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OPERATIONAL SAFETY UNDER THE OPINION OF MANAGEMENT IN MAINTENANCE OF AIRPORT FLOORS

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Abstract: The flooring of runways of big airports, go through losses due to intense airplane traffic and weather conditions along time. The consequences of losses are cracks, disintegration imperfections, superficial deformations and the loss of friction during the airplane movements. The runway that shows these problems can risk the safety of aeronautical operations. For this reason, the airport administration should proceed with the right keeping for preservation and improvement of the runway conditions. In this sense, the management of the maintenance of the flooring helps to improve and prioritize the needed adjustments to be done on it and, besides keeping the runway according to the safety standard it helps decrease the costs and optim the budget for the airport manager.

Keywords: Pavement; Maintenance; Management; Safety; Operational.

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1. INTRODUCTION

This article is presented as a study with the aim of contributing to aeronautical knowledge and falls within the line of research “Man, the Environment and the Machine” of the Aeronautical Research Center (NUPAER). The theme results from the intention to highlight to the aeronautical community and people interested in the subject, the strong influence and importance that the runway pavement has on operational safety, being one of the aids to braking the aircraft during landing or in the case of take-off procedures. aborted. It is also of interest to the research to reveal the need to carry out correct maintenance management in order to offer the expected safety and savings in the most relevant part of the aeronautical infrastructure.

If the pavement in an airport infrastructure is the most important part, then it is the one that requires the most investment, attention to maintenance and quality of service. If the pavements do not offer adequate safety, the use of the runway may be prohibited until it is released and in operational conditions, as was the case in February 2014 at Val-de-Cans Airport in the city of Belém do Pará, where , on rainy days, the airport's main runway could not be used due to the accumulation of water and the poor condition of the pavement.

With these measures, the airport operator stops making profits by directly interfering with flights and disrupting the air network that would operate at the airport. Another relevant intervention, according to the newspaper O Globo, took place at Leite Lopes Airport in Ribeirão Preto, in January 2011, where landings and takeoffs were prohibited on rainy days due to the low level of friction. Shortly after the ban, the airport operator carried out tests and trials and found that there was excess rubber on the runway. This happened due to the fact that days before the ban, a plane from the Passaredo company skidded and left the runway, which was wet.

It is clear how important issues related to paving are in the daily life of airports and, in this sense, this research aims to verify how the management and maintenance of aeronautical pavement can influence operational safety. Therefore, the general objective is to demonstrate the importance of managing maintenance on airport pavement for operational safety. In lines of specific objectives, it is presented, given the historical context, when human beings were aware of the relevance of the pavement in aircraft landing and take-off operations, in addition to presenting the information that airport operators must comply with to maintain the pavement. in operational conditions. It is still essential to describe airport pavement maintenance methods and tests and clarify how the Pavement Management System can offer economic and qualitative benefits to a runway in the long term.

The Brazilian regulatory agency offers information that airport operators can base on when carrying out maintenance on pavements. By managing pavement maintenance at the correct time, maintenance offers economic and safety benefits. Among the various factors that can influence a

aeronautical accident, generally not just one, infrastructure is one of these factors.

There is a concern in the aeronautical environment when the subject addressed is operational safety and what motivated the theme of this article was to discuss the importance that the aeronautical pavement has for carrying out a procedure such as landing or take-off with due safety on the part of the pavement. This article presents methods, concepts and tools necessary to maintain the pavement in operational and safe conditions.

The research on the topic was based on dissertations, studies and books that involve the aeronautical pavement from its history to forms of maintenance. Magazines and materials presented in seminars focused on the subject were used as complementary references. This type of research is carried out when analyzing, correlating and recording facts without manipulating them, therefore, describing the maintenance of aeronautical pavement and clarifying its importance. The methodology used in this article was Hypothetical-Deductive, in that through hypothesis proposals, their development may or may not occur.

Among the authors who contributed to the completion of the research, the following stand out:

Gunnar Antvik (1997) and Oswaldo Sansone Rodrigues Filho (2006), who contributed to a more targeted view on the subject, Brazilian Resolution nº 236 (2012) which establishes adherence requirements for landing and take-off runways and the author Cristina Isabel Fernandes (2010), among other authors of equivalent relevance.

To achieve the proposed objectives, the work was divided into two parts. The first contains the historical context of specific bibliography in which the first methods of evaluating the condition of the pavement reported are presented and some studies that were demonstrated to the aeronautical community at the time and identified the importance that the pavement had in carrying out the procedures successfully. The second part addresses some pavement maintenance methods, the description of certain equipment and tests that allow to qualify the condition of the pavement, and presents the function and what the Pavement Management System is about, what are the benefits it offers to the airport operator and the pavement. The result of the survey of appropriate literature aims to establish the reasons for the relevance of the management in the maintenance of airport pavements for operational safety when considering the methods, research and materials studied, filtering the ideas of the aforementioned authors to make the final finding.

[3] Defined area on land, water or floating, intended for the arrival, departure and movement of aircraft.

2. THE HISTORY OF AIRPORT PAVING

At the beginning of aviation, airport managers, airline pilots and those involved in the area noticed that to improve flight safety in landing and take-off operations it was necessary to have quality control on the aerodrome runways3. Gunnar Antivik (1997) reports that previously many aerodromes had a runway surface covered with grass, with few having a pavement on the runways.

Gunnar Antvik shows that around 1920 the first concerns about airport pavements arose. Le Bourget, Paris airport4, a city that initiated the development of the air transport system, was the first to have a rigid surface, and at that time there were no customs and standards for carrying out friction measures, and thus, there were no technical conditions and specific methods of evaluating the pavement.

[4] It is a public aerodrome equipped with facilities and facilities to support aircraft operations and the loading and unloading of people and cargo.

On that occasion, adds Gunnar Antivik (1997), the airport manager was in charge of checking the runway's friction through a test that identified how much the runway skidded. If the skidding on the track was long, the manager prohibited its operation. Over the years it was necessary to develop methods to measure road surface friction due to accidents and incidents that were occurring.

Gunnar Antivik (1997) explains that with the constant evolution of aircraft becoming larger and faster, it was noted that the tests carried out by the Paris airport manager were no longer efficient in defining the quality of friction provided by the pavement surface. As a result, techniques and equipment began to be developed according to the need for greater aircraft deceleration, as these, increasingly faster and heavier, consumed greater runway distance during landing and takeoff.

Despite the improvement in techniques and equipment, argues Gunnar Antivik (1997), difficulties continued to appear even with the evolution of paving and aviation. The tests had to be carried out in winter, and in some countries at this time it snowed and in others there were long rainy periods. In this way, research groups and authorities from different countries were looking for solutions to avoid accidents and aeronautical incidents when the pavement was contaminated with water or snow.

Gunnar Antivik (1997) points out that several tests and equipment were developed in an attempt to reach an acceptable conclusion about the friction between aircraft tires and the runway. Tests were carried out with trucks and cars that carried attached equipment and passed on the runway at different speeds, taking measurements to later conclude which condition would be the best in terms of tire friction with the ground to aid aircraft braking.

Around 1946, Osvaldo Sansone Rodrigues Filho (2006) reports that Scandinavian Airlines System5 (SAS) began a new route to New York. The aircraft operated at the time were the Douglas DC-4 model. For logistical and maintenance reasons, the DC-4s had to operate at Fornebu Airport in Oslo, which had a runway of just 1,200 meters long, with slopes at the headwaters. To avoid accidents, Ottar Kollerud, manager of the

[5] Airlines of the Scandinavian countries

airport, began measuring runway friction in winter. He developed and started using a test method using a truck loaded with sand and at around 30 km/h he would press the brakes, locking the wheels with the aim of measuring and recording the distance for the vehicle to come to a complete stop.

In the late 1940s and early 1950s, the problem involving friction on airport runways was not known internationally. However, Bertil Florman, administrator of Bromma airport, Stockholm, needed to measure friction at his airport. And he started with the Kollerud method, however, it took a lot of time, as the airport had a greater number of aircraft movements and the tires and brakes of the trucks used were worn out very quickly (RODRIGUES FILHO, 2006).

Osvaldo Sansone Rodrigues Filho (2006) reports that Florman, seeing the need to speed up ground operations to free up the runway in use, introduced the Tapley meter, an instrument that was a decelerometer easily installed in a vehicle. This procedure was similar to Kollerud's method, it accelerated the vehicle to a certain speed and braked by locking the wheels. As soon as they started to slip, the meter took the reading. The difference, however, is that it was not necessary

the vehicle stops completely and thus avoids wear and tear on it. The measurement was carried out at nine points along three lines. The first was located on the runway axis and the other two were spaced five meters apart on each side of the axis.

However, Florman decided to place the slide meter at the airport where he was manager. For this purpose, a special slide meter was developed that operated in the form of a trailer. For those involved, the equipment had to be heavy in order to represent the weight of the aircraft at the time. At the beginning, during the implementation of the equipment, it was decided that to carry out the measurements, a load of one thousand kilograms would be applied to the equipment and the entire equipment would weigh around three thousand kilograms. This equipment contained an axle with three wheels and was widely used at Bromma airport. (RODRIGUES FILHO, 2006)

For Osvaldo Sansone Rodrigues Filho (2006), after admitting the use of the slide meter, the way of evaluating the friction condition changed, and it is possible to find in current publications and online

International Civil Aviation Organization6 (ICAO). Over the years, experiments have shown that the loads on the equipment could be lower without influencing the test.

Gunnar Antivik (1997) states that the first research carried out in the early 1950s that is known about friction occurred in a partnership between the aeronautical authority at Bromma airport and SAS founded in 1946.

The research was carried out during the landing of the aircraft, the friction characteristics of the middle part to the end of the runway were of greatest importance. The runway was divided into three parts following the landing direction. These parts were named A, B, C. Part A referred to the lowest number compared to the numbers applied to the runway thresholds. SAS and Swedish domestic operators knew what the friction numbers meant, however, pilots coming from other airports and international ones when they arrived at Bromma did not understand what those numbers reported. In this way, the expressions: good, average, poor were assigned to classify the friction condition (ANTVIK, 1997).Segundo Gunnar Antivik (1997)

[6] International Civil Aviation Organization (ICAO)

Consequently, SAS delivered questionnaires to the pilots asking what they experienced and found when braking the aircraft and its controllability in crosswinds in the direction of landing. Around 3,000 (three thousand) questionnaires were answered. The answers showed that the friction coefficient, when greater than 0.40, did not present problems with controllability in crosswinds and aircraft braking. However, when the number was 0.25 or lower, there were reports that the problems and difficulties were serious.

Gunnar Antivik (1997) explains that in 1952 the International Air Transport Association7 (IATA), concerned about aircraft safety, decided to organize meetings, opening space for specialists who had experience in runway friction characteristics in different conditions, where SAS had the opportunity to present your friction assessment experience. These meetings included the presence of several people with experience in the area, representing various entities that carried out scientific research on the subject.

According to Osvaldo Sansone

[7] International Air Transport Association

Rodrigues Filho (2006) após os resultados das reuniões de 1952, a IATA concordou com a necessidade de dispor informações confiáveis referentes às características de atrito de pistas contaminadas com gelo, neve ou água. Nessas reuniões, consolidou- se a parceria de cooperação entre técnicos da Suécia e *da National Aeronautics and Space Administration*[8] (NASA) para realização das pesquisas sobre atrito que durou longos anos.

Por volta dos anos 1960 a *Svenska Aeroplan AB* (SAAB) desenvolveu um aparelhamento capaz de medir o atrito. Era um equipamento analógico à quinta roda de um carro desenvolvido pela SAAB intitulado como *SAAB Friction Tester* (SFT). O ponto positivo

The reason for using this equipment was that measurements were carried out quickly and the runway could soon be opened to air traffic, which resulted in a big difference in busy airports (ANTVIK, 1997).

Seeing contaminated tracks as a problem, Thomas Yager (1971) created a technique called grooving. This technique involved transverse grooves in the track that were made in cuts of exact dimensions to the size of the diamond discs, draining and speeding up the flow of water present on the pavement to the construction site through the cuts. Through tests and studies, a NASA article was published in 1971 with Thomas Yager and other researchers as authors. The tests were carried out to measure the performance of the brakes on pavements with and without grooving.

The results of tests carried out by Thomas Yager (1971) showed that pavements that had grooving had significant improvements in aircraft braking and directional control with the pavement contaminated with water. Measurements and observations showed that the tires did not damage the grooving surface. Braking comparisons were tested and obtained with the Douglas F-4D fighter, the Convair 990A aircraft and a Lockheed C-141[a] military transport jet aircraft. All equipped with an antiskid system, a system that prevents the tire from locking and causing skidding during braking.

After testing, Osvaldo Sansone Rodrigues Filho (2006) comments that in 1968, on some airport runways in the United States and England, the grooving technique was applied to the pavement, extending to American roads where high numbers dominated

[8] National Aeronautics and Space Administration (U.S.)

of accidents when the pavement was wet. Initially, the evaluations carried out brought positive results.

After the first results, civil and military aviation wanted more far-reaching and full-scale research. This occurred between 1969 and 1972 with the B-727 and DC-9 aircraft, on more than 50 different runways with and without grooving. The results obtained showed the benefit of the technique, which increased and improved the friction between aircraft tires and the pavement. In 1991, the United States calculated 646 runways that used grooving (NASA, 2003 apud RODRIGUES FILHO, 2006).

Even with considerable advances in terms of pavement surface and coefficient of friction, contaminated runways were still a challenge for the aeronautical community. Runways in which operations contained this characteristic of contaminated pavement became one of several factors that influenced more than 100 accidents between 1958 and 1993 (RODRIGUES FILHO, 2006).

Gunnar Antivik (1997) confirms that around 1970 accidents and incidents led to new rules on runway pavement friction measures when

wet. An accident that resulted in the total loss of a DC-10 Jumbo aircraft at Los Angeles International Airport, whose investigation showed that the touchdown zone was extremely slippery when wet. The investigation also brought up the need to standardize the use of measuring equipment. Not only this, but other accidents and incidents occurred due to the slippery road when wet.

Thomas Yager (1971) adds that in view of these circumstances, a study group was established, which was formed by NASA, Transport Canada9 (TC) and the Federal Aviation Administration10 (FAA), in which the program was entitled The Joint Winter Runway Friction Measurement Program11. Interest was widespread and everyone contributed to the program, including several organizations and also manufacturers of measuring equipment.

Osvaldo Sansone Rodrigues Filho (2006) states that one of the main objectives of the program was to establish a reliable relationship between the values obtained through friction coefficient measuring equipment and the effective braking performance of aircraft.

[9] Government Department of Transport
ern of Canada.

[10] Federal Aviation Administration (U.S.A.).

[11] Joint Friction Measurement Program on Airport Runways in Winter

Rodrigues Filho (2006) explains that to start the program it was necessary to have a large team and many collaborators, around eighty engineers from ten different countries. The initial location for studies on friction between the aircraft tire and the pavement in modified conditions was intended for aeronautical research, located in the state of Virginia in the United States, where the Wallops Flight Facility, a NASA research center, was located.

In the study, more than eight hundred friction tests were carried out with more than four hundred pavement texture measurements. Rodrigues Filho (2006) explains that to obtain more data, thirteen friction measuring devices were used, applying seven different techniques to measure the pavement texture on eleven different track surfaces.

According to Osvaldo Sansone Rodrigues Filho (2006), the first tests of this research were carried out in 1996 in the United States and Canada and the research used B-737 aircraft and a Falcon 20 performing a sequence of landings for test purposes on runways. contaminated with ice and snow. To expand the range of data collection, the test contained some artificial modifications. After obtaining data from the measuring equipment, they were compared with the

obtained in the braking performance of aircraft. New studies were subsequently carried out involving 9 aircraft and 18 different pieces of equipment were used to measure friction.

According to Rodrigues Filho (2006), the various data collected by the program between the years 1996 and 1999 totaled around four hundred aircraft runs and more than ten thousand passes of friction measuring equipment over different pavements and surfaces with different operating conditions. contamination on the runway.

The amount of data collected over the years of research enabled researchers to develop an international friction index for aeronautical pavements. According to Osvaldo Sansone Rodrigues Filho (2006), this index was called the International Runway Friction Index12 (IRFI) and can thus use a standard for aircraft friction, making it an index that aerodrome operators use to check runway friction conditions. . Even with this historical context presented, when it comes to operational safety, all factors involved in a risk procedure must be within the standard, because if some of them are interconnected, it could lead to an air accident. It is hardly suggeste

[12] International Lane Friction Index

only one factor that has contributed to this, as there are at least four factors that appear most frequently involved: man, the weather condition, the infrastructure and the plane (RODRIGUES FILHO, 2006).

3. FLOOR MAINTENANCE AND MANAGEMENT

In order to explain more about runway pavement and operational safety, it is important to understand, in a specific and objective way, about friction, texture, maintenance and current runway paving.

For Ivilen Gonçalves Martins Gomes (2009), the surface of a body, no matter how polished it is, presents roughness when analyzed microscopically. As a consequence, two surfaces in contact have some tendency to move in relation to each other, then there is a resistant force, the friction force.

Consequently, and analyzing the contact of an aircraft's tires with the pavement, the friction force that is exerted is of great importance for braking. Therefore, in the history of aviation, scholars and researchers dedicated so much time to obtaining a solution that would bring safety to aircraft users and crew, showing that the pavement of an aerodrome runway plays an important role in safety.

operational.

The most objective way to distinguish the surface of a pavement is by evaluating the texture. It is understood that the surface of

track forms a set of properties

which serves the traffic of vehicles that use it in a comfortable, reliable and economical way. Airlines have requested guidance from Boeing so that it can provide, through a guide, the various types of surfaces used to describe the pavement of a runway, which are: macadam, gravel runway, flexible pavement, rigid pavement, concrete coating. sealing and “mud coating” applied to treat the asphalt surface (RODRIGUES FILHO, 2006; BOEING, 2014).

Liedi Bariani Bernucci (2007) points out that, regarding appearance, there are four recognized scales: macrotexture, microtexture, megatexture and irregularity. The texture of a given pavement is one of the aspects of adhesion, the classification of a texture depends on the extent between two peaks of depressions on the surface.

The surface textures of airport pavements are characterized by microtexture and macrotexture, being the two elements that provide the most stability on the surface.

Both are important in composing the friction coefficient and improving tire-pavement adhesion, a result of the anti-slip characteristics (OLIVEIRA, 2008).

Osvaldo Sansone Rodrigues Filho (2006) and Liedi Bariani Bernucci et al., (2007) explain that the microtexture differs by the degree of roughness, and it is not possible to be seen with the naked eye, with a size smaller than or equal to 0, 5mm. However, it can be identified through touch, differentiating it from a smooth or rough surface. The microtexture can be evaluated and measured by equipment called the British Pendulum, it is a portable equipment whose operation is based on a pendulum with a rubber base, which is thrown onto the wet pavement in order to measure the loss of energy that occurs when part of the equipment slides on the pavement (BERNUCCI et al., 2007; RODRIGUES FILHO, 2006).

However, the macrotexture is distinguished by the size of the aggregate, by the voids present in the mixture. Some pavements that have a high macrotexture contain a large volume of voids between the closest particles. To obtain the macrotexture classification, the test known as sand spot is carried out. This test determines the average depth

of the stain on the surface of pavements that consists of filling in the voids in the surface texture of the given pavement. The sand must be natural, clean and dry with rounded grains and pass through a 0.3mm sieve and remain in a 0.15mm sieve. The test site must be cleaned with a brush and the sand spread over the dry surface with the support of a wooden disc, making circular and uniform movements, thus filling the surface voids and achieving a circular final area (BERNUCCI et al., 2007; RODRIGUES FILHO, 2006).

The aerodrome operator must maintain the average depth of the macrotexture with an index equal to or greater than 0.60mm for the runway that is in operation within safety standards, and must monitor the depth through the test described above according to the defined frequency. Using as a reference table 1 of Resolution No. 236 of 2012, the frequency at which measurements of the runway macrotexture must be carried out, in the case of more than 210 landings on a threshold carried out by fixed-wing aircraft with a jet engine or turbojet, are every 30 days.

Table 1: Minimum frequency of macrotexture measurements

Tracks	Daily landings at the head of fixed-wing and jet engine or turbojet aircraft	Minimum frequency of macrotexture measurements
1	Less than or equal to 15	Every 360 days
2	16 a 30	Every 180 days
3	31 a 90	Every 90 days
4	91 a 150	Every 60 days
5	151 a 210	Every 45 days
6	More than 210	Every 30 days

Source: Brazil, 2012

The composite action of macrotexture and microtexture results in the value of friction coefficient, so desired and researched for decades in aviation. This coefficient can be measured using various equipment, one of which is the "Mu-Meter". The equipment travels the track at a certain speed and can identify the coefficient of friction. Taking into account BRASIL (2012), the friction coefficient of 0.40 or more, whose index does not present controllability and braking problems, must be verified by the minimum frequency of friction measurements at airports. The frequency of measurements to be carried out depends on the number of landing operations daily per headland, for example, if there are more than 210 landings it is necessary to measure friction every 7 days (BRASIL, 2012; ARDÚZ, 2002).

The friction on the runways allows aircraft to decelerate after landing and accelerate during the takeoff procedure safely. If the friction on the runway is not in good condition, occurrences such as skidding, aquaplaning and sliding may occur, initiating a loss of control of the aircraft, which could lead to serious accidents on a possible runway excursion13 (WELLS, 2004, apud, OLIVEIRA, 2009).

Table 2: Minimum frequency of friction measurements (BRASIL, 2012)

Tracks	Daily landings at the head of fixed-wing and jet engine or turbojet aircraft	Minimum frequency of friction measurements
1	Less than or equal to 15	Every 360 days
2	16 a 30	Every 180 days
3	31 a 90	Every 90 days
4	91 a 150	Every 30 days
5	151 a 210	Every 15 days

[13] Moment when an aircraft passes the lateral ends of the runway.

6	More than 210	Every 7 days

Source: BRAZIL, 2012.

For Julio Ernesto Veslasco Ardúz (2002), a maintenance method to be carefully analyzed and carried out is de-rubber removal. This is a process that removes rubber that is accumulated on airport pavements, originating from aircraft tires, focusing on the aircraft's touch zone where the rubber can completely cover the texture of the pavement. It is a maintenance program to preserve or restore its operational function, carried out according to a certain time or number of landings, with compulsory compliance with this method in accordance with Resolution No. 236 of the National Civil Aviation Agency (ANAC). If there are more than 210 daily landings of fixed-wing aircraft with jet or turbojet engines on a given threshold, the method must be carried out to remove the rubber from the runway.

Table 03: Minimum frequency of rubber removal (BRAZIL, 2012)

Tracks	Daily landings at the head of fixed-wing aircraft with jet engines or turbojets	Minimum frequency rubber removal
1	Less than or equal to 15	Every 720 days
2	16 a 30	Every 360 days
3	31 a 90	Every 180 days
4	91 a 150	Every 120 days
5	151 a 210	Every 90 days
6	More than 210	Every 60 days

Source: BRAZIL, 2012.

ICAO, 2002 apud Oliveira, 2008 points out that the removal of rubber from the pavement has several ways and methods to be carried out, however, the most used is hydrojetting, in which high pressure water and some chemical additives are used with the aim of removing the pavement rubber. There is a variety of equipment to perform this procedure.

In general, defects that may appear on airport pavements are classified into four categories: cracks, disintegration defects, surface deformations and loss of skid resistance. Airport pavement maintenance is a group of measures aimed at conserving or improving the level of service for landing and takeoff operations. It is extremely important to know the characteristics of the pavement so that an appropriate schedule of maintenance activities can be drawn up (ARDÚZ, 2002).

Julio Ernesto Velasco Ardúz (2002) adds that the absence of correct and acceptable maintenance that seeks to use preventive or corrective measures in the case of defects found, makes it possible to generate problems such as deterioration and degradation. With this effect that can occur over time on airport pavements, it creates the need for time-consuming renovations, preventing operations on the runway and generating large costs for the aerodrome operator, both in renovating the pavement and in the time needed to complete the construction. constructions.

According to Dale Peterson (1987) maintenance can be classified into two different types: preventive and corrective. Therefore, according to the Brazilian Association of Standards and Techniques ABNT (1994), preventive maintenance is carried out at predetermined intervals, or according to specific criteria, with the aim of reducing the chance of a failure or deterioration in the functioning of an item. . Corrective maintenance is based on the principle of being carried out after the occurrence of a failure or irregularity with the aim of returning an item to a condition to perform its or a required function.

According to Stolzer (2011) still

there is predictive maintenance, where predictive methods allow finding points that contain possible failures, through a process of monitoring and data collection. It can bring savings and increase safety with a method of early defect prevention.

According to Pade (2007), maintenance activities when related to airport pavement need to be carried out satisfactorily and be characterized as operational and functional. Operational is related to safety and the daily conditions and operation of airport pavements on the landing and take-off runways, taxiways14 and aircraft parking aprons. Such services as vegetation removal, pavement drainage, testing, inspections for foreign objects and animals are necessary to prevent aircraft and equipment from being damaged. The functional objective is actions that aim to maintain quality and safety on the pavement surface, such as de-rubberization.

Francisco Heber Lacerda Oliveira (2009) states that the priority task of a company or operator of the respective

[14] Strip of runway on an aerodrome where aircraft can taxi to or from a hangar, terminal or runway.

aerodrome, is to be aware that the effective management of pavements has to be at the top of your responsibilities. Practices related to pavement conservation and restoration are essential and contribute to improving operational safety, as this is the most important part of the airport infrastructure (OLIVEIRA, 2009).

According to Transport Canada (2007), it is the responsibility of the aerodrome operator to emphasize the monitoring and evaluation of the characteristics of the surface of the pavements regarding their quality to verify the execution of safety rules, and it is important to evaluate the deficiencies, the behavior to identify the needs and thus have a useful life forecast to plan restorations or new constructions.

The National Civil Aviation Agency (ANAC) establishes requirements in resolution number 236 for compulsory compliance by airport operators that receive regular air transport, which may be extended to civil aerodromes that do not receive regular flights. If the operator does not submit appropriate frequent measurements, requirements below the standard required by the regulatory agency or fails to submit appropriate reports

required, the aerodrome operator will be liable to receive administrative punishments and will have to remain in possession of the document for at least 5 years (BRASIL, 2012).

Another important factor for a floor that is not properly maintained is when it is contaminated. ICAO recommends that when the presence of water on the pavement is verified, the condition of the runway should be disclosed to interested parties, such as the Notice to airmen15 (NOTAM) for pilots. With this tool, the air regulations state that the pilot must carry out consultations on the current condition of the runway before landing (RODRIGUES FILHO, 2006)

Currently, landing on a contaminated runway is common. An unpleasant statistic is that 75% of accidents and incidents during the landing procedure have strong winds and a contaminated runway as a contributing factor, and it is not difficult to find a combination of these two factors at certain times of the year. With this comes the importance of the pavement being up to date with its maintenance, providing greater friction and grip to aircraft, both during landing and takeoff, maintaining the

[15] Document with the function of informing in advance aeronautical information that is part of the direct and immediate interest to safety.

perational safety up to date and with the necessary quality for operations in adverse conditions. (TAVEIRA, 2011).

operational safety up to date and with the necessary quality for operations in adverse conditions. (TAVEIRA, 2011).

ANAC, through Resolution No. 236, explains that in an aeronautical context, operational safety is usually conceptualized as the absence of accidents. Although the abolition of aeronautical accidents is desirable, it must be borne in mind that absolute safety is a difficult intention to achieve, because errors and failures are prone to occur, thus resulting in efforts to avoid them. However, it is always necessary to seek control of a process that could lead to a situation

dangerous to ensure that exposure to any risk is as small as possible and, if an accident occurs, its results are minimized (BRASIL, 2012).

Operational security refers to a condition where the risk or loss is within an acceptable level and the airport operator responsible for its administration must show its commitment to it through the provision of resources that are suitable for the safe operation of the airport.

For James Reason (2000), an accident is caused by series and multiple factors that collaborate, forming a chain of events that break the defensive obstacles that act as filters and aim to reduce and protect oneself from possible damage. operational. To do this, it is necessary to know the initial type of failure, which are: active failures and latent failures. Active events are unsafe events with immediate effect related to the front line of the aviation system, for example: pilot or traffic controller. Latent elements are elements that are in the system in an inapparent way for many years, until they manifest themselves with the combination of some active failure where a chance of accident is created depending on the existing defenses. James Reason (2000) chose

Swiss cheese is used as a graphic image to explain its model that represents the course of the accident through the defensive obstacles existing in the system. In Swiss cheese, active faults cause accidents when they combine with some faults in defensive obstacles. Latent faults are spaces in the system's defense obstacles creating chances and paths for an accident. These spaces are aligned in the various defensive obstacles that constitute an accident, thus the paths of latent and active faults come together.

James Reason (2000) explains that strategic decisions have the power to add elements to the system and due to the conditions and properties of the latent failure, it can be identified and weakened before the occurrence of an event that is outside of plans.

Regarding the quality assessment of aeronautical pavements, Fernandes (2010) states that different performance indicator analyzes are involved, and indicator selections may vary depending on the characteristics of the aerodrome, its size, the size of the traffic it receives and the weather conditions. locations. One of the evaluation methods used in much of the world is called Pavement Condition Index16

(PCI) developed for aeronautical pavements by a group of engineers from the American army, whose objective was to obtain a numerical index that would make it possible to observe the degradation of the pavement, being able to reach a conclusion about the real structural and functional conditions.

Cristina Isabel Fernandes (2010) explains that the PCI is based on the principle of values from 0 to 100, with 100 being perfect pavement in its best condition and 0 in its worst possible situation.

The PCI does not measure the structural capacity and resistance that the pavement offers to aircraft braking. It's a visual inspection.

To correctly carry out maintenance on airport pavements, there is a system in place that may be what is needed for correct and efficient runway maintenance. The system's acronym is SGPA, which is an Airport Pavement Management System applied to preventive and corrective maintenance, exactly within the established deadlines, achieving better cost-benefit and extending the large investment that is the construction of a new pavement. The activities contained in the SGPA include preventive activities that must be intense and continuous (OLIVEIRA, 2008).

[16] Pavement Condition Index

Alan Stolzer (2011) presents a definition of management that focuses on the process in which tasks are carried out and completed effectively and efficiently. Some functions are normally unified with management, which are: planning, organization, employee management, coordination, control and budget management. In other words: managing is the act of directing and leading an organization or activity in which resources are made available and allocated, whether financial, human, material or intellectual.

In terms of system, Alan Stolzer (2011) explains that it goes beyond a sum of two parts. A system concept is that it corresponds to a set of people, processes, procedures and integrated equipment where a specific function or activity is carried out in an environment.

For Marcelo de Canossa Macedo (2008), the central function of the SGPA is to support administrators in making decisions about which economic strategy will be the most viable to maintain airport pavements in serviceable conditions and with the appropriate safety that must be offered. The program provides a consistent, objective and systematic way to define priorities, programming and allocation of resources, thus being able to quantify costs and generate recommendations specific areas where the pavement is maintained at an acceptable level of service and safety.

Pavement management can be carried out in two different types, according to Marcelo de Canossa Macedo (2008), at the network level where all assets corresponding to the pavement infrastructure are taken into account, and the project level where it is specific to a given area of the pavement, identified as potential or possible restoration.

The SGPA can be grouped into two essential categories: economic and administrative. From an administrative point of view, it allows you to have full knowledge of the general condition of the pavement network, thus being able to plan and plan repair and conservation activities and, in this way, establish the most effective observation method, define the consequences of the different levels of financing about what condition the pavement is in, thus using an objective basis for political decisions. For the economic category, agree to manage the necessary resources, thus determining the most appropriate level of financing, create a plan for what is best in relation to available resources, define the importance of advancing conservation work and use a system in which priorities are based on comparison between costs and benefits in the various alternatives (BRANCO, 2006 apud FERNANDES, 2010).

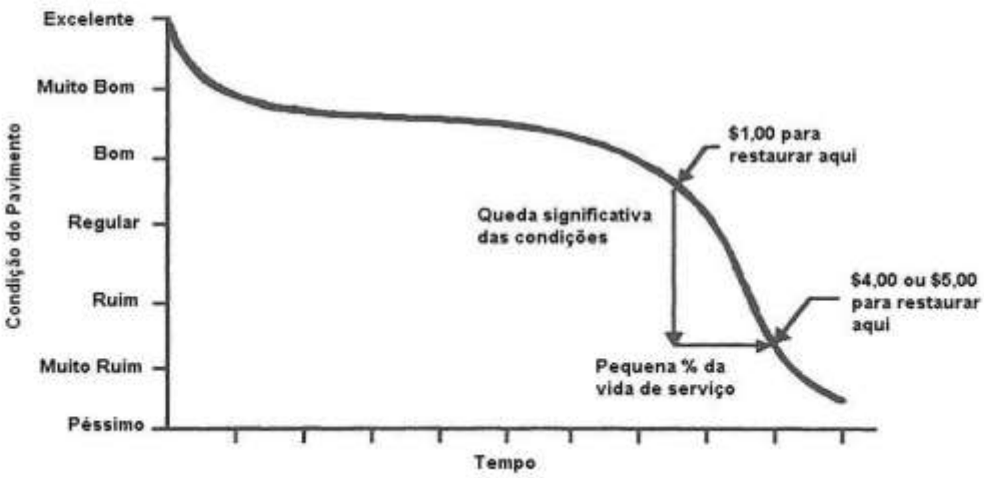
For Francisco Heber Lacerda Oliveira (2009), in most occurrences, it is noted that restoration services are carried out more frequently as they are not applied in the correct way and at the most appropriate time for effective actions that generate conservation or simply not are carried out, this situation results in unnecessary and exaggerated costs that could not exist if appropriate conservation practices were applied.

Francisco Heber Lacerda Oliveira (2009) emphasizes that during the 75% of life

The useful performance of the pavement is relatively stable, however, the remaining 25% of the pavement deteriorates rapidly.

One of the SGPA's tasks is to prevent this percentage mark from being exceeded to avoid the total loss of the pavement and increased costs. Below, figure 2 shows graphically how the deterioration of a pavement occurs over time. It also presents the relative cost of restoration at different times throughout the useful life of the pavement.

Figure 1: Pavement conditions in relation to time (SHAHIN, 2005, apud OLIVEIRA, 2008



Source: SHAHIN, 2005, apud OLIVEIRA, 2008

Cristina Isabel Fernandes (2010) explains that an SGPA is essentially an information system, therefore, the central element is the database, where all the data relating to the pavement infrastructure and its state at a given time. Therefore, when implementing the system, it is necessary to incur a cost of data collection and inventory of the floors, which allows the construction of an information base that must be kept updated and appropriate expenses allocated to the hardware and software and the maintenance and operation team of the system. system.

Cristina Isabel Fernandes (2010) adds that when there is a need for maintenance, first an economic analysis is carried out and what the application priority is, therefore, it is necessary to optimize application priorities and then evaluate the strategies to be taken and application of resources destined to start the pavement conservation program. Immediately after completing all stages of the program, the data must be included in the database that will serve as a reference for future maintenance.

4. FINAL CONSIDERATIONS

The research demonstrated that when it comes to airport maintenance management, Brazil has different realities. There are airports and aerodromes managed by the state, concessionaires and private individuals. It was noticed that state management that mainly serves regular flights presents better results in terms of airport management, due to the rigorous supervision of the regulatory agency. However, aerodromes and small airports still lack efficient administration, particularly due to the few resources allocated to these institutions.

By presenting issues relating to the maintenance management of airport pavements, its importance for the fluidity of airport activities and its representativeness for operational safety was validated. It is important to highlight that most airport operators and administrators adopt maintenance service decisions based on immediate needs or their own experience, thus not allowing the assessment of the conditions.

Among them, the cost and the priori, thus being able to spend more resources than necessary to maintain security.

The different methods of assessing the condition of the pavement and maintenance are high cost and time consuming to carry out. Therefore, the pavement as the main part of an aerodrome is also an essential part of a budget in general, due to the value it involves for maintenance and construction. However, one must also analyze the costs of a stoppage in the aerodrome operation where the aerodrome operator stops making a profit when the runway is not used.

After the evolution of aircraft, the pavement was seen as an aid that should be in good condition to help with their braking and prevent hydroplaning on rainy days. It was then that the first researchers saw the need to study and through research improve the conditions of the pavement to aid landings and takeoffs. After testing and research, they came up with some specific numbers that could standardize maintenance and characterize how procedures should be carried out.

When evaluating the hypotheses proposed in this research, the Brazilian regulatory agency ANAC establishes, through resolution nº 236, when maintenance procedures must be carried out and which specific numbers of characteristics the pavement must offer, in order to provide due adherence to the aircraft and friction, to aid in braking. In this sense, infrastructure is a considerable factor that can influence an aeronautical accident.

And whenever the subject comes to operational safety, the aeronautical community must pay attention, as any detail can be a factor in resulting in an airplane accident where the majority of

often involve hundreds of victims. To this end, this research explains and helps, even if only in a small way, to report the importance that pavement has for flight safety.

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