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Performance of Ralumac Micro Surfacing at LATAR Highway

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ABSTRACT

Maintaining pavement to desired level of serviceability as required by Malaysian Highway Authority (MHA) give immense pressure to highways operators. Pavement distress such as roughness, rutting and cracking are common problems that occur after the highway has been operational. Pavement preservation has been sought as a potential alternative for managing all the pavement distress. This paper evaluates the performance of Ralumac Micro surfacing at accident prone areas KM23.7 Eastbound, KM8.5 Eastbound, Puncak Alam Interchange PA-D and Puncak Alam Interchange PA-A, LATAR Highway. The evaluation comprises of International Roughness Index (IRI), rutting, texture depth, Pavement Condition Index (PCI) and skid resistance. The result revealed that Ralumac Micro surfacing system has significant improvement on pavement condition thus very effective for reducing traffic accidents due to skidding. It performed better at downhill area, uphill area and interchange ramps.

Keywords:
Ralumac Micro surfacing, pavement preservation, accidents prone, roughness, rutting, skid resistance

1. Introduction

Micro surfacing is a cold-applied paving mixture composed of polymer-modified asphalt emulsion, crushed aggregate, mineral filler, water and a hardening-controlling additive, proportioned, mixed and uniformly spread over a properly prepared surface [1]. It can be used as blanket cover on pavements to prevent loss of skid resistance, oxidation, ravelling and surface permeability. In addition, Micro surfacing can be used to fill ruts and improve rideability by removing minor surface irregularities. Micro surfacing performs best when applied to correct pavement defects that have adequate structural capacity [2] and cost-effective maintenance technique for higher severity cracks for at least a year [3]. Even more importantly, Micro surfacing is poised above all other treatments to comply strict environmental regulations and to optimize budget availability[4]. According to Koichi Takamura [5] Micro surfacing is more “eco-efficient” than hot mix overlay because of less material being used, less transportation of materials and lower overall emissions during the life of the treatment. This treatment can last on average 8 to 9 years [6].

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Micro surfacing system is an alternative method used for pavement maintenance by LATAR highway. It was used mainly to improve existing pavement that cause skidding to road users. Based on traffic accidents statistic indicated in Table 1, there are four (4) accident prone areas need to be mitigated. The locations are KM23.7 Eastbound, KM8.5 Eastbound, Puncak Alam Interchange PA-D and Puncak Alam Interchange PA-A, LATAR Highway. Most of the traffic accidents occurred during raining where previous research acknowledge wet-pavement conditions significantly increase the number of traffic accident [7]. Road safety studies indicate that approximately 20% of all traffic accidents occurred during wet weather, and that the skid resistance of wet pavements have a major influence on the occurrences of wet-weather accidents [8]. Very good pavement conditions might also induce speeding behaviours and therefore could have caused more severe crashes [9].

Table 1
Traffic Accidents at Accident Prone Areas, LATAR Highway

Year	Average Daily Traffic (ADT)	Section I KM23.7 EB	Section II KM8.5 EB	Section III PA-A	Section IV PA-D
2011	29,794	3	0	0	0
2012	36,606	11	1	0	1
2013	47,387	8	1	1	4
2014	56,031	8	1	2	0
2015	66,520	0	2	0	0
2016	67,616	0	2	1	5
2017	69,530	0	2	0	4
2018	74,631	0	0	0	1
Total		30	9	4	15

The hydroplaning and road profiles were identified as contributory factors to higher traffic accidents at the four (4) locations. Higher degrees of curvature possible for greater injury occurred, while lower skid numbers correlated to a higher percent of wet road crashes [10]. The pavement conditions could lead to hydroplaning and inconsistency tyre pavement contact and also reduction in tyre gripping the pavement which eventually causes accidents. There are also other factors which contribute to accidents such as driver awareness, driver behaviour, manoeuvring, speeding, weather, environment effects and vehicle conditions.

However, this study aims to evaluate pavement conditions related to the accident such as roughness, rutting, texture depth, PCI and skid resistance before and after improvement works carried out at site. Many studies have found that pavement conditions such as roughness, rutting depth, and the overall pavement condition significantly have variable effects on accident occurrences – accident frequencies, rates, or injury-severities[11] [12] with poor pavement conditions were associated with more severe crash [9]. Serious attention by relevant authorities are needed for pavement deterioration and defects as it leads to skidding, driving off tracks, improper manoeuvring to avoid the road defects and also prolonged driver braking distance [13].

2. Methodology

This study has been carried out to evaluate the performance of Ralumac Micro surfacing system at four (4) accident-prone areas along LATAR Highway. These performance tests are roughness, rutting, texture depth, pavement condition index (PCI) and skid resistance. The evaluations had considered different road profiles such as interchange ramps, downhill and uphill mainline.

Pavement roughness is the irregularities on pavement surface that affect the ride quality of vehicles, the vehicles vibrations, operating speed, the wear and tear of tyre and also the operating cost of the vehicle. It constitutes the smoothness and frictional properties of the pavement surface and in turn is related to the safety, and the ease of the driving path [14]. The measurement for the roughness in determination of the acceptable road condition is known as International Roughness Index (IRI). The Malaysia Highway Authority (MHA) recommended the IRI threshold value of 2 m/km for new highways and 2.8 m/km for opened highways.

Meanwhile pavement rutting is a longitudinal permanent deformation along its surface. It is a deformation which was created by repetitive vehicle loading along the wheel path. Accumulation of water on the rut surfaces reduces the skid resistance and increase the hydroplaning. The rutting which is not maintained can lead to cracking and disintegration from the pavement structure. The Malaysia Highway Authority (MHA) recommended the threshold for rutting is below than 5.0mm.

Pavement surface texture has been used to describe the rugosity of the surfacing. It has different components which make different contributions to tyre/pavement interaction. The deeper textures reduce the extent to which skidding resistance falls as speed increases [15]. A good texture depth must have above 0.5mm as required by the Malaysia Highway Authority (MHA).

The pavement condition index (PCI) is a widely used numerical index for the evaluation of the structural integrity and operational condition of pavements. Pavement Condition Index (PCI) is the numerical summation of Crack Index and Rut Index. Acceptable pavement condition index (PCI) by Malaysia Highway Authority (MHA) is below 2.

IRI, rutting, texture depth and pavement cracks are measured by the road scanner along the pavement lanes [13]. Road scanner can capture pavement functional condition data, survey mapping information and roadside asset details whilst travelling at highway speed. This fully-featured vehicle contains a compact workstation capable of capturing and storing individual data elements for texture and surface condition, as well as providing high-detail video images of road and road side assets along the LATAR Highway.

Pavement must be designed in a way that the sufficient pavement friction must be available throughout the entire life of the pavement and must be able to withstand wet weather condition. Friction was found to be a significant factor affecting the ratios of both wet and dry condition vehicle crashes [16]. A lower skid resistance value increases accident risk on wet roads due to insufficient friction force develops within tyre and road [17]. A pavement with higher skid resistance minimizes the skidding thus increase the road safety [13]. The Malaysia Highway Authority (MHA) recommends the threshold for skid resistance is SCRIM value above 0.38. However to minimize traffic accident the minimum skid number 60 or SCRIM value 0.55 is recommended [10].

The sideway-force coefficient routine investigation machine (SCRIM) was developed by Transport Road Research Laboratory (TRRL) in the UK in the early-1970s and is frequently used in Europe and other parts of the world. A test wheel, mounted mid-machine in line with the nearside wheel track and angled at 20◦ to the direction of travel, is applied to the road surface under a known load. During a test run, a controlled water jet wets 0.25 mm thick water film the road surface immediately in front of the test wheel, so that when the vehicle moves forward, the test wheel slides in a forward direction on a wet road surface while rotating freely in its own plane. The force generated by the resistance to sliding is related to the wet skidding resistance of the road surface. The measurement of this sideways component allows the sideway-force or SCRIM coefficient to be calculated. The usual test speed is 50km/h [18]. Skid resistance at the accident-prone areas was performed using the Grip Tester (GT) accordance to ASTM E 1844 (test tire specification). The information surveyed by GT was process and the Grip Number was converted to SCRIM value by the following relationship:

SCRIM value = 0.85 x Grip Number (1)

2.1 Material used

The aggregate gradation for Ralumac Micro surfacing was designed in accordance to the JKR specification JKR/SPJ/2008-S4 [19] as shown in Table 2.

Table 2
Aggregate Gradation for Ralumac Micro surfacing

ASTM Sieve Size (mm)	% Passing by weight
8.0	90 -100
4.75	60 – 74
3.35	45 – 58
2.0	36 – 50
1.0	23 – 38
0.710	20 – 33
0.090	5 – 12

The sieve analyses were carried out by taking representative samples of each individual coarse and fine aggregates. The combined aggregate used for Ralumac Micro surfacing was blended in the proportion of quary dust:chipping = 3:1.

The bitumen used for the manufacturing of the Ralumac is from Shell pen. Grade 60/70. The average penetration is 86.82 while average softening point is 46.43 °C. The Ralumac emulsion content included Bitumen 60/70, Peral 416, and Latex.

The average Binder residue test result for Ralumac emulsion is 67.40%, 50.44mm penetration (0.1mm) and 58.5°C of softening point. The laboratory mix for Ralumac Micro surfacing is shown in Table 3.

Table 3
Laboratory Mix for Ralumac Micro surfacing

Item Description	Requirement / Results
Combined aggregates	100%
Ralumac emulsion	10 – 12% by the weight of aggregate
Cement	2% by the weight of aggregate
Water	8 – 10% by the weight of aggregate
Additive	0.05% by the weight of aggregate
Cohesion test 30 minutes 60 minutes	 16.28 kg-cm 22.67 kg-cm
Wet track abrasion test	38.67 g/ft^2
Mix time	60 sec

3. Result and discussion

The data performance of roughness, rutting, texture depth, PCI and skid resistance on Ralumac Micro surfacing has been evaluated and discussed in the next subsection.

3.1 Roughness

Table 4 shows the roughness of Ralumac Micro surfacing after 4 years (2015-2018) of operation in Section I, while Section II, Section III and Section IV have been in operation for 2 years (2017 – 2018). The roughness after a year of Ralumac Micro surfacing installed was improved but later showing increasing trend in both lanes. Roughness in the slow lane was slightly higher than the roughness in the fast lane as the pavement receives more heavy vehicles that always driving in the left lane. However, the overall roughness after the Ralumac Micro surfacing installed are less 2.8 m/km as required by Malaysian Highway Authority (MHA). The testing result also indicates the Ralumac Micro surfacing had good performance in various road profiles. Based on performance at Section I, pavement preservation with Ralumac Micro surfacing could extend pavement life cycle with additional 4 years.

Table 4
Pavement Roughness for Ralumac Micro surfacing

Location	MHA's KPI	Lane	2014	2015	2016	2017	2018
Section I: KM23.70 - KM24.1 EB Road profile: Superelevation & Downhill	IRI < 2.8 m/km	Fast Lane	1.93	1.51	1.60	1.61	1.89
		Slow Lane	1.66	1.59	1.68	1.68	1.69
Section II: KM 8.5 - KM 9.0 Road profile: Uphill		Fast Lane	Ralumac not start		1.52	2.07	1.97
		Slow Lane			1.44	1.76	1.71
Section III: PA-A Road profile: Interchange ramp downhill		Fast Lane			1.86	1.68	2.03
		Slow Lane			2.44	2.25	2.67
Section IV: PA-D Road profile: Interchange ramp uphill		Single Lane			2.00	2.14	2.14

3.2 Rutting

Table 5 presents the pavement rutting of Ralumac Micro surfacing after 4 years (2015-2018) operating in Section I, while Section II, Section III and Section IV have been in operation for 2 years (2017 – 2018). The testing results showing increasing rutting on pavement although Ralumac Micro surfacing had installed on the pavement. Extra loadings from heavy vehicles could be part of contributory factors to accelerate the pavement deterioration. Nevertheless, overall pavement rutting for all sections after 7 years operational are still below 5mm as required by Malaysia Highway Authority (MHA).

Table 5
Pavement Rutting for Ralumac Micro surfacing

Location	MHA's KPI	Lane	2014	2015	2016	2017	2018
Section I: KM23.70 - KM24.1 EB Road profile: Superelevation & Downhill	< 5mm	Fast Lane	1.90	2.39	3.28	2.20	3.17
		Slow Lane	2.34	3.65	3.03	3.83	4.29
Section II: KM 8.5 - KM 9.0 Road profile: Uphill		Fast Lane	Ralumac not start		1.10	2.00	2.98
		Slow Lane			3.40	3.48	2.78
Section III: PA-A Road profile: Interchange ramp downhill		Fast Lane			1.46	1.81	2.08
		Slow Lane			6.85	3.81	4.83
Section IV: PA-D Road profile: Interchange ramp uphill		Single Lane			1.95	2.54	3.18

3.3 Texture depth

Table 6 presents the texture depth of Ralumac Micro surfacing after 4 years (2015-2018) operating in Section I, while Section II, Section III and Section IV have been in operation for 2 years (2017 – 2018). Overall the texture depth of Ralumac Micro surfacing had increased 25% to 83% after a year operational. However the performance decreasing after the second years in operation but the average results still had a good texture depth.

Table 6
Texture depth for Ralumac Micro surfacing

Location	MHA's KPI	Lane	2014	2015	2016	2017	2018
Section I: KM23.70 - KM24.1 EB Road profile: Superelevation & Downhill	> 0.5mm	Fast Lane	0.74	0.58	0.56	0.71	0.52
		Slow Lane	0.62	0.45	0.43	0.53	0.45
Section II: KM 8.5 - KM 9.0 Road profile: Uphill		Fast Lane	Ralumac not start		0.43	0.79	0.68
		Slow Lane			0.43	0.65	0.52
Section III: PA-A Road profile: Interchange ramp downhill		Fast Lane			0.52	0.74	0.67
		Slow Lane			0.46	0.57	0.44
Section IV: PA-D Road profile: Interchange ramp uphill		Single Lane			0.50	0.80	0.73

3.4 Pavement Condition Index

Table 7 presents the pavement condition index (PCI) of Ralumac Micro surfacing after 4 years (2015-2018) operating in Section I, while Section II, Section III and Section IV have been in operation for 2 years (2017 – 2018). The testing results showing the PCI increased after a year operational but still less than 2 as required by the Malaysia Highway Authority (MHA).

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Table 7
Pavement Condition Index (PCI) for Ralumac Micro surfacing

Location	MHA's KPI	Lane	2014	2015	2016	2017	2018
Section I: KM23.70 - KM24.1 EB Road profile: Superelevation & Downhill	< 2	Fast Lane	0.00	0.08	0.27	0.07	0.16
		Slow Lane	0.00	0.12	0.10	0.13	0.19
Section II: KM 8.5 - KM 9.0 Road profile: Uphill		Fast Lane	Ralumac not start		0.01	0.04	0.10
		Slow Lane			0.10	0.11	0.08
Section III: PA-A Road profile: Interchange ramp downhill		Fast Lane			0.03	0.22	0.12
		Slow Lane			0.78	0.33	0.48
Section IV: PA-D Road profile: Interchange ramp uphill		Single Lane			0.11	0.06	0.16

3.5 Skid resistance

Table 8 presents the skid resistance for Ralumac Micro surfacing after 4 years (2015-2018) operating in Section I, while Section II, Section III and Section IV have been in operation for 2 years (2017 – 2018). The skid resistance had increasing trend after the Ralumac Micro surfacing installed on existing pavement. This can help resist skid and to avoid the traffic accident. Furthermore, an improvement in macrotexture had contributed to reducing splash, spray and hydroplaning while microtexture to increase friction at low and high speeds.

Table 8
Skid Resistance for Ralumac Micro surfacing

Location	MHA's KPI	Lane	2014	2015	2016	2017	2018
Section I: KM23.70 - KM24.1 EB Road profile: Superelevation & Downhill	SCRIM value > 0.38	Fast Lane	0.60	0.55	0.61	0.66	0.65
		Slow Lane	0.58	0.52	0.52	0.52	0.63
Section II: KM 8.5 - KM 9.0 Road profile: Uphill		Fast Lane	Ralumac not start		0.52	0.55	0.73
		Slow Lane			0.52	0.57	0.80
Section III: PA-A Road profile: Interchange ramp downhill		Fast Lane			0.48	0.63	0.53
		Slow Lane			0.46	0.54	0.54
Section IV: PA-D Road profile: Interchange ramp uphill		Single Lane			0.42	0.47	0.65

4. Conclusions

This study found numbers of traffic accidents at four (4) sections of accident-prone areas along the LATAR highway were reducing after the Ralumac Micro surfacing had installed in 2014 at Section I and in 2017 at Section II, III and IV. These achievements were mainly contributed from improvement on macrotexture and microtexture by Ralumac Micro surfacing. Other studies also indicate improvement on pavement friction were found to yield significant reductions in wet-pavement crash rates averaging 68% [7]. The skid resistance of Ralumac Micro surfacing has shown uptrend meanwhile downtrend for other pavement durability measures. The testing results in Section I indicate pavement preservation with Ralumac Micro surfacing could extend additional 4 years for pavement life cycle. It subsequently helps road agency to reduce cost of the highway maintenance.

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