THE CORRELATION BETWEEN TEXTURE DEPTH, PENDULUM TEST VALUE AND ROUGHNESS INDEX OF VARIOUS ASPHALT SURFACES IN MALAYSIA

***Suleiman Arafat Yero, Mohd. Rosli Hainin & Haryati Yacoob**
Department of Transportation and Geotechnics,
Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 skudai, Johor, Malaysia.
Email: arafatyero@yahoo.com

ABSTRACT

This study is aim at determining the correlation between the pendulum test value (PTV), texture depth (TD), and roughness index (IRI) of various bituminous road surfaces. The study investigated 180 test points, and three different tests were conducted on the 6 selected test road surfaces. The texture depth is a measure of the macrotexture of the pavement surface, while the microtexture, is referred to as the interstices of the aggregate that can resist polishing by traffic. The roughness of the road surface is a factor for determining the roughness index (IRI). The study was conducted on three different bituminous surfaces these includes, asphalt concrete wearing (ACW), stone mastic asphalt (SMA), and surface dressed(SD) surfaces on Jalan Tebrau, Jalan Pontian and Jalan Parit Yaani in Batu Pahad. From the results obtained from the study shows a weak correlation between the texture depth and the roughness index of the SD road surfaces. For the SMA and ACW surfaces there was weak or no correlation as the coefficient of variance (R^2) is relatively less than unity. But the general trend shows that the higher the texture depth (TD), the higher the roughness index (IRI) and the pendulum test values (PTV).

Keywords: *microtexture, macrotexture, pendulum test value, texture depth, and IRI.*

1. INTRODUCTION

As the road system of transportation becomes the leading means of transporting goods and services in Malaysia, there has been considerable publicity on the safety of these roads as there is significant increase in the occurrence of road accidents in the country, which is often mentioned to be related to the texture of the road surfaces. The road surface oftenly used by motorist has some frictional properties that are relatively associated with performance of the road and its safety to the road user [1]. The frictional properties of the surface consist of the microtexture and macrotexture which are oftenly mentioned as contributory factors to road accident [2]. The microtexture is the interstices of the aggregate that is characterized by the resistance to polishing, while the macrotexture is the coarse component of the texture due to the aggregate particle on the road surface [2].

The skidding resistance is a measure of the friction generated between a pavement surface and a vehicle tire [3]. Skidding is said to take place when the available friction generated is insufficient to counter the forces imposed by a moving vehicle [4]. This friction depends upon the microtexture, macrotexture of the road surface, the properties of the tire, vehicle speed and weather conditions [3]. This study evaluated the microtexture and the macrotexture of the selected test roads, the study was conducted on three different Asphaltic pavements, these includes the asphaltic concrete wearing (ACW), stone mastic asphalt (SMA) and surface dressed (SD) surfaces.

In Malaysia there has been an increase in the rate of accident occurrence, with an accident record of 215,632 in 1997 to 363,314 in 2007 [5]. This indicated an increase in road accident by over 160% within 10years. In view of this predicament the Government of Malaysia financed a joint investigation by Jabatan Kerja Raya (JKR) and the Transport Research Laboratory (TRL) of the U.K to carry out a comprehensive assessment on the skid resistance, microtexture and the macrotexture of bituminous surfaces in Malaysia [6]. The study investigated 81 sites across the Malaysian peninsular, and three types of surfaces were tested, they include asphalt concrete (AC), dense bitumen macadam (DBM) and surface dressing (SD). The study shows that the asphaltic concrete and the dense bitumen surfaces showed an average skid resistance of 55, while for the surface dressed roads is 58 [6].

The mean texture depth for the asphaltic concrete, dense bitumen macadam and the Surface dressed pavements are 0.35mm, 0.55mm and 1.47mm respectively [6]. Government had continued to take steps aimed at reducing the incidences of road accidents, these includes road maintenance, road rehabilitation, the use of warning sign, and accident campaigns. It is expected that good roads should provide an economical, convenient, comfortable and safe riding path to the road user [7]. The IRI values obtained in this study were compared with the acceptable limits in the JKR specification [8] for Malaysian roads.

1.1 Objective of the study

The objective of the study is to determine the relationship between the pendulum test value, texture depth, and roughness index of the three classes of bituminous pavement surfaces in Batu Pahat and Johor, these includes the stone mastic asphalt(SMA14), asphalt concrete wearing (ACW14 and ACW20), and surface dressed (SD14). The study reviewed literature works pertaining frictional theories, aggregate microtexture, macrotexture properties, and surface roughness.

1.2 Significance of the study

This study shall provide useful data for determining the relationship between the skidding resistance, texture depth, and roughness index of the three types of bituminous pavement surfaces. The findings from this study shall also be useful in determining the texture depth, and pendulum test value for the SMA surfaces in Malaysia.

2. METHODOLOGY

The study involved field test on the various selected sites to determine the texture depth, surface roughness and the pendulum test value. The study investigated 10 test points on each of the six (6) selected test roads. The test was conducted at an interval of 100m along each of the test road spanning 1km each, and a total of 180 tests were conducted on the whole six road surfaces The sand patch test was conducted on the test surfaces to determine the texture depth in accordance to BS EN 13036-1:2002 [9]. While the British pendulum tester was used to determine the pendulum test value (PTV) in accordance to BS EN 13036-4:2003 [10]. The surface roughness was determined using the Australian Road Research Board (ARRB) walking profilometer in accordance with AG: PT/T450-ARRB [11]. Table 1 below shows the location and categorization of the test roads;

Table 1: Surface Type and Locations

No	Surface Type	Location	Age(mn)
1	ACW20	Jalan Pontian	24
2	ACW14	Jalan Utama UTM	4
3	SMA14	Jalan Tebrau 01	24
4	SMA14	Jalan Tebrau 02	24
5	SD14	Jalan Parit Yaani	60
6	SD14	Jalan Pt.Bulat	36

3. RESULTS

All the data collected from the survey for the texture depth, pendulum test value and the roughness index values were analyzed and the following results obtained.

3.1 Texture depth

The results obtained from the study shows that the surface dressed surface SD14 has the highest average texture depth of 2.6mm, while the asphalt concrete wearing ACW14 showed the lowest average texture depth of 0.72mm, the average texture depth values obtained from the study can be seen in Table 2 below;

Table 2: Texture depth values

Surface Type	Age (month)	No of site	Texture depth(mm)		
			Max.	Min.	Mean
ACW20	24	1	0.88	1.08	0.82
ACW14	4	1	0.58	0.94	0.72
SMA14	24	1	1.34	1.72	1.5
SMA14	24	1	1.29	1.80	1.5
SD14	60	1	1.83	2.54	2.1
SD14	36	1	1.45	3.18	2.6

Moreover, increase in texture depth indicates also an increase in the pendulum test value for all the surfaces investigated, with the surface dressing indicating a significant change compared to the stone mastic asphalt and asphaltic concrete surfaces as presented in Figure 1.

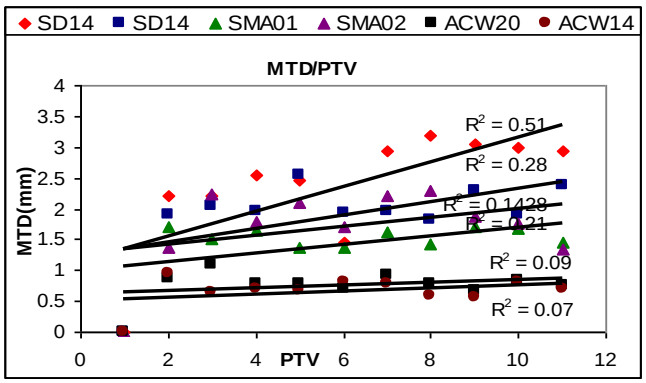

Figure 1: Correlation between MTD and PTV

The correlation between the texture depth and the roughness index shows that as the TD increases the IRI also increases. Especially with the surface dressed surfaces as can be seen in Figure 2. The coefficient of variance (R^2) is low indicating weak correlation between MTD and PTV and also between MTD and IRI

.

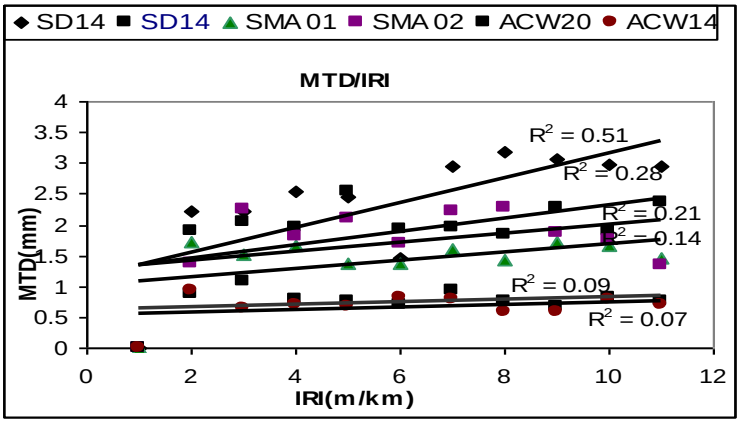

Figure2: Correlation between MTD and IRI

3.2 Pendulum test

The pendulum test result obtained from the study indicated that the surface dressed surface has the highest average PTV of 57. The result of PTV from this study as presented in Table 3.

Table 3: Pendulum test values

Surface Type	Age (month)	No of site	Pendulum test		
			Min.	Max.	Mean
ACW20	24	1	50	67	57
ACW14	4	1	58	68	62
SMA14	24	1	52	63	56
SMA14	24	1	53	66	57
SD14	60	1	53	77	66
SD14	36	1	61	77	68

Figure 3 shows the correlation between the pendulum test value and the international roughness index of the various asphalt surfaces investigated in this study. The result indicates an increase in the roughness index as the pendulum test value increases for the surfaces investigated, with low R^2 indicating weak correlation between IRI and PTV.

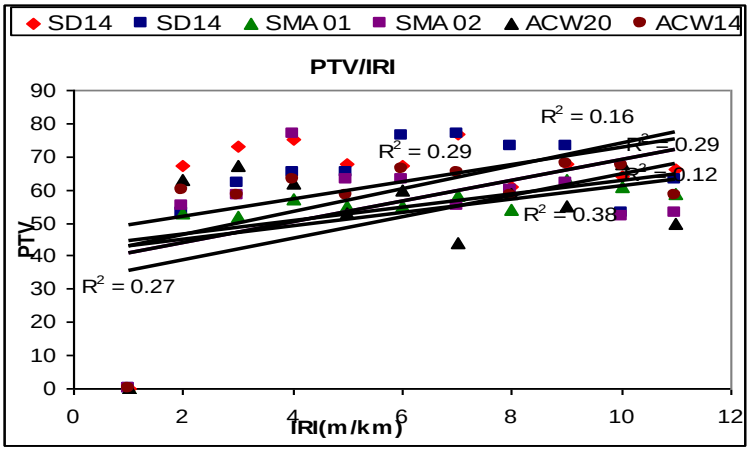

Figure 3: Correlation between PTV and IRI

The correlation between the pendulum test value (PTV) and the texture depth (TD) in this study shows the PTV increases as the TD also increases, with no correlation between PTV and MTD as illustrated in Figure 4.

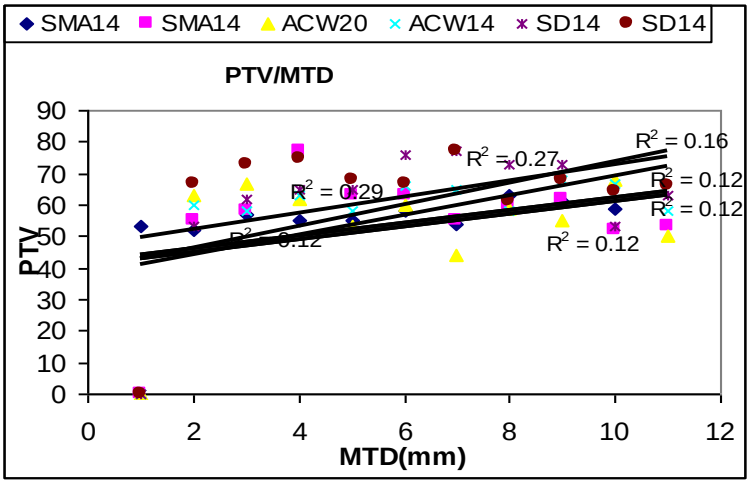

Figure 4: Correlation between PTV and MTD

3.3 Roughness index

The roughness index values obtained from the study showed that the surface dressed surface (Jalan Pt.Bulat) showed the highest IRI of 5.7m/km, and the ACW14 indicated the lowest average IRI value of 2.0m/km. The results for the IRI obtained for the various test surfaces can be seen in Table 4.

Table 4: International roughness index values

Surface Type	Age (month)	No of site	International roughness index(m/km)		
			Min.	Max.	Mean
ACW20	24	1	1.24	4.47	2.7
ACW14	4	1	1.28	2.88	2.0
SMA14	24	1	1.17	4.24	2.5
SMA14	24	1	1.20	3.90	2.6
SD14	60	1	4.12	8.95	5.7
SD14	36	1	1.33	8.15	3.3

The Figure 5 shows the correlation between the surface roughness index and the texture depth of all the six (6) test road surfaces. With the Surface dressed surfaces and the Stone mastic asphalt indicating an increase in the texture depth as the surface roughness increases, while for the ACW14 and ACW20 surfaces as the surface roughness increases the pendulum test values decreases, with no correlation between IRI and MTD as the R^2 values are low as presented in Figure 5.

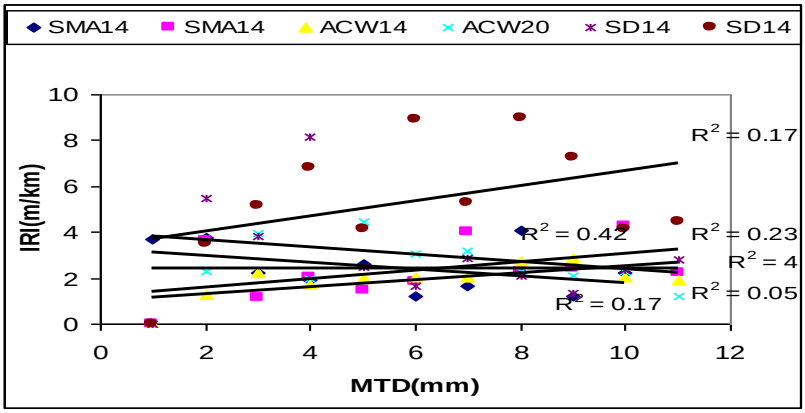

Figure 5: Correlation between IRI and MTD

The correlation between the surface roughness and the pendulum test value of the various surfaces investigated shows that as the surface roughness increases the pendulum test values also increase for both the surface dressed and the stone mastic asphalt surfaces, while it indicated an opposite trend for the asphalt concrete surfaces, as presented in Figure 6.

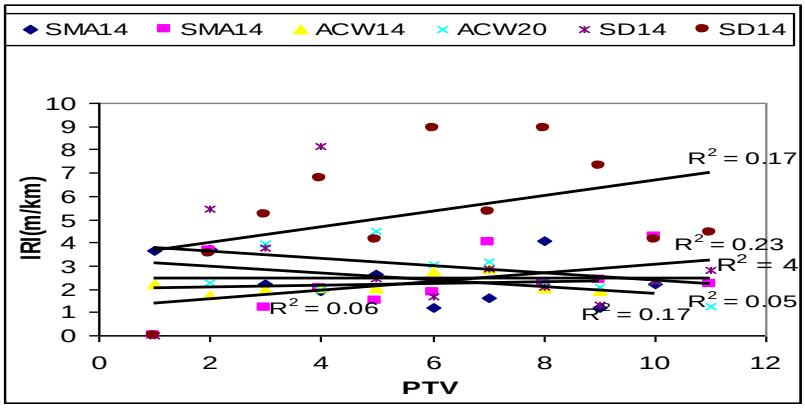

Figure 6: Correlation between IRI and PTV

4. DISCUSSION

The results obtained from this study indicates that all the average PTV for the six test surfaces are significantly higher than the PTV of 55 normally specified for low trafficked roads in Malaysia. The average texture depth results obtained from this study showed that the average texture depth for the ACW14, ACW20 and SD14 are relatively higher than the average texture depth of 0.35mm for Asphaltic concrete surfaces and 1.5mm for surface dressed roads in Malaysia.

The roughness index obtained from the study for the various bituminous pavement surfaces investigated indicates that the ACW14 showed the lowest IRI of 2.0m/km, and the surface dressed road surface showed the highest IRI of 5.7m/km. It is pertinent to note that all the IRI values obtained from this study conforms to the specification of IRI of 1.6m/km for 4lane highway, 2.5m/km for 2lane, and 8m/km for minor roads in accordance with the JKR of Malaysia.

From the results obtained from this study indicates a weak correlation trend for the surface dressed road surface between the texture depth and the surface roughness, the texture depth and the pendulum test value, with the SMA and the ACW having no correlation. This outcome of the result obtained from the study conforms to a study

conducted by Birmingham City Council in 2004 which also indicated that the correlation between surface texture measurements and SCRIM results (skid resistance) is relatively low. The results obtained from that study shows that there is little overlap between roads exhibiting low skid resistance and low texture depth. From all the results obtained from this study showed that as the surface texture increases the surface roughness and pendulum test values also increases for most of the surfaces.

5. CONCLUSSION

The investigation was undertaken with the primary objective to determine the correlation between the frictional properties of the road surface. From the study it was found that;

The correlation between the texture depth and the roughness index on the surface dressed pavement surface is weak with low coefficients of variance, while for SMA and ACW indicated no correlations.

The IRI values obtained from the study indicated only the surface dressed values are within the JKR acceptable limits for minor roads in Malaysia, while for asphaltic concrete and stone mastic surfaces the IRI values were higher than the maximum acceptable.

The study recommends further investigation on more test surfaces with a propare view of understanding the correlation between the texture depth, pendulum test and the surface roughness of these pavement surfaces, which contributes immensely on the safety of these roads.

6. REFERENCES

[1]. Hunter R.N (2000). Asphalt in Road construction. *pp.125-196*.
[2]. D.J Wilson and R.C.M Dunn (2005). *Polishing aggregates to equilibrium skid resistance. pp. 55-71*.
[3]. Beaven and L.W Tubey (1978*) The polishing of road stone in peninsular Malaysia.* TRRL supplementary report.
[4]. H.R Smith,W. Ford , and Z.Suffian (1996). The benefits of using Chipseals in Malaysia. *pp. 10-19.*
[5]. Accident records (2007).www.miros.gov.my.
[6]. H.J Kwang, G.Morosiuk and J.Emby (1992) *Assessment of skid resistance and macrotexture of bituminous road surface in Malaysia. Seventh REAA conference, Singapore. pp.443-449.*
[7]. Development and performance of portable skid resistance tester, TRRL no 66, 1964.
[8]. Design and specification of flexible pavement JKR, 2008.
[9]. Determination of texture depth BS EN 13036 - 1.2002.
[10]. British pendulum test BS EN 13036 – 4.2003.
[11]. ARRB, Walking profiler G2, ARRB technology note, 2006. *pp.1-37*