International Civil Aviation Organization

Eighth Meeting of the Aerodromes Operations and Planning Sub-Group (AOP/SG/8)

Bangkok, Thailand, 15 to 19 July 2024

Agenda Item 9 : Any other business

- **State's update on Implementation of ACR-PCR Method of Reporting Aerodrome Pavement Bearing Strength**

STRATEGIES FOR IMPLEMENTING ACR-PCR

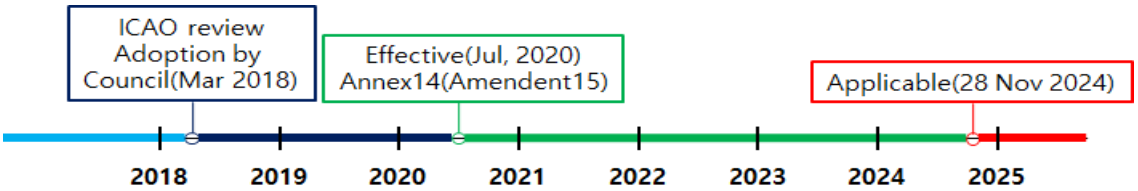
(Presented by Republic of Korea)

SUMMARY

This paper outlines the implementation strategy for the new ACR-PCR (Aircraft Classification Rating-Pavement Classification Rating) method for evaluating aerodrome pavement bearing strength. The strategy is illustrated using actual examples from Incheon International Airport, highlighting the evaluation procedure, key considerations, and differences between the old ACN-PCN method and the new ACR-PCR method.

1. INTRODUCTION

1.1 The ACR-PCR method, finalized by the Airport Pavement Expert Group (APEG) in early 2018 and adopted by the ICAO Council in March 2020 (Amendment 15 to Annex 14), has been effective since July 2020. Full applicability is expected by November 28, 2024. The Republic of Korea revised its regulations in 2022 to support the implementation of this new system, with Incheon International Airport Corporation (IIAC) preparing for its adoption by evaluating pavement conditions and establishing strategies based on recent assessments.



2. DISCUSSION

Basic Concept

2.1 The basic definition for describing ACR-PCR is as follows.

- ACR (Aircraft Classification Rating) : A number expressing the relative effect of an aircraft on a pavement for a specified standard subgrade strength.

- PCR (Aircraft Classification Rating) : A number expressing the bearing strength of a pavement for unrestricted operations.
- ACR ≤ PCR : Aircraft can operate on the pavement without restriction
- ACR > PCR : Aircraft allowed to operate subject to weight/frequency limit or may be excluded
- (EXAMPLE) PCR ①1,000 / ②F / ③B / ④W / ⑤T

① PCR number : represent strength of pavement(Calculated by computer program)

② Pavement type : F (Flexible=Asphalt Concrete) / R (Rigid=Cement Concrete)

③ Subgrade Category: according to the strength of subgrade as expressed by elastic modulus

(A:High 150MPa≤E, B:Medium 100MPa≤E＜150 MPa, C:Low 60 MPa ≤E＜100 MPa, D:Ultra Low E＜60MPa)

④ Tire pressure : Maximum allowable tire pressure

(W:No Limit, X:1.75 MPa, Y:Low 1.25MPa, Z:0.25MPa)

⑤ Evaluate Method : U (using experience operating) / T (technical evaluation)

Significant Changes

2.2 As the existing ACN-PCN method(Aerodrome Design Manual part3, 1983) changed to new ACR-PCR method, certain criteria and calculation mechanism were changed as following.

	ACN-PCN	ACR-PCR
Aircraft	Affect the most on pavement (require most thickest pavement)	All aircraft in operations
Number Of Flight	10,000 flights for reference pavement thickness	Annual Departures (considering past and future)
Method	Design Chart(Derived Single Wheel Load) Equation for reference pavement thickness	CDF(Cumulative Damage Factor) (actual wheel placement and wander)
Subgrade Strength	Flexible for CBR Rigid for K	E(Elastic Modulus) Using LEA(Layered Elastic Analysis) with computer program

2.3 ACN-PCN method only consider a representative aircraft and virtual DSWL(Derived Single Wheel Load) that satisfies reference thickness, but new ACR-PCR method is derived with all fleet mix, CDF concepts, LEA which is more closer to the actual aircraft operation.(See Appendix for more information about CDF)

PCR Evaluate Procedure

2.4 In ICAO Aerodrome Design Manual(Doc 9157, 2022) part3, the calculation method of PCR is described in detail. Based on this, PCR of Incheon International Airport was calculated. Important considerations for each step classified into four categories are as follows.

- Identify annual departure (Classification by aircraft type and construction phase[1])
- Identify characteristic of pavement (Material, Thickness, Basic property, Bending Strength)
- Evaluate PCR using FAARFIEDL program (v.2.1.1, `23.12)

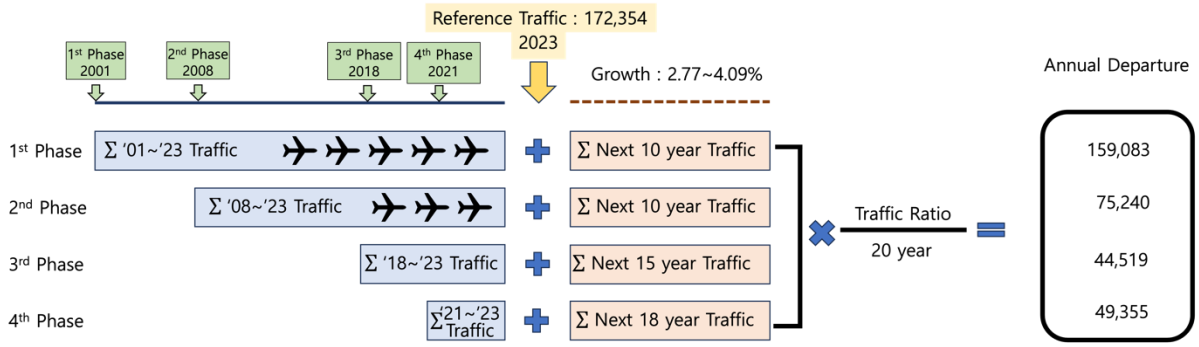
2.5 The ACR and CDF values for each aircraft type are automatically setted in the program by input the data of annual departing traffic for each aircraft type. Therefore, it is important to analyze the exact air traffic volume of the airport in operation. And it is also necessary to identify difference in air traffic volume due to different construction period.

2.6 Identify characteristic of pavement starts from distinguish pavement material which is whether it is flexible or rigid. The composition of the layer varies depending on the material of the pavement material and it is necessary to identify all the basic properties according to the layer configuration. Also, the properties of the subgrade which is under the pavement, such as the modulus of elasticity, should be checked, and the conversion method provided by Aerodrome Design Manual or the field test result should be used.

2.7 After these annual departure and pavement characteristics are analyzed, put the corresponding factors into the program to calculate the PCR.

Analysis of Annual Departure

2.8 In the case of evaluating PCR for the currently operating airport, if only expected traffic volume in the future is considered, it will miss accumulated damage in the past after the initial use. Therefore, to consider the cumulative damage to past traffic volume, annual traffic volume is calculated including past traffic since it is used and all future traffic in the next 20 year, based on current traffic. Once again, in case of Incheon International Airport's traffic is classified by construction stage(phase 1 to 4) and aircraft type.



< Analysis of Annual Departure>

[1] Incheon International Airport have conducted 4 phases construction project since 2001.

Characteristic of Pavement

2.9 The rigid pavement of Incheon International Airport is divided into four phase according to the period of construction, and the thickness of the concrete slab is 45-50cm as shown in the table below, and it consists of an asphalt base layer, a lean concrete layer, and an subbase layer. The elastic modulus of the concrete slab applied 4,000,000 psi, and 80% of the indoor test value (about 950 psi) of the bending strength was applied.

	Thickness(cm) / Properties(psi)			
	1st Phase	2nd Phase	3rd Phase	4th Phase
Concrete Slab	50 / 4,000,000	45 / 4,000,000	50 / 4,000,000	50 / 4,000,000
Asphalt Base Layer	5 / -	5 / -	5 / -	5 / -
Lean Concrete Layer	20 / 700,000	20 / 700,000	15 / 700,000	15 / 700,000
Subbase Layer	20 / 50,000	15 / 50,000	15 / 50,000	15 / 50,000
Subgrade	200pci	216pci	210pci	210pci
Bending Strength	740psi	750psi	740psi	770psi

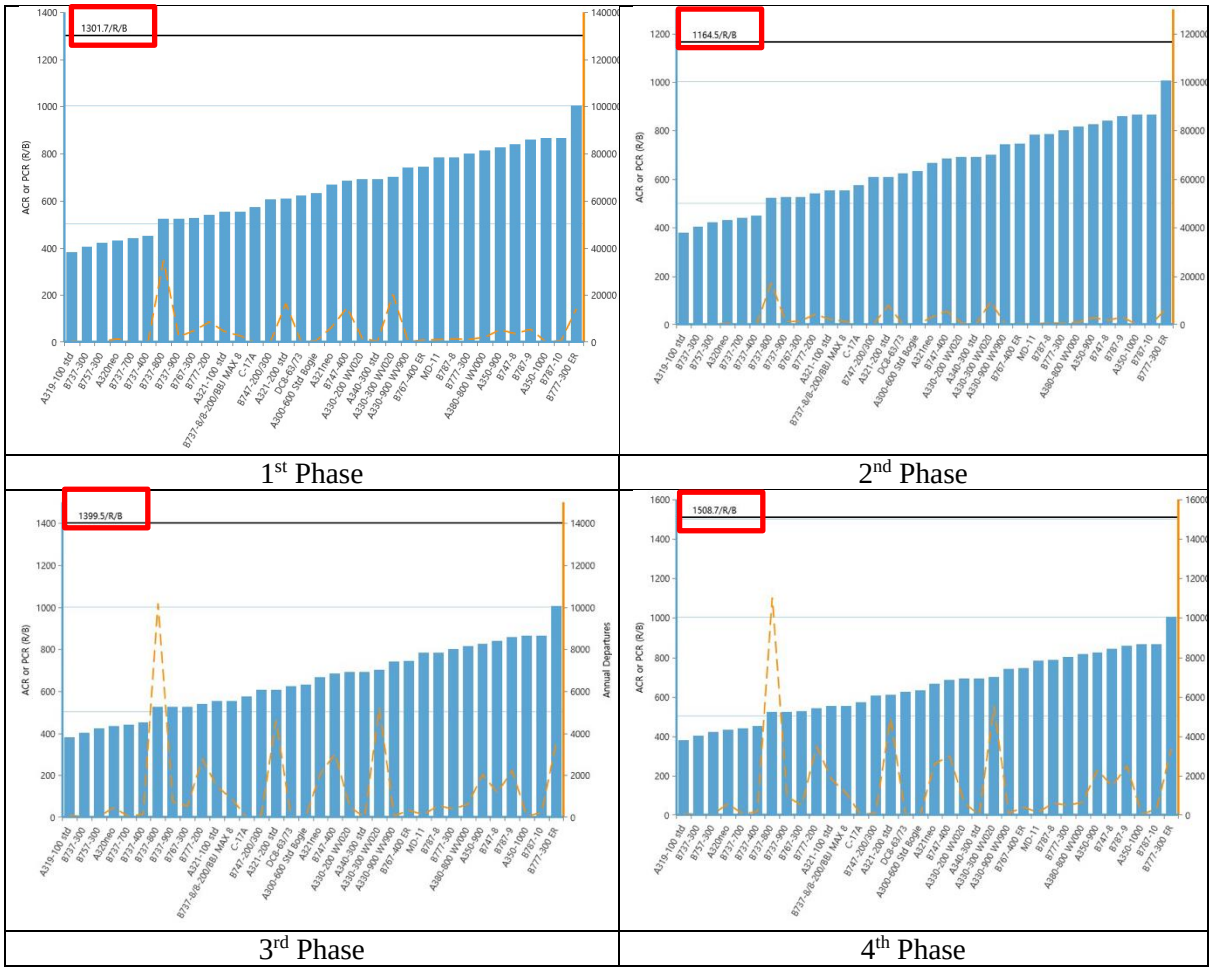
2.10 The flexible pavement of Incheon International Airport is divided into three phase(1,2,4) according to the period of construction, and the thickness of the surface layer is 15cm, base layer 15~20cm, and other base(crushed aggregate) and subbase are as shown in the table below. The elastic modulus of the surface course(asphalt) applied 400,000 psi.

	Thickness(cm) / Properties(psi)			
	1st Phase	2nd Phase	3rd Phase	4th Phase
Surface Layer(Asphalt)	15 / 400,000	15 / 400,000	-	15 / 400,000
Base Layer(Asphalt)	20 / 400,000	15 / 400,000	-	15 / 400,000
Base Layer (Crushed Aggregate)	35 / 80,000	25 / 80,000	-	25 / 80,000
Subbase Layer	35 / 80,000	35 / 80,000	-	35 / 80,000
Subgrade(CBR%)	10	12	-	12

Evaluate PCR

2.11 The results of calculating the PCR for rigid pavement of Incheon International Airport are shown in the table below. On the Left Top of graph, evaluated PCR number is shown. And blue box is ACR of aircraft. And yellow broken line means annual departure of each aircraft.

2.12 The critical aircraft is B777-300ER, and it's ACR is 1,006 at subgrade category B. The PCR evaluated 1st Phase 1,300 / 2nd Phase 1,160 / 3rd Phase 1,400 / 4th Phase 1,510. The aircraft type exceeding the ACR of B777-300ER in the future is B777-9, and the ACR of B777-9 is confirmed to be 1,043 at subgrade category B. As the PCR is higher than ACR, it is considered that there will be no restrictions on the operation of Incheon International Airport.



1st Phase | 2nd Phase

3rd Phase | 4th Phase

<Result of evaluate PCR>

	1st Phase	2nd Phase	3rd Phase	4th Phase
PCR	1,300 / R / B / X / T	1,160 / R / B / X / T	1,400 / R / B / X / T	1,510 / R / B / X / T

<A draft to be announced for PCR(rigid pavement)>

2.13 The results of calculating the PCR for flexible pavement of Incheon International Airport are shown in the table below. Just as the result of rigid pavement, on the Left Top of graph, evaluated PCR number is shown. And blue box is ACR of aircraft. And yellow broken line means annual departure of each aircraft.

2.14 The critical aircraft is A350-900, and it's ACR is 693 at subgrade category B. The PCR evaluated 1st Phase 1,610 / 2nd Phase 1,290 / 4th Phase 1,370. The aircraft that scheduled to be operated in the future is B777-900 which of ACR is 647. As the PCR is higher than ACR, it is considered that there will be no restrictions on the operation of Incheon International Airport.

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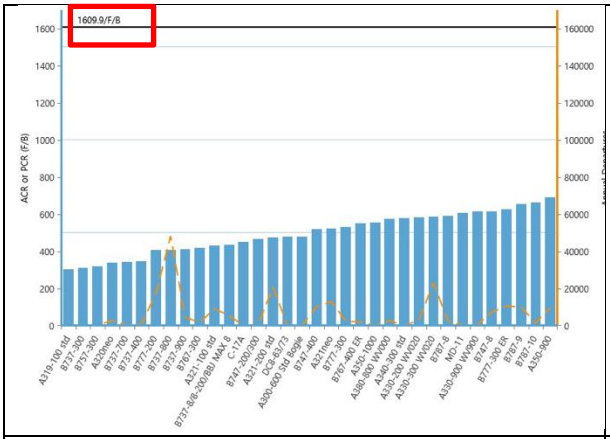
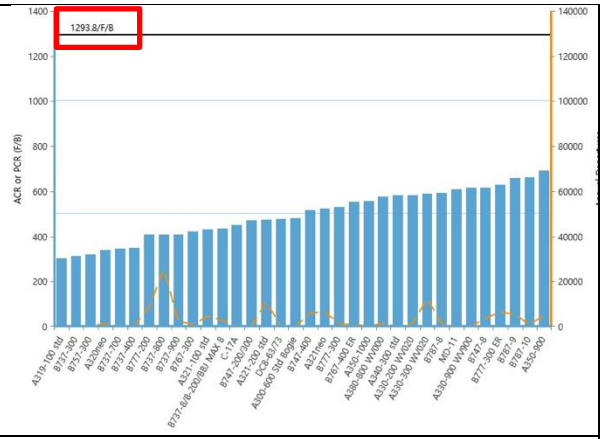
<tr><td> 
</td><td> 
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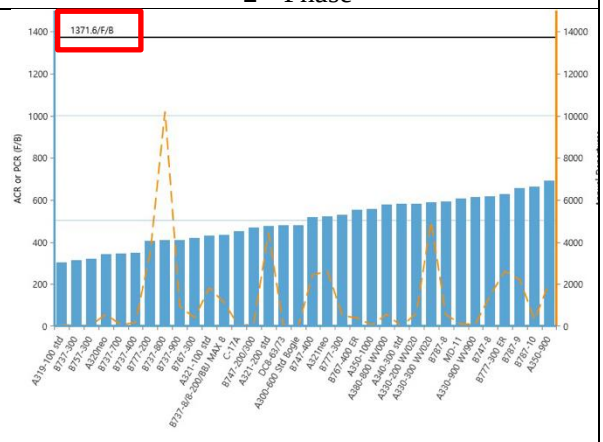
<tr><td>Not Applicable[1]</td><td> 
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<Result of evaluate PCR>

	1st Phase	2nd Phase	3rd Phase	4th Phase
PCR	1,610 / F / B / X / T	1,290 / R / B / X / T	-	1,370 / R / B / X / T

<A draft to be announced for PCR(flexible pavement)>

[1] There's no flexible pavement in the construction of the third phase of Incheon International Airport.

Overload Operation

2.15 If ACR is greater than PCR what will occur is pavement failures rarely happen due to a single excessive load. Failure comes due to the repetition of loads exceeding the load rating for which the pavement was designed. As a result, occasional minor overloading is acceptable, when expedient, with only limited loss in pavement life expectancy and relatively small acceleration of pavement deterioration. ICAO Aerodrome Design Manual suggested the following criteria.

- 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; and
- The annual number of overload movements should not exceed approximately 5 per cent of the total annual movements, excluding light aircraft.

3. CONCLUSION

3.1 The strategies for implementing ACR-PCR represent a significant advancement in aerodrome pavement management. This new pavement strength reporting system is crucial for the safety of aircraft operations. Through collaboration and exchange of opinions with ICAO, member states, and industry stakeholders, the Republic of Korea aims to ensure the efficient and accurate implementation of this new system.

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APPENDIX : CDF(CUMULATIVE DAMAGE FACTOR)

Concept

The concept of CDF is described in detail in Aerodrome Design Manual(Doc 9157, 2022) Part3. 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:

$$CDF = \frac{Applied\ coverage}{Coverages\ to\ failure}$$

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.

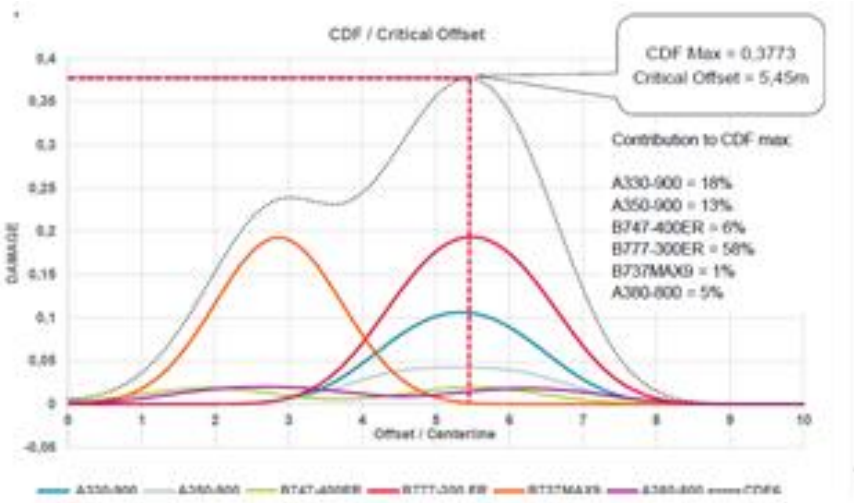
Considerations for various types of aircraft

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 aircrafts in the mix.

Examples of application



If you look at the chart, the horizontal axis is offset from the center of the runway, and the vertical axis is the CDF value. And you can see that different curves are drawn by dividing the aircraft type by color. This is because the main gear position is different for each model. And by adding a weight that converts the CDF value for each aircraft type into the each aircraft traffic relative to the total traffic, all of them are added together to create a gray line. Using the total CDF obtained in this way, calculate the PCR.

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