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A Comparative Study of Pavement Evaluation using PCI and PCN: Review Article

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Abstract
Pavement evaluation is a critical aspect of maintaining a safe and functional transportation infrastructure. Two commonly used methods for pavement evaluation are the Pavement Condition Index (PCI) and the Pavement Condition Number (PCN). This paper aims to provide a comparative study of these two methods, highlighting their strengths, weaknesses, and areas of application. Roads and airfields are the most used communication means to connect people around the world. The infrastructure of a country is an important parameter for the economic and social health of a country. The number of people using this mean of communication is growing every year. Better and long lasting pavements are needed to meet the present requirements for transport infrastructure. Air travel demand has experienced very rapid increase in the last two decades. With increased industrialization and economic growth, the number of air passengers and freight is projected to rise even more rapidly in the near future. Continued growth in traffic requires successful longer term advance planning and a systematic approach to the design, construction and operation of future airports. Among this increasing air travel demand there should be paramount consideration about the airfield pavement. A runway pavement is expected to deteriorate heavily in the long run due to increasing air traffic in India. To adequately assess the causes of performance breakdowns in existing airport systems and to plan facilities to meet future demand needs, it is essential to predict the level and distribution of demand of the various components of airport system.

Keywords: Pavement, Functional Evaluation, Structural Evaluation, PCI, ACN-PCN

Introduction

Qassim (2012) applied the ICAO method in the form of an ACN / PCN ratio using different aircraft weights to assess the airfield pavement strength at airports in Iraq. The results suggested that the airport pavement be improved which has an ACN / PCN ratio greater than 1.0. The strength of the pavement structure can be improved either by overlaying the surface currently in use or by desiring a new build. Osman (2015) recommended the interpretation of heavy weight deflectometer (HWD) data in conjunction with layer thickness data obtained from GPR to propose methodology for the structural evaluation of the airport pavement. The GRIP Tester was operated to find the runway friction

coefficient, and then used free computer software (FAARFIELD and COMFAA 3.0) to evaluation and design the new runways. This evaluation was presented in a PCN number and a classification ACN / PCN. By comparing these two numbers it came to the conclusion that the PCN is larger than the ACN. This implied the pavement could be safely landed.

This paper intends to summarize the findings from the published literature related to the methods for evaluating structural strength, calculating Pavement Classification Number (PCN), and designing maintenance and rehabilitation (M&R) policy of airport pavements. Further, this paper focuses on pavement structural analysis and evaluation of the airport pavement strength. To avoid confusion, this paper does not mainly address airport pavement design methods. This paper has five sections. Section 1 introduces the background of strength rating systems of airport pavements. Section 2 introduces the methods to back calculate the measures from FWD and HWD tests. Section 3 focuses on the determination process for PCN based on the evaluated pavement structural properties after the basic theory of PCN calculation methods is reviewed. Section 4 describes the procedures using the results of the evaluation of pavement structural conditions for the design of maintenance and rehabilitation (M&R) policy and Sect. 5 ends the paper by summarizing the findings.

Pavement Condition Index (PCI)

The PCI is a numerical rating system developed by the United States Army Corps of Engineers to quantify the condition of pavements. It ranges from 0 to 100, with 100 representing a brand-new pavement and 0 indicating a pavement in complete failure. The PCI is calculated based on the distresses observed on the pavement surface, such as cracking, patching, and roughness. The distresses are quantified in terms of their extent, length, and width, and then combined using a set of predefined equations to calculate the PCI.

Pavement Condition Number (PCN)

The PCN is a pavement evaluation method used in the United Kingdom and other countries. It is based on the concept of the Load Equivalence Factor (LEF), which is a measure of the load-bearing capacity of a pavement. The PCN is calculated based on the LEF and the traffic volume and weight. The PCN ranges from 1 to 5, with 1 indicating a pavement in poor condition and 5 indicating a pavement in excellent condition.

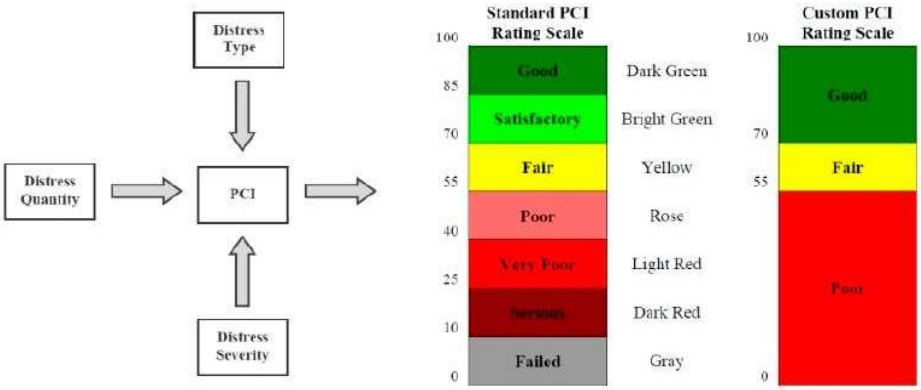
Pavement Evaluation

Systematic monitoring of pavement performance, including structural and functional assessment using modern equipment, helps achieve long-lasting within a given budget and efficient management of better performing pavement networks. Pavement condition data is an essential part of any Pavement Management System. The general objectives of pavement condition data collection and evaluation are to determine the current pavement condition at the time of inspection, establish immediate pavement maintenance needs, and plan for future needs. The pavement evaluation systems are basically categorized into two major types.

a) Functional Evaluation

Pavement condition refers to the condition of the surface of the pavement as to its general appearance. A perfect pavement is leveled and has a continuous and unbroken surface whereas a distressed pavement may be fractured, disintegrated or distorted. To obtain a useful condition assessment of pavement,

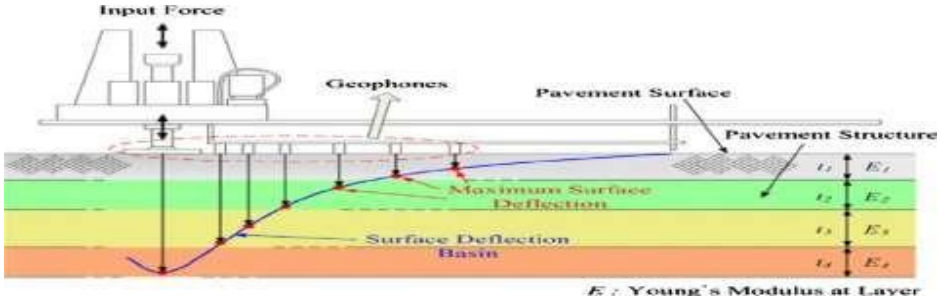
unbiased and repeatable survey procedures must be used. To provide for maximum usefulness, the survey procedures must be easily understood and relatively simple to perform in the field. The most common survey technique used in the World Wide is the Pavement Condition Index (PCI) procedure developed by the US Army Corps of Engineers. The condition of the pavements is determined by a field survey of the surface operational condition of all pavements using this procedure. The PCI a measure of the pavement's surface operational condition and ride quality on a scale of zero to 100 as shown in figure 2, with 100 being excellent - has several unique qualities, which make it a useful visual surveying tool. As part of the analysis, paver has determined the pavement condition Index (PCI) for several runway, taxiways and apron. It agrees closely with the collective judgment of experienced pavement engineers and has a high degree of repeatability.



Figure–1 PCI Rating Scales for pavement

b) Structural Evaluation

Structural evaluation deals with the quantitative assessment of structural capability of the pavement for rehabilitation. It is dependent upon the engineer's ability to evaluate the structural properties of the pavement component. Structural capability is the primary response of the pavement to transient loads and consists in deflection, stress, strains and pavement deformation at critical points in pavement layers. The pavement condition can be evaluated by integrating its surface condition with its structural capacity. So alternatives to maintenance can be selected based on the actual condition of the pavement. However, the process of evaluating structural condition is more expensive and time consuming than functional condition evaluation. The falling weight Deflectometer (FWD) test and ACN-PCN method carried out a structural evaluation of airfield pavement. Difference between the two failure (structural and functional) is important and an engineer must be able to distinguished them. As an example consider a rigid pavement has been resurfaced with an asphaltic overlay. The surface may develop rough spots as a result of break up in the bituminous overlay (functional failure) without structural breakdown of the over-all-structural, On the other hand, due to overload (structural failure) the same pavement could crack and break up. The maintenance measure for the first situation may consist of resurfacing to restore smooth rising quality to the pavement, however the structural type failure may require complete reconstruction.



Figure–2 Falling weight deflectometer operation scheme diagram

Objective

The main purpose of this study is to show the importance of all steps in order to evaluate properly the pavement of an airport, not only the runway. This study includes two main evaluation methods, functional and structural evaluation.

- Functional evaluation of an airfield pavements are typically evaluated using the PCI and structural evaluation using
- ACN-PCN method.

ACN-PCN Method

ICAO is developing a single international reporting method (AC 150/5335-5C) for pavement strengths. ICAO adopted the method Aircraft Classification Number-Pavement Classification Number (ACN-PCN). Using this method, the effect of an individual aircraft on different pavements can be expressed with a single unique number that varies depending on aircraft weight and configuration (e.g. tire pressure, geometry, etc.), type of pavement, and strength of the sub-grade. Using the ACNPCN method, pavement bearing strength intended for aircraft with a mass greater than 5,700 kg shall be made available. ACN is defined as a number which expresses an aircraft's relative effect on a pavement for the specified standard sub-grade strength. PCN is defined as a number expressing the bearing strength of a pavement for unrestricted operations. The ACN-PCN method uses a code format to report to PCN. The PCN code is shown in Table 4. This includes the pavement type, sub-grade category, allowable tire pressure, and the method used to determine the PCN. Sub-grade strength and tires pressures are divided into categories as indicated in Table-5 and sub-grade Strength and tire pressures can be represented within the range of each category Character of that category [ICAO, 2004].

PCN Value	Pavement Type	Sub-grade category	Allowable tire pressure	Method used to Determine PCN
A Number	R=Rigid F=Flexible	A=High B=Medium C=Low D=Ultralow	W = No limit X=to1.5 Mpa Y=to1.0 Mpa Z=to0.5 Mpa	T=Technical U=Using Aircraft

Table-1 PCN Code Format

Table-1 illustrates two ways of obtaining the PCN value, technical (T) and using aircraft (U) method. Each method describe below:

T method

The T method is based on the measurement of the response of pavement to load. Deflection of a pavement under static plate or tire load can be used to predict its behavior. Also there are various devices for applying dynamic loads to a pavement and observing its response and using this to predict its behavior.

U method

When a technical evaluation is not feasible for economic or other reasons, evaluation can be based on the "Using Aircraft" experience. The U method adopts the highest ACN value of the aircraft in missed traffic as the PCN value. Once the runway adopts this ACN value as the PCN and signs of distress operating are observed, the rating must be adjusted downward in order to maintain normal airport operations. If one or more aircraft have ACNs that exceed the lowered PCN, then the allowable gross weight for those aircraft may need to be restricted.

Sub-grade category	**Flexible Pavement**	**Flexible Pavement**
	CBR range	**K-value range**
A	Above13	Above120 MN/m^3
B	From8 to 13	From60to120MN/m^3
C	From4 to 8	From25 to 60MN/m^3
D	Below4	Below25MN/m^3

Table-2 Sub-grade strength category

The Summary of Section represented by this four limitations

1. ACN PCN < 1 , the pavement should perform satisfactorily and require only routine maintenance.
2. 1< ACN PCN < 1.25 , the pavement have minimal impact on pavement life`` .
3. 1.25 < ACN PCN < 1.5, aircraft operations should be limited to 10 passes and the pavement inspected after each operation.
4. ACN PCN > 1.5, should not be allowed except for emergencies

Advantage

1. Rapid test
2. No damage to pavement
3. Much less interruption to flying
4. Best simulates moving aircraft loads
5. Results interpretable satisfactory

Disadvantage

The PCI has the advantage of being simple and easy to use, as it does not require any specialized equipment or data. However, it is subjective and may vary depending on the inspector's experience and judgment. The PCN, on the other hand, is more objective and provides a more accurate measure of the pavement's load-bearing capacity. However, it requires more data and specialized equipment, which may increase the cost and complexity of the evaluation.

Comparison

The PCI and PCN methods have some similarities, such as their goal of quantifying pavement condition, but they differ in their approach and application. The PCI focuses on the visual distresses on the pavement surface, while the PCN focuses on the load-bearing capacity of the pavement. The PCI is more subjective, as it relies on the judgment of the inspector, while the PCN is more objective, as it is based on the LEF and traffic data.

The PCI is widely used in the United States and other countries, while the PCN is mainly used in the United Kingdom and other countries that follow the British pavement design guidelines. The PCI is more suitable for evaluating the condition of flexible pavements, while the PCN is more suitable for evaluating the condition of rigid pavements.

Conclusion

In conclusion, the PCI and PCN are two useful methods for pavement evaluation, each with its strengths and weaknesses. The choice of method depends on the type of pavement, the available data, and the desired level of accuracy and objectivity. A comprehensive pavement management system should consider both methods and use them in a complementary manner to ensure the safety and longevity of the transportation infrastructure.

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