

ICAO ACR-PCR Procedure of Reporting Airport Pavement Strength

Introduction to FAA AC 150/5335-5D

Presented to: Fourth Meeting of the Asia/Pacific
Aerodrome Design and Operations Task
Force (AP-ADO/TF/4 Hybrid)

By: Harold Honey, P.E., PMP
Jeff Crislip

Date: 11 January 2023



**Federal Aviation
Administration**



Introductions

- **FAA Office of Airports, Airport Engineering Division (AAS-100)**
- **Engineering, Design and Construction Branch (AAS-110)**

The FAA develops engineering, design, and construction standards for all civil airports, heliports, and seaplane bases. This includes standards for airfield pavement; airport lighting, marking, signs, and other visual aids; safety during construction; surveying and GIS data; deicing, ARFF and other facilities; bird radar and foreign object detection systems; and more.

- **Airfield Pavement Engineering Subject Matter Experts**
 - Harold Honey, P.E., PMP
 - Jeffrey Crislip
 - Harold Muniz-Ruiz



Pavement Strength Reporting Background

- **Prior to 1981 there were many strength reporting methods**
 - FAA used Maximum Allowable Weight Method (MAW)
 - UK used Load Classification Number/Group Methods (LCN/LCG)
 - Other methods used by various international agencies
- **In late 1970's, ICAO recognized the need for a standardized method of reporting pavement strength to support increasing international traffic**
- **ICAO adopted the ACN-PCN Method of reporting airport pavement strength in 1981**



ACN-PCN System

Pavement Type

R = rigid, concrete

F = flexible, asphalt

Evaluation Method

T = technical

U = type of using aircraft



56 / R / B / W / T

Subgrade Strength

A = high, ≥ 13 CBR, ≥ 120 K

B = med, > 8 CBR, > 60 K

C = low, > 4 CBR, > 25 K

D = ultra low, ≤ 4 CBR, ≤ 25 K

Tire Pressure

W = high, no limit

X = med, ≤ 1.75 MPa

Y = low, ≤ 1.25 MPa

Z = very low, ≤ 0.5 MPa



ACR-PCR System

- **ICAO Aerodrome Pavement Expert Group (APEG)**
 - ACN-PCN Task Force established in 2011 to investigate an update to method
 - Participants included Airbus, Boeing, ACI World, FAA, DGAC (France), others
 - Developed ACR-PCR Method (Aircraft Classification Rating – Pavement Classification Rating)
- **Same concepts as ACN-PCN method, but:**
 - Fully layered elastic-based analysis (ACN-PCN largely CBR/Westergaard)
 - Uses uniform standard subgrade categories for flexible and rigid pavement
 - **NO alpha factor, layer equivalency factors, top-of-base k, etc.**
 - If you don't know what these are don't worry, they allowed the method to work with various pavement structures and complex gear configurations



ACR-PCR Definitions

- **Aircraft Classification Rating (ACR)**
 - A number that expresses the relative effect of an aircraft at a given configuration on a pavement structure for a specified standard subgrade strength.
- **Pavement Classification Rating (PCR)**
 - A number that expresses the load-carrying capacity of a pavement for **unrestricted operations**
- **System Methodology**
 - The ACR-PCR system is structured so a pavement with a particular PCR value can support an aircraft that has an ACR value equal to or less than the pavement's PCR. This is possible because ACR and PCR values are computed using the same technical basis.

$$ACR \leq PCR$$



ICAO ACR-PCR Implementation

- **Amendment 15 to Annex 14, Volume 1 to the Convention on International Civil Aviation**
 - Adopted by the Council at the fourth meeting of its 219th session on 9 March 2020
 - Effective 20 July 2020
 - Applicable 28 November 2024 for provisions related to pavement rating
- **Doc 9157 Aerodrome Design Manual Part 3 – Pavements, Third Edition, 2022**
 - Provides detailed information on ACR-PCR method
 - State Practices will be updated when ACR-PCR becomes applicable in 2024



ACR-PCR System

Pavement Type

R = rigid, concrete

F = flexible, asphalt

Evaluation Method

T = technical

U = type of using aircraft

PCR (ACR)

(485 / R / B) / W / T
ACR Components

Subgrade Strength

A = high, ≥ 150 MPa (E)

B = med, > 100 MPa (E)

C = low, > 60 MPa (E)

D = ultra low, ≤ 60 MPa (E)

Tire Pressure

W = high, no limit

X = med, ≤ 254 psi

Y = low, ≤ 181 psi

Z = very low, ≤ 73 psi



How are ACRs Reported?

- **The official ACRs for an aircraft are published by the aircraft manufacturer:**
 - Boeing and Airbus are updating their aircraft characteristics documents and software to incorporate ACR curves
 - ACRs are unique to an aircraft at a specified weight. Most manufacturers provide an ACR curve to determine ACR at specific weight desired
- **ICAO ACR Computer Programme has been developed to report ACRs**
 - Incorporates aircraft characteristic data provided by aircraft manufacturers
 - Most aircraft are in the database, but some manufacturers have not provided the FAA with the information needed to incorporate some aircraft
 - The manufacturer's ACR data is official data so if there is discrepancy with ICAO ACR programme the manufacturer's data will control



Aircraft Manufacturer ACR Data

737 MAX

Airplane Characteristics for Airport Planning

Revision Record

Revision Letter	G
Revision Date	May 2022
Changes in This Revision	Section 2.0 Updated Usable Cargo Volume, Minor Updates Section 6.0 Updated Jet Engine Exhaust Contour Conditions, Inlet Hazard Areas Section 7.0 Updated ACR/PCR Information

AIRCRAFT TYPE	MAXIMUM TAXI WEIGHT ----- MINIMUM WEIGHT * [1] lb (kg)	LOAD ON ONE MAIN GEAR LEG (%)	TIRE PRESSURE psi (MPa)	ACR FOR RIGID PAVEMENT SUBGRADES				ACR FOR FLEXIBLE PAVEMENT SUBGRADES			
				HIGH E = 200 MPa	MEDIUM E = 120 MPa	LOW E = 80 MPa	ULTRA LOW E = 50 MPa	HIGH E = 200 MPa	MEDIUM E = 120 MPa	LOW E = 80 MPa	ULTRA LOW E = 50 MPa
737-7	177,500 (81,512)	46.69	205 (1.41)	511	533	549	565	384	417	456	517
	95,000 (43,091)			242	254	264	274	198	206	215	234
737-8 / -8-200 / BBJ MAX 8	182,700 (82,871)	46.67	212 (1.46)	533	554	570	586	399	434	474	537
	95,000 (43,091)			244	256	265	275	200	207	215	235
737-9 / BBJ MAX 9	195,200 (88,541)	47.07	230 (1.59)	593	614	629	645	443	481	526	598
	95,000 (43,091)			252	263	272	281	206	211	219	238
737-10	198,400 (89,992)	47.22	235 (1.62)	609	631	645	661	455	494	540	614
	95,000 (43,091)			254	265	274	283	208	212	220	240

*[1] Minimum weight used solely as a baseline for ACR curve generation.



ICAO ACR 1.3

- **FAA Developed Program**
- **Calculates standard ACRs for aircraft**
 - Remember Manufacturer Data is official
- **Core library can be linked to other programs that compute PCR**
- **Developed using FAA LEAF computer programme**

ICAO-ACR Version 1.3 Date March 16, 2020

Input Data

Pavement Type Flexible Rigid

Gross Weight (lbs) 141,978

Percent GW 0.926

Number of Wheels 4

Tire Pressure (psi) 172.60

Wheel Coordinates (in)

No	X	Y
1	-167.66	0.00
2	-131.16	0.00
3	167.66	0.00
4	131.16	0.00

Select Airplane Group Airbus

Select Airplane A319-100 std

Calculate ACR *

Display Select Wheels (SW) Metric

Subgrade Category	Subgrade Modulus [psi]	Flexible ACR Number	ACR Thickness t [in]
D	7,251.89	364.72	26.97
C	11,603.02	326.02	22.03
B	17,404.53	302.33	18.63
A	29,007.55	280.69	14.23

Calculation time: 1.83 sec.

Input Data - Gear 2

Percent GW 2

Number of Wheels 2

Tire Pressure 2 (psi)

Wheel Coordinates (in)

No	X	Y

<http://www.airporttech.tc.faa.gov/Products/Airport-Pavement-Software-Programs/Airport-Software-Detail/ArtMID/3708/ArticleID/2838/ICAO-ACR-13>

PCR Computation Procedure

- The Aerodrome Design Manual provides a model procedure for PCR determination and publication, using the CDF Concept.
- States may develop their own methods for PCR determination, consistent with the overall parameters of the ACR-PCR Method
- **CDF – Cumulative Damage Factor Concept**
 - The CDF is the amount of structural fatigue life of a pavement which has been used up
 - It is expressed as the ratio of applied load repetitions to allowable load repetitions to failure

$$CDF = \frac{\text{Applied coverages}}{\text{Coverages to failure}}$$

Note 1.— When CDF = 1, the pavement subgrade will have used all of its fatigue life.

Note 2.— When CDF < 1, the pavement subgrade will have some remaining life and the value of CDF will give the fraction of the life used.

Note 3.— When CDF > 1, all of the fatigue life will have been used and the pavement subgrade will have failed.



Determination of PCR – Technical Method (T)

- **The technical evaluation should be used when pavement characteristics and aircraft mix are consistently known and documented.**
- **The PCR procedure does not dictate the use of a preferred subgrade failure/damage model nor a method for treating the multi-axle loading.**
- **Therefore, States can use their existing pavement design and evaluation methodologies.**
 - FAA has incorporated PCR computation into its FAARFIELD 2.0 software
 - French DGAC has incorporated PCR computation into its Alize-Aeronautics software
- **The use of the initial pavement design parameters will ensure consistency between what the actual pavement is able to withstand and the PCR assignment.**



PCR Procedure – Using Aircraft Method (U)

- **When, for economic or other reasons a technical evaluation is not feasible, evaluation can be based on experience with “using aircraft”.**
- **A pavement satisfactorily support aircraft using it, can accept other aircraft if they are no more demanding than the using aircraft.**
- **Inaccuracies:**
 - Accuracy depends on having records of past aircraft traffic
 - Significant over-estimation of the pavement capacity can result if an excessively damaging aircraft, which uses the pavement infrequently, is used to determine PCR.
 - Significant underestimation of the pavement capacity can lead to uneconomic use of the pavement by preventing acceptable traffic
- **Whenever possible, reported pavement strength should be based on a “technical evaluation”.**



AC 150/5335-5D Standardized Method of Reporting Airport Pavement Strength - PCR

- Adopts FAA standard method for reporting pavement strength using ICAO ACR-PCR method
- Establishes September 30, 2024 deadline for Commercial Service Airports to report PCR
- Provides guidance on FAA procedures to compute PCR using FAARFIELD 2.0 software
- Establishes procedures for reporting PCR



U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: Standardized Method of Reporting
Airport Pavement Strength - PCR

Date: 4/29/2022

Initiated By: AAS-110

AC No: 150/5335-5D

Change:

- 1 **Purpose.**
This advisory circular (AC) provides guidance for the reporting of runway, taxiway and apron pavement strength in accordance with standardized International Civil Aviation Organization (ICAO) methods.
- 2 **Cancellation.**
This AC cancels AC 150/5335-5C, *Standardized Method of Reporting Airport Pavement Strength – PCN*, dated August 14, 2014.



Federal Aviation
Administration

FAARFIELD 2.0 PCR Module

ICAO ACR is the backbone of FAARFIELD 2.0 PCR computations

The screenshot displays the FAARFIELD 2.0.7 (Build 09/14/2021) software interface. The main window is titled 'Section' and contains the following elements:

- Job Information:** Job Name: ACC Workshop PCR, Section Name: Example 1. Includes checkboxes for 'Include in Summary Report' and 'Add To Batch'.
- Pavement Layers:**

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	17.0	55840	
Subgrade		13500	9
- Design Parameters:** Design Life (Years): 20, P/TC Ratio: 1. Results: Calculated Life (Years): [empty], Total thickness to the top of the subgrade: 26.0 in.
- Structure Diagram:** A cross-sectional diagram of the pavement structure with layers labeled: P-401/P-403 HMA Surface (T=4.0 inches, E=200000 psi), P-401/P-403 HMA Stabilized (T=5.0 inches, E=400000 psi), P-209 Crushed Aggregate (T=17.0 inches, E=55840 psi), and Subgrade (CBR=9, E=13500 psi).
- Traffic Data:** A table showing aircraft mix data for 'ACC Workshop PCR'.

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 Tire Spacing (in.)	Tandem Tire Spacing (in.)	Tire Contact Width (in.)	Tire Contact Length (in.)
B737-200	116000	6000	0	120000	0	0	0	158	0.4638	30.5	0.0	14.1	22.6
A319-100 std	141978	1200	0	24000	0	0	0	173	0.463	36.5	0.0	12.3	19.7
B747-400	877000	3000	0	60000	0	0	0	200	0.2333	44.0	58.0	13.7	21.9
B747-400 Belly	877000	3000	0	60000	0	0	0	200	0.2333	44.0	58.0	13.2	21.1
B767-300 ER	388000	2000	0	40000	0	0	0	190	0.462	45.0	56.0	12.6	20.1
DC8-63/73	358000	800	0	16000	0	0	0	196	0.4806	32.0	55.0	14.0	22.5
A300-B4/C4 Std Bojje	365747	1500	0	30000	0	0	0	216	0.47	36.5	55.0	12.6	20.1

Reporting Pavement Strength in Airport Master Record

RUNWAY DATA

- > 30 RUNWAY IDENT:
- > 31 LENGTH:
- > 32 WIDTH:
- > 33 SURF TYPE-COND:
- > 34 SURF TREATMENT:
- 35 GROSS WT: S
- 36 (IN THSDS) D
- 37 2D
- 38 2D/2DS
- > 39 PCN / PCR:

12L/30R	07/25	12R/30L
4,199	5,005	5,000
75	75	75
ASPH-G	ASPH-G	ASPH-G
30.0	30.0	30.0
15/F/C/X/T (PCN)	58/F/C/X/T (PCN)	48/F/C/X/T (PCN)

RUNWAY DATA

- > 30 RUNWAY IDENT:
- > 31 LENGTH:
- > 32 WIDTH:
- > 33 SURF TYPE-COND:
- > 34 SURF TREATMENT:
- 35 GROSS WT: S
- 36 (IN THSDS) D
- 37 2D
- 38 2D/2DS
- > 39 PCN / PCR:

H2	H1	04/22	13/31
60	60	7,300	7,299
60	60	150	100
CONC-G	CONC-G	ASPH-G	ASPH-F
		30.0	30.0
		125.0	104.0
		63/F/C/W/T (PCR)	63/F/C/W/T (PCR)



How is the FAA Implementing ACR-PCR

- **Release of AC 150/5335-5D established ACR-PCR as the new FAA standard method for reporting airport pavement strength**
 - Allows projects funded under federal grant assistance programs to include PCR development into project scopes
 - Establishes new standard which Part 139 commercial service airports must adhere to
- **Establishes September 30, 2024 as deadline after which all Part 139 certificated airports shall report PCRs in the AMR**
 - During transition PCNs and PCRs will both be included
 - A single runway cannot report both PCN and PCR
- **At this time the FAA has complied with the implementation of ICAO ACR-PCR as the new standard practice of the United States for reporting pavement strength**
 - No difference exist between the FAA PCR computation procedure and ICAO



When Does the FAA Recommend Developing a PCR?

- **When pavement structure changes**
 - New construction
 - Structural capacity increased (i.e. overlay)
 - Partial or full-depth reconstruction
- **When aircraft fleet mix changes**
 - New aircraft operations added (recommended only when regular operations)
 - Significant increase in operations by an aircraft
 - Change in aircraft variant (i.e. 777-200 to 777X)
- **Periodically throughout pavement life**
 - Update as part of pavement management program
 - If premature structural distresses observed



Determining PCR during Design

- **A PCR should be a part of design scope**
 - When a new pavement is constructed
 - When there is a change in the structural capacity of the pavement (i.e. structural overlay)
 - A pavement is reconstructed either partial depth or full depth
 - Not typically part of a repair project, but could be considered if there is sufficient data to compute PCR without significant scope increase.
- **Draft PCR should be included as part of the Engineer's Design Report.**
- **Final PCR should be computed as part of as-built development.**
 - If as-built structure is same as design PCR can be validated.
- **For runways Airport Sponsor must update PCR and maximum allowable weights in AMR prior to opening runway for operations**



PCR for Pavement Management

- **Structural evaluation for pavement management focused on life remaining and not pavement strength reporting**
- **PCR can be developed at same time since it uses the same data as life remaining analysis**
 - Typically, a PCR in pavement management will use material strengths that are computed through non-destructive testing.
 - Traffic should look at 20-year projection, not just life remaining.
- **Typical interval for structural evaluation is 8-12 years**
- **It is not logical to develop PCRs for all pavement at an airport**
 - Runway pavement strengths must be reported on all paved runways
 - Taxiways should be assessed based on usage and projected traffic
 - Aprons should be assessed based on aircraft that can access the pavement and usage



Questions?

FAA Airport Safety & Standards
Airport Engineering Division
Design and Construction Branch (AAS-110)

Jeff Crislip
Jeffrey.d.crislip@faa.gov
(202) 267-9373

Harold Honey, P.E., PMP
Harold.honey@faa.gov
(202) 267-4689



Federal Aviation
Administration