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Texture of airport pavements in terms of their drainage efficiency

Abstract: Characteristics of the drainage of the surface movement area of airports, and more precisely the rapid drainage of water from the surface, is the main safety factor taken into account at the stage of designing, building, and maintaining the movement area and adjacent areas. Drainage of water from the pavement is a basic requirement and serves to reduce the thickness of the water layer on the surface. Adequate drainage is ensured primarily by surfaces with a suitable slope, both longitudinally and transversely (natural water drainage). On the other hand, dynamic drainage is achieved through the texture of the pavement. The paper presents the results of research on the texture of airport pavements and their analysis in relation to the current requirements. In the tests, apart from the currently used point measurement method, an innovative method of assessing anti-skid properties was used, which allowed for the simultaneous measurement of the friction coefficient μ and a new coefficient of continuous mean profile depth and CMPTD texture. The obtained results allowed us to present conclusions that when assessing the texture of airport pavements and thus designing structural solutions in terms of their drainage, it is reasonable to take into account the technology of its implementation (cement concrete or asphalt concrete).

Keywords: Drainage of airport pavements; Texture of airport pavements; Safety of air operations

Introduction

Ensuring safety is one of the most important goals during air operations, the achievement of which, apart from man and aircraft (SP), will of course be influenced by the airport pavement, and more precisely by its technical condition. One of the components of the process of determining the technical condition of the airport pavement is the assessment of its anti-skid properties. They determine the adhesion of the aircraft tire to the surface, i.e. the ability to generate the friction force between the surface of the aerodrome functional element (EFL) and the wheels of the aircraft in the conditions of mutual slip. Until recently, when determining the technical condition of airport pavements in terms of anti-skid properties, only the friction coefficient, measured during the roughness test, was used. Currently, the assessment of the anti-skid properties of airport pavements also includes measurements of the pavement texture depth, which directly affects the process of water drainage from the pavement. Quick drainage of water from the surface is the main safety factor, taken into account at the design and construction stage and of course the maintenance of the movement area and adjacent areas. Drainage of water from the pavement is a basic requirement and serves to reduce the thickness of the water layer on the surface. Adequate drainage is ensured primarily by surfaces with an appropriate slope, both longitudinally and transversely (natural water drainage). On the other hand, dynamic drainage is achieved through the texture of the surface.

Bearing the above in mind, in practice, it is aimed at ensuring that airport pavements have good anti-skid properties, i.e. that they meet certain required values (criteria) for both the friction coefficient and the texture depth. Unfortunately, the current reference documents concerning the texture of airport pavements raise many doubts in practice. Namely, they do not define the required minimum values in relation to the technology in which the pavement was made (cement concrete, asphalt concrete), as well as for the individual age ranges of the pavement, i.e. "design values for new pavements", "values for planning corrective actions" and "minimum values" (as is the case with the coefficient of friction) [11]. However, the experience gained by the authors in the field of testing anti-skid properties in terms of texture clearly indicates that when assessing them, one should distinguish between whether the assessment concerns a pavement made in the technology of cement concrete or asphalt concrete. Therefore, the authors analyzed the obtained results of texture tests for new airport pavements in relation to the current requirements. In the tests, in addition to the currently used point measuring method, an innovative method of assessing anti-skid properties was used, allowing the simultaneous measurement of the friction coefficient μ and a new coefficient of continuous mean profile depth and texture *CMPTD*.

Antiskid properties - requirements

The assessment of the friction characteristics of airport pavements (with an indication of the runways) is carried out in two aspects, i.e.:

- evaluation of friction characteristics of artificial surfaces covered with a layer of snow, slush, ice, or frost,
- assessment (determination) of pavement friction characteristics for construction and operation purposes.

When assessing the pavement according to the first aspect, the anticipated pavement friction should be classified as good, medium to good, medium, medium to bad, bad. The predicted pavement friction, based on the measured coefficient with the runway covered with packed snow or ice only, may be reported in accordance with Table **1** [9].

Tab. 1: Summary of the values of friction coefficients and the assessment of braking efficiency for snow-covered and ice-covered airport surfaces

The measured friction coefficient μ	Predicted pavement friction	Code digit
0.40 and above	Good	5
0.39 do 0.36	Average to good	4
0.35 do 0.30	Average	3
0.29 do 0.26	Average to bad	2
0.25 and below	Bad	1

The friction characteristics when assessing the surface according to the second aspect (mainly on the runway) should be:

- assessed to verify the friction characteristics of the paved surface on a new or refurbished runway,
- periodically assessed to determine the slipperiness of a paved runway.

During measurements with ASFT (Airport Surface Friction Tester) devices, the values of the friction coefficient for "new surfaces", "surfaces in service, beyond which remedial actions should be taken" and "minimum limit values" should be in accordance with Table **2** [11].

Tab. 2: List of measuring devices (ASFT) used to test the roughness of airport pavements and the average values of the required friction coefficients

Measuring device	Measurement speed [km/h]	Friction coefficient μ		
		Design values for new pavements	Values for planning corrective actions	Minimal values (limiting)
Trailer Surface Friction Tester	65	0.70	0.50	0.40
and Vehicle Airport Surface Friction Tester (ASFT)	95	0.60	0.40	0.32

In addition, in 2021 EASA (European Aviation Safety Authority) introduced the assessment of the runway surface condition for maintenance purposes by means of a document [2]. In this case, only two levels of friction (required value criteria) are used, i.e. the values at which maintenance planning should start and the minimum values (for the pavement to be operable).

The examination of the texture of airport pavements is currently carried out using point measuring methods, i.e. volumetric or volumetric method (measurement of the average texture depth MTD) according to PN-EN 13036-1: 2010 *Surface features of road and airport surfaces. Test methods. Part 1: Measurement of the macrotexture depth using the volumetric [12] or profilometric method* (measurement of the average depth of the MPD/dMPD profile) according to PN-EN ISO 13473-1: 2019. *Characteristics of the texture of the pavement using surface profiles. Part 1: Determination of the mean depth profile [18]*. The MPD value can be converted into an estimated ETD texture depth by the transformation equation ETD = 0.2 + 0.8 MPD for this purpose.

The requirements for the texture depth that must be met by new airport pavements are included in the documents issued by global aviation organizations, such as: EASA, ICAO (International Civil Aviation Organization), and FAA (Federal Aviation Administration), which are presented in Table **3**.

In terms of texture depth, the applicable aviation documents define the requirements practically only for new airport pavements and they mainly concern the runway pavement, what is more, they are not unambiguous, as shown in Table 3. When reviewing them, the question arises as to what the required minimum value should be. for new surfaces - 1.0 mm or 1.14 mm, but also how to treat the entry allowing a value below 1.0 mm. However, for the assessment of older airport pavements, at present only the ESDU (Engineering Sciences Data Unit) classification developed for a runway based on the information on the texture presented in Table **4** [9] can be used. It is assumed that the value of the texture depth equal to 0.25 mm should ensure the safety of air operations. It should be noted that the texture depth requirements for airport pavements refer to the MTD parameter (ETD).

Tab. 3: Texture depth requirements for new airport pavements

Document	Texture depth [mm]
Annex 14 to the Convention on International Civil Aviation, Airports Volume I - Aerodrome Design and Operation (ICAO) [19] Doc. 9157 AN / 901 Aerodrome Design Manual Part 1 - Runways (ICAO) [14] Easy Access Rules for Aerodromes (Regulation (EU) No 139/2014) (EASA) [15]	≥ 1.00
Doc. 9137 AN/898 Airport Service Manual Part 2 – Pavement Surface Conditions (ICAO) [13]	< 1.00 mm
Advisory Circular no: 150/5320-12C, U.S. Department of Transportation (FAA) [11]	≥ 1.14 mm

Tab. 4: Texture depth requirements for the airport pavements in use

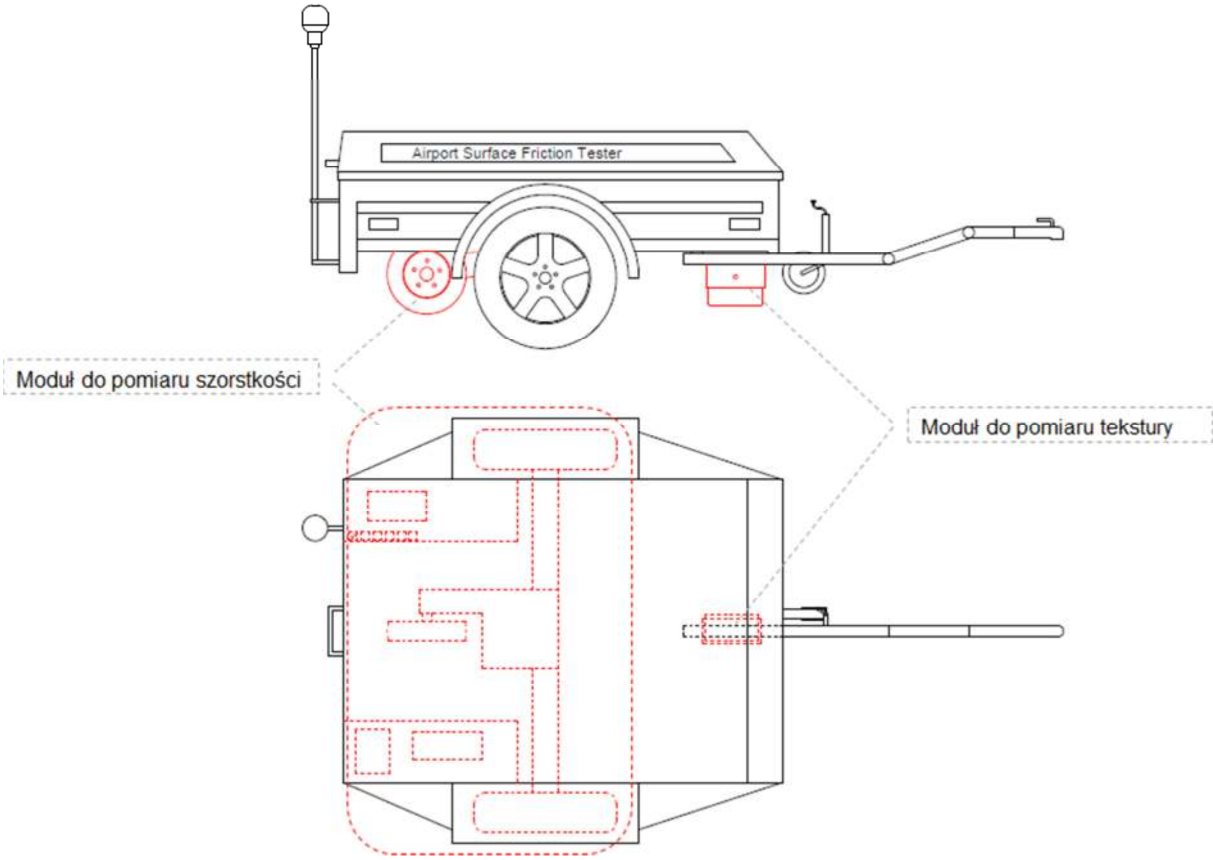
Name of the aviation organization	Runway classification	Texture depth [mm]
ICAO, EASA	A	0.10 – 0.14
	B	0.15 – 0.24
	C	0.25 – 0.50
	D	0.51 – 1.00
	E	1.01 – 2.54

Research methodology and research results

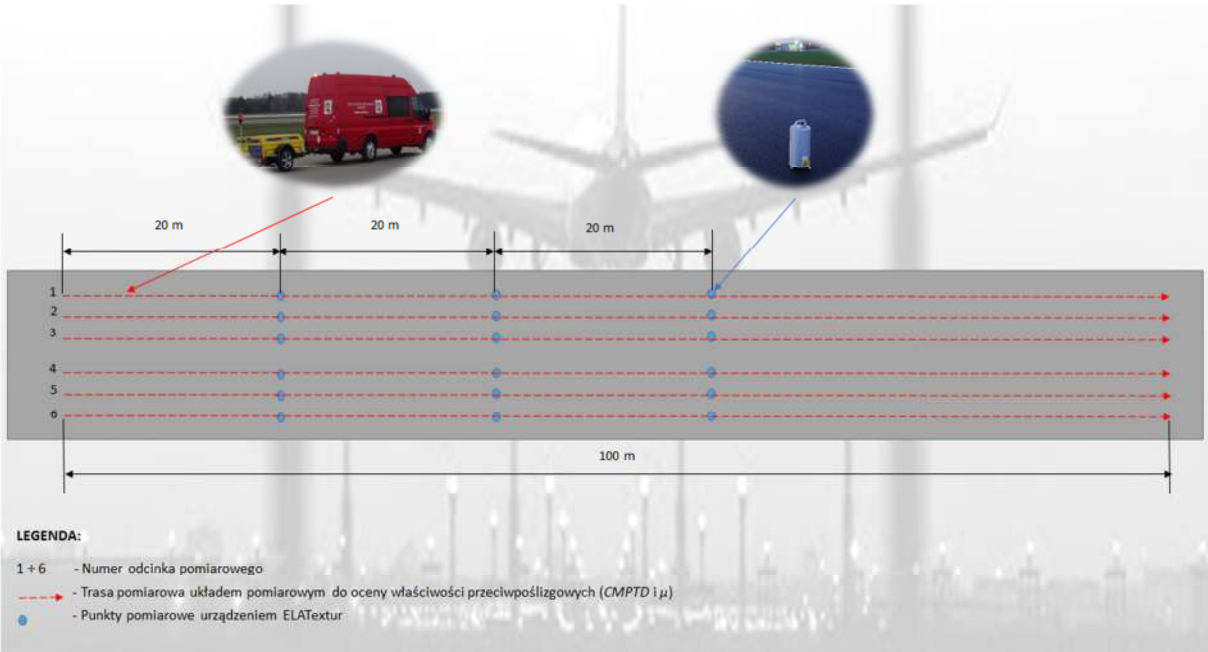
The tests were carried out using a measuring system built on the basis of the ASFT airport surface friction tester on the T-10 trailer, additionally equipped with a high-frequency 2D / 3D laser scanner (measuring the friction tester in the traces of the measuring wheel). Similar attempts are also made by others, not mentioned earlier [4, 7, 8, 10, 18], but the research methods adopted by them do not include the simultaneous measurement of these two parameters. It should also be noted that, in contrast to the currently used measurement method (profilometric), the proposed method of measuring the texture depth as part of the assessment of the anti-skid properties of airport pavements allows for measurements both in parallel and parallel directions and perpendicular to the direction of movement of the friction tester. This method is not limited by the spot measurement, i.e. the measurement is not carried out only as a function of the length of the measurement section, but also as a function of its width (corresponding to the contact width of the measuring wheel tire of the friction tester with the surface). The measuring system for the adopted method of assessing the anti-skid properties includes (Fig. **1**):

- Roughness evaluation module - measurement of the friction coefficient,
- texture depth assessment module - measurement of the new CMPTD coefficient defining the continuous average depth of the profile and texture.

Measurements under the tests were carried out on selected airport facilities, at measuring speeds of 65 km/h and 95 km/h, on surfaces made both in cement concrete and asphalt concrete technology, the age of the pavement was adopted on the basis of the actual service life, i.e. up to 3 years. According to the adopted field research plan, for each of the specified measurement conditions (e.g. measuring speed 65 km/h, pavement made in the asphalt concrete technology), 6 measurement sections were determined, each 100 m long. Sections for specific measurement conditions were located on one EFL, e.g. the taxiway of the selected test facility. The individual sections were treated as a single sample, while the 6 sections for the given measurement conditions were treated as a population of samples. The CMPTD and μ coefficients (built-in measuring system) were measured continuously along the entire length of the measuring section, with the reading frequency every 0.2 m for CMPTD and 10 m for μ. Therefore, for further analysis, the results from 10 m sections for individual measurement sections were adopted. In addition, point measurements were also made with the ELATextur device on each section (at 20 m, 40 m, and 60 m of the measuring section). The measurement scheme according to the adopted methodology is presented in Figure **2**.



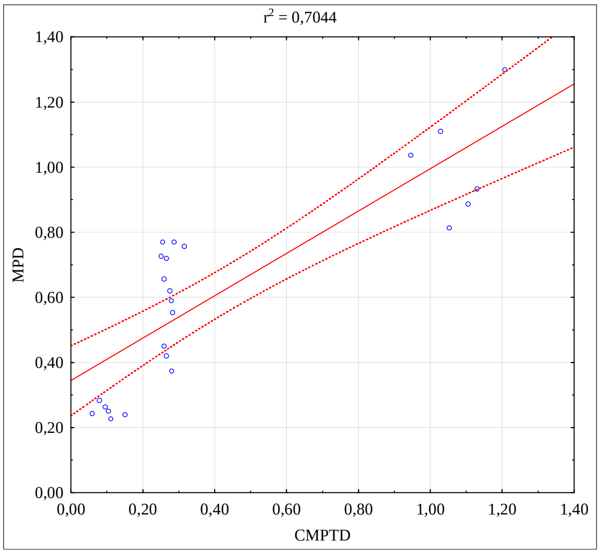
1. Scheme of the measuring system for the evaluation of anti-skid properties



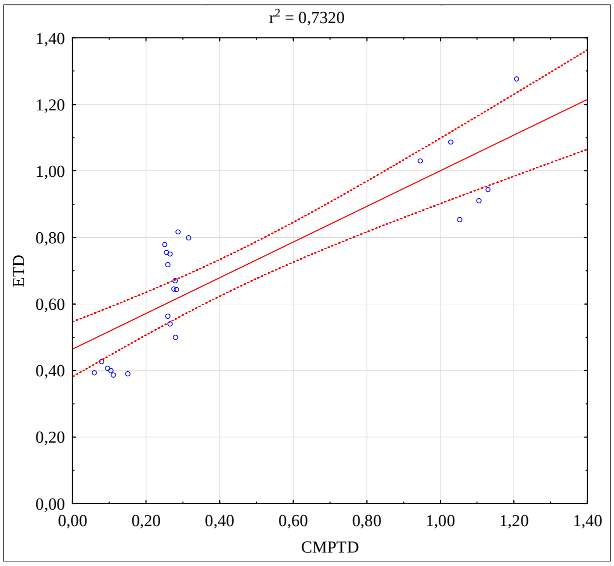
2. Scheme of measurements during field research

As a result of the conducted field measurements, the values for the coefficients determining the anti-skid properties of airport pavements were measured. The results of the field measurements of the CMPTD, MPD, and ETD coefficients are presented in Tables **5 - 8** below. Figures **3 - 4** present the histograms showing the linear correlation coefficients that determine the level of linear dependence between the CMPTD and MPD and ETD coefficients (confidence interval 0.95). However, the transformation equations determined on this basis for the transition from CMPTD to MPD and ETD are as follows: MPD = 0.65 × CMPTD + 0.34; ETD = 0.54 × CMPTD + 0.46 [10]. Thanks to the determined equations of transformation, after taking the measurements using the proposed method of testing anti-skid properties, MPD and EDT coefficients can be determined based on which airport pavements can be assessed in relation to the current requirements. Nevertheless, the determined equations also make it possible to propose a new criterion of the average texture depth (ETD) for new airport pavements, i.e.:

- for pavements made in the technology of asphalted concrete - 0.82 mm,
- for pavements made in the cement concrete technology - 0.61 mm.



3. The level of linear dependence between the CMPTD and MPD coefficients



4. The level of linear dependence between the CMPTD and ETD coefficients

Tab. 5: Results from field measurements for asphalt concrete (65 km/h)

Measurement speed [km/h]	Technology of the surface execution	Segment (sample)	Measurement values [mm]		
			CMPTD	***MPD***	***ETD***
65	Asphalt concrete	1	1.05	0.81	0.85
		2	1.13	0.93	0.94
		3	1.03	1.11	1.09
		4	1.21	1.30	1.28
		5	0.95	1.04	1.03
		6	1.11	0.89	0.91
		Average:	1.08	1.01	1.02

Tab. 6: Results from field measurements for asphalt concrete (95 km/h)

Measurement speed [km/h]	Technology of the surface execution	Segment (sample)	Measurement values [mm]		
			CMPTD	***MPD***	***ETD***
95	Asphalt concrete	1	0.27	0.72	0.75
		2	0.26	0.66	0.72
		3	0.26	0.77	0.76
		4	0.32	0.76	0.80
		5	0.25	0.73	0.78
		6	0.28	0.62	0.65
		Average:	0.27	0.71	0.74

Tab. 7: Results from field measurements for cement concrete (65 km/h)

Measurement speed [km/h]	Technology of the surface execution	Segment (sample)	Measurement values [mm]		
			CMPTD	***MPD***	***ETD***
65	Asphalt concrete	1	0.27	0.42	0.54
		2	0.26	0.45	0.56
		3	0.28	0.59	0.67
		4	0.28	0.55	0.64
		5	0.29	0.77	0.82
		6	0.28	0.37	0.50
		Average:	0.28	0.53	0.62

Tab. 8: Results from field measurements for cement concrete (95 km/h)

Measurement speed [km/h]	Technology of the surface execution	Segment (sample)	Measurement values [mm]		
			CMPTD	***MPD***	***ETD***
95	Asphalt concrete	1	0.08	0.28	0.43
		2	0.10	0.26	0.41
		3	0.10	0.25	0.40
		4	0.06	0.24	0.39
		5	0.11	0.23	0.39
		6	0.15	0.24	0.39
		Average:	0.10	0.25	0.40

Summary

From a practical point of view, the topic raised by the authors is extremely important, primarily in terms of the safety of air operations. There is always an effort to ensure that airport pavements have good anti-skid properties. which should be defined by certain (required) values, in this case, the friction coefficient and the texture depth.

The obtained results clearly indicate that when assessing airport pavements in terms of their texture, it should first of all be distinguished whether the assessment concerns the surface made in the cement concrete or asphalt concrete technology. As can be seen, both in the case of the pavement assessment using the point measurement method (MPD and ETD), as well as the proposed new measurement method (CMPTD), the values of the coefficients characterizing the pavement texture are correspondingly higher for the pavement made in the asphalt concrete technology, and for the pavement made correspondingly lower in the cement concrete technology. Therefore, according to the authors, separate requirements in this respect should be considered in relation to the technology of the airport pavement.

The proposed new measurement method, compared to the currently used (point) measurement method, gives greater possibilities. From the research point of view, it enables, first of all, the continuous measurement of the pavement texture, which, as can be seen, is not without significance when comparing the values from field measurements (the visible difference of).

Taking into account the results obtained so far and presented, the authors plan further work related to the analysis of the results concerning the remaining age ranges of the pavement. The results of research and analyzes in this area will supplement the current set of works [3, 14, 15, 16] and will constitute the basis for further studies related to the subject of airport pavement texture.

Source materials

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