A STUDY OF AN AIRFIELD PAVEMENT EVALUATION

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Abstract – The airfield pavement deteriorates during service due to traffic and climate effects therefore systematic monitoring is required in order to assess their structural and functional condition. Maintenance of the airfield pavement in a good state is an important factor in increasing the level of flight safety and protecting human life and health. This research study is intended to explain the entire process of evaluating an airfield pavement runway. It's categorized into two main evaluation, structural and functional evaluations. Both of them were explained for flexible and rigid pavements. Functional evaluation of the airfield pavement is evaluated by the pavement condition Index (PCI) and structural evaluation by Aircraft classification number-Pavement classification number (ACN-PCN) method and Heavy weight deflectometer (HWD). Pavement evaluation is essential to monitoring pavement performance, establishing the adequacy or otherwise of the service provided by the pavement and reliable rehabilitation technique. Evaluation is needed in respect of both functional and structural aspect of serviceability and the process essentially involve a definition of the problem to determine the cause and extent of the existing deterioration.

***Index Terms* –Airfield pavement, Functional Evaluation, Structural Evaluation, PCI, ACN-PCN.**

I. INTRODUCTION

Nowadays, 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. An understanding of future demand, airbus landing information will help in performance in light of existing and improved facilities, to evaluate, maintenance and rehabilitation of airfield pavement.

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 thicknessdata 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.

Difference between airfield pavement and Road pavement:

There is no fundamental difference between road and airfield, and the general principles of design apply to both of them. However, some key differences exist between the airfield pavement and road pavement which showed in Table-1

Characteristic	Airfiled Pavement	Road Pavement
Load repetition	Low, often 100,000 or less	High, often 1,000,000 or more
Traffic wander	High, wide spread of aircraft across pavement width	Low, Very channelized traffic in designated lanes.
Wheel load	High, Up to 25 tonnes per wheel	Low, Generally only up to 3 tonnes per wheel
Tyre pressure	High, Typically up to 1.7 MPa & sometimes up to 2.5 MPa for military jets.	Moderate, Generally not more than 0.8 MPa
Surface texture	Moderate, Low traffic volumes do not generally flush seals.	High, Especially for maintaining skid resistance.
Resistance to polishing	Low, With low traffic volume	High, Especially for maintaining skid resistance.
Durability	High, Especially in the touch zones.	Moderate, particular at turns and intersection, less so on straight runs.

Table-1 Comparison of Airfield and Road pavement

II. 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.

III. 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.

Figure – 1 Type of Pavement Evaluation

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.

During PCI inspection 16 distress types are identified and evaluated for asphalt pavement and 15 distress types for concrete pavement along with their cause, severity levels such as Low (L), Medium (M) and High (H) as shown in table 2 and 3.

Distress	**Cause**	**Severity Level**
Alligator Cracking	Load/fatigue failure	L-M-H
Ravelling	Climate/load	L-M-H
Weathering	Climate	L-M-H
Rutting	Repeated traffic loading	L-M-H
Corrugation	Load/construction quality	L-M-H
Shoving	PCC pavement growth/movement	L-M-H
Depression	Sub-grade quality	L-M-H
Upheaval	Climate/sub-grade	L-M-H
Block Cracking	Climate/age	L-M-H
Jt. Reflection	Climate/prior pavement	L-M-H
Patching	Utility/pavement repair	L-M-H
L&T Crack	Climate/age	L-M-H
Bleeding	Construction quality/mix design	N/A
Slippage Cracking	Load/pavement bond	N/A
Polished Aggregate	Repeated traffic loading	N/A
Oil Spillage	Aircraft/vehicle	N/A
Jet Blast	Aircraft	N/A

Table- 2 Airfield pavement distress summary for flexible pavement

Distress	**Cause**	**Severity Level**
Blow Up	Climate/alkali silica reaction	L-M
Corner Break	Load repetition	L-M-H
L & T Crack	Freeze-thaw cycling	L-M-H
Durability Crack	Material deterioration	L-M-H
Joint seal damage	Pavement repair	N/A
Small Patching	Utility/pavement repair	L-M-H
Patching, Utility Cut	Freeze-thaw cycling	L-M-H
Pumping	Construction quality	N/A
Scaling	Load repetition	L-M-H
Settlement	Overloading	L-M-H
Shattered slab	Construction quality/load	L-M-H
Shrinkage Crack	Climate/age	N/A
Joint Spalling	Load repetition	L-M-H
Corner Spalling	Load repetition	L-M-H
ASR	Construction quality/climate	L-M-H
Popout	Poor joint sealant	N/A

Table- 3 Airfield pavement distress summary for rigid pavement

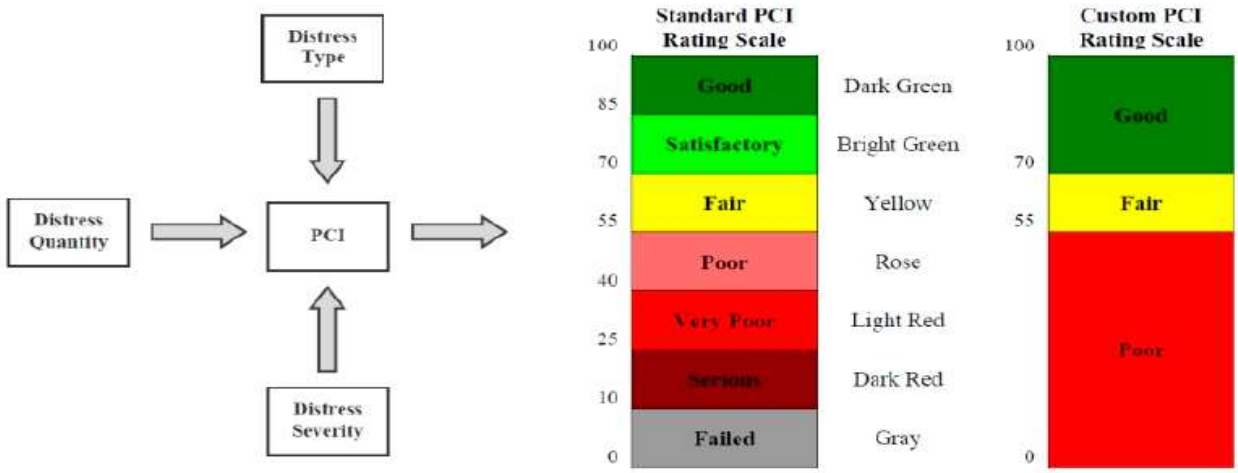

Figure – 2 PCI Rating Scales for Airfield pavement (source- *FAA/AC 150/5380-7B "Airport Pavement Management Program")*

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.

i. Heavy Weight Deflectometer (HWD)

Heavy weight deflectometer (an upgraded version of FWD) is used for non-destructive of airfield pavement. HWD capable of applying a dynamic loads up to 240KN over a preselected plate and simulates the effects of a heavy aircraft moving on a pavement. The deflection caused by such dynamic loads are measured over a number of points in the deflection bowl and the data are analyzed in a micro-processor to give the strength, residual life and strengthening over an existing pavement.

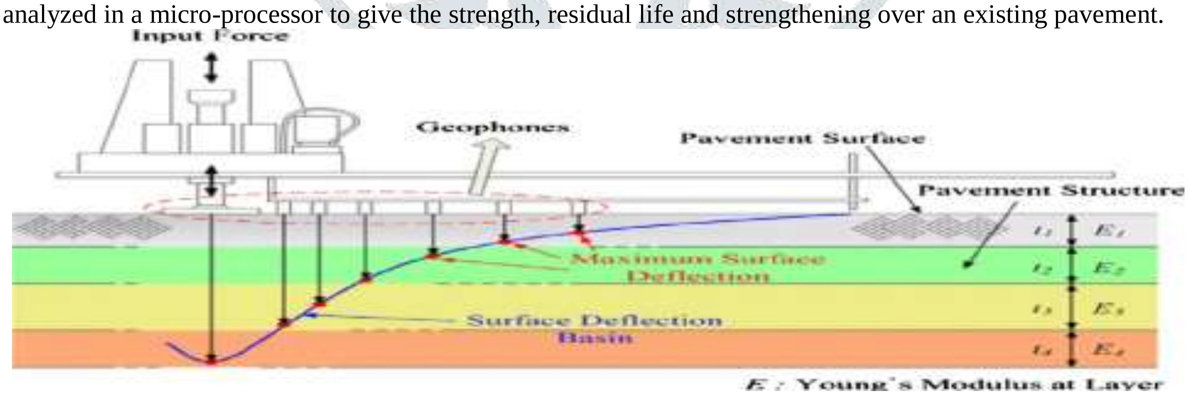

Figure – 3 Falling weight deflectometer operation scheme diagram

This method is best suited for pavement evaluation because of following advantages:

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

The test basically involves a mass that is lifted to predetermined height and released. The mass falls free guided by a vertical rod and impact on spring shock system resting in the pavement. The magnitude of force and duration of impulse on the pavement can be controlled can be changing the height of drop and the rate of declaration. A circular plate transmitted the load caused by the deceleration mass to the pavement and deflection of the pavement is recorded.

ii. 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 ACN-PCN 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 = Ultra low	W = No limit X = to 1.5 Mpa Y = to 1.0 Mpa Z = to 0.5 Mpa	T = Technical U = Using Aircraft

Table -4 PCN Code Format

Table-4 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	Above 13	Above 120 MN/m^3
B	From 8 to 13	From 60 to 120 MN/m^3
C	From 4 to 8	From 25 to 60 MN/m^3
D	Below 4	Below 25 MN/m^3

Table -5 Sub-grade strength category

IV. CONCLUSIONS

1. Based on survey parameter , the PCI will function as a condition index, which will score the status as excellent or poor. The runways can be ensuing good maintenance.
2. Some other parameters, such as runway pavement surface distress, profile, friction, pavement classification number along with some health indicators, will be used to determine the maintenance strategies with the rating score.

3. This study also evaluate with a PCN number, or even better with a classification ACN / PCN, which is the ratio between the classification number of the aircraft and the classification number of the pavements. This ratio is the most common condition that a particular aircraft may use a specific runway. It is expressed so that pilots of an aircraft can relate their Aircraft Classification Number to the Pavement Classification Number of the runway. All that is required is to search for the ACN shown in the aircraft manual and compare it with the airport runway PCN; this information is available and should be reported by the authorities of the airport. So airport athorities that compares these two numbers and concludes that the PCN is bigger than the ACN, aircraft can land safely on that pavement.

4. The Summary of Section represented by this four limitations:

a) $\frac{ACN}{PCN} < 1$, the pavement should perform satisfactorily and require only routine maintenance.

b) $1 < \frac{ACN}{PCN} < 1.25$, the pavement have minimal impact on pavement life``

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c) $1.25 < \frac{ACN}{PCN} < 1.5$, aircraft operations should be limited to 10 passes and the pavement inspected after each operation.

d) $\frac{ACN}{PCN} > 1.5$, should not be allowed except for emergencies

5. An Airfield pavement evaluation aim is to assist decision-makers in developing economically viable strategies for maintaining the pavements in a serviceable condition over a given time period. Evaluation of airfield pavement provides a consistent, objective and systematic process for setting priorities, schedules, and resource allocations. It can also quantify information and provide specific recommendations to maintain an acceptable level of service through a pavement network while minimizing pavement-related expenditure.

6. Implementing the airfield pavement evaluation includes identifying evaluation types, and their needs, selecting evaluation software, conducting pavement inventory, evaluation of airfield pavement condition, analyzing data, generating reports and other outputs.

7. The entire length of the pavement would be resurfaced after a certain period of time or, in case of deterioration and the weak portion of the pavement could be identified well in advance to take the necessary rehabilitation or repair measures.

8. The damage or fault in the pavement can be identified well in advance, which will help to prevent complete restructuring of the pavement on the airfield.

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