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

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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.

According to the Center for Research and 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

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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 Duràn 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.

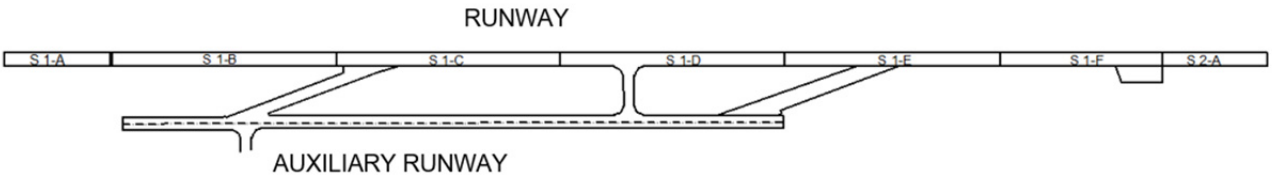
The studied airfield extends 3,300 meters, and is 45 meters wide, with 300 meters of rigid pavement at the beginning and end, with flexible pavement in between, which can be seen in Fig. 1. To quantify the distress in the pavement, the runway was divided into sections of 10 by 10 linear meters, providing 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	3,300 m
Width	45 m
Paved surface	121,500 m^2
Pavement	Concrete
Extension	600 m
Pavement	Flexible
Extension	2,700 m



BRANCH	SECTION	SAMPLES	BRANCH	SECTION	SAMPLES
RUNWAY (Asphalt)	S 1-B	54	RUNWAY (Concrete)	S 1-A	30
	S 1-C	54		S 2-A	30
	S 1-D	54			
	S 1-E	54			
	S 1-F	54			

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:

$$PCI_{sample} = 100 - VDC \qquad (1)$$

where:

PCI_{sample} = PCI the sample;

VDF = value deducted fixed

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

$$PCI_s = \frac{\sum_{i=1}^{n}(PCI_{r,i} * A_{r,i})}{\sum_{i=1}^{n} A_{r,i}} \qquad (2)$$

where:

PCI_s = section pavement condition value;

$PCI_{r,i}$ = PCI of sample i randomly selected;

$A_{r,i}$ = sample area i randomly selected;

n = 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.

Fig. 2 PCI and rating scale, ASTM D-5340-2012 [4].

Table 3 Section area and PCI calculated from samples measured by the evaluators.

Section	Area of section (m^2)	PCI (sample)	Section	Area of section (m^2)	PCI (sample)	Section	Area of section (m^2)	PCI (sample)	Section	Area of section (m^2)	PCI (sample)
1	450	35	84	450	41	167	450	55	250	450	50
2	450	35	85	450	41	168	450	55	251	450	57.5
3	450	35	86	450	35	169	450	55	252	450	57.5
4	450	35	87	450	35	170	450	55	253	450	57.5
5	450	35	88	450	35	171	450	57.5	254	450	57.5
6	450	35	89	450	35	172	450	57.5	255	450	57.5
7	450	35	90	450	35	173	450	57.5	256	450	35
8	450	35	91	450	41	174	450	57.5	257	450	35
9	450	35	92	450	41	175	450	57.5	258	450	35
10	450	35	93	450	41	176	450	50	259	450	35
11	450	35	94	450	41	177	450	50	260	450	35
12	450	35	95	450	41	178	450	50	261	450	46.25
13	450	35	96	450	38.75	179	450	50	262	450	46.25
14	450	35	97	450	38.75	180	450	50	263	450	46.25
15	450	35	98	450	38.75	181	450	55	264	450	46.25
16	450	35	99	450	38.75	182	450	55	265	450	46.25
17	450	35	100	450	38.75	183	450	55	266	450	35
18	450	35	101	450	50	184	450	55	267	450	35
19	450	35	102	450	50	185	450	55	268	450	35
20	450	35	103	450	50	186	450	45	269	450	35
21	450	50	104	450	50	187	450	45	270	450	35
22	450	50	105	450	50	188	450	45	271	450	65
23	450	50	106	450	47	189	450	45	272	450	65
24	450	50	107	450	47	190	450	45	273	450	65
25	450	50	108	450	47	191	450	50	274	450	65
26	450	45	109	450	47	192	450	50	275	450	65
27	450	45	110	450	47	193	450	50	276	450	65
28	450	45	111	450	47	194	450	50	277	450	65
29	450	45	112	450	47	195	450	50	278	450	65
30	450	45	113	450	47	196	450	45	279	450	65
31	450	35	114	450	47	197	450	45	280	450	65
32	450	35	115	450	47	198	450	45	281	450	65
33	450	35	116	450	50	199	450	45	282	450	65
34	450	35	117	450	50	200	450	45	283	450	65
35	450	35	118	450	50	201	450	45	284	450	65
36	450	35	119	450	50	202	450	45	285	450	65
37	450	35	120	450	50	203	450	45	286	450	50
38	450	35	121	450	42.5	204	450	45	287	450	50
39	450	35	122	450	42.5	205	450	45	288	450	50
40	450	35	123	450	42.5	206	450	50	289	450	50
41	450	35	124	450	42.5	207	450	50	290	450	50
42	450	35	125	450	42.5	208	450	50	291	450	50
43	450	35	126	450	50	209	450	50	292	450	50
44	450	35	127	450	50	210	450	50	293	450	50
45	450	35	128	450	50	211	450	50	294	450	50
46	450	35	129	450	50	212	450	50	295	450	50
47	450	35	130	450	50	213	450	50	296	450	45

(Table 3 to be continued)

48	450	35	131	450	42.5	214	450	50	297	450	45
49	450	35	132	450	42.5	215	450	50	298	450	45
50	450	35	133	450	42.5	216	450	55	299	450	45
51	450	57.5	134	450	42.5	217	450	55	300	450	45
52	450	57.5	135	450	42.5	218	450	55	301	450	50
53	450	57.5	136	450	50	219	450	55	302	450	50
54	450	57.5	137	450	50	220	450	55	303	450	50
55	450	57.5	138	450	50	221	450	55	304	450	50
56	450	55	139	450	50	222	450	55	305	450	50
57	450	55	140	450	50	223	450	55	306	450	45
58	450	55	141	450	55	224	450	55	307	450	45
59	450	55	142	450	55	225	450	55	308	450	45
60	450	55	143	450	55	226	450	45	309	450	45
61	450	65	144	450	55	227	450	45	310	450	45
62	450	65	145	450	55	228	450	45	311	450	50
63	450	65	146	450	47	229	450	45	312	450	50
64	450	65	147	450	47	230	450	45	313	450	50
65	450	65	148	450	47	231	450	45	314	450	50
66	450	46.25	149	450	47	232	450	45	315	450	50
67	450	46.25	150	450	47	233	450	45	316	450	35
68	450	46.25	151	450	57.5	234	450	45	317	450	35
69	450	46.25	152	450	57.5	235	450	45	318	450	35
70	450	46.25	153	450	57.5	236	450	50	319	450	35
71	450	65	154	450	57.5	237	450	50	320	450	35
72	450	65	155	450	57.5	238	450	50	321	450	55
73	450	65	156	450	50	239	450	50	322	450	55
74	450	65	157	450	50	240	450	50	323	450	55
75	450	65	158	450	50	241	450	50	324	450	55
76	450	59	159	450	50	242	450	50	325	450	55
77	450	59	160	450	50	243	450	50	326	450	55
78	450	59	161	450	55	244	450	50	327	450	55
79	450	59	162	450	55	245	450	50	328	450	55
80	450	59	163	450	55	246	450	50	329	450	55
81	450	41	164	450	55	247	450	50	330	450	55
82	450	41	165	450	55	248	450	50			
83	450	41	166	450	55	249	450	50			

Table 4 Area and PCI calculated, military airfield sections.

Section	Area of section (m^2)	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 apposed 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.

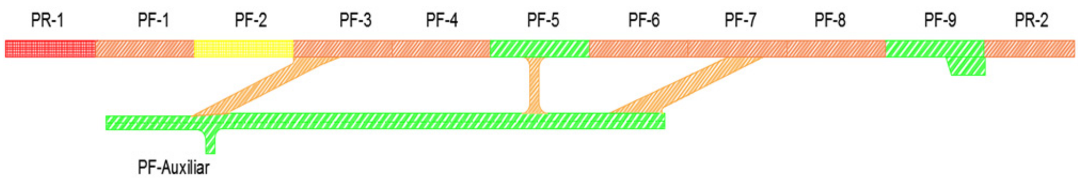


Fig. 3 Military airfield runway under study, characterisation of sections according to PCI.

Fig. 4 Airfield distress in the study, weathering, and cracking.

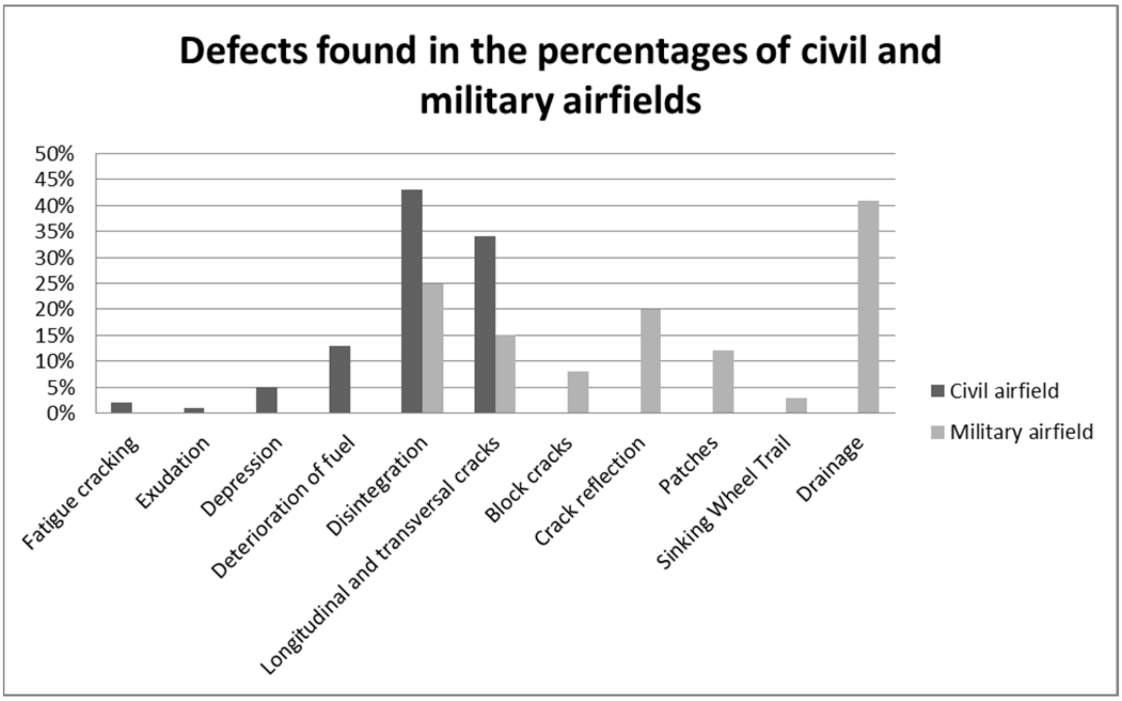


Fig. 5 Percentages of distress found in the civil and military airfield pavement.

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.

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