Drainability Study Of Airport Pavements Through Outflow Meter Equipment

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ABSTRACT

Hydroplaning effect is an issue that occurs when there is a water film between the aircraft tires and runway pavement reducing the frictional force and directly affecting the ability to keep the tire's rotating. Therefore, it is possible to infer that the pavement drainability is an essential parameter that has to be well dimensioned and monitored avoiding the hydroplaning effect and to maintain operational safety.

The outflow meter test is standardized through the ASTM E 2380[1] normative, which presents the procedures to measure the horizontal drainability of the pavement's surface. The test using this equipment provides essential information to guarantee the necessary attrite and adherence of the surface will not be compromised by accumulated water.

In order to generate enough data for this study, tests were realized using this equipment at three small and mid-sized airports with distinct operators and four different types of pavement structures (Ribeiro, 2012) [2]. Additionally, the drainability test were also realized in a large-side airport runway (Souza, 2017) to evaluated the drainability and superficial macrotexture using the outflow meter and sand patch tests in other conditions.

Comparing the pavements outflow meter and sand patch tests results, it is conclusive that the variation with the sand patch results were small but considerably higher than the variation obtained using the outflow meter test. Another advantage of this test is the possibility to proceed even with wet pavements. Besides that, is possible to measure the water flow at the same time providing an empiric parameter as well.

Keywords: pavement drainability, tire-pavement friction, macrotexture, airport pavement

1. INTRODUCTION

The global air transportation network grows more them the other transportation methods every year. It is possible to observe the same profile in Brazil where the air transportation market share continues to increase for passenger and cargo. According to ANAC (Civil Aviation National Agency) responsible for the regulations and control of Brazilian civil aviation, between

2000 and 2008 there was a growth of 122% at seats/km for domestic flights. During the same period the air cargo industry grow 71% (ANAC, 2009)[3]

Many aspects have contributed for the growth of the numbers of flights, among them are the reduction of ticket prices, the increase of aircraft efficiency, simplification of sales method and others. With more flights, the necessity of safety measures to avoid aircraft accidents also has grown.

A study from 2010 stated that between 1996 and 2005 28.3% of all accidents with aircrafts happened during take-off, landing or taxying. An FAA (Federal Aviation Administration, n.d.)[4] study also showed that 21% of all aircraft accidents between 1994 and 2003 at the United States of America and other countries regulated by the agency had as cause meteorological conditions. In adverse meteorological conditions, the adherence tire-surface can make the difference and avoid serious accidents.

Therefore to investigate the factors responsible for the tire-surface adherence at airport runways this study evaluated the superficial drainability of the pavement associated to its macrotexture in four Brazilian airports.

2. STUDIED AIRPORTS

The outflow meter equipment was used for field tests at two small, one medium (Ribeiro, 2012) and one big Brazilian airport (Souza, 2017).

The 2012 study was realized with data collected from Arthur Siqueira State airport, Campos dos Amarais State Airport and Bertram Luiz Leupolz State Airport. All this airports have only non-regular flights and one runway composed of an asphaltic pavement.

FIGURE 1 Arthur Siqueira State Airport. Source: Google, 2017

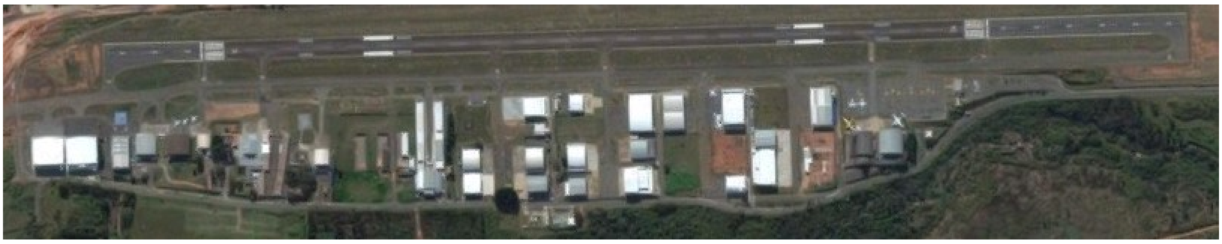

FIGURE 2 Campos dos Amarais State Airport. Source: Google, 2017

FIGURE 3 Bertram Luiz Leupolz State Airport. Source: Google, 2017

In 2017 the same study was realized at Tancredo Neves International Airport, the fifth airport in terms of passengers processed per year. This airport has a majority of regular flights and one runway with 3000 meters and composed of an asphaltic concrete. In addition, the runway at Tancredo Neves Interntional Airport has a layer of C.P.A. (porous alphalt layer) an asphaltic mixture with an open grading.

FIGURE 4 Tancredo Neves International Airport. Source: Google, 2017

3. OUTFLOW METER

The outflow meter equipment is an equipment composed by a transparent plastic cylinder and a metal base with two sensors to measure the time needed to complete de field test. With the measures it is possible to evaluate the water flow and identify the macrotexture and drainability of the surface micro fissures simulating the drainage of the pavement when under stress circumstances.

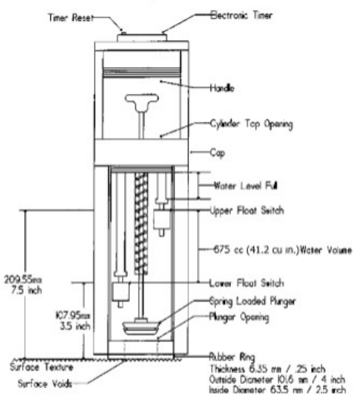

FIGURE 5 Outflow meter scheme. Source: ASTM

Since the test measures the punctual drainability of the pavement it is crucial to choose with attention the location and number of field tests to represent the real situation of the runway.

Fissures, painted lanes have to be avoided to prevent from unrealistic results. A special area of interest is the touchdown zone, a critical area where the pavement is highly stressed.

FIGURE 6 Outflow meter equipment photo. Source: ASTM

The ASTM E 2380-05 indicates the Equation 1 to estimate the mean depth of the texture (Mean Profile Texture – MTD) where OFT is the total time measured by the equipment during the field test.

Eq. (1): $$MTD = \frac{3,114}{OFM} + 0,636 \qquad [1]$$

Since the equipment evaluates the drainage capability through the voids of the pavements, the closure of the grading affects directly the time spent to drain water. An asphaltic mixture with less voids and a closed grading corresponds to more time spent during the drainage process. On the contrary, a less closed grading corresponds to a faster drainage process and less time registered during the test.

4. TESTS AND RESULTS

The field tests with the outflow meter equipment were realized at Campos Siqueira State Airport, Campos dos Amarais State Airport, Bertrm Luiz Leupolz State Airport and Tancredo Neves International Airport. In order to compare the obtained results of macrotexture with a Brazilian standardized test the sand path method was applied at the same sample points.

4.1 DRAINABILITY TEST METHODOLOGY

The drainability test using the outflow meter equipment follows the steps below:

1) Definition of the test areas and test points
2) Humidification of the test area
3) Conference of the sealing ring and stability
4) Cylinder water filling (attention to cover the top sensor)
5) Reset timer
6) Pulling of the piston
7) Measurement of the time spent to dispense the water of the known volume between the top and bottom sensors

4.2 RESULTS

The outflow meter and sand path test results are shown in the tables below.

TABLE 1 Outflow meter results (2012)

Arthur Siqueira State Airport													
	Measurements (s)										Average	Standard	Calculated
Operator	1	2	3	4	5	6	7	8	9	10	time (s)	deviation	MTD
1	34	33	33	36	37	37	34	35	36	36	35,1	1,52	0,72
2	35	33	35	37	35	34	31	33	34	36	34,3	1,70	0,73
3	33	34	34	32	35	34	33	35	36	34	34	1,15	0,73

Campos dos Amarais State Airport													
	Measurements (s)										Average	Standard	Calculated
Operator	1	2	3	4	5	6	7	8	9	10	time (s)	deviation	MTD
1	16	16	16	16	17	17	17	17	17	17	16,6	0,52	0,82
2	17	17	17	17	17	18	18	18	18	18	17,5	0,53	0,81
3	16	15	15	16	16	15	15	16	16	16	15,6	0,52	0,84

Bertram Luiz Leupolz State Airport													
	Measurements (s)										Average	Standard	Calculated
Operator	1	2	3	4	5	6	7	8	9	10	time (s)	deviation	MTD
1	25	25	24	25	24	26	26	25	25	24	24,9	0,74	0,76
2	26	25	26	26	27	25	24	25	25	24	25,3	0,95	0,76
3	24	25	25	23	26	25	24	25	26	25	24,8	0,92	0,76

Source: Ribeiro, 2012

TABLE 2 Outflow meter results (2017)

Tancredo Neves International Airport													
	Measurements (s)										Average	Standard	Calculated
Operator	1	2	3	4	5	6	7	8	9	10	time (s)	deviation	MTD
1	3	3	3	4	3	2	3	2	2	3	2,8	0,63	1,75
2	3	2	4	3	3	3	2	3	2	4	2,9	0,74	1,71

Source: Souza, 2017

TABLE 2 Sand path results (2012)

Arthur Siqueira State Airport												
	Measurements (m)										Average diameter	Standard
Operator	1	2	3	4	5	6	7	8	9	10	(m)	deviation
1	25,18	24,65	25,23	24,78	24,83	25,35	25,13	25,58	25,13	25,33	25,119	0,29
2	24,9	25,35	24,85	24,93	25,4	25,65	25,28	25,93	25,6	25,9	25,379	0,40
3	25,58	26,1	26,43	26,53	26,48	26,55	26,15	26,95	27,33	26,65	26,475	0,48

Campos dos Amarais State Airport												
	Measurements (m)										Average diameter	Standard
Operator	1	2	3	4	5	6	7	8	9	10	(m)	deviation
1	22,75	23,18	23,4	23,38	23,63	23,73	23,38	23,7	23,48	23,65	23,428	0,29
2	25,25	26,58	28,05	28,2	28,55	27,2	28,53	28,18	25,45	26,75	27,274	1,23
3	22,33	22,83	23,8	24,55	25,18	25,38	25,83	26	26	26,55	24,845	1,44

Bertram Luiz Leupolz State Airport												
	Measurements (m)										Average diameter	Standard
Operator	1	2	3	4	5	6	7	8	9	10	(m)	deviation
1	24,13	24,02	23,35	23,58	23,68	23,38	24,15	23,75	23,93	23,83	23,78	0,29
2	23,65	25	23,68	25,25	24,75	23,75	25,68	26,05	25,5	25,75	24,906	0,92
3	24,45	23,3	25,75	24,15	23,7	24,25	25,18	26,35	25,75	25,4	24,828	1,00

Source: Ribeiro, 2012

TABLE 2 Sand path results (2017)

Tancredo Neves International Airport												
	Macrotexture measurements										Average	Standard
Operator	1	2	3	4	5	6	7	8	9	10	diameter	deviation
1	2,2	3,16	3,12	3,47	3,27	3,35	3,87	3,87	3,23	3,06	3,26	0,47

Source: Souza, 2017

The difference between the results found at Tancredo Neves International Airport by the composition of the pavement; the seccion studied at this airport is made of C.P.A. (porous alphalt layer) and the other studied airports have asphalt with a closer grading.

5. CONCLUSION

The drainability test is very simple, quick and low cost. The average time spent to execute one cycle of the test is inferior to five minutes and the requirements are one operator, the equipment and water. The test was executed by different operators always with successful results.

The use of the outflow meter to measure the drainability of pavements with an open grading such as C.P.A. (porous alphalt layer) also led to good results, the data obtained at Tancredo Neves International Airport showed consistency when compared to the other airports and its layer composition.

The results obtained with the two different test methods were very similar regardless of the pavement or airport. By a correlation analysis it was possible to identify that there is potential to use the outflow meter test with great efficiency when trying to measure the macrotexture of a pavement. The R2 values (between 0,73 and 0,90) are very similar to other authors values.

Since the outflow meter test can be applied to pavements in conditions where the sand patch test could not, for example wet pavements, also considering that it provides more accurate data and measures “extra” parameters the outflow meter test shows potential as a substitute for the sand patch test.

6. REFERENCES

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