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Evaluation Pavement Distresses for Runway Asphalt Using Pavement Condition Index (PCI)

A Case Study Sabha International Airport

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Abstract

Due to the long period of time since the construction of the surfaces designated for landing and take-off of aircraft (Airport Pavement) at Sabha International Airport and as a result of several factors that lead to causing significant distress to it, the most important of which is the distress resulting from obsolescence, as these surfaces usually have a specific maintenance program. Early failure of runway pavement structure can be detected by the distress on the asphalt surface of flexible runway pavement and obtain the value of runway pavement condition, it was analyzed using Pavement Condition Index (PCI) method. PCI is a simple, convenient and inexpensive measure to evaluate the condition of flexible pavement surfaces for rehabilitation or maintenance and predict future costs. In this study, we evaluated the current condition of flexible pavement defects present at Sebha airstrip, by conducting visual inspection. A total of 15 sample units were examined on the runway in the distress survey,

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which is a process to collect accurate type and quantity of distress data that occur in flexible runway pavement structure. After visual inspection, a variety of defects were found on runway surface, such as longitudinal and transverse cracks, alligator cracks, erosion/weathering, block cracks, swelling cracks, and oil spillage. Through this examination, the level of distress severity in the flexible pavement surfaces of the runways was determined as high, medium and low for most of the distress, and the results of the analysis using the PCI method concluded that the runway at Sabha International Airport has an average PCI value of 40, which falls within the poor category, and the PCI value of the runway that needs to be reconstructed.

Keywords: Pavement Condition Index, Flexible Pavement, Visual Inspection, distress

تقييم أضرار الرصف الاسفلتي للمهبط باستخدام مؤشر حالة الرصيف (PCI) "دراسة حالة مطار سبها الدولي"

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ملخص

نظرًا لطول الفترة الزمنية منذ إنشاء الأسطح المخصصة لهبوط وإقلاع الطائرات (رصف المطار) في مطار سبها الدولي ونتيجة لعدة عوامل تؤدي إلى إحداث أضرار كبيرة بها، وأهمها الضرر الناتج عن التقادم، حيث أن هذه الأسطح عادةً ما يكون لها برنامج صيانة محدد. يمكن اكتشاف الفشل المبكر لهيكل رصف المهبط من خلال الضرر على السطح

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الأسفلتي لرصف المهبط المرن والحصول على قيمة حالة رصف المهبط، وذلك باستخدام طريقة مؤشر حالة الرصف (PCI). مؤشر حالة الرصف (PCI)هو مقياس بسيط ومريح وغير مكلف لتقييم حالة أسطح الرصف المرنة لإعادة التأهيل أو الصيانة والتنبؤ بالتكاليف المستقبلية. ففي هذه الدراسة، قمنا بتقييم الحالة الحالية لعيوب الرصف المرن الموجودة في مهبط مطار سبها، من خلال إجراء الفحص البصري، وهي عملية لجمع بيانات دقيقة عن نوع وكمية الاضرار التي تحدث في هيكل رصف المهبط المرن. تم فحص إجمالي 15 وحدة عينة على المدرج في مسح الضائقة، وبعد الفحص البصري تم العثور على مجموعة متنوعة من العيوب على سطح المهبط مثل الشقوق الطولية والعرضية وشقوق التمساح والتآكل/التجوية والشقوق الشبكية والانتفاخ وتسرب النفط ومن خلال هذا الفحص تم تحديد مستوى شدة الضرر في الأسطح الإسفلتية المرنة للمهبط على أنه مرتفع ومتوسط ومنخفض لأغلب الاضرار، وخلصت نتائج التحليل باستخدام طريقة PCI إلى أن المهبط الاسفلتي في مطار سبها الدولي لديه متوسط قيمة PCI تساوي 40 والتي تقع ضمن الفئة الضعيفة والذي يحتاج إلى إعادة بناء من جديد.

الكلمات المفتاحية: مؤشر حالة الرصيف، الرصيف المرن، الفحص البصري، الضرر.

Introduction

There are in total around more than 100 airports in Libya among which 18 airports are in operation currently. Amongst the 18 operational airports, there are 4 international airports, and more 10 domestic airports. Moreover, Sabha airport is one international airport in south of Libya. The international airport runway was paved in the fifties of the last century. And airport It was developed over several periods, including the year 1979. [1]

Majority of the pavement at Runway, in Sabha airport consists of flexible pavement with only a small share of rigid pavement at touch down. As the runway is one of the basic parts of the Airport, continuous maintenance and rehabilitation works should be conducted periodically to prevent deterioration caused by repetitive traffic loading and environmental factors. AASHTO defines a precision pavement management system as: “A set of tools or

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methods that teach mathematically optimal strategies for evaluating, maintaining, and maintaining pavement in good serviceability for the long term. [2]

The previous maintenance of the Sabha airstrip Temporary maintenance, i.e. patching in case of minor distress Areas when identified. A systematic system is needed A framework for routine pavement evaluation Allow timely maintenance to reduce maintenance cost Avoid any safety risks during the flight process. This type is known as Pavement Management Program (PMP) that has proven its effectiveness a vital tool for conservation decision makers' Acceptable level of pavement condition while also reducing expenses. [3]

Determine an aim and consistent measure paving conditions for airports across the country the first demined for performance of such system. Pavement Condition Index (PCI) is the most Used by FAA and other organization as the key measure in their APMS prominently used measure for (PMP) worldwide when developed by US Army Corps of Engineers. [4]

The (PCI) method is a visually based digital distress indicator observed on the sidewalk surface. PCI It ranges from 0 for a failed dock to 100 for a The pavement is in excellent, standard condition Discount value curves for a particular pavement type to determine maintenance and repair. flexible pavement distress includes the following deformations: (crocodile cracks, longitudinal and transverse cracks, bleeding, patches, potholes, undulations, service track crossings, grid cracks, abrasion or grinding of gravel, convexities and concavities, rutting, side cracks, shoulder depressions, bulging, scatter, creep, reflection cracks, slip cracks, and erosion ASTM covers standard practice for this procedure under the nomenclature: D 6433. [5]

Research Problem

The flexible surfaces designated for aircraft movement at the airport suffer over time from significant deterioration from distress and collapses resulting from aging as a function of the interaction of many factors such as the weakness of the pavement structure,

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including the subgrade, the volume of aircraft movement, axial loads, and environmental conditions in general. Maintenance is an essential element for heavily loaded pavements including runways and taxiways. Maintaining the structural capacity of the entire pavement structure. Pavement failure can be classified into structural failure and functional failure.

To determine the most appropriate and least expensive type of maintenance for these surfaces, the role of evaluating the condition of the pavement comes to identify the types of distress spread on it in addition to its severity and quantities.

Objectives

The objective of this research is to investigate the various feature associated with determining the PCI of airport pavement. The certain aims of this research are:

1. Study and determine the pavement condition of the asphalt surfaces of the airport and define the evaluation method followed in this study.
2. Determine the maintenance levels of the airport runway by calculating the PCI and the pavement sample units that were surveyed on the expected in PCI values and recommending the appropriate percentage of sample units.

Literature Review

Several studies are concrete on the application of PCI in pavement management for roads and runways, and to use on the run of PCI determination through PAVERS software in distress survey and data analysis. [6]

other researchers by using Micro PAVER to fund PCI after distress survey following ASTM procedure for 19 airports. Also, found a good connection between the PCI and the Structural Condition Index. [7]

PCI prediction models establish for years of PCI vs. Pavement Age are used to predict pavement condition. It is usual to determine runway PCI each year consist on the aircraft traffic, environmental conditions, construction history etc. [8]

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The distress survey in 64 sample units at Simara Airport only found 16 distress types and were be faced with several severities. based of 64 sample units, advisable that the PCI is satisfying with PCI ratting 76. [9].

Other study for roads distress by erosion in Nasiriyah city located in southern Iraq. By visual inspection to find type and severity of erosion in the pavement. Estimated the PCI of the entire pavement section was determined. PCI was evaluated with the pavement condition classification and rating ranged from acceptable to poor, very poor and one serious condition, but it never reached the failure condition in any of the studied roads. [10]

Add the totals for each distress type at each severity level and record them under" Total" on the survey form. Quantities of distress are measured in square meters, linear meters, or number of occurrences, depending on the distress type. The procedure for calculating PCI as per ASTM D 5340-2012 is reproduced here. Determining the number of sample units to be tests required:

$$N = \frac{\text{Area of the section}}{\text{Area of the sample}} \quad (1)$$

$$n \frac{(NS)^2}{\frac{e^2}{4} \times (N-1) + S^2} \quad (2)$$

N =Total number of samples in the section
e =allowable error (5%; standard)
S =standard deviation of PCI between sample units (Asphalt pavements=10)

Determining the samples interval:

$$i = \frac{N}{n} \quad (3)$$

N =Total number of samples in the section
n =number samples units of tests required

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During a PCI survey, visible signs of deterioration were recorded and analyzed to determine the distress density which was calculated as follows:

$$\text{Distress Density} = \frac{\text{Distress amount in m2}}{\text{Sample unit area in m2}} \times 100\ \% \quad (4)$$

The total deducts values (TDV) and maximum corrected deduct values (CDV) were obtained in order to estimate the PCI value as recommended by PCI method.

$$\text{PCI value} = 100 - \text{Corrected deduct value} \quad (5)$$

$$PCI = \sum \frac{PCIs}{N} \quad (6)$$

$PCIs$ =value for each sample unit
N = Number of samples

PCI of the pavement section was fund from the data collected from visual inspection survey. PCI of the individual sample units was calculated on Corrected Deduct Value (CDV) calculation form sheet (ASTM D 5340-2012). The combined PCI of sample unit PCIs was taken into account by weighted average. Figure (1) shows the qualitative rating of pavement section and the condition of the selected pavement section. [11]

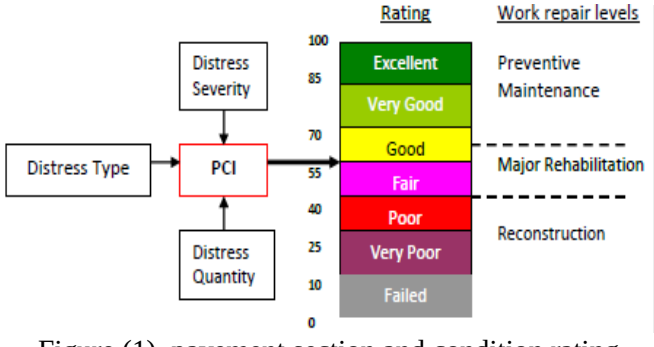

Figure (1). pavement section and condition rating

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Research Methodology

Pavement distress survey was conducted at Sebha Airport, an international airport in Sebha State. There are approximately 5000 aircraft movements per year at the airport and the runway direction is 310/130 RW. The runway dimensions are 3600 m x 45 m of which 3000 m are flexible pavement and 600 m are rigid pavement from the start and end of the runway. The distress survey was conducted on the runway, following the procedure prescribed in ASTM, D5340 –12, Standard Test Method for Airport with the help of specially prepared field reference guides extracted from the Standard Distress Identification Guide.

The entire pavement at Sebha Airport consisting of the runway was divided into sample units.

This field survey has been done at Runway 13-31, with the total areas observed, are 3000 x 45 m^2, divided into 30 segments, with an area about 4500 m^2 per segment as showing in figure 2.

The pavement was divided into sample units with an area ranging from 450 ± 180 m^2 in line with the literature.

Figure (2). Satellite image of Sebha Airport, divided into 30 segments and sample units

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Determine the locations of the sample units that represent the sector in which they are located according to each feature. Measuring tapes were used to measure the length and area of the observed distress within a given sample unit shows in table (1). A ruler was used to measure depression or congestion with a measuring tape. Documentation with hand drawings of each sample unit examined was included in the field sheet showing below in figure (3).

Table (1) Number of samples that need to be tested for a section

ID	Pavement Network	Section	samples interval (i)	number samples units (n)	Total number of samples (N)
RY133 1-001	310°/130° Runway 13/31	Area =135000m². Width = 45m. Length = 3000m.	16	15	240

Then, detailed surveys were started for each sample unit, in which the types of distress in the pavement surface, their severity and their spread (density) to the airport pavement network were determined, and the survey information was recorded in the pavement condition survey data form and documented by photography. The results of the distress survey and survey were used to calculate the pavement condition index (PCI) for each sample unit according to the standard specification (ASTM D 5340-2012), and the same forms were used to analyze and calculate the pavement condition index for each sample unit. Figure (3) shows an example of a pavement distress survey and survey data form and the model for calculating the value of the pavement condition index.

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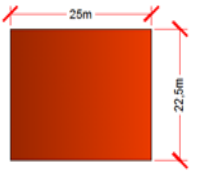
AIRFIELD ASPHALT PAVEMENT

CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

SKETCH:



Sebha International Airport.

BRANCH: RY1331 SECTION: ALL SAMPLE UNIT: 1

SURVEYED BY: Project Team DATE: SAMPLE AREA: 562.5

1. Alligator cracking.	5. Depression.	9. Oil spillage.	13. Rutting.
2. Bleeding.	6. Jet blast.	10. Patching.	14. Shoving from PCC.
3. Block cracking.	7. Jt. reflection (PCC).	11. Polished aggregate.	15. Slippage cracking.
4. Corrugation.	8. Long. & trans. Cracking.	12. Raveling/Weathering.	16. Swell.

DISTRESS SERVERITY	QUANTITY						TOTAL	DENSITY %	DEDUCT VALUE
1L	17.8×1	21.2×1.8	21.2×1.8	21.2×1.8			132.28	23.51	54
3L	8×25						200	35.55	25

Figure (3). Pavement condition survey and PCI value calculation on RY 13/31

Several site investigations were carried to collect the required data about distresses. Based on the results of visual inspection, several types of distress were examined on the runway surface of Sabha International Airport, such as longitudinal and transverse, alligator cracking, raveling / weathering, block cracking, swelling cracking, oil spillage cracking. Figure (4) below show several types of distress on the runway fixable surface on RY 13/31.

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Figure (4). Several types of distress on the runway fixable surface on RY 13/31

A visual inspection of the pavement surface with field measurements provided valuable information, which are used to evaluate the current pavement condition. The types of distress were represented by numbers from 1 to 6 while the severity of distress, where applicable, was represented by its initials such as “L” for low, “M” for moderate and “H” for height. The table (2) below shows the recapitulation of distress type and density percentage of segment divided into samples units.

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Table (2) The recapitulation of distress type and density percentage on RY 13/31

Section	Sample Units ID	DISTRESS TYPE					
		Block Cracking	Long. & trans. Cracking	Raveling/ Weathering	Alligator Cracking	Swell	Oil spillage
All	1	✓	-	-	✓	-	-
	18	✓	-	-	✓	-	-
	33	✓	-	-	✓	-	-
	50	✓	✓	-	✓	-	-
	65	✓	-	-	✓	-	-
	82	✓	✓	-	✓	-	-
	97	✓	✓	-	✓	-	-
	114	✓	✓	-	✓	-	-
	129	✓	✓	✓	✓	-	-
	146	✓	✓	✓	✓	-	-
	161	✓	✓	✓	✓	-	-
	178	✓	✓	✓	✓	-	-
	193	✓	-	✓	✓	-	-
	210	✓	✓	✓	✓	-	-
	240	✓	✓	✓	✓	✓	✓
Percentage (%)		100	66.67	45.67	100	6.67	6.67

As a result of the distress survey and assessment process for the landmark (RY 13/31) as shown in table (2), the types of distress found in the sample units were very similar, if not identical and completely duplicated. The types of distress are limited to alligator cracking at 100%, and block cracking at 100%. The difference lies in the distress of longitudinal and transverse cracks at 66.67%, and weathering/raveling at 45.67%. As for swell distress, and oil stains in one sample model only at 7.14%, Figure (4) shows a group of images of the distress that were identified in the runway (RY 13/31),

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and the rest of the images of the distress that were identified in the runway are shown in figure (4).

Analysis and Results

The results of the distress survey and the survey were used to calculate the pavement condition index (Pavement Condition Index - PCI) for each sample model according to the standard specification (ASTM D 5340-2012). This was done by calculating the density for each distress and each severity separately and using the discount value curves (Deduct Value Curves) to determine the discount value in the pavement condition index resulting from each distress according to its severity using the curves specific to each distress. Then the discount value resulting from the total distress for each sample model (Total Deduct Value- DV) was determined and then the corrected discount value for each sample model (Corrected Deduct Value- CDV) was determined using the total deduct value curve.

Table (3) provides a summary of the results of the analysis and calculation of the pavement condition factor PCI for the sample models for the flexible part of the airport under study. We note from this table that the general evaluation of the pavement condition of the runway (RY 13/31) is (Poor) and the rate is 40.

Table (3) Summary of the results of the analysis and calculation PCI on RY 13/31

Branch ID	Section	Sample Unit ID	PCI	Rating	Average PCI	General Rating
RY 13/31	ALL	1	40	Fair	40	Poor
		18	53	Fair		
		35	46	Fair		
		52	55	Good		
		69	34	Poor		
		86	41	Fair		
		103	56	Good		
		120	70	Good		
		137	34	Poor		

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		154	38	Poor		
		171	31	Poor		
		188	16	Very poor		
		205	40	Fair		
		222	18	Very poor		
		239	22	Very poor		

The process of determining the required maintenance level is based on the evaluation results of the pavements by matching the average pavement condition factor for the features that make up the flexible pavement of the Sebha International Airport runway with the pavement condition assessment scale and maintenance levels (PCI rating scale and repair levels). Table (4) shows the required maintenance levels for the flexible part of the Sebha International Airport runway. It is noted from this table that the required maintenance level for runway RY 13/31 falls within the maintenance level (reconstruction) and this maintenance level constitutes 100% of the total area of the flexible part of the runway under study.

Table (4) Determining the required maintenance level for the flexible pavement

Branch ID	Branch Area m^2	Average PCI	General PCI Rating	maintenance and rehabilitation
RY 13/31	135000	40	Poor	Reconstruction

Calculation

In this study, an attempt was made to adopt the PCI method to evaluate the pavement state and suggest suitable maintenance and repair. A total of 15 sample units were examined on the runway in the distress survey, as distress survey found crocodile crack, block crack, longitudinal and transverse crack, drift, bulge and oil spill.

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The results show that the PCI Rating evaluation was ranging fail of the studied runway. The study shows that the (PCI) method provides a suitable measure of the present condition of the pavement based on the distress observed on the surface of the pavement. The main conclusion of the study is the ability to conduct the PCI method to diagnose pavement distresses and evaluate pavement condition in the studied area. The use of (PCI) method is efficient in the prior evaluation of road condition in order to implement suitable maintenance to the distressed pavement.

The evaluation process is considered one of the most important ways to maintain the pavement in good condition when it is done continuously, and thus determine the best maintenance proposals, as the correct diagnosis of distress is followed by the correct diagnosis and effective treatment.

By determining the value of the pavement condition factor PCI for the sample models (slices), the pavement condition was determined for most of the studied slices in the flexible pavement sector of the Sabha International Airport runway, so that it was ranging poor.

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