Applicability of PAVEAIR for Airport Pavement Management: Comparison between Military and Civilian Runways

Matheus Silva Oliveira¹, Cláudia Azevedo Pereira² and Pollyany Cristie de Assis Farias¹
1. Instituto Federal de Educação, Ciência e Tecnologia de Goiás - IFG, Anápolis 74055-110, Brasil
2. Instituto Tecnológico de Aeronáutica- ITA and Instituto Federal de Educação Ciência e Tecnologia de Goiás – IFG

Abstract: Nowadays, globalization has become essential, and interconnection between people and cargo has become necessary due to international trade and investment. In this context, aviation is an important modal because of its efficiency in security, range, and speed; however, the aerodrome infrastructure capacity is not always sized according to the demand and safety regulations required during operations. The number of runway occurrences in Brazil increased considerably since 2011. These occurrences are consequences of several contributing factors, of which runway conditions and airport infrastructure can be considered the most important; however, the quality of runways and the flight safety they provide can’t be quantified through direct statistics. Adhering to a high standard of airfield quality while also knowing airport infrastructure, a study that applies an evaluation of the Pavement Condition Index (PCI) methodology has been developed. First, the airfield pavement at a military base was analyzed and later compared to the results found in a civil airfield study done by another author. The methods used to identify distress in the pavement’s surface were based on ASTM D 5340-12, as are PCI calculations. Secondly, the system was infused into PAVEAIR-FAA (Federal Aviation Administration) to apply an airport management method at a military base to compare the results obtained by other authors for a civil airfield study, where it was intended to analyze the performance characteristics of the runway for each type use. Subsequently, one can obtain subsidies of decisions for the optimization of resources used in airfield maintenance and rehabilitation, and increase operational safety.

Key words: Pavement, airfield, PCI.

1. Introduction

Considering the size of Brazil, interconnections between geographical areas require infrastructure, so the nation’s development is related to its infrastructure. In Brazil, the most utilized method of cargo transportation is by trucks. However, this is not the most efficient method because of the large displacements between lands and because of lack of safety; therefore, the need for different transportation methods is significant. Air transportation becomes relevant, but the quality of airfields is not always favorable to this demand and safety of operations. Prevention of Aeronautical Accidents—CENIPA [1], the military branch of the Brazilian Aeronautics Command that is responsible for the safety of air operations, the number of runway excursion occurrences in Brazil has increased considerably since 2011. These occurrences are the consequence of several factors, including runway conditions and airport infrastructure. The quality and safety that runways provide during landing and takeoff can hardly be quantified through direct statistics.

By adhering to a high standard of aerodromes and knowledge of airport infrastructure, a comparison was made between landing and takeoff at civil airports and military bases. The comparison discusses tools that evaluate the Pavement Condition Index (PCI) of military and civil airfields to identify distresses that...
are present in both.

The methodology used to identify distress in a pavement’s surface, as are PCI calculations, is based on ASTM D 5340-12. This method of evaluating PCI conditions is adopted by software PAVEAIR-FAA—Federal Aviation Administration [2]. This work aims to apply an airport management methodology at a military base and compare the results obtained by Durán and Fernandes Junior [3], for a civil airfield.

Thus, it is expected to analyze the runway performance for each type of use. Subsequently, one can obtain subsidies of decisions for the optimization of resources used in airfield maintenance and rehabilitation, and increase operational safety.

2. Development

2.1 Methodology

This work’s development begins with a data collection of landing and takeoffs on a runway at a military base, based on ASTM D5340-12. Table 1 evidences some operational characteristics of the analyzed airfield.

The studied airfield extends 3,300 meters, and is 45 meters wide, with 300 meters of rigid pavement at the beginning and end, with flexible pavement in between, which can be seen in Fig. 1. To quantify the distress in the pavement, the runway was divided into sections of 10 by 10 linear meters, providing analysis sections equivalent to 450 square meters, thus, being able to run a continuous visual analysis of the pavement by ASTM method [4].

The methodology used for the identification of distress present in the sampled area is utilized by ASTM D5340-12 [4], which is also used for PCI calculations. ASTM D5340-12 [4] adopted seventeen types of distress present in the flexible pavement, which is the predominant pavement at the studied airfield. Applicants in pavement management software called PAVEAIR were developed by the FAA, which calculates PCI in the airfield, as can be seen in Table 2.

To verify the distresses that were detected in the airfield, a method of evaluation of data collection has been adopted by three different assessors, by which they used a methodology that provides quantifiable data relating to the types of distress, the level of severity, and the percentage of that present along the landing and takeoff runway.

Table 1  Data from a military airfield in the study.

| Extension | m         |
|-----------|-----------|
| Width     | 45 m      |
| Paved surface | 121,500 m² |
| Pavement  | Concrete  |
| Extension | 600 m     |
| Pavement  | Flexible  |
| Extension | 2,700 m   |

Fig. 1  Airfield scheme sectioned (2018).
Table 2  Flexible pavement condition [4].

| Distresses on flexible airport pavements |
|-----------------------------------------|
| 1. Alligator cracking                    |
| 2. Bleeding                              |
| 3. Block cracking                        |
| 4. Corrugation                           |
| 5. Depression                            |
| 6. Jet blast                             |
| 7. Joint reflection, PCC                 |
| 8. Longitudinal & transversal cracking   |
| 9. Oil spillage                          |
| 10. Patching                            |
| 11. Polished aggregate                   |
| 12. Raveling                             |
| 13. Rutting                              |
| 14. Shoving from PCC                     |
| 15. Slippage cracking                    |
| 16. Swelling                             |
| 17. Weathering                           |

PCI consists of the pavement assessment method, originating in a study conducted by the United States Army Corps of Engineers. The method developed for airport pavements, whether Hot Mixture Asphalt (HMA) or Portland Cement Concrete (single and armed), enables a qualifying numerical list that portrays the real condition of the pavement, and can then sort the pavement operating capacity, determine the maintenance, repair measures, and predict the useful life.

The pavement classification is relevant for PCI calculation, where the PCI is measured on a scale of 0 to 100, with 0 for destroyed and 100 being in excellent condition (Fig. 2).

2.2 PCI Calculation

With the database from the inventory of distress present in the pavement surface, which are originating in measuring the results obtained from the relevant analysis of the airfield, made by three different evaluators and the PAVEAIR software, enabled them to calculate the PCI of the military airfield, as seen in Table 3. For this calculation, the method of segmenting the runway and takeoff ramp into sections and samples and calculations that were made to obtain the PCI refers to the following equations:

\[
PCI_{sample} = 100 - VDC
\]  

(1)

where:

\[
PCI_{sample} = PCI \text{ the sample};
\]

\[
VDF = \text{value deducted fixed}
\]

For the PCI calculation of sections is used Eq. (2):

\[
PCI_s = \frac{\sum_{i=1}^{n}(PCI_{r,i} \times A_{r,i})}{\sum_{i=1}^{n}A_{r,i}}
\]  

(2)

where:

\[
PCI_s = \text{section pavement condition value};
\]

\[
PCI_{r,i} = PCI \text{ of sample } i \text{ randomly selected};
\]

\[
A_{r,i} = \text{sample area } i \text{ randomly selected};
\]

\[
n = \text{total number of evaluated random samples}.
\]

Regarding the data collected through the concise analysis of the landing and takeoff at the military base, with the help of the PAVEAIR tool and the calculation of each sample PCI, it was possible to get the index of the condition of the pavement aerodrome sections, according to Table 4.

![PCI and rating scale, ASTM D-5340-2012](image)
Table 3  Section area and PCI calculated from samples measured by the evaluators.

| Section | Area of section (m²) | PCI (sample) | Section | Area of section (m²) | PCI (sample) | Section | Area of section (m²) | PCI (sample) |
|---------|----------------------|--------------|---------|----------------------|--------------|---------|----------------------|--------------|
| 1       | 450 35 84            | 450 41 167   | 2       | 450 35 85            | 450 41 168   | 3       | 450 35 86            | 450 35 169   |
| 4       | 450 35 87            | 450 35 170   | 5       | 450 35 88            | 450 35 171   | 6       | 450 35 89            | 450 35 172   |
| 7       | 450 35 90            | 450 35 173   | 8       | 450 35 91            | 450 35 174   | 9       | 450 35 92            | 450 35 175   |
| 10      | 450 35 93            | 450 35 176   | 11      | 450 35 94            | 450 35 177   | 12      | 450 35 95            | 450 35 178   |
| 13      | 450 35 96            | 450 35 179   | 14      | 450 35 97            | 450 35 180   | 15      | 450 35 98            | 450 35 181   |
| 16      | 450 35 99            | 450 35 182   | 17      | 450 35 100           | 450 35 183   | 18      | 450 35 101           | 450 35 184   |
| 19      | 450 35 102           | 450 35 185   | 20      | 450 35 103           | 450 35 186   | 21      | 450 50 104           | 450 50 187   |
| 22      | 450 50 105           | 450 50 188   | 23      | 450 50 106           | 450 47 189   | 24      | 450 50 107           | 450 47 190   |
| 25      | 450 50 108           | 450 47 191   | 26      | 450 45 109           | 450 47 192   | 27      | 450 45 110           | 450 47 193   |
| 28      | 450 45 111           | 450 47 194   | 29      | 450 45 112           | 450 47 195   | 30      | 450 45 113           | 450 47 196   |
| 31      | 450 35 114           | 450 47 197   | 32      | 450 35 115           | 450 47 198   | 33      | 450 35 116           | 450 50 199   |
| 34      | 450 35 117           | 450 50 200   | 35      | 450 35 118           | 450 50 201   | 36      | 450 35 119           | 450 50 202   |
| 37      | 450 35 120           | 450 50 203   | 38      | 450 35 121           | 450 50 204   | 39      | 450 35 122           | 450 47 205   |
| 40      | 450 35 123           | 450 47 206   | 41      | 450 35 124           | 450 47 207   | 42      | 450 35 125           | 450 47 208   |
| 43      | 450 35 126           | 450 47 209   | 44      | 450 35 127           | 450 47 210   | 45      | 450 35 128           | 450 50 211   |
| 46      | 450 35 129           | 450 50 212   | 47      | 450 35 130           | 450 50 213   | 48      | 450 35 131           | 450 50 214   |

Note: PCI values are calculated from the samples measured by the evaluators.
Table 3 to be continued

| Section | Area of section (m²) | PCI (sample) |
|---------|----------------------|--------------|
| PR-1    | 13,500               | 39.17        |
| PF-1    | 13,500               | 42.08        |
| PF-2    | 13,500               | 51.87        |
| PF-3    | 13,500               | 45.62        |
| PF-4    | 13,500               | 47.83        |
| PF-5    | 13,500               | 54.17        |
| PF-6    | 13,500               | 48.33        |
| PF-7    | 13,500               | 50.00        |
| PF-8    | 13,500               | 45.62        |
| PF-9    | 13,500               | 56.67        |
| PR-2    | 13,500               | 48.33        |

Table 4  Area and PCI calculated, military airfield sections.

| Section | Area of section (m²) | PCI (sample) |
|---------|----------------------|--------------|
| PR-1    | 13,500               | 39.17        |
| PF-1    | 13,500               | 42.08        |
| PF-2    | 13,500               | 51.87        |
| PF-3    | 13,500               | 45.62        |
| PF-4    | 13,500               | 47.83        |
| PF-5    | 13,500               | 54.17        |
| PF-6    | 13,500               | 48.33        |
| PF-7    | 13,500               | 50.00        |
| PF-8    | 13,500               | 45.62        |
| PF-9    | 13,500               | 56.67        |
| PR-2    | 13,500               | 48.33        |
3. Results

Through all the surveys regarding pavement conditions and the calculations of PCI, it is noted that the points of distress appear from the 600 initial meters of the airfield in PF-1 section (Fig. 3), and is 300 meters from the PR-1 runway threshold, which is the predominant bedside for the landing of the aircraft, which is believed to be the largest area of application of the aircraft since this is the area of touchdown and braking initiation section. Continuous analysis of the points of a distress in the pavement’s surface could be seen in the sections where they are more severe. In PF-1 to PF-7 from the 1,430 initial meter airfield extension, there is a characterization of distress in ascending scale with the presence of the relevant ASTM 5340-12 [4] reflection problems, such as cracks and weathering, and also structural distress, such as the drainage of the runway and takeoff.

By analyzing the sectioned areas of the airfield, it is found the type, severity and the percentage of each distress in the study, where with matched the data collected by the evaluators and made the calculation of PCI, it was possible to obtain the percentage of distress present on the runway of the military base. In these samples, the distress with the highest incidence had the presence of Longitudinal and Transversal Cracking 15%, Block Cracking 8%, Joint Reflection 20%, Patching 12%, Rutting 3% and loosening material around the edges of the track due to lack of proper drainage 25%, where drainage problems persist in 41% of the aerodrome being quantified in the analyzed sections (Fig. 4).

According to the data presented by Duran and Fernandes Junior [3], recorded in the civil airfield, when comparing the pavement management system for such different airfields, this request is noteworthy in both, since civil airports receive larger aircraft as opposed to military bases, whose airfield constantly operates with smaller aircraft. It is noted that the distress present in the civilian airport are similar to the military trend, and the distress that best expressed; Alligator Cracking 2%, Bleeding 1%, Depression 5%, Oil Spillage 13% and higher incidence, the Raveling 43% and presence of Longitudinal and Transverse Cracking 34% (Fig. 5).

Therefore, in the analysis of distress present in both military airfield and the civil airport, it can be noted that the pathologies which manifest in a larger scale on the surface of these pavements are longitudinal and transversal cracking, as in several sections the cracking was caused by the execution mode.

![Fig. 3 Military airfield runway under study, characterisation of sections according to PCI.](image-url)
4. Conclusion

In this project, data relating to a military airfield and civil airfield were compared. Through sampling and the application of diverse methodologies, such as the applicability of the PAVEAIR software system, and the calculation of PCI according to ASTM 5340-12 [4], it was possible to identify and contrast distress between both pavements used in each airfield.

With the results obtained from the PCI calculations, which verify the condition of the military airfield...
pavement, an airport pavement management system designed to identify the distress and severity present in the track and make the repairs necessary should be put into action. Following this process, a new comparison can observe the main peculiarities found to better recognize each type of aircraft in operation, and how each aircraft may influence the use and deterioration of pavement used on runways, obtaining requests at each aerodrome.

References

[1] CENIPA - Centro de Investigação e Prevenção de Acidentes Aeronáuticos. 2013. Aeródromo - Sumário Estatístico. Brasília, Brasil.
[2] FAA PAVEAIR. 2018. “Federal Aviation Administration.” Accessed Nov. 03, 2018. https://faapaveair.faa.gov.
[3] Durán, J. B. C., and Fernandes Júnior, J. L. 2014. “Uso do PAVEAIR para a Gerência de pavimentos aeroportuários: estudo de caso no aeroporto estadual de Araraquara.” Presented at Congresso de Pesquisa e Ensino em Transportes—XXVII ANPET, Curitiba, Paraná, Brasil.
[4] ASTM. 2018. D5340-12 (2018, reapproved) Standard Test Method for Airport Pavement Condition Index Surveys. American Society for Testing and Materials, USA.