

# Comparison of Sand Patch Test and Multi Laser Profiler in Pavement Surface Measurement

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## Graphical abstract



## Abstract

Pavement surface texture has been assessed with variety of test methods such as sand patch test and multi laser profiler. In recent years, road administrations face the issues of handling data acquired by totally different methods and the inconsistent correlation between different methods. Therefore, the objective of this study is to determine and compare the texture depth value of road pavement measured by different methods namely sand patch test and multi laser profiler. This paper compares the results of two measurement methods for pavement surface macro texture which referred as mean texture depth (MTD). Tests were conducted along North–South Expressway, between km 110.5 and km 107.2 (Southbound). T-test analysis shows that there is statistically significance difference on the result obtained between these methods along emergency lane. However for slow lanes, it was found that there is no significance between sand patch test and laser based measurement. Regression analysis shows that the coefficient of correlation, R obtained from emergency lane is 0.3719 and slow lane is 0.4579. These results generally conclude that there were weak correlations between the result of these two measurement techniques.

**Keywords:** Mean texture depth (MTD); sand patch test; multi laser profiler; t-test, regression

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## 1.0 INTRODUCTION

Characteristics such as safety [1], noise emission [2], driving comfort [3], rolling resistance, wear of tyre [4] and operating costs are influenced, to a great extent, by pavement surface irregularities and therefore by surface texture and unevenness.

Pavement surface texture has been classified into three major categories based on wavelength ( $\lambda$ ): micro texture (1  $\mu$ m to 0.5 mm), macro texture (0.5 to 50 mm), and mega texture (50 to 500 mm). Larger irregularities within the pavement surface are expressed as roughness (0.5 to 10 m)[5,6]. Higher amplitudes of surface micro- and macro texture intensify wet friction, decreasing the possibility of wet weather accidents

There are many conventional and rising ways to observe and quantify pavement surface texture, in order that a top quality management and quality assurance program is engineered into the planning and construction of HMA pavements. Lots of research has been done to compare the accuracy of various methods for measuring macro texture [7-10].

The sand patch method is a manual technique that requires the user to spread a known volume of sand on the road surface in such a way as to fill all the voids in the surface with the sand. The

volume of sand divided by the covered surface area gives a measure of the road texture called mean texture depth, MTD [11].

At the network level, macro texture is commonly measured using a multi laser profiler. This profile is then processed by applying the ASTM standard which specifies the calculation of the mean profile depth (MPD) or Sensor Measured Texture Depth (SMTD) depending on the equipment and analysis method used.

Meegoda *et al.* [9] discuss the use of laser systems to collect Mean Profile Depth (MPD) data. Laser data was compared to sand patch tests. Additionally, visual surveys were performed so as to substantiate the results of these tests. From the testing and comparisons, it had been found that laser data failed to provide comparable estimated texture depth (ETD) measurements to the mean texture depth (MTD) measurements from sand patch tests. This difference in MTD and ETD measurements was attributed to the inability to fix the test location, because it is difficult to follow a similar line during a testing vehicle. It had been found, though, that the distribution was a similar for each test and furthermore, the sand patch tests and laser tests captured a similar trend. Besides, laser testing was substantial to be the simplest of the ways, because of its efficient ways in collecting and processing data compare with sand patch test which consuming time and facing lots of difficulty in gathering and processing data.

Flintsch *et al.* [12] in conjunction with the Virginia Department of Transportation compare various macro texture measuring devices. They compare pavement macro texture measurements acquired using sand patch test and three laser-based devices: Circular Texture Meter (CT Meter), International Cybernetics Corporation (ICC) profiler, and MGPS profiler. The ICC and MGPS profilers were vehicle mounted and very similar in operation principles, with both using short-range laser range finder, an accelerometer, and a distance measuring transducer to measure and compute the pavement profile. From the experiments, it had been found that the CT Meter correlated the most effective out of the three laser systems to the sand patch data for all surfaces, because it had the smallest standard error, and ICC profiler was found to had the worst correlation.

The use of laser system also reduces the probability of human error. The sand patch test is exposed to a greater probability of human error; it is a test that cannot be performed quickly. If the test is performed too quickly, the accuracy is compromised. Laser based system such as multi laser profiler is a better device to use when there is a time constraint. The test can be performed quickly without compromising accuracy [13].

As for limitations, the sand patch test can produce a lot of variability. The test appears to be user dependent with a lot of variability among users. With laser based device, there is less variability among users. However, the equipment associated with the laser system is more costly than a sand patch kit [13].

This paper will present the comparison result between conventional method which is sand patch test and multi laser profiler. Comparison between these methods has been done using statistical analysis.

## 2.0 METHODOLOGY

The test was conducted between km 110.5 to km 107.2 (Southbound) along Pagoh to Yong Peng Utara, Section 3, North-South Expressway. Sand patch tests were conducted at 64 locations for every 50 meter alternately between left hand side and right hand side of the wheel path. Then on the same location the multi laser profiler had been used to measure the MTD of the pavement. The tests were conducted on the emergency lane and slow lane of the expressway. The MTD data by sand patch test was measured on 1<sup>st</sup> February 2013, 26<sup>th</sup> March 2013, and 27<sup>th</sup> March 2013 for emergency lane. While for slow lane, the MTD was measured on 26<sup>th</sup> March 2013 and 27<sup>th</sup> March 2013. The MTD data by multi laser profiler was measured on 15<sup>th</sup> April 2013 for emergency lane and 17<sup>th</sup> April 2013 for slow lane. Figure 1 shows the location of the site test.

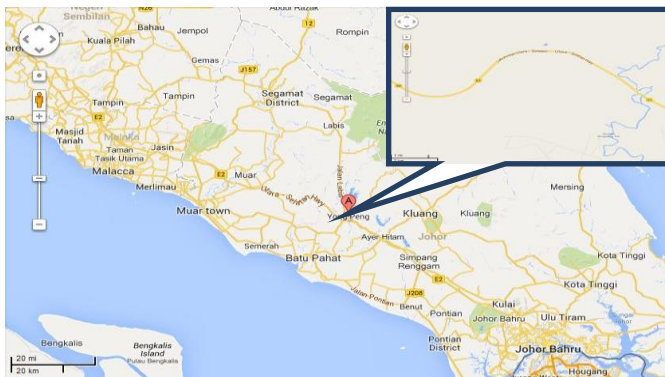


Figure 1 Site location

The sand patch test was conducted based on standard from ASTM E965-06, standard test method for measuring pavement macro texture depth using a volumetric technique. Figure 2 shows sand patch test was being conducted. The multi laser profiler was conducted based on manufacturer's user manual from Soil Centralab Sdn Bhd. Figure 3 shows the multi laser profiler used for the test. This test was carried out under normal operation conditions, on dry weather. The data recorded was used as provided by the operator and possible outlier values were included. Therefore, all possible sources of error are included and will be reflected in the repeatability and the reproducibility of the methods under analysis. Any unusual features and events that have influenced the result were recorded. The test results were then analysed using statistical analysis tools which were SPSS Statistics 20 and Microsoft Excel 2010.



Figure 2 Sand patch test



Figure 3 Multi laser profiler

## 3.0 RESULTS AND DISCUSSION

### 3.1 Mean Texture Depth

Table 1 shows average MTD measured by sand patch test and multi laser profiler along emergency lane and slow lane. The MTD values were found to be good which is greater than 0.5 mm as recommended by Soil Centralab [14]. Table 1 also shows the standard deviation and coefficient of variation value for both measurement methods along both lanes. The standard deviation values are very small as the values tend to be near zero for both measurement methods. It indicates that the data point tends to be very close to the mean. By this result, it can be assumed that the precision of the data is high. The value of CV from both

measurement methods seem to be quite small as it tend to be near zero concluded that the sample data has low variability and it can be seen that the sample data is reliable.

**Table 1** Statistical results for MTD

	Emergency lane		Soil Centralab <sup>14</sup>	Slow lane		Soil Centralab <sup>14</sup>
Average MTD (mm)	0.60	0.57	> 0.5	0.57	0.57	> 0.5
Standard Deviation	0.08	0.06	-	0.02	0.03	-
Coefficient of Variation	0.14	0.08	-	0.03	0.05	-

**3.2 T-Test Analysis**

Table 2 shows, the p-values obtained for emergency lane were very small and less than the level of significance value which was 0.05. This result shows that there is a significant difference between the average of MTD measured by sand patch test and multi laser profiler. While for slow lane, by referring to Table 3, the p-values obtained from this comparison was 0.193 which was higher than the level of significance value which was 0.05. This explains that there was no significant difference between the average of MTD measured by sand patch test and multi laser profiler when tested along slow lane. The discrepancy of MTD values by sand patch test and multi laser profiler at the emergency lane probably due to the operator who operated the multi laser profiler. The speed of the vehicle mounted laser might be faster at the emergency lane than slow lane due to the zero traffic along the emergency lane.

**Table 2** Results of t-test comparing MTD results from sand patch test and multi laser profiler (emergency lane)

	Paired Differences						t	df	Sig (2 tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the difference					
				Lower	Upper				
Pair 1 SPT-MLP	.100	.08214	.010	.120	.07995	9.78	63	.000	
	47		27	99	5				

**3.3 Regression Analysis**

Figure 4 and Figure 5 presents the correlation data of MTD measured using sand patch test and MLP along emergency lane and slow lane respectively. The coefficient of correlation obtained for emergency lane is 0.3719 while coefficient of correlation obtained for slow lane is 0.4579. While the coefficient of determination obtained for emergency lane is 0.1383 while coefficient of determination obtained for slow lane is 0.2096. From the data obtained by emergency lane and slow lane, there does not appear to have a strong correlation between two measurement techniques. This may probably due to the location for each of measurement technique is not really exactly the same

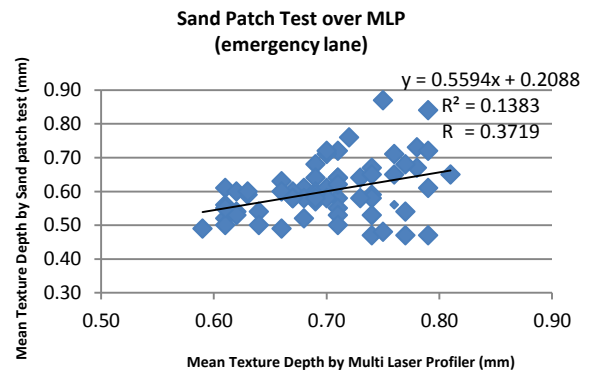
because of the ways the texture depth being measured. Measurement of texture depth by sand patch test was conducted at one small spot to represent the 50m length. While measurement by multi laser profiler is in horizontal line along the pavement surface.

**Table 3** Results of t-test comparing MTD results from sand patch test and multi laser profiler (slow lane)

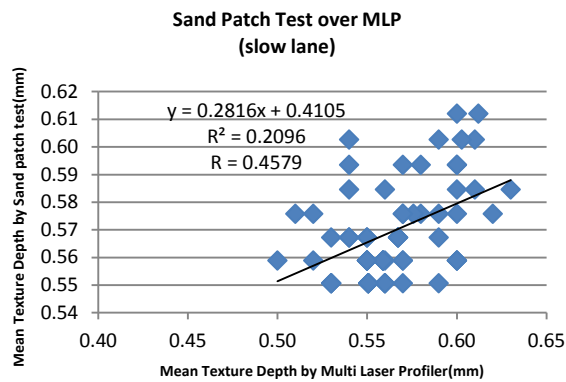
	Paired Differences						t	df	Sig (2 tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the difference					
				Lower	Upper				
Pair 1 SPT-MLP	.004	.025	.003	-.002	.010	1.3	6	.1	
	22	62	20	18	62	17	3	93	

The different time of conducting both of test methods also contribute to the weakness in the correlation between sand patch test and multi laser profiler along emergency lane and slow lane. The measurement by sand patch test was conducted first followed by multi laser profiler about one month later. The change of the surface may occurred during the time interval. During the time interval, the aggregate was polished by the vehicle tires and this will lead to the discrepancy on the texture depth value between both tests.

This result contradicts, where strong correlation was found by Halil Sezen *et al.* [15] between sand patch test and multi laser profiler. However, by looking at the data, Halil Sezen *et al.* [15] cover a wide range of texture depth range from 0.5 mm to 2.0 mm. This explains the reasons of having a strong correlation between these two methods.



**Figure 4** Correlation between MTD data measured using Sand Patch and MLP for emergency lane



**Figure 5** Correlation between MTD data measured by Sand Patch and MLP for slow lane

#### 4.0 CONCLUSION

T-test results for emergency lane shows that the mean between these two groups of data is statistically significance difference at 0.05 of level of significance. While for slow lane, there is no difference between the mean of these two groups of data at 0.05 of level of significance.

Regression analysis results for both emergency lane and slow lane shows that there does not appear to be a strong correlation between the two measurement techniques as the coefficient of correlation were quite small. Though it was found there is no significance difference between results of these two tests, the use of multi laser profiler in order to predict MTD value for sand patch test is inappropriate due to low value of regression coefficient for both emergency and slow lane.

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