Vol. 04, Iss. 1 (2026) 48-55, DOI: 10.61552/JME.2026.01.005

JME

Journal of Materials and Engineering

www.jme.aspur.rs

Research article

Influence of Rubber Deposits on Tyre - Runway Friction

Ionut Marius Nazarie[a,*], Ilie Musca[a]

[a]*Stefan cel Mare University, Suceava, Faculty of Mechanical Engineering, Automotive and Robotics, 13 University Street, 720229, Suceava, Romania.*

Keywords:

Friction coefficient
Rubber deposits
Airport traffic

* Corresponding author:

Ionut Marius Nazarie
E-mail: ionut.nazarie@gmail.com

Received: 15 June 2025
Revised: 22 July 2025
Accepted: 25 August 2025

A B S T R A C T

The condition of the runway surface plays a critical role in the safety of aircraft during landing and take-off operations and procedures. A major problem at the airport is represented by vulcanized rubber deposits from aircraft tyres that accumulate on the optimal area (touchdown) of touching the runway for a safe landing. The rubber deposits tend to fill and smooth the pavement macrotexture and microtexture, thus affecting the aircraft braking characteristics on runway. In this study, the phenomenon of reducing the friction coefficient, generated by the presence of rubber deposits, is analyzed by field measurements. Measurements taken were compared to defined thresholds for new runway designs, maintenance planning, and minimum friction level below which a runway may become slippery wet. During the analysis, runway friction measurements were made using specialized airport measurement equipment, the information being correlated with visual, tactile assessment work visits and observations on the runway. Contamination of the surface with rubber leads to a decrease in the friction coefficient, thus causing a loss of grip, a deterioration of the tyre-runway friction characteristics, which compromises the level of safety of operations during landing-takeoff procedures.

1. INTRODUCTION

1.1 About friction and rubber deposits

Friction is a crucial factor affecting the likelihood of accidents. The tyre-surface friction contributes directly to the stability of the aircraft on the ground. The taxiing aircraft relies on the friction generated by the tires on the surface of the runway, which allows the aircraft to brake, taxi, turn, and finally stop.

Tyre-runway friction characteristics vary over time, as the runway surface is subject to wear (polishing), the accumulation of rubber deposits and the effects of environmental conditions. For example, when cumulative conditions are met, rubber deposits - wet surface- surface degradation - other contamination, the friction coefficient is significantly reduced.

The measurements and information presented in this paper was correlated with airport traffic and it was shown that the reduction in friction coefficient is also due to the accumulation of rubber on the runway surface and traffic density. In this paper we examine potential influence and safety related aspects approaches for tyre-runway friction decay due to rubber deposits.

1.2 How rubber deposits accumulate

Most airports in the world manage hundreds of runway operations and they have to deal with this potential problem of removing rubber from runways for safer operations. The material that accumulates on the runway surface is no longer rubber as it is in aircraft tyres, tyre rubber is relatively soft and flexible and designed to absorb some of the shock in landing procedures.

In general, the area where the aircraft tyres touches the runway surface during landing procedures is approximately 300-400 meters in length, but may vary due to the type of aircraft, the landing procedure, local procedures or weather conditions. After the initial contact of the tyres with the runway surface, the tyres first slip without spin and then begin to rotate under the effect of the interaction with the runway and, after a certain time, acquire a certain rotational speed, named as "spin up speed", [1].

The pressure at the tyre-runway contact interface is high, and combined with the sliding friction generates wear and a significant amount of heat. The heat created causes the rubber to polymerize, a chemical reaction, turning it into a very hard material that spreads over the surface, in the contact area, in the form of a thin layer, [2].

Pavement macrotexture is the deviation of a pavement surface from a true planar surface. The characteristic dimensions for the macrotexture vary in the range 0.5-50 mm. Peak-to-peak amplitudes may (normally) vary in the range 0.01-20 mm. Pavement microtexture is the deviation of an aggregate from a true planar surface. The characteristic dimension for the microtexture is less than 0,5 mm. Peak-to-peak amplitudes usually vary in the range 0.001-0.5 mm, [3].

This rubber can fill the microtexture of the runway and make it more slippery, and this can adversely affect the landing and stopping process of the aircraft. On the other hand, this rubber will fill the macrotexture of the runway surface and therefore reduce the ability to properly drain rainwater, thus creating the risk of aquaplaning, [4].

2. DATA COLLECTION AND ANALISYS

2.1 Methodology and equipment

The measurements were made on a flexible runway surface, the contact surface being of the asphalt carpet type. The runway is mainly used by A320/321 and B737 aircraft. Information on airport traffic was obtained from the airport authority and photos showing the degree of contamination of the landing areas were taken through field work visits.

The friction coefficient measurements were carried out on 5 lines left and 5 lines right of the axis in the direction of runway 34 (landing from the South of runway). The measurement distances from the axis were 2 m, 3 m, 4 m, 5 m, 6 m left and 2 m, 3 m, 4 m, 5 m, 6 m right. The measurement length was 1800 meters (the starting area was the threshold from 34, the area from where the aircraft coming to land and has to put the wheels down, to make contact with the runway) and the measurement step was 50 m, at an average speed of 95 km/h.

The Griptester MK2, [5], airport friction tester, measures the longitudinal friction coefficient defined as the ratio of the tangential friction force generated between the tire and the contact surface, and the normal force (or vertical load). The measurement principle is that of a braked wheel with a constant slip rate, of the order of 15%, close to the optimum of anti-lock systems. The slip rate that generates the adhesion force is obtained from the mechanical drive of the measuring wheel by the two carrier wheels by means of gear wheels and a chain.

The longitudinal friction coefficient is a measure of the adhesion in the direction of travel of the vehicle, and its value is inversely proportional to the value of the braking distance. Figure 1 shows component parts of the equipment: the measuring system (a) and the measuring wheel (b).

(a)

(b)

Fig. 1. Griptester MK2 : the measuring system (a) and the measuring wheel (b).

2.2. Measurements of the friction coefficient

In figure 2, the measured values of the friction coefficient for the 5 measuring lines, left and right of the runway centerline, in total the 10 tests are presented.

Analyzing the discrete values of the friction coefficient and the shape of graph, it is observed that in the areas between 200 - 600 m and 1000 - 1600 m, the friction coefficient values are lower, this difference being generated by the presence of rubber deposits and the condition of the surface, rubber deposits that are not uniform over the entire surface of the runway.

It is also observed that the friction coefficient values are in the range of 0.40 - 0.83, which is considered to be generated by the local surface roughness characteristics and the presence of rubber deposits as main factors.

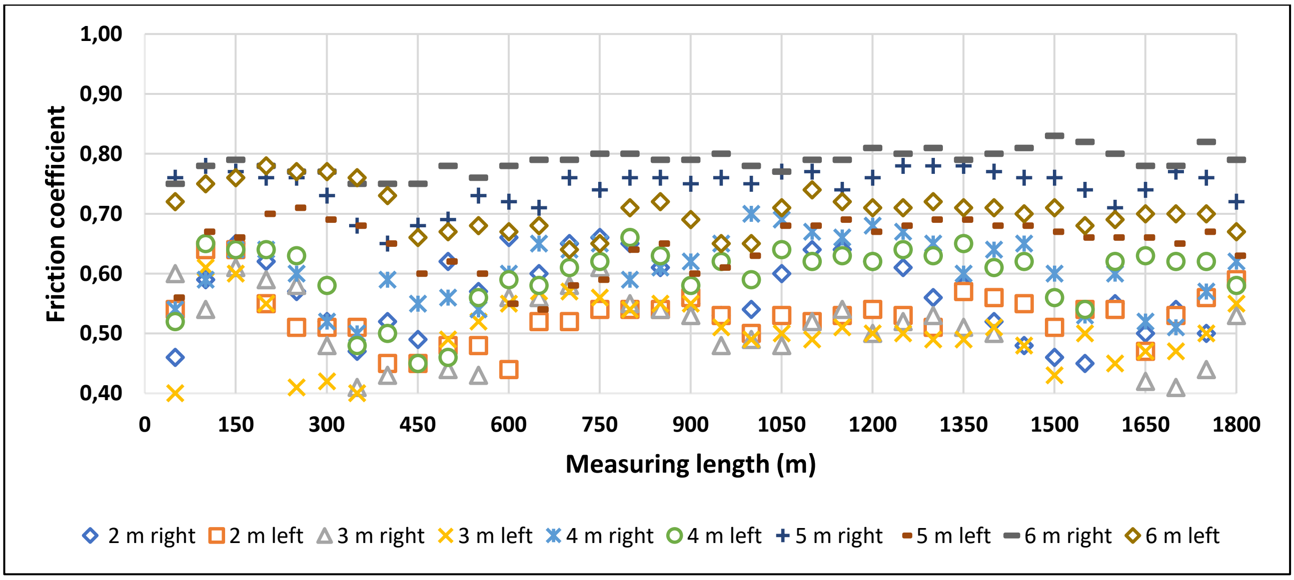


Fig. 2. Measured values of the friction coefficient.

Figure 3 presents the values of the friction coefficients over measurement distances and the lateral distance from the centerline (for 2,4,6 m left and right). From this graph it can be seen that the way in which landings are carried out, either centered or slightly lateral to the axis, and the types of aircraft using the runway (A320 or AT45 aircraft or smaller aircraft) lead to a different rubber contamination of the areas near the runway axis and to different values of the friction coefficients. Thus, the measured values of the friction coefficient are strongly influenced by the situation in that place, where the measuring wheel encounters or not a rubber deposit.

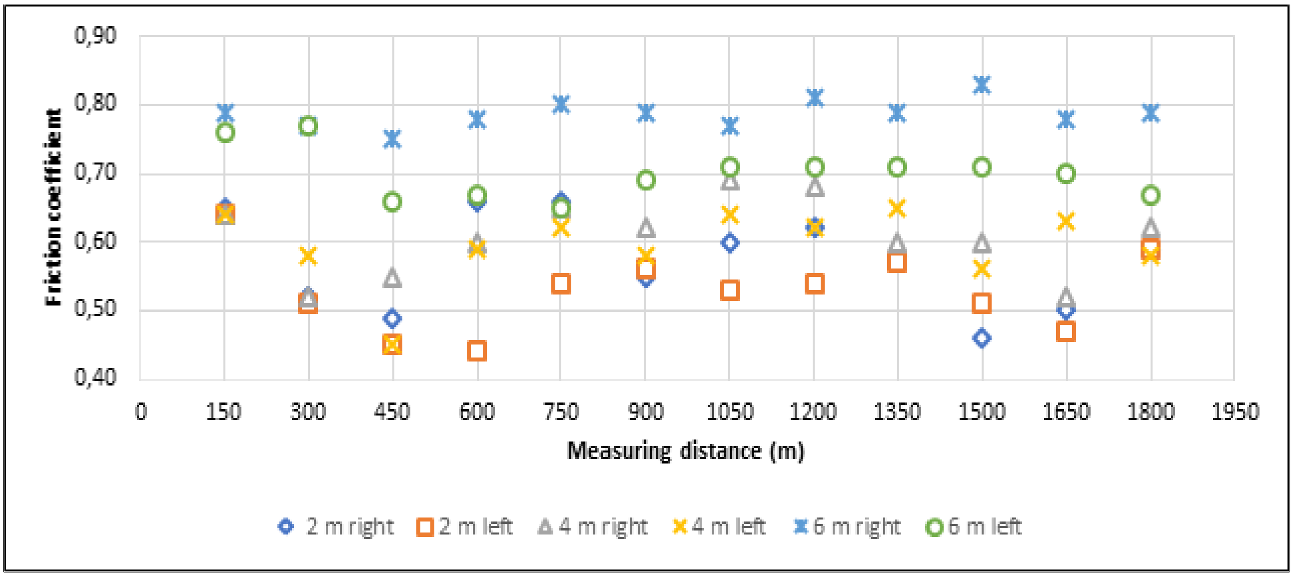


Fig. 3. Measured friction coefficient left/right from runway centerline.

The impact that a large category aircraft has on the surface condition, for example an A320, leads to a contamination over a lateral distance of approximately 4.5 m left - 4.5 m right more pronounced, compared to an AT45 aircraft for which the distance corresponding to the main landing gear is approximately 2 m left and 2 meters right.

In figure 4 is shown the graph of the mean values of friction coefficient, corresponding to the distances over which the measurements were made.

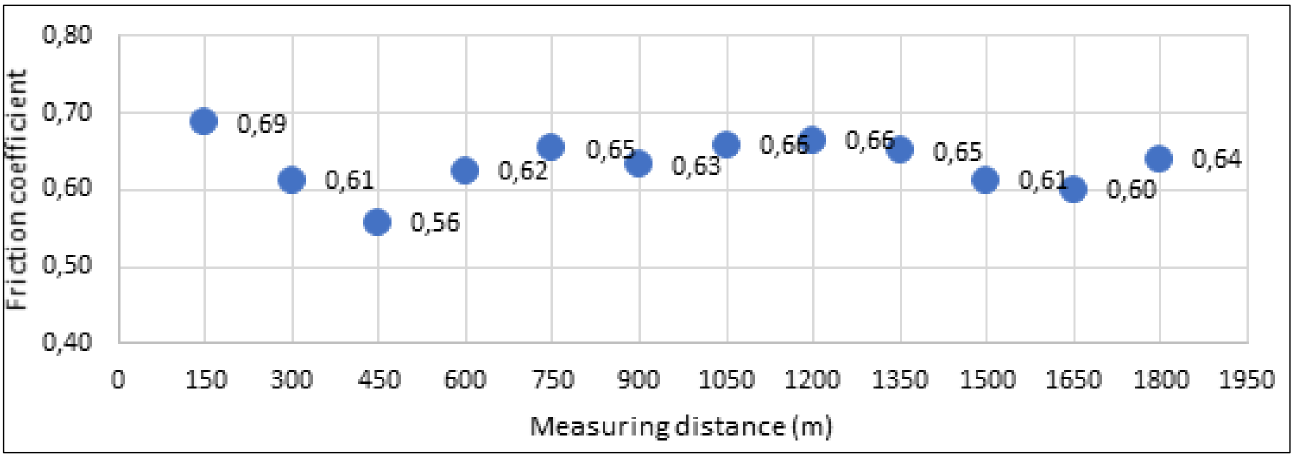


Fig. 4. Average values of friction coefficient.

In the case of measurements, the variation of the average values, calculated as an arithmetic mean, of the friction coefficient, is from 0.56 to 0.69. This highlight the areas that are predominantly contaminated with rubber deposits and are subject to majority of landings, respectively 200 - 600 m and 1200 - 1600 m. As can be seen until now in the study, the contact surface tyre-runway, contaminated with rubber deposits, significantly influences the friction coefficient values. The analysis continues with a comparation of two measurement lines, the 2 meter line and the 6 meter line right from runway centerline. The 2 meter line corresponds to the area where rubber deposits are predominant due to frequent landings on those areas and the 6 meter line corresponds to the area where landings are very rare (these correspond to areas where class D aircraft could put their wheels down if they landed).

Below, figure 5, are the measured friction coefficient values on two lines, the 2 meter and the 6 meter right from runway centerline.

For the 2 m line the values of the coefficient of friction vary between 0.45 and 0.66. On the other hand for the 6 m line the values of the coefficient of friction have a minimum of 0.75 and a maximum of 0.83.

Thus a decrease of approximately 0.2 in the value of the friction coefficient, from a clean and dry surface to a surface contaminated with rubber deposits, is significant. It can be seen from what is presented, that rubber deposits on the runway significantly influence the values of the friction coefficient, determining in the studied case a decrease of approximately 0.2 in its value.

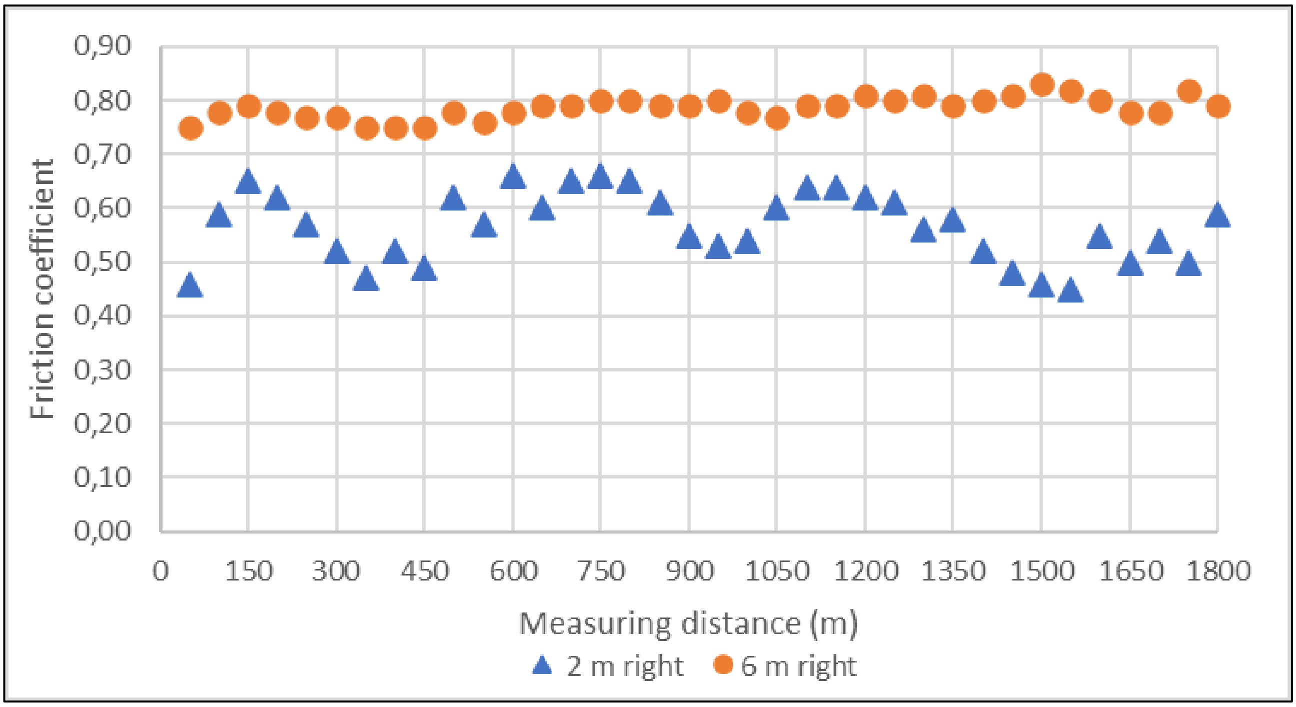


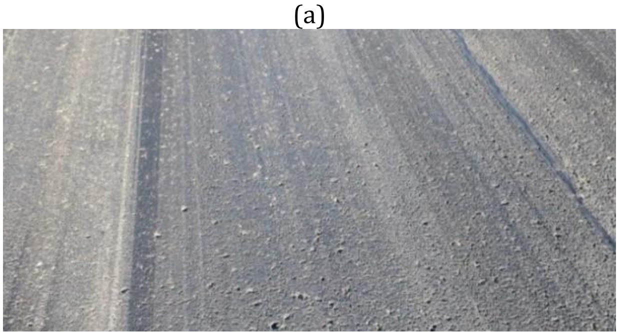
Fig. 5. Friction coefficient values 2 meter and the 6 meter right from runway centerline.

2.3 Visual and tactile assessment observations regarding the rubber contamination

During field observation of the runway, the clear visual differentiation of area 1 (0-4 meters from runway centerline) and area 2 (4-6 meters from runway centerline) and their degree of contamination due to the rubber deposits on the runway surface was observed. Fig. 6 and Fig. 7 show the difference in color and texture of the contaminated surfaces.

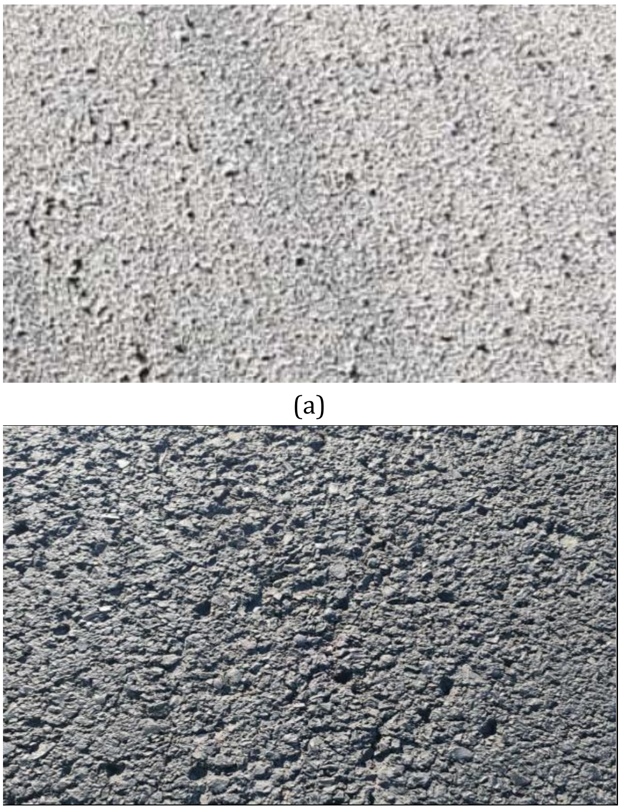
As can be seen, there are clear differences between the contamination of the two areas, the friction is thus different, the presence of rubber deposits negatively influencing the friction characteristics. The change in color of the runway surface from gray to black is an indicator of the degradation of the friction conditions and the contamination on the surface.

(a)



(b)

Fig. 6. Visual comparison regarding rubber contamination (a) area 1, (b) area 2.



(a)

(b)

Fig. 7. A closer view of rubber deposits (a) area 1, (b) area 2.

Also another method used on field was assessment by touching the surface, method that can differentiate between degree of loss of macro texture but can not quantify this difference. Also by touch was identify that in some areas microtexture has been filled in/covered by rubber build-up, [6].

The data obtained during the measurements on the surface, without contamination with rubber deposits, are located in the range of 0.45-0.66, while the values on the clean surface were in the range of 0.75 -0.83. On field visual observations and tactile assessment confirms that areas with lower friction coefficient are corresponding to those darker in color (black in our case).

The obvious conclusion is that the rubber contamination of the measured surface negatively influences the friction coefficient values. Related to the contact surface, a major problem with surface microtexture is that it can change over short periods of time without being easily detected. A typical example of this is the accumulation of rubber deposits which will largely mask the microtexture without necessarily reducing the macrotexture.

In conclusion, rubber contamination of the surface leads to a decrease of friction coefficient of the runway that takes to a degradation/decay of the friction characteristics and surface quality. It is very important to maintain friction characteristics that are within the minimum regulated runways standards in [7], that address that the minimum requirements for triggering infrastructure maintenance, for measures made with Gripteste MK2, for measurement speeds of 95 km/h is at a value of friction coefficient of 0.36.

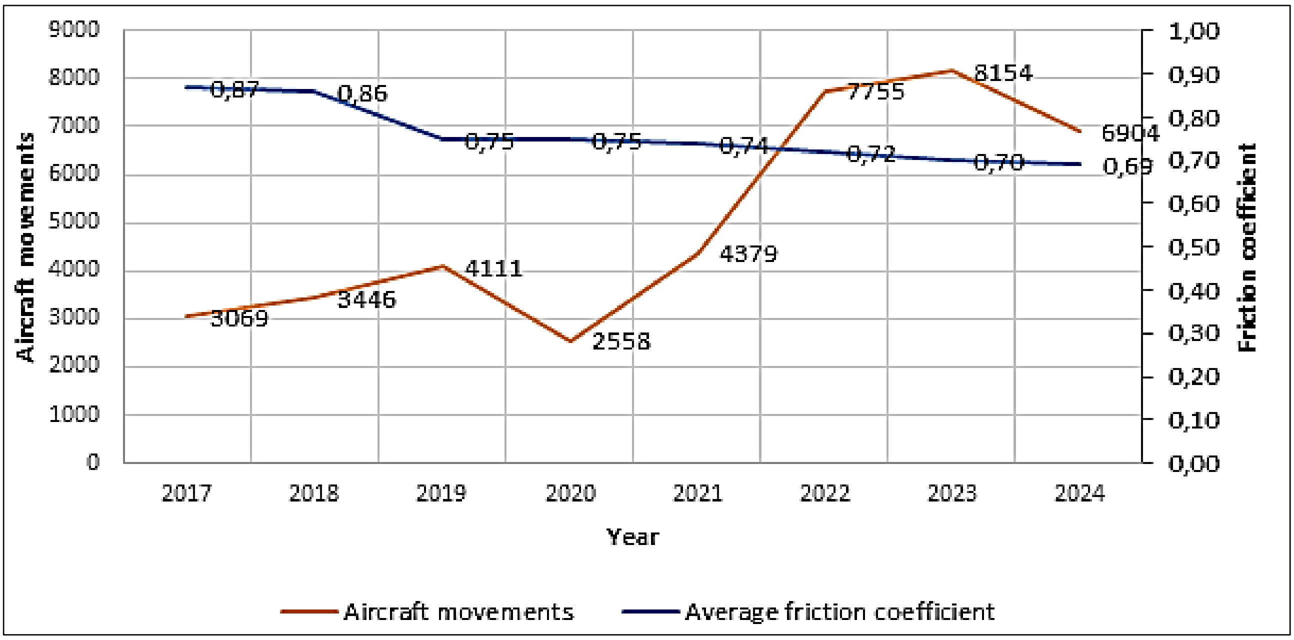


Fig. 8. Friction decay related to airport traffic.

2.4 Aiport statistical data analysis

If we analyze the following available data (from airport authority): in 2017 the average coefficient, calculated as an arithmetic mean of the coefficients for each third of the runway surface, was 0.87, compared to 2024 where the average coefficient is 0.68, the number of aircraft movements with significant impact on the rubber contamination of the runway: almost 33500 movements (aircraft type A320/21 and other types of aircraft that used the running surface), a decay of approximately 0.2 in the friction coefficient is observed.

The graph, figure 8, shows the significant decrease in the friction coefficient with the increase in traffic (the difference between movements in 2018 almost 3500 movements and 2019 just over 4000 movements, a significant increase in traffic that led to an increased use of runway surface, that led to the decrease of the friction coefficient). It is observed also a slight decrease in the friction coefficient during the COVID period (2020-2021) when aircraft movements were significantly reduced, which makes sense reported to the recorded traffic.

3. RESULTS AND DISCUSSIONS

This research focused on analyzing the influence of rubber deposits on runway friction. As observed, in our study, rubber deposits significantly influence the friction coefficient on the measured area causing a decrease in it of approximate 0.2.

The paper incorporates several elements that contribute to the study of the effect of rubber deposits on the friction coefficient : measurements of the friction coefficient the runway surface, visual observations, tactile assessment, correlations with aircraft traffic.

The research work identified the possibilities of developing a way to estimate and analyze the influence of rubber deposits combining: friction measurements, visual and tactile assessment, corelated to airport traffic volume. By combining quantitative and qualitative methods, a relatively accurate estimate can be obtained.

The implementation of other modes of analysis, such as optical analysis, microscopic analysis of the influence of rubber deposits, are other good solutions in the context of their integration with the previously described methods, thus the accuracy of the information and the results obtained will increase.

The study took a macro approach, which involved on site measurements, on the runway, under real operating conditions, with airport friction coefficient measurement equipment. These results are part of a larger study that incorporates a micro approach, measurements in the laboratory under controlled conditions, using an advanced tribometer.

The objective is to develop a probabilistic analysis of friction coefficient values to understand and quantify the variables and uncertainties associated with the factors that influence its value, in order to evaluate the overall behavior of the system.

REFERENCES

[1] Jordanian Civil Aviation Regulatory Commission, *How Rubber Deposits Accumulate*, Rubber Removal Techniques Technical Information Paper, Jun. 2010. [Online]. Available: https://carc.gov.jo/sites/default/files/inline-files/091829rubber-removal-technique-information-paper.pdf

[2] C. R. K. Karthik and M. J. Raja, “Reason for rubber deposition and its influence on the runway pavement,” *International Journal of Civil Engineering and Technology*, vol. 9, no. 2, pp. 63–75, Feb. 2018. [Online]. Available: https://iaeme.com/MasterAdmin/Journal_uploads/IJCIET/VOLUME_9_ISSUE_2/IJCIET_09_02_008.pdf

[3] L. P. T. Fontes, A. A. P. Paulo, C. P. Jorge, and G. Trichês, “Pavement surface texture: Improvement of the functional pavement quality with asphalt rubber mixtures,” 2006. [Online]. Available: https://www.civil.uminho.pt/transportinfra/publications/2006_(AR2006)_Liseane_Pais_Pereira_Triches_A.pdf

[4] D. J. Speidel, “Macrotexture,” in *Proceedings of the 2002 Federal Aviation Administration Airport Technology Transfer Conference*, Atlantic City, USA, 2002.

[5] Compania Națională de Autostrăzi și Drumuri Naţionale din România, *Buletin Tehnic Rutier*, vol. XI, no. 5, 2014.

[6] International Civil Aviation Organization, *ICAO (PANS) – Aerodromes* (Doc 9981), 2020.

[7] European Union Aviation Safety Agency, *Easy Access Rules for Aerodromes Regulation (EU) No 139/2014, AMC1 ADR.OPS.C.010(b)(3): Maintenance of pavements, other ground surfaces and drainage*, Dec. 2024.