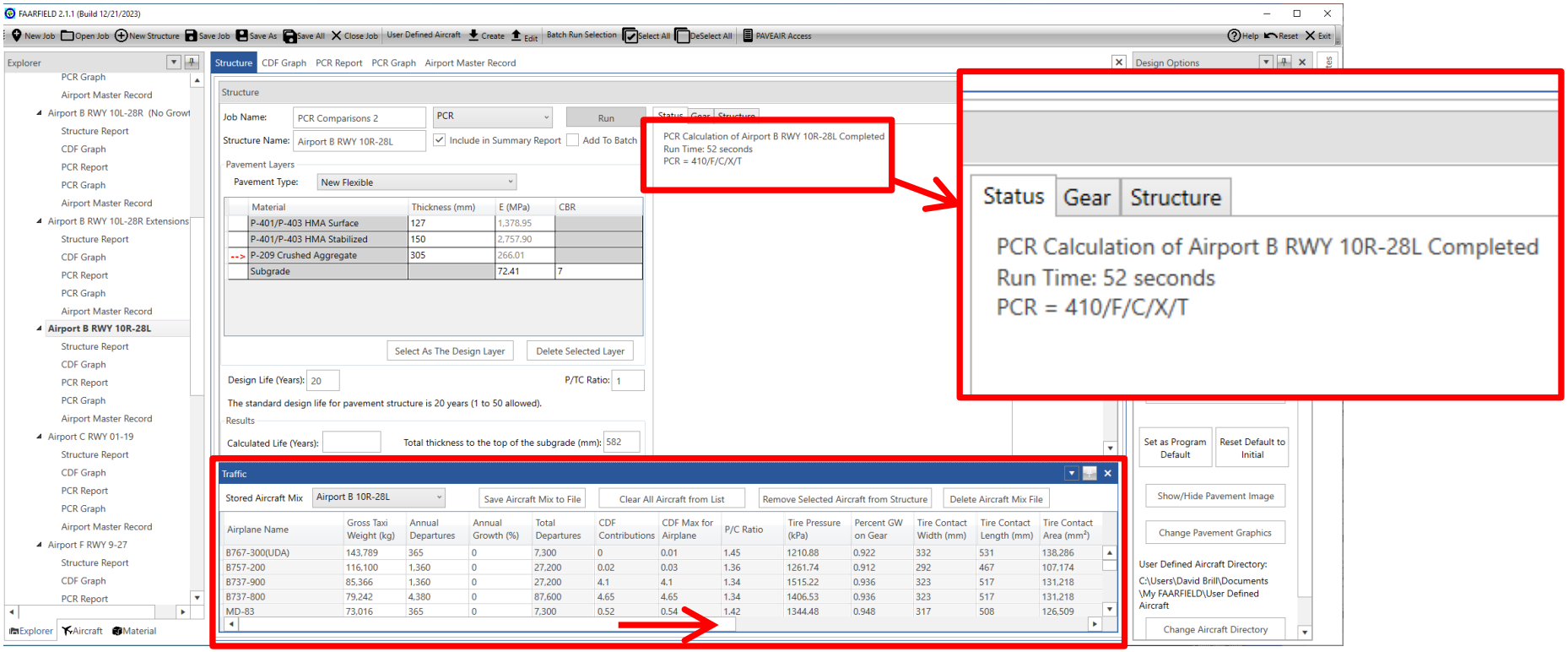


Select PCR Mode / Hit Run



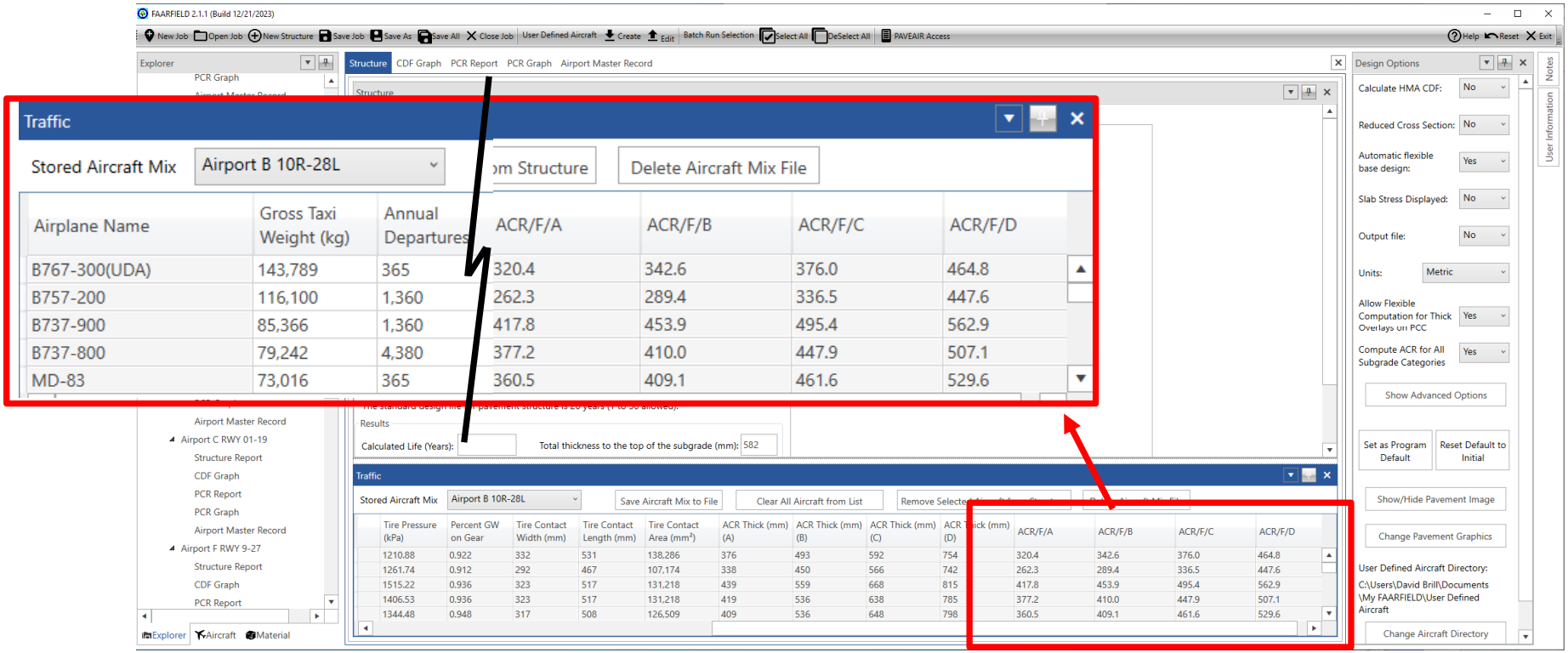
PCR Complete

Scroll Traffic Table to the Right



Traffic Table

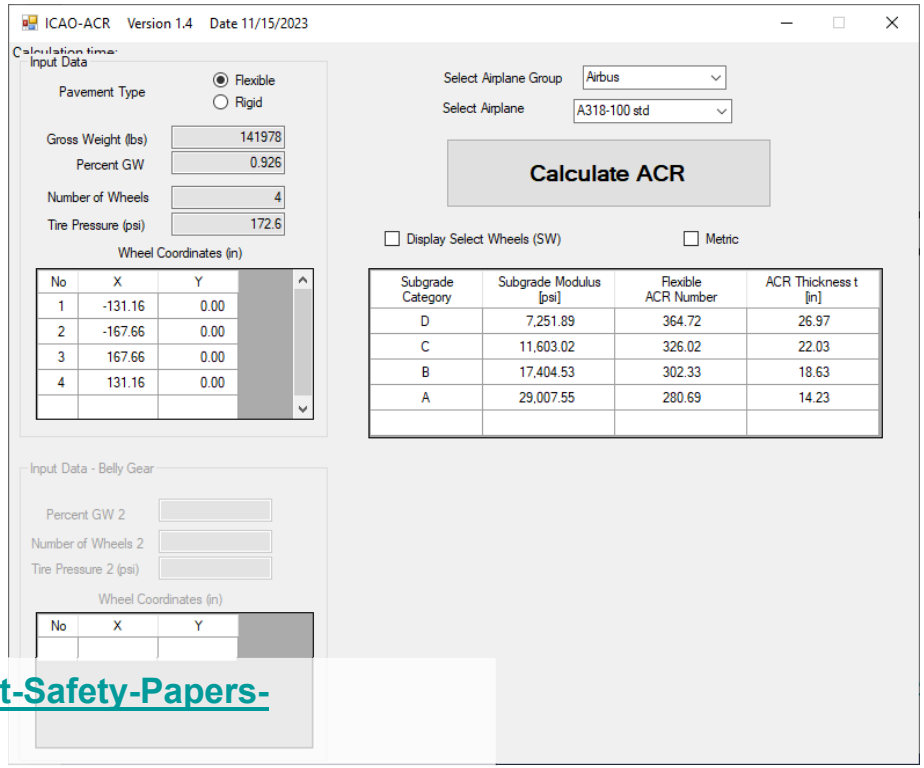
Now displays ACR values for all 4 subgrade categories.

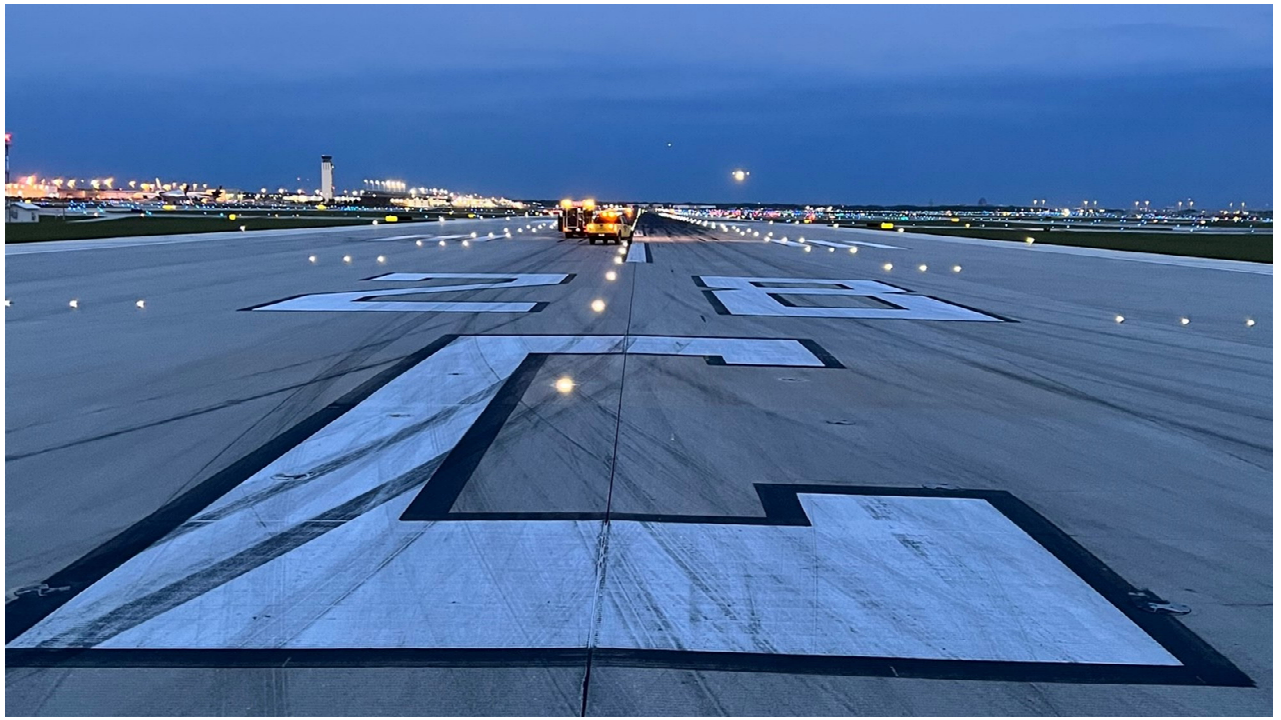


ICAO-ACR Version 1.4

- FAA developed program.
- Calculates standard ACR numbers for aircraft operating on flexible and rigid airport pavements.
- Core library can be linked directly to other programs to either compute ACR directly or use as part of a technical PCR evaluation.
- New – Reads the FAARFIELD aircraft library directly.
- Get technical information on how to link the library to a calling program from the ICAO-ACR download page:

https://www.airporttech.tc.faa.gov/Products/Airport-Safety-Papers-Publications/Airport-Safety-Detail/icao-acr-14





Rigid Pavement PCR Example

FAARFIELD 2.0 PCR Example

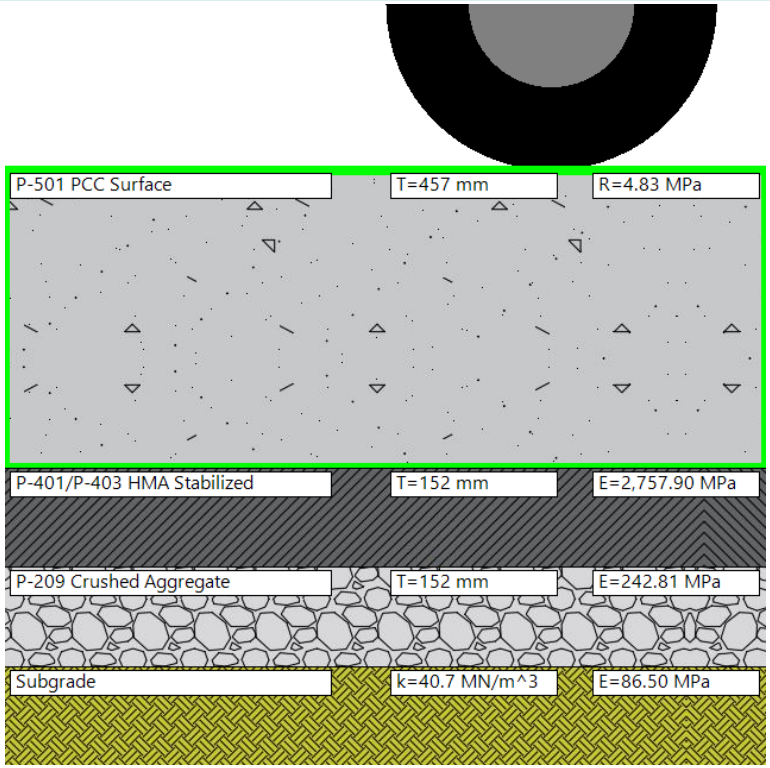
- **Airport E**
  - Large-hub airport in the U.S.
  - Runway 10C-28C is a rigid runway constructed in 2013.
- **Design Section:**
  - 18 in. (457 mm) PCC surface (P-501)
  - 6 in. (152 mm) HMA base (P-403)
  - 6 in. (152 mm) asphalt-treated permeable base (ATPB)
  - 12 in. (305 mm) stabilized subgrade over natural subgrade
- **For design purposes, ATPB is assumed equivalent to standard granular base course P-209.**
- **Subgrade stabilization provides estimated *k* = 150 pci at top of subgrade.**
- **Airport reported PCN 96/R/C/W/T using COMFAA 3.0 (Old ACN/PCN system).**

04L/22R	04R/22L	09C/27C	09L/27R	09R/27L	10C/28C	10L/28R	10R/28L	10X	H1

Runway Data		Obstruction Data	
Runway Identification	10C/28C	FAR 77 Category	PIR/PIR
Length	10,800	Displaced Threshold	/
Width	200	Controlling Obstruction	/
Surface Type-Condition	CONC-E	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)	135.0	Obstruction Clearance Slope	50/50
2 Dual Wheels in Tandem (2D)	375.0	Close-In Obstruction	N/N
2 Dual Wheels in Tandem/ 2 Dual Wheels in Double Tandem (2D/2D2)	902.0		
Pavement Classification Number (PCN)	96 /R/C/W/T		

FAARFIELD 2.0 PCR - Data

Airport E - Runway 10C-28C



Traffic

Stored Aircraft Mix: Airport A

Save Aircraft Mix to File

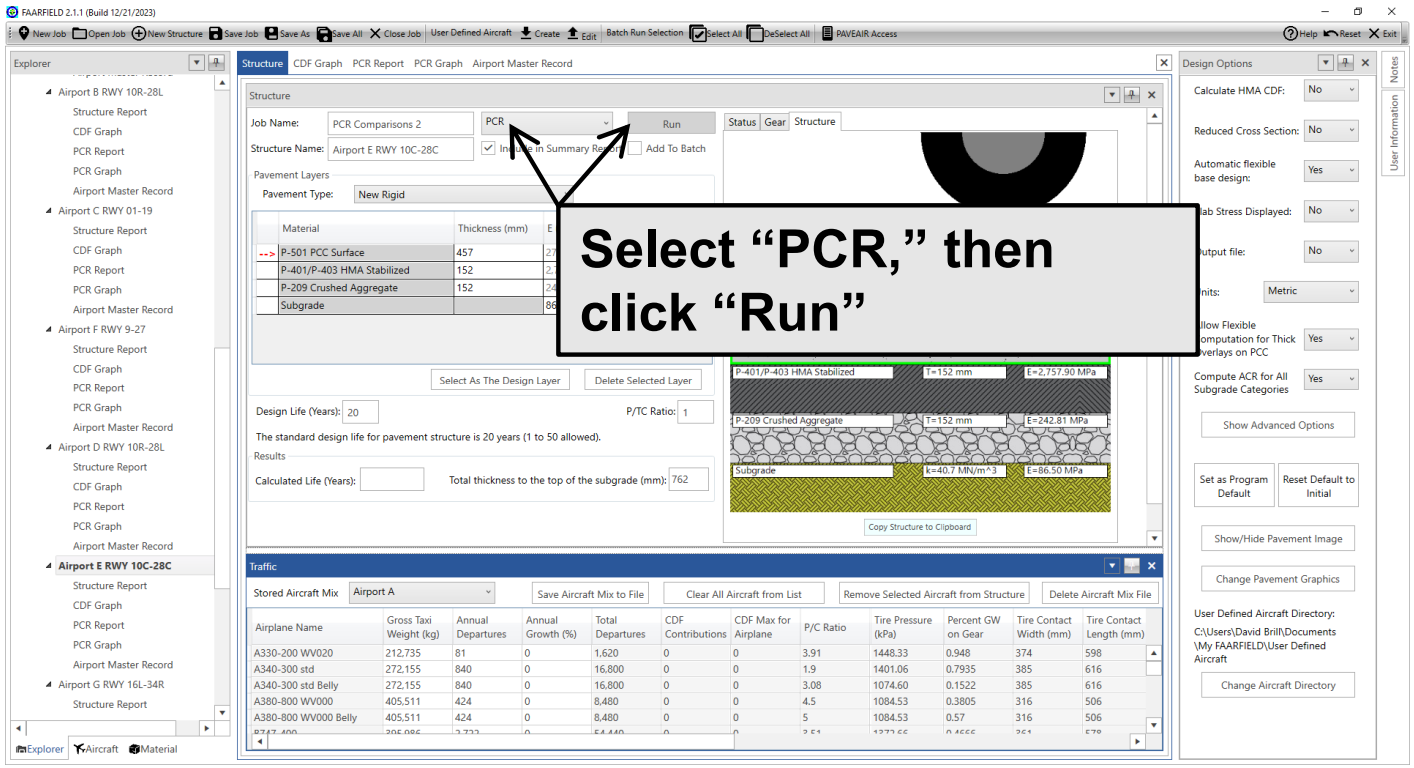
Airplane Name	Gross Taxi Weight (kg)	Annual Departures	Annual Growth (%)	Total Departures
A330-200 WV020	212,735	81	0	1,620
A340-300 std	272,155	840	0	16,800
A340-300 std Belly	272,155	840	0	16,800
A380-800 WV000	405,511	424	0	8,480
A380-800 WV000 Belly	405,511	424	0	8,480
B747-400	395,986	2,722	0	54,440
B747-400 Belly	395,986	2,722	0	54,440
B767-300 ER/Freighter	185,519	3,454	0	69,080
B777-300	327,493	3,372	0	67,440
A300-600 Std Bogie	170,097	1,019	0	20,380
DC/MD-10-10/10F	207,746	71	0	1,420
MD-11	281,681	606	0	12,120
MD-11 Belly	281,681	606	0	12,120
B757-200	113,398	291	0	5,820
A320-200 std	68,039	24,656	0	493,120
B737-800	78,471	26,655	0	533,100
B727-200 Advanced Basic	78,018	1,346	0	26,920
D-50	20,412	28,229	0	564,580
S-30	10,206	3,808	0	76,160

One-Step PCR Procedure

- For PCR following design, the evaluation structure and traffic mix are already entered in FAARFIELD.
- No equivalent thickness calculation needed.
- In PCR mode, FAARFIELD automatically switches to standard CG and tire pressure conditions for ACR evaluation.
- FAARFIELD automatically determines the subgrade category from subgrade data.
- FAARFIELD automatically determines the critical aircraft from the traffic list.

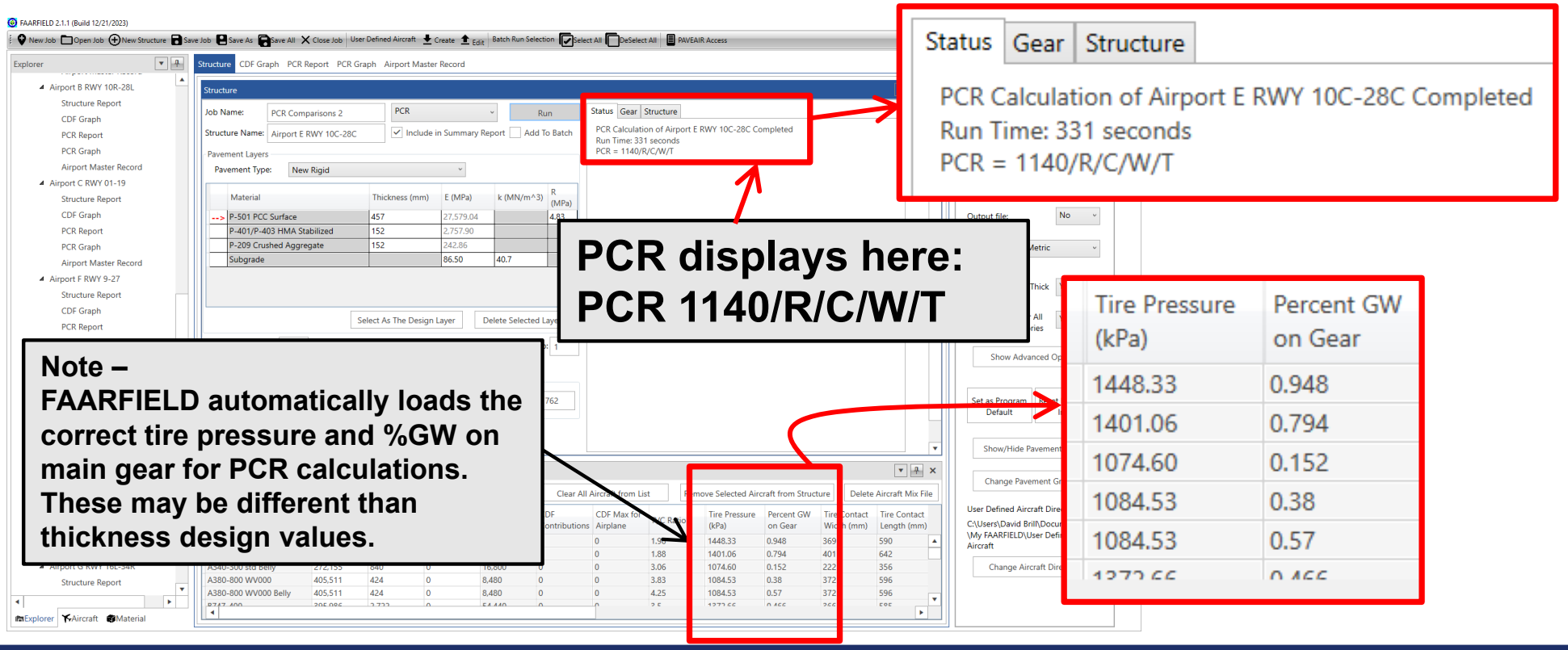
FAARFIELD 2.0 PCR Example

One-Step Procedure

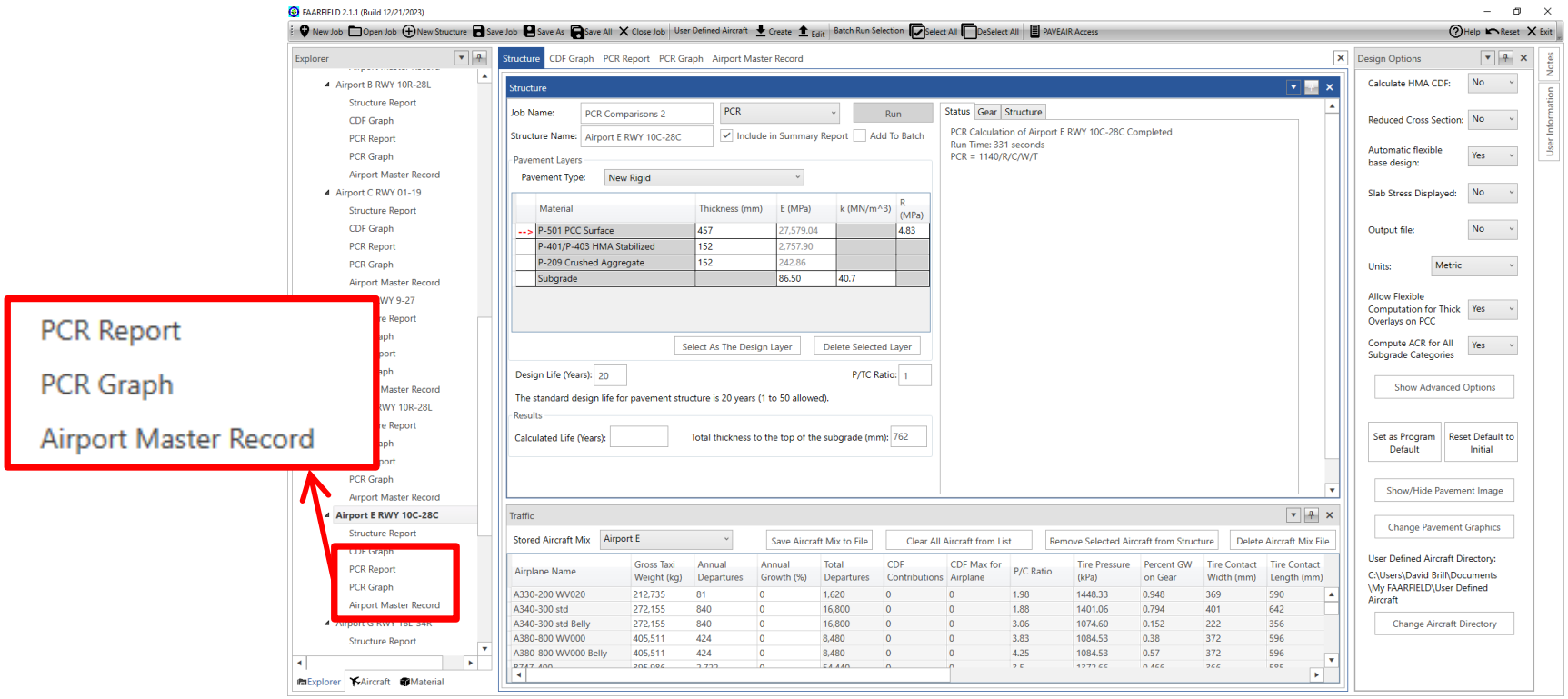


FAARFIELD 2.0 PCR Example

PCR = 1140/R/C/W/T



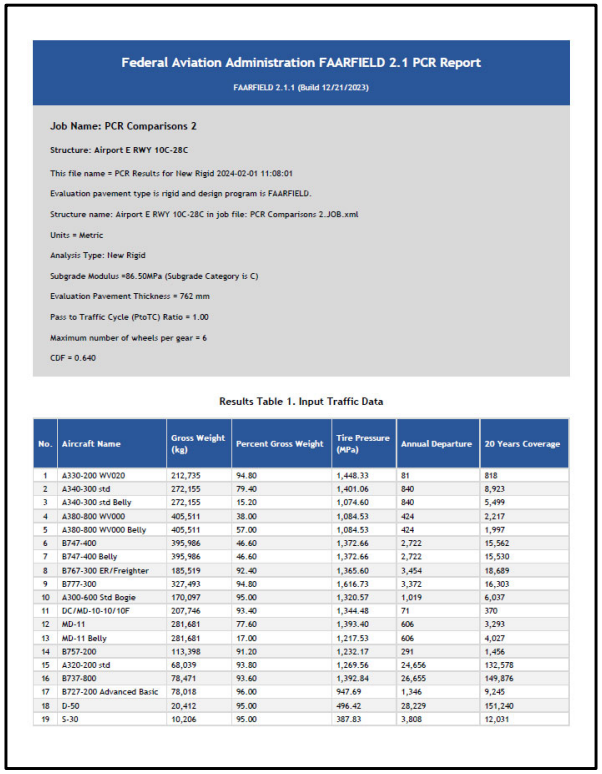
PCR Reports and Graphs



PCR Report

Summary Data

Results Table 1



Federal Aviation Administration FAARFIELD 2.1 PCR Report

FAARFIELD 2.1.1 (Build 12/21/2023)

Job Name: PCR Comparisons 2

Structure: Airport E RWY 10C-28C

This file name = PCR Results for New Rigid 2024-02-01 11:08:01

Evaluation pavement type is rigid and design program is FAARFIELD.

Structure name: Airport E RWY 10C-28C in job file: PCR Comparisons 2.JOB.xml

Units = Metric

Analysis Type: New Rigid

Subgrade Modulus =86.50MPa (Subgrade Category is C)

Evaluation Pavement Thickness = 762 mm

Pass to Traffic Cycle (PtoTC) Ratio = 1.00

Maximum number of wheels per gear = 6

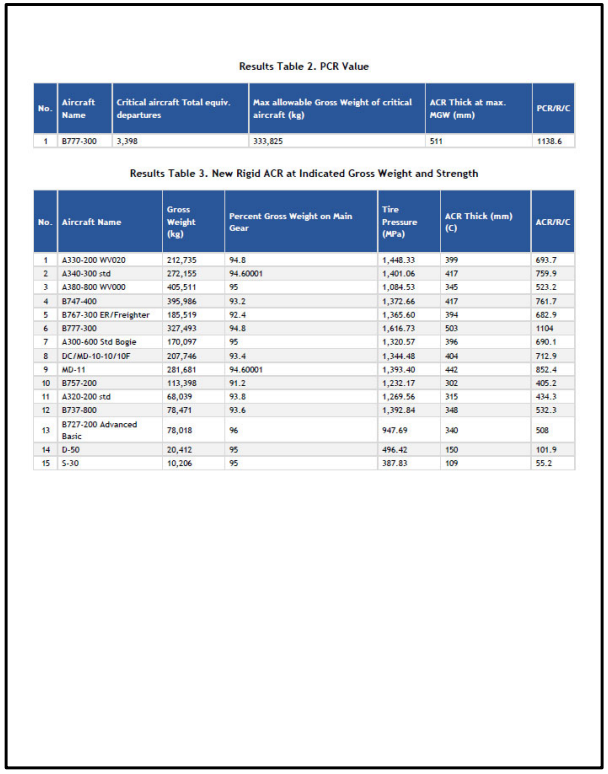
CDF = 0.640

Results Table 1. Input Traffic Data

No.	Aircraft Name	Gross Weight (kg)	Percent Gross Weight	Tire Pressure (MPa)	Annual Departure	20 Years Coverage
1	A330-200 WV020	212,735	94.80	1,448.33	81	818
2	A340-300 std	272,155	79.40	1,401.06	840	8,923
3	A340-300 std Belly	272,155	15.20	1,074.60	840	5,499
4	A380-800 WV000	405,511	38.00	1,084.53	424	2,217
5	A380-800 WV000 Belly	405,511	57.00	1,084.53	424	1,997
6	B747-400	395,986	46.60	1,372.66	2,722	15,562
7	B747-400 Belly	395,986	46.60	1,372.66	2,722	15,530
8	B767-300 ER/Freighter	185,519	92.40	1,365.60	3,454	18,689
9	B777-300	327,493	94.80	1,616.73	3,372	16,303
10	A300-600 Std Bogie	170,097	95.00	1,320.57	1,019	6,037
11	DC/MD-10-10/10F	207,746	93.40	1,344.48	71	370
12	MD-11	281,681	77.60	1,393.40	606	3,293
13	MD-11 Belly	281,681	17.00	1,217.53	606	4,027
14	B757-200	113,398	91.20	1,232.17	291	1,456
15	A320-200 std	68,039	93.80	1,269.56	24,656	132,578
16	B737-800	78,471	93.60	1,392.84	26,655	149,876
17	B727-200 Advanced Basic	78,018	96.00	947.69	1,346	9,245
18	D-50	20,412	95.00	496.42	28,229	151,240
19	S-30	10,206	95.00	387.83	3,808	12,031

Results Table 2

Results Table 3



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/R/C
1	B777-300	3,398	333,825	511	1138.6

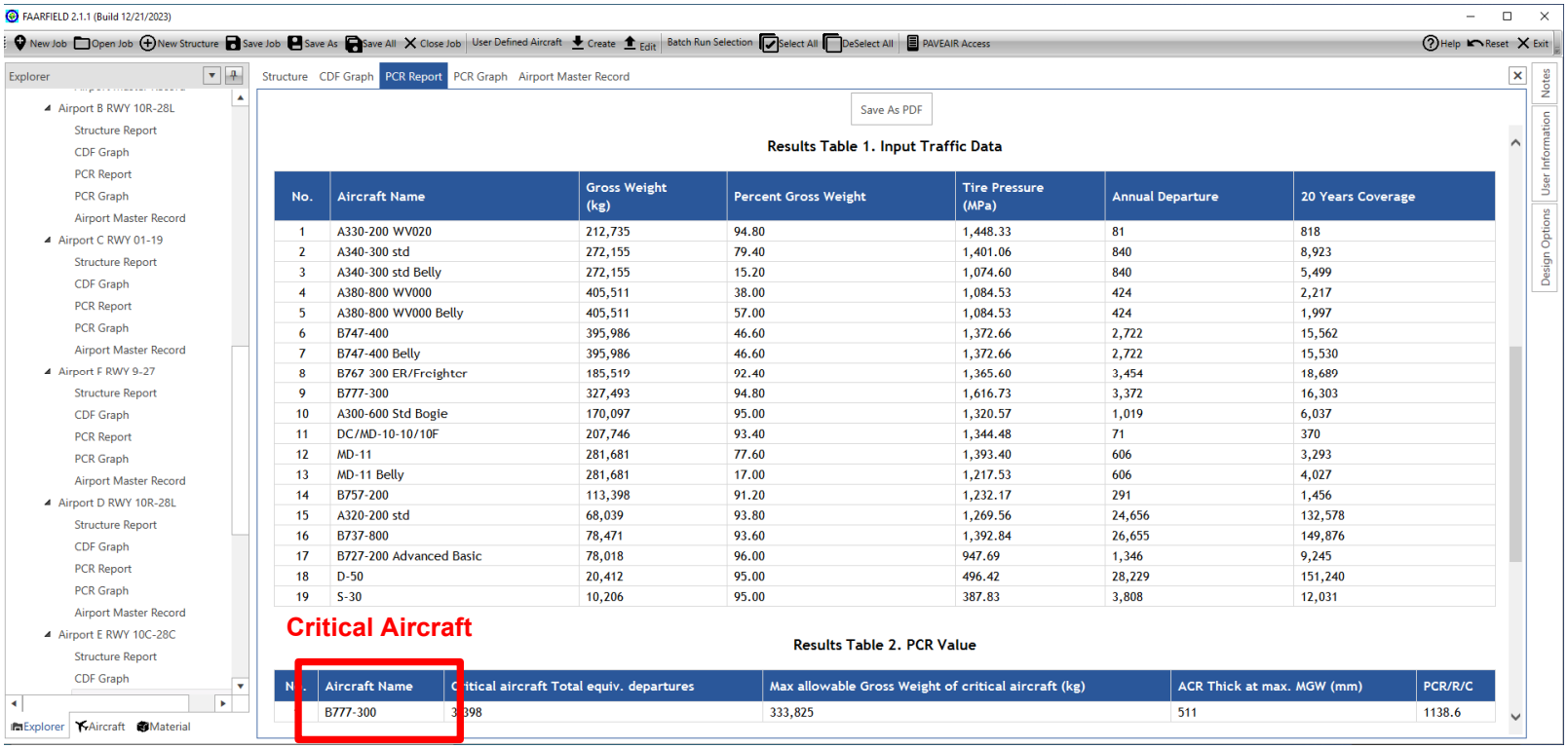
Results Table 3. New Rigid ACR at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight (kg)	Percent Gross Weight on Main Gear	Tire Pressure (MPa)	ACR Thick (mm) (C)	ACR/R/C
1	A330-200 WV020	212,735	94.8	1,448.33	399	693.7
2	A340-300 std	272,155	94.60001	1,401.06	417	759.9
3	A380-800 WV000	405,511	95	1,084.53	345	523.2
4	B747-400	395,986	93.2	1,372.66	417	761.7
5	B767-300 ER/Freighter	185,519	92.4	1,365.60	394	682.9
6	B777-300	327,493	94.8	1,616.73	503	1104
7	A300-600 Std Bogie	170,097	95	1,320.57	396	690.1
8	DC/MD-10-10/10F	207,746	93.4	1,344.48	404	712.9
9	MD-11	281,681	94.60001	1,393.40	442	852.4
10	B757-200	113,398	91.2	1,232.17	302	405.2
11	A320-200 std	68,039	93.8	1,269.56	315	434.3
12	B737-800	78,471	93.6	1,392.84	348	532.3
13	B727-200 Advanced Basic	78,018	96	947.69	340	508
14	D-50	20,412	95	496.42	150	101.9
15	S-30	10,206	95	387.83	109	55.2

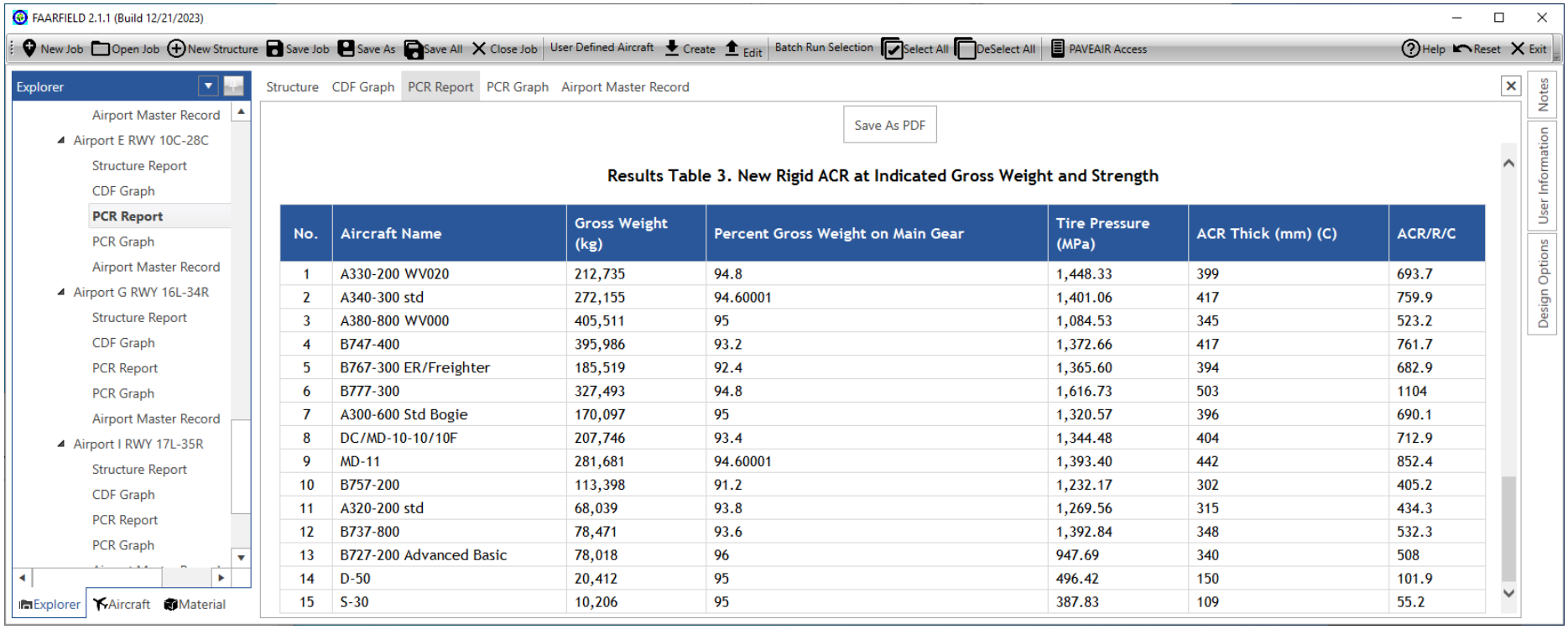
Review – PCR Report

- **Results Table 1 – Input Traffic Data.**
- **Results Table 2 displays PCR data for the critical (reference) aircraft only.**
  - PCR is defined as the ACR of the critical aircraft at the maximum allowable gross weight (MAGW).
  - Can report PCR to the nearest whole multiple of 10.
- **Results Table 3 – ACR Data.**

Results Tables 1 and 2



Results Table 3



Results Table 3. New Rigid 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) (C)	ACR/R/C
1	A330-200 WV020	212,735	94.8	1,448.33	399	693.7
2	A340-300 std	272,155	94.60001	1,401.06	417	759.9
3	A380-800 WV000	405,511	95	1,084.53	345	523.2
4	B747-400	395,986	93.2	1,372.66	417	761.7
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6	B777-300	327,493	94.8	1,616.73	503	1104
7	A300-600 Std Bogie	170,097	95	1,320.57	396	690.1
8	DC/MD-10-10/10F	207,746	93.4	1,344.48	404	712.9
9	MD-11	281,681	94.60001	1,393.40	442	852.4
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12	B737-800	78,471	93.6	1,392.84	348	532.3
13	B727-200 Advanced Basic	78,018	96	947.69	340	508
14	D-50	20,412	95	496.42	150	101.9
15	S-30	10,206	95	387.83	109	55.2

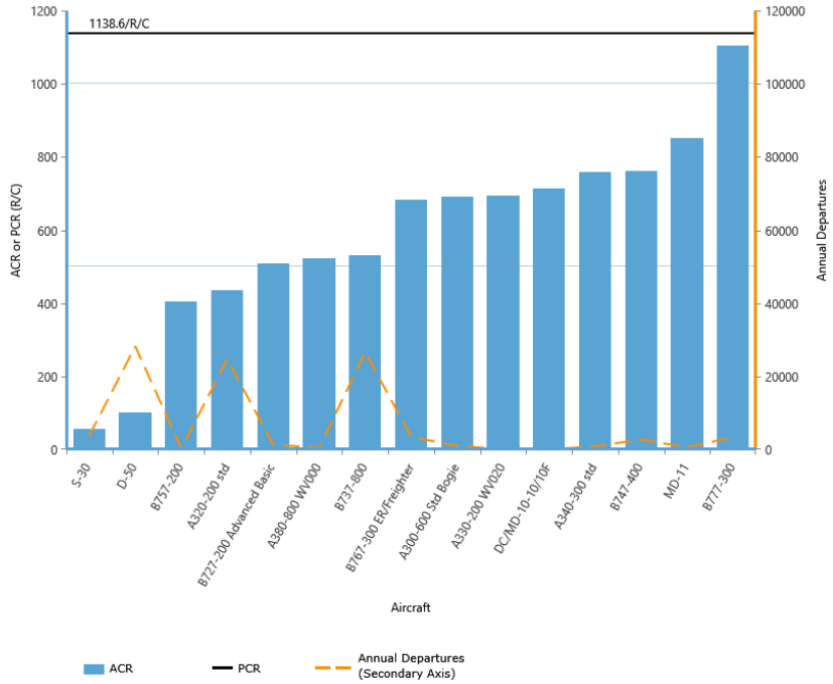
PCR Graph for Example

Critical aircraft: B777-300

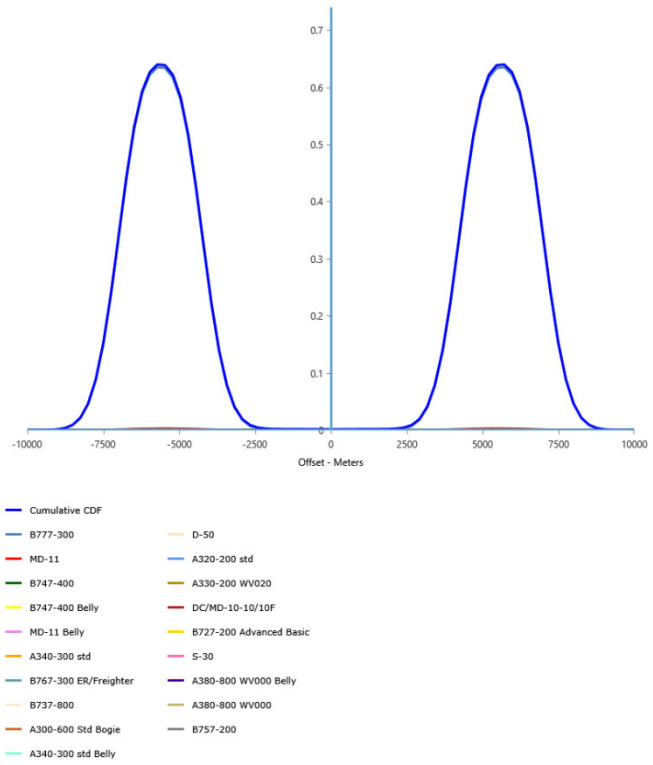
No.	Aircraft Name	Aircraft ACR	Calculated PCR	Annual Departure
1	B777-300	1104	1138.6	3,372
2	MD-11	852.4	-	606
3	B747-400	761.7	-	2,722
4	A340-300 std	759.9	-	840
5	DC/MD-10-10/10F	712.9	-	71
6	A330-200 WV020	693.7	-	81
7	A300-600 Std Bogie	690.1	-	1,019
8	B767-300 ER/Freighter	682.9	-	3,454
9	B737-800	532.3	-	26,655
10	A380-800 WV000	523.2	-	424
11	B727-200 Advanced Basic	508	-	1,346
12	A320-200 std	434.3	-	24,656
13	B757-200	405.2	-	291
14	D-50	101.9	-	28,229

All design aircraft have ACR < PCR.

What does that mean?



CDF Graph



- **CDF for this example < 1**
  - Excess strength.
  - Consistent with no restrictions on using aircraft.
  - Maximum CDF is dominated by critical aircraft in this case.
- **Maximum CDF for PCR is usually less than CDF for design.**
  - Due to different gear characteristics used for PCR computation
  - For design, we assume 95% of gross weight on the main gear (conservative).
  - PCR assumes maximum ramp mass and actual corresponding aft c.g.

Rigid Pavement PCR Reminders

- **Rigid pavement PCR is sensitive to concrete flexural strength (*R*).**
- **Subgrade strength categories have changed from ACN/PCN system.**
  - Subgrade category is based on the *E*-modulus at top of subgrade. (No more estimation of top-of-base *k*.)
  - Subgrade category may be different from PCN.
- **More examples: See FAA Report No. DOT/FAA/TC-23/57 (2023): *PCN–PCR Comparisons for Large- and Medium-Hub Airport Runways***

Questions?

Acknowledgments:

FAA Airport Technology R&D Branch:
James Layton, Branch Manager;
Murphy Flynn, Airport Pavement Section Manager

FAA Airport Engineering Division:
D'Lorah Small, Harold Honey, Jeff Crislip, Harold Muniz-Ruiz

ARA:
Tim Parsons; Richard Speir; Dr. Ali Z. Ashtiani; Dr. Kairat Tuleubekov

APEG:
Cyril Fabre (Airbus); Liana Ding, Dr. Priyanka Sarker (Boeing);
Prisca Nkolo (ACI); Dr. Michael Broutin, Lucy Travailleur (DGAC-France);
John Cook (MOD-UK); Dr. Greg White

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