AVIATION SAFETY DEPARTMENT

Aircraft Classification Rating Pavement Classification Rating ACR-PCR Method

Guidance Material

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Foreword

This document has been compiled to enhance aviation safety in the aerodrome's environment. It is not intended to supersede or replace existing laws or regulations produced by the DGCA of the State of Kuwait. The distribution or publication of this document does not prejudice the State's ability to enforce existing National rules and regulations as stipulated in the KCASRs.

To the extent of any inconsistency between this document and the National law, regulations (KCASRs), Safety Bulletins and advisory publications shall prevail.

Scope

This document is intended to provide guidance for aerodrome operators and other stakeholders involved in Aircraft Classification Rating Pavement Classification Rating ACR-PCR Method.

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Amendment/Revision Record

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0	**Sep, 2025**	**-**

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ABBREVIATIONS AND ACRONYMS

ACN	Aircraft classification number
ACR	Aircraft classification rating
AIP	Aeronautical information publication
CBR	California bearing ratio
CDF	Cumulative Damage Factor
DGCA	Directorate general of civil aviation
E	Modulus of elasticity
F	Flexible
K	Modulus of subgrade reaction
MPa	Megapascal
pci	Pound per cubic inch
PCN	Pavement classification number
PCR	Pavement classification rating
psi	Pound per square inch
R	Rigid
T	Technical
U	Using aircraft experience

Chapter 1: General

1.1. Introduction

This guidance material outlines the essential steps and recommended actions for compliance to ensure the consistent implementation of the ACR-PCR method across Kuwait’s aerodromes. It specifies the acceptable methodologies for determining PCR values through aircraft experience and provides illustrative examples for calculating ACR and PCR values. Following these guidelines, the DGCA seeks to facilitate a seamless transition while maintaining Kuwait's aviation sector's safety and operational efficiency.

ACR-PCR method aims to represent the pavements' load-bearing capacity accurately. ACR-PCR includes:

- A unique procedure for ACR calculation (for aircraft manufacturers),
- A recommended step-by-step procedure for PCR determination and publication (for aerodrome operators).

ACR-PCR ratings will be crucial for publishing pavement strength data in the Aeronautical Information Publication (AIP). Aerodrome operator will determine the PCR values for pavements servicing aircraft that weigh over 5,700 kg, ensuring accurate reporting to the aeronautical information services providers.

1.2. Overview of the ACR-PCR Method

The ACR-PCR method is an advanced system for reporting pavement bearing strength.
Its design focuses on the aircraft's load during operations. Where:

- Manufacturers derive the aircraft classification rating (ACR), a numerical value, to illustrate how an aircraft affects a particular pavement type.
- PCR stands for pavement classification rating, a number the aerodrome operator assigns to indicate the pavement’s strength to accommodate a given aircraft load.

1.3. Benefits of the ACR-PCR Method

The ACR-PCR system brings significant advantages:

- **Improved Accuracy**: This method offers a more precise determination of pavement bearing strength by considering multiple aircraft and operational conditions.
- **Optimal Pavement Use**: This ensures that pavements are neither over- nor under-utilized, extending their lifespan and reducing maintenance costs.
- **Environmental and Economic Benefits**: The method allows for better pavement management, reducing carbon emissions and cost savings due to fewer repairs and reconstructions.

Chapter 2: Determining PCR Using Aircraft Experience

To determine the PCR using aircraft experience, the following elements are needed:

2.1. Pavement Type and Subgrade Determination

The pavement type is classified as rigid (R) or flexible (F) based on its structural composition. Determine the strength of the pavement subgrade and thicknesses, adhering to standard practices for ACR-PCR evaluations.

2.2. Pavement Condition Examination

In case of used pavements:

- Thoroughly examine the pavement condition, noting signs of distress such as cracking, deformation, or wear.
- Compare the pavement condition in high-traffic areas, like main taxiways, to lower-use regions to evaluate the overall performance.
- Review key structural concerns, such as weak points or previous repairs, to ensure accurate pavement analysis.

The results should be considered when determining PCR. ACR gained values may be multiplied by a safety factor that depends on each pavement element and its condition.

2.3. Identification of Using Aircraft

Identify aircraft that used the pavement regularly, e.g.: defined as those with at least 250 annual departures. Occasional or rare uses by heavier aircraft are not considered in the final evaluation, as only regular traffic was relevant for deciding the PCR (Pavement Classification Rating).

2.4. Critical Aircraft Determination

Identify the heaviest regularly used aircraft as the critical one. The condition of the pavement under the weight and traffic of this aircraft to be evaluated, if it is determined that the pavement had sustained this aircraft without significant distress, qualifying it for PCR determination.

2.5. Tire Pressure and Evaluation Codes

The study assigns tire pressure codes (W, X, Y, or Z) based on the aircraft with the highest tire pressure. It assigned the tire pressure code X for flexible pavements. It applied the tire pressure code W to rigid pavements, adhering to ICAO recommendations.

2.6. Assigning PCR Based on the Heaviest ACR

The highest ACR from the critical aircraft served as the basis for the pavement's PCR assignment. This rating indicated the pavement's ability to support aircraft of equivalent or lesser ACR without significant wear or damage.

2.7. Adjustments for Future Traffic:

Future traffic loads to be reviewed. Study projected significant increases in traffic volume and weight, leading to adjustments in the PCR values. If future traffic projections indicated a substantial increase in load repetitions, more downward adjustments to the PCR would be necessary to maintain pavement integrity.

2.8. Calculating the ACR using the ICAO-ACR program

1. Install the ICAO ACR software (Figure 1). (https://www.airporttech.tc.faa.gov/Products/Airport-Safety-Papers- Publications/Airport-Safety-Detail/icao-acr-13).
2. Identify and select the pavement type: flexible (F) for asphalt and rigid (R) for concrete.
3. Choose the group of airplanes based on their movements, as shown in traffic table
4. Table 1 provided the highest number of movements to select the airplane type.
5. The entered weight represents the aircraft's maximum gross weight in tons.
6. After pressing the "calculate ACR" button, the software displays the ACR values for the four subgrade categories.
7. The software shows the ACR values depending on the type of pavement and the weight selected.
8. Repeat steps 5 to 9, replacing the maximum gross weight with the gross weight desired.
9. These steps will calculate each aircraft's ACR number based on its maximum and desired gross weights. The calculations considered the pavement type (R or F), and the subgrade strength targeted.
10. Select the highest ACR value for the critical aircraft from the integrated ACR pavement values.

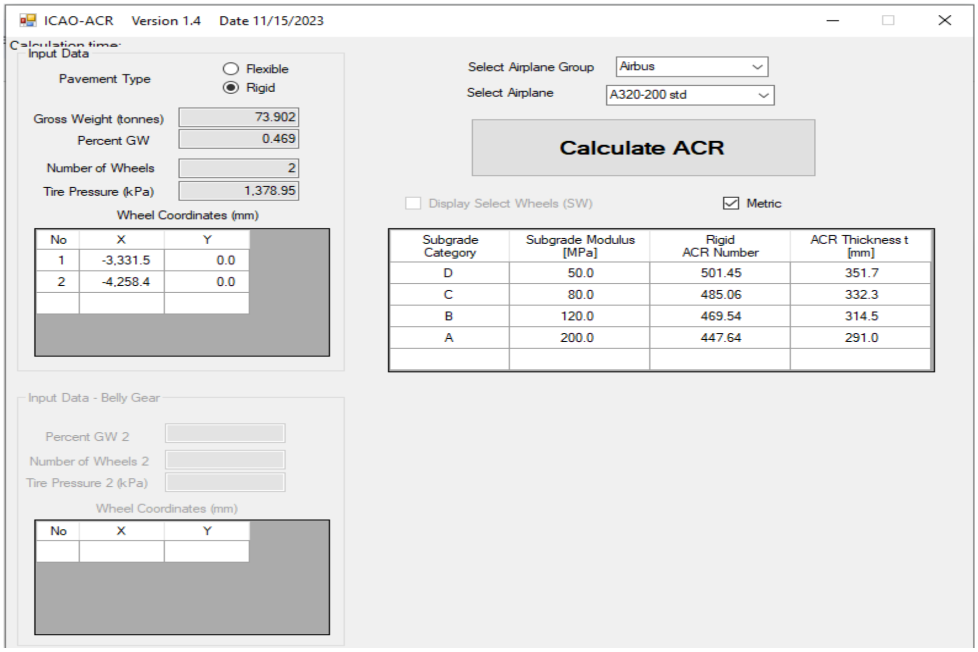

Figure 1: A picture of the ICAO-ACR software provided by the FAA to calculate the ACR.

2.9. Assigning the PCR Value

This method will determine and choose the PCR as the calculated ACR.

Assign the PCR value based on the load (ACR) of the heaviest aircraft it supports without damage.

Chapter 3: Determining PCR Using Technical Evaluation

3.1. Data Collection and Analysis

The new method relies on the elasticity (E) modules applied to the subgrade. It replaces the subgrade reactions (k) for rigid pavements and the California bearing ratios (CBR) for flexible pavements.

The new method employs the following equations to convert to the elasticity (E) module:

For flexible pavement: EE = 10 × CBR, where EE in (MPa).

For rigid pavement: ESG = 20.15 × k1.284, where EE in (psi)and k in (psi).

The PCR procedure is now based on the Cumulative Damage Factor (CDF), in which, each aircraft composing a mix is evaluated with regard to its contribution to the maximum CDF of the mix at the critical offset.

The CDF depends on:

- The failure criterion
- The elementary damage law associated to the failure criterion
- The method for computing the damage of multi-axles load aircraft
- The method for computing the damage with the lateral wandering effect and its associated standard deviation

Modulus of elasticity (E-Modulus) adjustment with regard to the equivalent temperature and frequency (derived from the aircraft speed).

PCR accuracy strongly relates to CDF calculation. All software Layered Elastic Analysis (LEA-based) use the same calculation model to calculate the pavement responses (Stress, strain, deflection), but may differ according to the damage model.

The use of the most appropriate damage model will ensure consistency between what the actual pavement is able to withstand over its evaluation period and the PCR assignment.

As there is no universal damage model, it is important to understand their assumptions and check their adequacy to the specific PCR calculation context. In particular, ensure that the damage model implemented in a PCR calculation process is consistent with the design parameters before using it. Failing that, the PCR would be incorrectly assessed.

Under-estimated PCR would lead to aircraft operating weight limitation at best or aircraft refusal in the worst case, thus a loss of airport revenues and a pavement not used up to its optimum structural capacity.

Conversely, over-rated PCR would lead to an increase of overload operations and a pavement design-life reduction. The extra revenues from operations would be negatively balanced by the resulting pavement damage.

3.2. PCR concept for technical evaluation (T)

The CDF is the amount of the structural fatigue life of a pavement that has been used up. It is expressed as the ratio of applied load repetitions to allowable load repetitions to failure, or, for one aircraft and constant annual departures where a 'coverage' is one application of the maximum strain or stress due to load on a given point in the pavement structure:

CDF = Applied Coverages/Coverages to Failure

Note:

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

A value of CDF greater than one does not mean that the pavement will no longer support traffic, but that it will have failed according to the definition of failure used in the design procedure.

The thickness design is based on the assumption that failure occurs when CDF = 1.

Multiple aircraft types are accounted for using Miner's Rule:

CDF = CDF1 + CDF2 + … + CDFN

where CDFi is the CDF for each aircraft in the traffic mix and N is the number of aircraft in the mix. Since the PCR relates to the structural pavement life, the CDF is based on the subgrade failure mode.

The PCR procedure considers the actual pavement characteristics at the time of the evaluation — considering the existing pavement structure, and the aircraft traffic forecast to use the pavement over its design structural life (for new pavement construction) or estimated remaining structural life (for in service pavements).

The PCR should be valid only for this usage period. In case of major pavement rehabilitation or significant traffic changes compared to the initial traffic, a new evaluation should be performed.

3.3. The PCR procedure involves the following steps:

The steps below can be used to convert the mix of using aircraft traffic to an equivalent critical, or reference aircraft at maximum allowable gross weight, which will then produce a CDF of 1.0 on the evaluated pavement:

1. collect all relevant pavement data (layer thicknesses, elastic moduli and Poisson's ratio of all layers, using projected aircraft traffic) using the best available sources.
2. define the aircraft mix by aircraft type, number of departures (or operations consistent with pavement design practices), and aircraft weight that the evaluated pavement is expected to experience over its design or estimated remaining structural life. According to the maneuvering area (runway, taxiway, apron/ramp), the traffic can be assigned a lateral wander characterized by a standard deviation.
   The distribution of aircraft passes for a given aircraft type over the life of the pavement is described by a Gaussian (or normal) distribution function, with a standard deviation that depends on several factors: the type of aircraft, its ground speed, and the maneuvering area.

Another term that is frequently used is the amplitude of lateral wander, which is twice the standard deviation. High-speed sections (e.g. runways) are associated with higher values of s than moderate speed sections (e.g. taxiways), while wander may be considered negligible (s ≅ 0) on low-speed sections (e.g. aprons).

The following values of standard deviation may be used independently of the type of aircraft:

3. compute the ACRs for each aircraft in the aircraft mix at its operating weight and record the maximum ACR aircraft.
4. compute the maximum CDF of the aircraft mix and record the value (the CDF is computed with any damage/failure model consistent with the procedure used for pavement design).
5. select the aircraft with the highest contribution to the maximum CDF as the critical aircraft. This aircraft is designated AC(i), where i is an index value with an initial value 1. Remove all aircraft other than the current critical aircraft AC(i) from the traffic list.
6. adjust the number of departures of the critical aircraft until the maximum aircraft

CDF is equal to the value recorded in step 4. Record the equivalent number of departures of the critical aircraft.

7. adjust the critical aircraft weight to obtain a maximum CDF of 1.0 for the number of departures obtained at step 6. This is the MAGW for the critical aircraft.
8. compute the ACR of the critical aircraft at its MAGW. The value obtained is designated as PCR(i).
9. if AC(i) is the maximum ACR aircraft from step 3 above, then skip to step 13, otherwise
10. remove the current critical aircraft AC(i) from the traffic list and re-introduce the other aircraft not previously considered as critical aircraft. The new aircraft list, which does not contain any of the previous critical aircraft, is referred to as the reduced aircraft list. Increment the index value (i = i+1).
11. compute the maximum CDF of the reduced aircraft list and select the new critical aircraft AC(i).
12. repeat steps 5-9 for AC(i). In step 6, use the same maximum CDF as computed for the initial aircraft mix to compute the equivalent number of departures for the reduced list; and
13. the PCR to be reported is the maximum value of all computed PCR(i). The critical aircraft is the aircraft associated with this maximum value of PCR(i).

The purpose of steps 10 to 13 is to account for certain cases with a large number of departures of a short/medium-range aircraft (e.g. B737) and a relatively small number of departures of a long-range aircraft (e.g. A350). Without these steps, the smaller aircraft would generally be identified as critical, with the result that the PCR would require unreasonable operating weight restrictions on larger aircraft (unreasonable because the design traffic already included the large aircraft). Note that if the initial critical aircraft is also the aircraft in the list with the maximum ACR at operating weight, then the procedure is completed in one iteration, with no subsequent reduction to the traffic list.

The above procedure returns a uniquely determined PCR numerical value based on the identified critical aircraft (Figure 2). The technical evaluation should be used when pavement characteristics and aircraft mix are consistently known and documented.

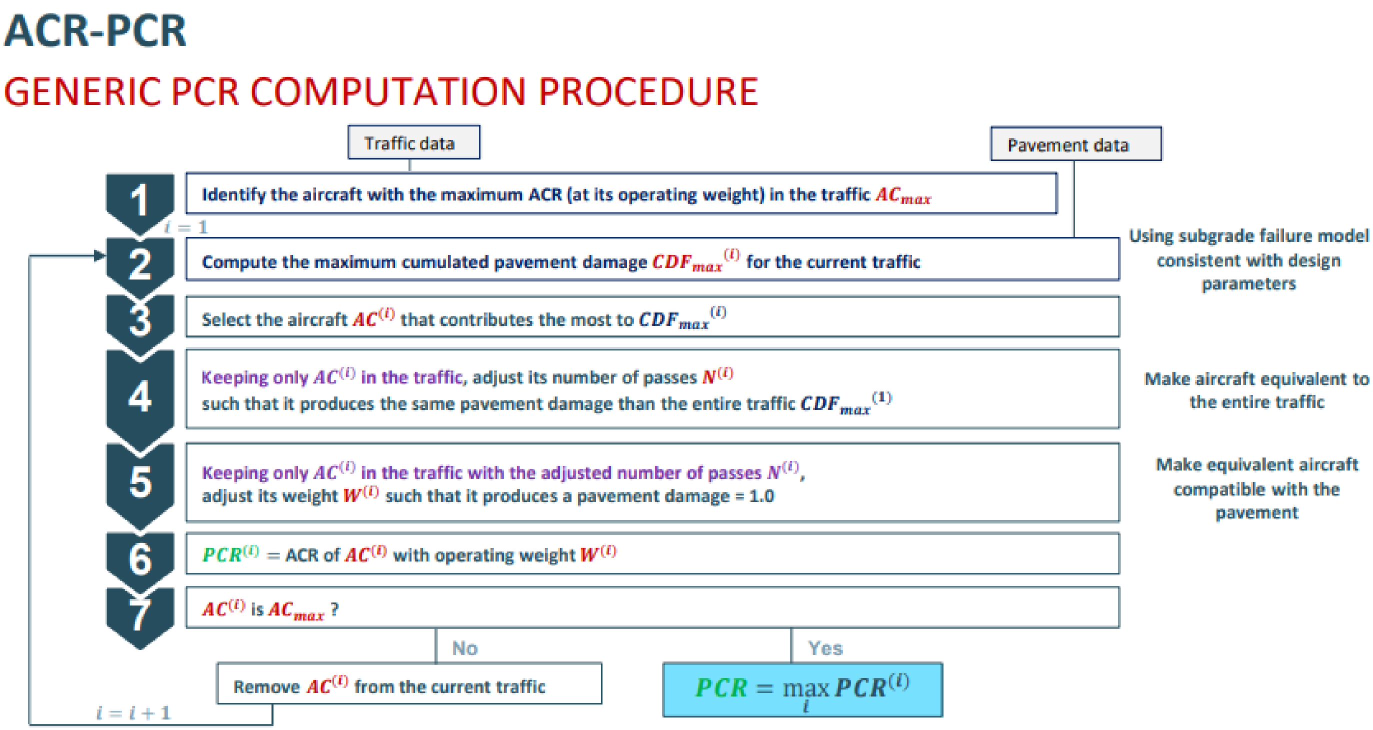

Figure 2: A process chart to calculate the PCR.

Chapter 4: Reporting to AIS

The PCR to be reported to the AIS is such that the pavement strength is sufficient for the current and future traffic analyzed and should be re-evaluated if traffic changes significantly.

The pavement bearing strength reported through the new ACR-PCR method uses the same five-part format and codes as described in KCASR 14 Vol. I.

Use the five-part format to represent the PCR values.

The standard KCASR 14 format reports the PCR value with details of pavement type, subgrade strength, and tire pressure limitations.

- **The numerical value** is based on the PCR rating of the heaviest aircraft.
- **The type of pavement** is either rigid (R) or flexible(F).
- **The subgrade strength** is classified as high (A), medium (B), low (C), or ultra-low (D).
- **Maximum allowable tire pressure:** Unlimited (W), High (X), Medium (Y), or Low (Z).
- **Evaluation Method**: Technical (Code T) or Using Aircraft Experience (Code U).

Responsibilities to Report PR:

1- The Aerodrome is responsible for the determination of the PCRs of each pavement intended for aircraft with ramp mass greater than 5 700 kg, i.e.: Runways, Taxiways, Aprons. ACR-PCR method is meant only for the publication of pavement strength data in the AIP.

2- Any significant change in traffic would be indicated by the introduction of a new aircraft type or an increase in current aircraft traffic levels not accounted for in the original PCR analysis.

3- Reports for determination of the PCRs to be submitted to DGCA Aviation Safety Department to validate the PCR determination reports.

4- AIS shall publish the data within the appropriate aeronautical publication framework.

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