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Evaluation of Longitudinal Irregularity in Airport Pavements and Unpaved Runway †

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Abstract: This paper presents a study about the effect of unevenness on conventional airport pavements and unpaved runways. During landing and take-off operations, aircraft tires are at high levels of tension and possible surface roughness can contribute to aircraft damage, landing gear fatigue, as well as the loss of aircraft directional stability, thus increasing the chances of accidents or incidents. The National Civil Aviation Agency (ANAC), responsible for regulating and supervising civil aviation activities in Brazil, regulates the need to evaluate longitudinal irregularity through the International Roughness Index (IRI) parameter on paved runways. In addition to the IRI, the Boeing Bump Index (BBI) and Runway Roughness Index (RRI) are indices also recommended by the Federal Aviation Administration (FAA). Moreover, this study understands the concept of unpaved runways and how these indexes can be evaluated on unpaved runways, however, with minimum requirements. Therefore, the present study addresses these bearing quality indices whose purpose is to guarantee the safety of operations.

Keywords: airport pavement; Roughness Index; paved runway; unpaved runway

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1. Introduction

Surface condition indexes are important to airport operations where the lack of a minimum surface condition on runways can contribute to accidents or incidents.

During the process when the aircraft is in contact with the pavement, the existence of possible unevenness in the surface may increase structural fatigue on the landing gear.

So, this paper presents a study of the anomalies represented by surface deviations, characteristic of the International Roughness Index (IRI), Boeing Bump Index (BBI), and Runway Roughness Index (RRI) on paved and unpaved runways, parameters that aim to guarantee the adequate safety and riding quality.

2. Roughness

Roughness can be measured by the International Roughness Index (IRI) and is an important parameter linked to riding and the comfort and quality experienced by a passenger. As defined by ASTM E 867 it is formed by surface deviations that can affect vehicle dynamics as well as surface drainage of the road, influencing the comfort and safety of the vehicle [1,2].

Some indicators of pavement condition through the assessment of unevenness are listed in Figure 1 [3]:

Figure 1 presents some anomalies that may contribute to the presence of unevenness on pavement, such as corrugation, defect usually of structural origin, depression, disintegration, slippage, swelling, as well as longitudinal and transversal cracking and patches usually have a functional origin [4].

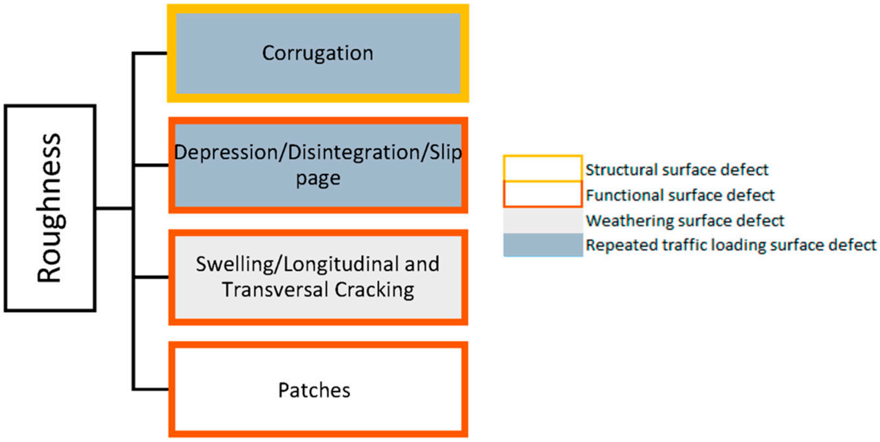

Figure 1. Condition indicators of airport pavements [3].

It is worth noting that pathologies such as corrugation, depression, disintegration, and slippage are usually derived from the cyclic loading of traffic while swelling and longitudinal/transversal cracking pathologies can occur due to climate change [4].

Some studies mention that the use of longitudinal irregularity (IRI), an index that is based on the response of the vibrational model of a quarter of a car, would not be suitable for the airport modal, due to the speeds during landing and takeoff operations, where the aircraft works with an approximate speed of 185 km/h (115 mph), diverging from the highway model, in addition to this parameter not considering the critical wavelengths and their amplitudes that can directly impact operations [5,6].

While the IRI, although has been adopted by many agencies and countries including Brazil, China, Italy, Canada, Mexico, and South Africa, would not be suitable for runways not only because of the speed but also due to the vehicle configuration. The Boeing method, Boeing Bump Index (BBI), the method used in the United States and recommended by the International Civil Aviation Organization (ICAO) and Federal Aviation Administration (FAA) through document AC 150/5380-9, is highly used to verify the functional parameters of co1mfort and rolling quality on takeoff and landing [7,8].

It is important to mention that the Boeing method was developed and is used on paved runways, either with asphalt concrete or Portland cement concrete, as well as for unpaved runways, an item that will be discussed later in this study [7].

Boeing's method consists of drawing a virtual line between two points, and checking the deviation from the surface, called "bump height". This index considers wavelengths from 0.5 m (1.6 ft) to 120m (393 ft), where wavelengths greater than 120 m (393 ft) do not contribute to the dynamic response of the aircraft [9].

It was observed that for the operating speeds for the landing and takeoff operations (approximately 185 km/h or 115 mph), wavelengths equivalent to 73 m (240 ft), would be critical, while for the taxiways (approximate speed of 37 km/h or 23 mph), even though this method has been developed for runways, 15 m (50 ft) wavelength can significantly impact the operation on taxiways [5].

As a limitation of the BBI parameter, it is worth mentioning that the method only identifies isolated events. However, the successive events of longitudinal irregularity are the most harmful to the aircraft [5].

Moreover, the Runway Roughness Index (RRI), an American index recently developed by the FAA's research and technology area, using the BBI, Pilot Subjective Rating (PSR) as a basis, evaluates the subjective rating by the pilots, as well as the resulting of the weighted root mean square of the vertical acceleration—WtRMS [10].

The RRI index is like the BBI when considering the pavement surface deviations; however, the RRI does not allow us to obtain the exact location of pavement anomalies as the BBI index, it presents the locations of acceleration events that would be experienced by the pilot in an aircraft, with a short wavelength [10].

Furthermore, it was identified that the RRI is a method only valid for runways, not applicable for taxiways or aprons where typical operating speeds are less than 185 km/h (115 mph) [10].

Therefore, the FAA suggests using more than one index to assess surface deviations on airport pavements, as well as allocating the necessary resources to correct the pathology [10].

3. Unpaved Runway

Unpaved runways are characterized by runways that do not have the structure of a paved runway but are free of debris (debris) and/or obstructions. They have been used by military aviation since World War II, where the aircraft must undergo fuselage adjustments, among others, to operate on this type of runway avoiding damage to the aircraft [11].

It is important to point out that short waves on pavement can cause fatigue on the aircraft's landing gear. If the unevenness is located on the wheel track, approximately 7.6 cm (3 inches) is enough to cause damage in some aircraft models [12].

For this type of runway, the document regarding the Certification Authorities for Large Transport Aircraft (CATA), represented by ANAC, European Union Aviation Safety Agency (EASA), FAA, and Transport Canada (TCCA), recommends that surface deviations be evaluated through wavelengths and peaks or by Power Spectral Density (PSD) to verify the assessment of fatigue in the landing gear caused by irregularity [13].

One of the challenges when working with a semi-prepared runway is the shear stress. Rutting is also a pathology that can be found on semi-prepared runways, as well as dust, foreign object damage (FOD), and uncertainties in takeoff performance [11].

Therefore, the analysis of surface deviations becomes important both on the paved and unpaved runway.

4. Conclusions

Based on the identified studies, it is possible to verify the importance of the proper evaluation of surface deviations aiming to guarantee the safety of operations, as well as the allocation of financial resources involved in correcting the anomaly when identified.

As previously mentioned, the IRI has a gap in the airport modal due to the critical wavelengths, as well as their amplitudes that can impact mechanically on aircraft operations, while the BBI results in a parameter to assist in the maintenance strategy through existing deviations in the pavement.

It is worth noting that the RRI is an index recently developed by the FAA for runways and is not suitable for taxiways and aprons due to speed operation. In addition to that, the FAA mentions that this parameter should not be used for acceptance of construction quality.

It is important to consider that the BBI is like the RRI in terms of deviations from the surface; however, the RRI does not allow the identification of the location of the anomaly. Therefore, this index should be considered an acceleration index and not a pavement index.

Thus, the replacement of the indices is not recommended by the FAA, but their use in a complementary way, where the BBI contributes to pavement defects, while the RRI helps with the interference effects due to the condition of the pavement.

So, it is suggested for paved runways use the three indices in a complementary way to define the most appropriate maintenance strategy due to the limitation of each index, as well as monitoring through IRI and BBI in taxiways.

Regarding surface deviations on semi-prepared runways, it is worth mentioning that this information is relevant to guarantee the safety of operations since it can interfere with the performance of the aircraft.

Therefore, it is recommended to carry out studies to define the most appropriate parameter for this type of survey.

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