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Performance of ralumac micro surfacing at blackspot eastbound, LATAR highway

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Abstract. Pavement condition is an important factor in reducing traffic accidents especially in tyre pavement friction. Macrotexture, microtexture and surface roughness are the important parameters in determining an acceptable and safe pavement condition. Poor surface macrotexture and microtexture could lead to hydroplaning and inconsistency tyre pavement contact and also a reduction of tyre gripping on the pavement which eventually causes traffic accidents. Acceptable friction between the tire and pavement should be established in order to resist skid and avoid the traffic accident. Nevertheless, the potential in a reduction of hydroplaning phenomenon can be achieved with an effective mitigation method. Based on record of traffic accidents for the year 2011 to 2013 from the Traffic Safety Department LATAR, KM23.7 Eastbound was identified as a blackspot. Preliminary site investigation found road curvature and hydroplaning phenomenon is the main contributor to the traffic skidding. This paper evaluates the performance of Ralumac Micro surfacing as mitigation method to curb traffic accidents at blackspot KM23.7 Eastbound, LATAR highway. The evaluation comprises of roughness, rutting, and skid resistance. Road Scanner (RS) were used to survey the roughness and rutting while skid resistance was performed using the Grip Tester (GT) along the left wheel path of the road. The result revealed that Ralumac Micro surfacing system has significant improvement on pavement condition thus very effective for reducing traffic accidents due to skidding.

1. Introduction

Traffic accident is defined as an occurrence event which involves one or more vehicle collision that result in damage, injuries or death. Table 1 obtained from Traffic Safety Department of LATAR shows a statistic of traffic accidents occurred due to skidding at KM23.7 Eastbound, LATAR highway. The highest traffic accident was recorded with 10 cases in 2012 and 8 cases in 2013 and 2014. The Average Daily Traffic (ADT) uptrend and frequent wet weather would expose LATAR highway to higher risk for traffic accidents. KM23.7 Eastbound was categorized as a blackspot due to recurring traffic accident mostly during wet weather. This problem had acknowledged by previous research results are consistent in indicating that wet-pavement conditions significantly increase the number of traffic accident [12]. 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 [4]. Very good pavement conditions might also induce speeding behaviours and therefore could have caused more severe crashes [8].

Table 1. Traffic Accident at KM23.7 Eastbound and Average Daily Traffic (ADT) at LATAR.

Year	Traffic Accident due to Skidding	Average Daily Traffic (ADT)
2011	3	29,794
2012	11	36,606
2013	8	47,387
2014	8	56,031
2015	0	66,520
2016	0	67,616
2017	0	69,530
2018	0	74,631

Preliminary site investigation at blackspot KM23.7 Eastbound found horizontal curve and hydroplaning are contributory factors to higher traffic accidents. 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 condition 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, maneuvering, speeding, weather, environment effects and vehicle conditions. However, this study focus on pavement conditions related to accident such as roughness, rutting and skid resistance. 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 [7] [14] with poor pavement conditions were associated with more severe crash [8]. Serious attention by traffic authorities are needed for pavement deterioration and defects as it leads to skidding, driving off tracks, improper maneuvering to avoid the road defects and also prolonged driver braking distance [2].

High Friction Surface Treatments are a low cost and sustainable means of improving roadway safety [10]. Micro surfacing performs best when applied to correct surface friction, oxidation, raveling and rutting on pavements that have adequate structural capacity [3]. The statistical analysis results indicate that Micro surfacing causes significantly greater friction number compare to other preservation treatment such as chip seal, thin overlay and crack seal [16]. Improvement on pavement friction were found to yield significant reductions in wet-pavement crash rates averaging 68% [12].

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 a blanket cover on pavements suffering from loss of skid resistance, oxidation, raveling and surface permeability. In addition, Micro surfacing can be used to fill ruts and improve rideability by removing minor surface irregularities and the treatment can last on average 8 to 9 years [15].

The Ralumac Micro surfacing on pavement with total length 1,000 lane-km at KM23.7 Eastbound has been studied since 2014. The evaluation comprises roughness, rutting, and skid resistance to determine effectiveness Ralumac Micro surfacing as mitigation treatment to reduce traffic accidents at blackspot KM23.7 Eastbound LATAR.

2. Methodology

This study has been carried out to determine the performance of Ralumac Micro surfacing system at blackspot KM23.7 Eastbound, LATAR highway. These performance tests are roughness, rutting and skid resistance. Evaluations have been measured on the Ralumac Micro surfacing installed at slow lane and fast lane from KM23.7 to KM24.1 LATAR highway as illustrated in Figure 1.

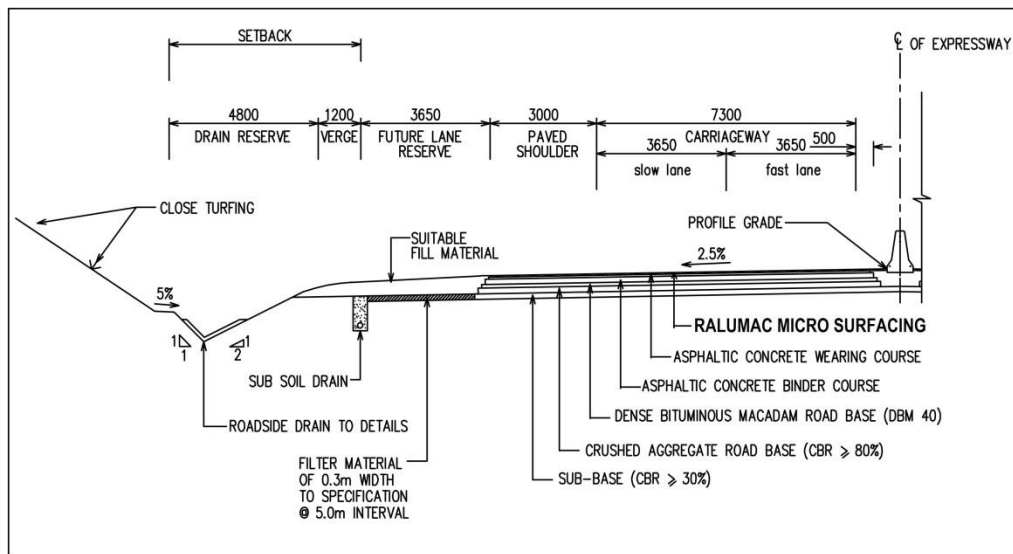


Figure 1. Pavement cross section at KM23.70 Eastbound, LATAR highway.

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 [13]. 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 2m/km for new highways and 2.8m/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.

IRI and rutting are measured by the Road Scanner as shown in Figure 2 along the pavement lanes [2]. Road Scanner is able to 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.



Figure 2. Road Scanner.

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 [11]. A lower skid resistance value increases accident risk on wet roads due to insufficient friction force develops within tyre and road [6]. A pavement with higher skid resistance minimizes the skidding thus increase the road safety [2]. The Malaysia Highway Authority (MHA) recommended the threshold for skid resistance is below than SCRIM Value 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 [5]. Skid resistance at KM23.7 Eastbound was performed using the Grip Tester (GT) accordance to ASTM E 1844 (test tire specification) as illustrated in Figure 3. The information surveyed by GT was process and the Grip Number was converted to SCRIM value by the following relationship:

$$SCRIM\ value = 0.85 \times Grip\ Number \tag{1}$$



Figure 3. Grip Tester (GT).

2.1 Material Used

The aggregate gradation for Ralumac Micro surfacing was designed in accordance with the JKR specification [9] as shown in Table 2.

Table 2. Aggregate Gradation.

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 quarry 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	16.28 kg-cm
60 minutes	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 and skid resistance on Ralumac Micro surfacing has been calculated and discussed in the next subsection.

3.1. Roughness

Table 4 indicates the results of pavement roughness for Ralumac Micro surfacing for fourth years operational which the average of roughness is 1.79m/km. The test results are complying with the minimum requirement by Malaysia Highway Authority (MHA) which is below than 2.8m/km for opened highway. The pavement roughness was improved by 13.4% on first year of the Ralumac Micro surfacing operational. Nevertheless the roughness results had been increased gradually starting from the second years until the fourth years as the Average Daily Traffic (ADT) had been increased by 12.2% from 66,520 to 74,631.

Table 4. Pavement Roughness for Ralumac Micro surfacing.

Location (KM)	Lane	2014 (0 year)	2015 (1 st year)	2016 (2 nd years)	2017 (3 rd years)	2018 (4 th years)
	ADT	56,031	66,520	67,616	69,530	74,631
23.70	Fast Lane	2.25	1.98	1.79	2.04	2.09
	Slow Lane	1.99	1.76	1.81	1.80	1.87
23.80	Fast Lane	1.77	1.61	1.41	1.75	1.70
	Slow Lane	1.47	1.69	1.32	1.84	1.67
23.90	Fast Lane	2.20	1.33	1.47	1.45	1.66
	Slow Lane	1.49	1.13	1.81	1.22	1.53
24.00	Fast Lane	1.77	1.33	1.54	1.40	2.06
	Slow Lane	1.72	1.58	1.83	1.72	1.57
24.10	Fast Lane	1.65	1.30	1.80	1.39	1.96

Slow Lane	1.63	1.77	1.62	1.83	1.79
Average (m/km)	1.79	1.55	1.64	1.64	1.79
MHA's requirement	< 2.8 m/km				

3.2. Rutting

Table 5 indicates the results of pavement rutting for Ralumac Micro surfacing for fourth years operational which the average of rutting is 3.73mm. The test results are complying with the minimum requirement by Malaysia Highway Authority (MHA) which is below than 5 mm. Nevertheless the performance of pavement rutting had continuously decreasing starting from the first year until the fourth years. The performance of Ralumac Micro surfacing are interrelated with pavement structural condition which can be affected by excessive loading from vehicles and increasing traffic volume at LATAR.

Table 5. Pavement Rutting for Ralumac Micro surfacing.

Location (KM)	Lane	2014 (0 year)	2015 (1 st year)	2016 (2 nd years)	2017 (3 rd years)	2018 (4 th years)
	ADT	56,031	66,520	67,616	69,530	74,631
23.70	Fast Lane	1.60	2.81	2.50	2.60	2.30
	Slow Lane	2.70	3.99	3.20	4.05	3.74
23.80	Fast Lane	2.00	2.52	2.90	2.36	3.75
	Slow Lane	2.20	3.47	2.40	3.71	4.90
23.90	Fast Lane	1.40	2.38	2.59	1.96	3.17
	Slow Lane	2.20	3.50	3.09	3.12	4.69
24.00	Fast Lane	2.20	2.19	3.04	1.71	3.80
	Slow Lane	2.30	3.23	3.29	3.26	3.36
24.10	Fast Lane	2.30	2.05	5.34	2.39	2.83
	Slow Lane	2.30	4.07	3.16	4.99	4.79
Average (mm)		2.12	3.02	3.15	3.02	3.73
MHA's requirement		< 5 mm				

3.3 Skid Resistance

Table 6 indicates the results of skid resistance for Ralumac Micro surfacing for fourth years operational which the average of skid resistance is 0.64. The minimum SCRIM value 0.55 are recommended to minimize traffic accident due to skidding [10]. The test results demonstrate that skid resistance for pavement had been increased after Ralumac Micro surfacing installed at location KM23.7 to KM24.1 Eastbound.

Table 6. Skid Resistance for Ralumac Micro surfacing.

Location (KM)	Lane	2014 (0 year)	2015 (1 st year)	2016 (2 nd years)	2017 (3 rd years)	2018 (4 th years)
	ADT	56,031	66,520	67,616	69,530	74,631
23.70	Fast Lane	0.55	0.55	0.62	0.68	0.61
	Slow Lane	0.51	0.53	0.52	0.50	0.61
23.80	Fast Lane	0.60	0.55	0.65	0.75	0.64
	Slow Lane	0.56	0.54	0.56	0.58	0.59
23.90	Fast Lane	0.62	0.57	0.61	0.64	0.65

	Slow Lane	0.60	0.53	0.54	0.55	0.67
24.00	Fast Lane	0.61	0.56	0.59	0.62	0.68
	Slow Lane	0.61	0.50	0.50	0.5	0.61
24.10	Fast Lane	0.61	0.53	0.57	0.61	0.67
	Slow Lane	0.60	0.49	0.49	0.48	0.67
Average SCRIM Value		0.59	0.54	0.56	0.59	0.64
MHA's requirement		SCRIM Value \geq 0.38				

3.4 Traffic Accident

Figure 4 indicates sharp decline on traffic accidents at blackspot KM23.7 Eastbound LATAR since the Ralumac Micro surfacing had been installed in May 2014. Based on the test results, this achievement were mainly contributed from higher frictions of Ralumac Micro surfacing. Other studies also indicate improvement on pavement friction were found to yield significant reductions in wet-pavement crash rates averaging 68% [12]. The skid resistance of Ralumac Micro surfacing have shown uptrend meanwhile downtrend for roughness and rutting. The downtrends performances of roughness and rutting were not impact to the road user safety at this moment as the test results are still above the MHA's requirement.

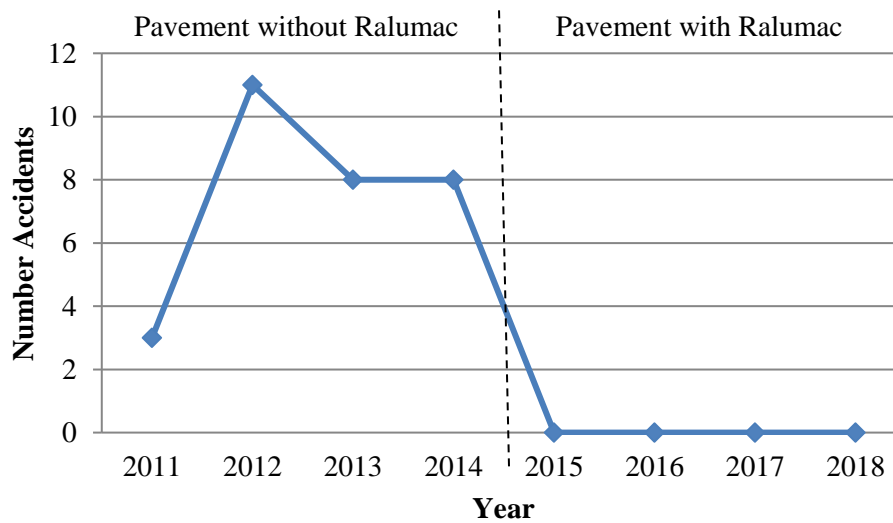


Figure 4. Traffic accidents at blackspot KM23.7 Eastbound, LATAR.

4. Conclusion

Overall performance of Ralumac Micro surfacing for roughness, rutting and skid resistance for fourth years operational at blackspot KM23.7 Eastbound are above the requirements by the Malaysia Highway Authority (MHA). However, pavement roughness and rutting results have shown uptrend as their values depend on pavement structural condition. The pavement conditions were deteriorated as results of excessive loading from the vehicles and increasing traffic volume at LATAR highway. Meanwhile, higher frictions offered by Ralumac Micro surfacing were contributed to instant reduction on traffic accident at blackspot KM23.7 Eastbound. Further monitoring at location KM23.7 to Km24.1 Eastbound LATAR is vital to determine actual service life of Ralumac Micro surfacing and to ensure the road is safe at all time.

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