CJ Technical Updates

Cawangan Jalan

Bulletin on: Assessment on the Skid Resistance and Texture Depth of AC14 and ACW20

Theme of the month: ROAD PAVEMENT

Issue No. 2 2/2018

JKR 20400-0214-18 **Website: http://www.jkr.gov.my** **ISSN 2231-7988**

1.0 INTRODUCTION

Skid resistance is the force developed when a tyre is prevented from rotating slides on a pavement surface (Highway Research Board, 1972). Skid resistance is an important pavement safety evaluation parameter because poor skid resistance can lead to skidding accidents and inadequate braking distance during emergency braking.

The characteristics of the aggregate mixes have profound effects on the performance of asphalt pavements. One of the important characteristics of a hot mix asphalt is the aggregate grading. JKR Standard Specification for Road Works Section 4: Flexible Pavement JKR/SPJ/2008-S4 is the latest revised version of the document currently in use and one of the significant change made was the aggregate size distribution for asphaltic wearing course. The AC10 and ACW14 grading design was introduced to replace the current aggregate grading i.e. ACW20.

Since its introduction there were claims that ACW14 could have been the cause of a number of road crashes on newly completed roads especially during wet weather. Acting on these complaints, BKF then conducted a study to compare some of the pavement properties of the two grading asphaltic courses. This study is to assess the skid resistance and texture depth properties of these asphaltic mix and to ensure that the safety of our road users is not compromised.

2.0 PROBLEM STATEMENT

ACW14 was introduced to replace ACW20 in the JKR Standard Specification for Road Works Section 4: Flexible Pavement JKR/SPJ/2008-S4. Feedbacks received since implementation of ACW14 pointed towards the problems of skidding which often resulting in out-of-control road crashes especially during wet weather. This has led to the assumption that ACW14 has lower skid resistance properties in comparison to ACW20 presumably due to the use of smaller aggregate size.

3.0 OBJECTIVE OF STUDY

The main objective of this study is to compare the data on Skid Resistance Values (SRV) and Mean Texture Depths (MTD) collected for ACW14 and ACW20 wearing courses. Analysis on these data should enable conclusion be made based on the comparison of the pavement friction properties between ACW14 and ACW20 pavement surfaces.

4.0 LITERATURE REVIEW

4.1 Wet-weather Crash and Pavement Surface Condition

It has been commonly recognised that road crashes are the result of one or more factors from 3 main categories: driver-related, vehicle-related and road condition-related (Noyce et al., 2005). Of the 3 categories, road and highway authorities have full control on the standard and condition of their roads through effective design, construction and maintenance policies.

Road crash investigations have shown significant link between accidents and pavement surface conditions for crashes not related to driver's mistake or vehicle's failure. Pavement surface properties such skid resistance and texture depth greatly influence the effectiveness of the physical contact of the pavement aggregates with vehicle's tyres.

Many research has been done, showing wet-weather crashes increases as pavement friction decreases. Risk of skid-related accidents (Cairney, 1997) was small for friction values above 60 but increased rapidly for friction values below 50. A study on M4 highway, England showed pavement resurfacing (increased pavement friction) resulted in 28% reduction of dry pavement crashes and 63% reduction of wet pavement crashes. French study (Larson, 1999) on the Bordeaux Ring Road indicated the risk of wet crashes increases greatly for surfaces with the estimated texture depth less than 0.4 mm. Study (Xiao et al., 2000) by Pennsylvania Transportation Institute (PTI) using fuzzy logic models showed safety condition can be improved nearly 60% if the skid number increased from 33.4 to 48.

4.2 Pavement Friction

Pavement friction is the force that resists relative motion between vehicle tyre and pavement surface. This force is generated as the tyre rolls or slide over the pavement surface. It plays an important role in keeping a vehicle on the road by allowing the driver to be in control of his vehicle in a safe manner. In road geometric design, pavement friction is an important parameter as it is used to determine the minimum stopping sight distance, minimum horizontal curve radius and maximum super-elevation.

Pavement friction is being provided by the skid resistance properties of the pavement surface aggregates. These properties depend on the aggregate surface's microtexture and macrotexture (Corley-Lay, 1998).

Microtexture refers to the small-scale texture of the pavement aggregate component which controls contact between the tyre rubber and the pavement surface by providing frictional potential during braking and accelerating. Micro-texture values can be measured using methods such as the British pendulum test.

While macrotexture refers to the large-scale texture of the pavement as a whole due to the aggregate sizes and particles arrangement which controls the escape of water from under the tyre. Poor draining of water during rainfall may create thin laminar of water which may reduce the physical contact in the tyre-pavement interaction and hence the loss of skid resistance. The pavement texture depth is typically measured using sand patch method and will vary depending on the voids of the surfacing.

Like micro-texture, the macro-texture of a wearing course can deteriorate over time from a combination raveling, stripping and embedment and should be monitored over the life of the surfacing.

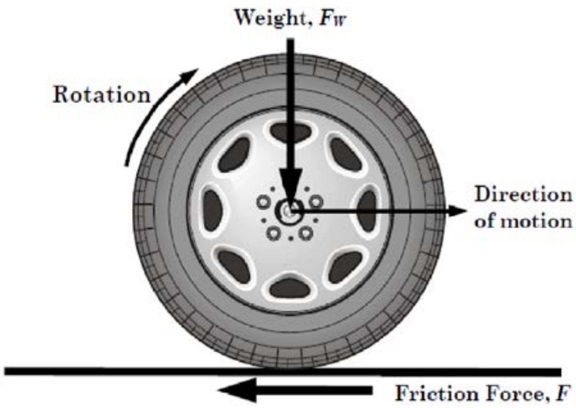


Figure 1: A Simplified Diagram of Forces Acting On a Rolling Wheel.

4.3 Friction Mechanism

Pavement friction is the result of interplay between two frictional force – adhesion and hysteresis

i. Adhesion (F_A) is the friction from small scale bonding of tyre rubber and the pavement surface when in contact.

ii. Hysteresis (F_H) is the result of energy loss from bulk deformation of vehicle tyre.

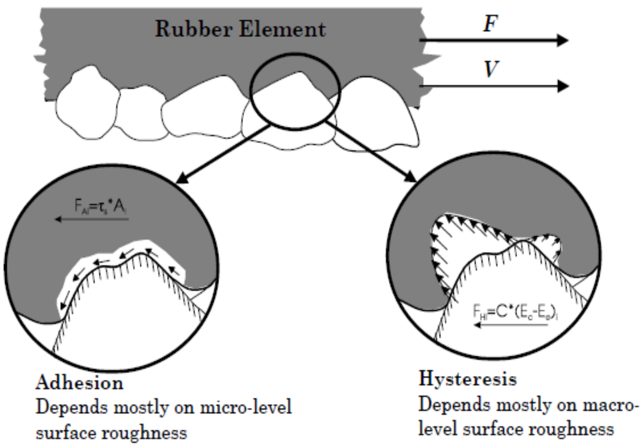


Figure 2: Mechanism of Pavement-tyre Friction.

Thus, pavement friction (F) is

$$\boldsymbol{F = F_A + F_H}$$

1. Adhesion force is most responsive to the micro asperities (micro-texture) of aggregate particles in the pavement surface.
2. Hysteresis force that develops within the tyre itself, is most responsive to macro asperities in the surface via mix design and construction methods.
3. As a result, adhesion governs overall friction on smooth-textured and dry pavements whereas hysteresis is dominant on rough-textured and wet pavements.

4.4 Overview of ACW14 and ACW20

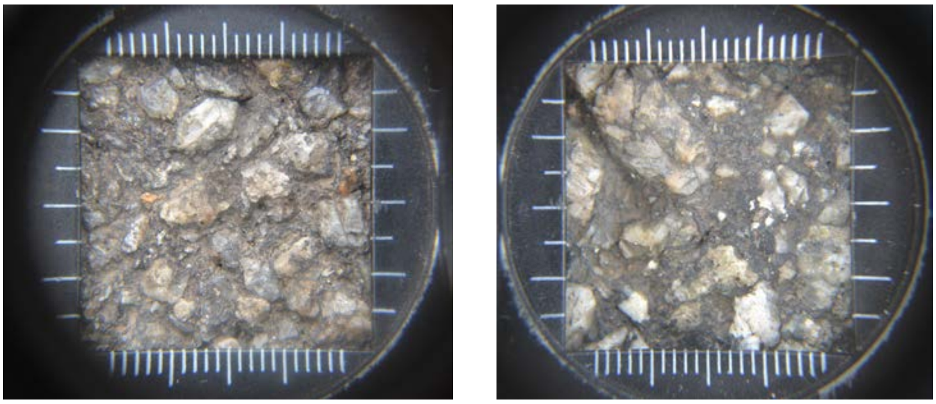
The aggregate gradation of ACW14 was adopted from AAPA National Asphalt Specifications and loosely based on SHRP Superpave research findings. Table 1 compares the percentage passing by weight for ACW14 and ACW20.

The percentage passing by weight for ACW14 starts from sieve size 14.0 mm while ACW20 starts from sieve size 20.0 mm. Figure 3 below shows the envelope generated from the grading of ACW14 and ACW20 which indicated that most of the ACW14 envelope overlaps with ACW20.

Except for the initial upper size, the range of percentage passing by weight for ACW14 is mostly within the range of that for ACW20 grading.

Specification	JKR/SPJ/2008-S4	JKR/SPJ/1988
Mix Designation	ACW14	ACW20
BS Sieve Size (mm)	Percentage Passing by Weight	
28.0	-	100
20.0	100	76 – 100
14.0	90 – 100	64 – 89
10.0	76 – 86	56 – 81
5.0	50 – 62	46 – 71
3.35	40 – 54	32 – 58
1.18	18 – 34	20 – 42
0.425	12 – 24	12 – 28
0.150	6 – 14	6 – 16
0.075	4 – 8	4 – 8

Table 1: Percentage Passing by Weight Between ACW14 Vs ACW20.
(Source: JKR Specification – Flexible Pavement)



Picture 1: Magnified Image of ACW14 (left) and ACW20 (right).

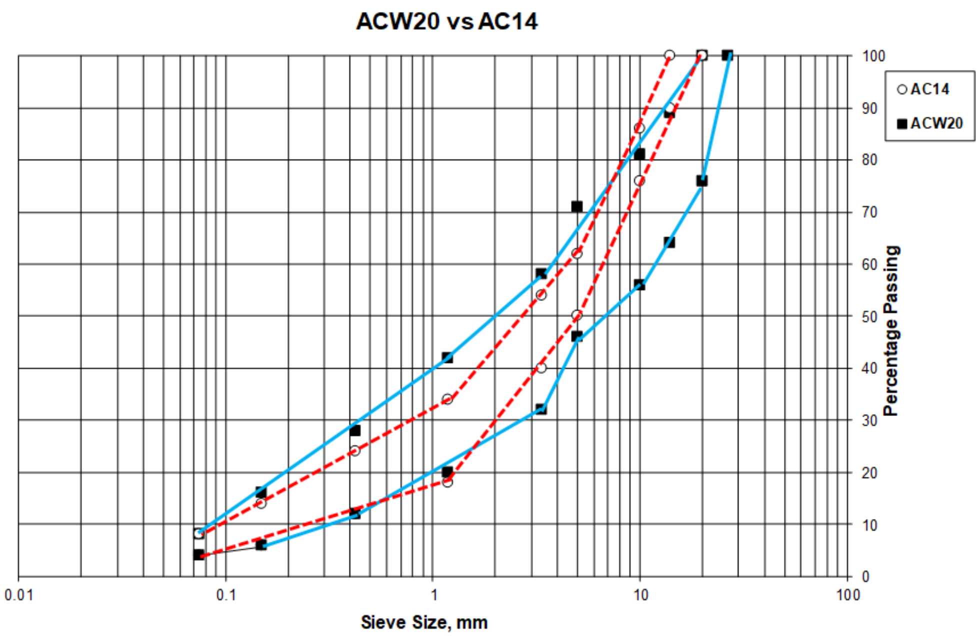


Figure 3: Grading Comparison Between ACW14 and ACW20
(Source: JKR Specification - Flexible Pavement)

Specification	JKR/SPJ/2008-S4					JKR/SPJ/1988				
Mix Designation	**ACW14**					**ACW20**				
BS Sieve Size (mm)	**Lower**	**Upper**	**Avg. % passing**	**% retained**	**Total % retained**	**Lower**	**Upper**	**Avg. % passing**	**% retained**	**Total % retained**
28	-		-		**44 (Coarse)**	100	100	100		**41.5 (Coarse)**
20	100	100	100	0		76	100	88	12	
14	90	100	95	5		64	89	76.5	11.5	
10	76	86	81	14		56	81	68.5	8	
5	50	62	56	25		46	71	58.5	10	
3.35	40	54	47	9	**50 (Fine)**	32	58	45	13.5	**52.5 (Fine)**
1.18	18	34	26	21		20	42	31	14	
0.425	12	24	18	8		12	28	20	11	
0.15	6	14	10	8		6	16	11	9	
0.075	4	8	6	4		4	8	6	5	

Table 2: Percentage Retained for Coarse and Fine Aggregate Between ACW14 vs ACW20.
(Source: JKR Specification – Flexible Pavement)

Table 2 shows the comparison analysis on the percentage retained by weight between ACW14 and ACW20. Coarse aggregates are those retained by sieve size 5 mm and above while fine aggregate are those that passes sieve size 5 mm. It shows that percentage of total retained for coarse aggregate for ACW14 is higher compared to ACW20. Total retained fine aggregate for ACW20 is higher than ACW14. There is about 23% of large aggregate (14 mm & 20 mm) in ACW20 and only 5% in ACW14 (Figure 4). This may have significant implication to the difference in performance of the two grading.

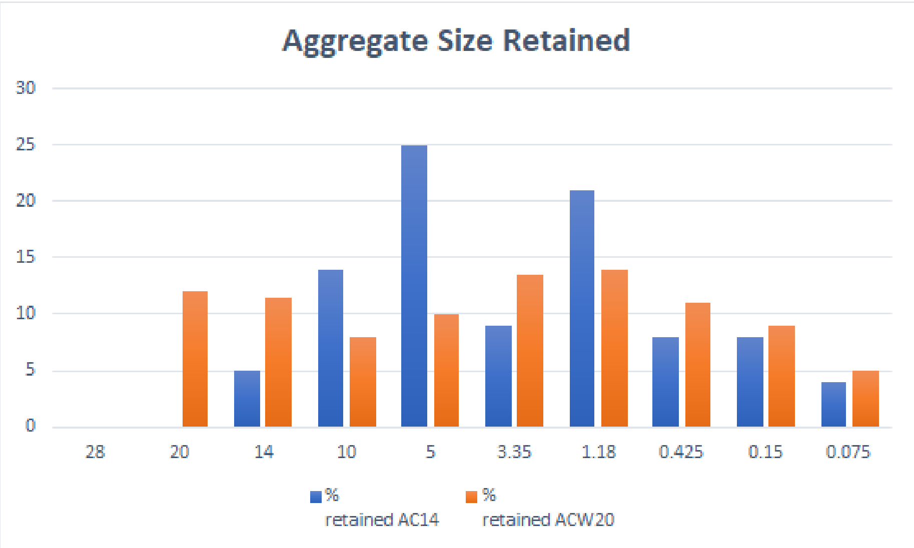


Figure 4: Chart of Percentage Retained vs Aggregate Size for ACW14 and ACW20.

5.0 METHODOLOGY

As part of the standard operating procedure during the investigation of a crash site, some important data on the condition of the pavement are also being collected. This procedure is to check on the possibility of the pavement could be the cause of the crash. There are a number of tests and measurements taken and among them are data that are very relevant in this study. They are as follows:

a) British Pendulum Tester (BPT) was conducted based on ASTM E303-87 to measures friction from micro-texture.
b) Sand Patch Test (Volumetric spot test) was conducted based on BS 598 Part 105 (1990) to provides mean texture depth (MTD) of pavement surface macrotexture.
c) The possible grading type of asphaltic wearing course of the existing pavement.

5.1 BRITISH PENDULUM TESTER (BPT)

Picture 2: Skid Resistance Values Are Measured using British Pendulum Skid Tester. The test is conducted based on ASTM E303-87.

Picture 2 showing a personnel using a British Pendulum Skid Tester to determine the skid resistance value of the pavement. A sample of completed form containing data collected on the Skid Resistance Value is given in Figure 5 above. To determine the skid resistance value of a section of road about 10 points (5 nos. per lane running diagonally) on the pavement surface must be identified. Each point shall be tested at least 5 times using the pendulum tester. The skid resistance values are recorded on the data collection form together with the pavement temperature. Finally, the mean value of the skid resistance is calculated taking into account of the pavement temperature variation.

JKR MALAYSIA	BAHAGIAN KEJURUTERAAN FORENSIK PAKAR KEJURUTERAAN JALAN & JAMBATAN	No. Dokumen : No. Keluaran : No. Pindaan : Tarikh : Muka Surat :

MEASURING SURFACE FRICTIONAL PROPERTIES USING THE BRITISH PENDULUM TESTER (ASTM E303)

Tarikh ujian:	08-10-15	Daerah :	Kuala Terengganu
Masa :	1.30 pm	Laluan :	F0003
Cuaca:	Cerah	Seksyen :	530.0
Pencerap:	Ahmad Shairazi Mohd Daud	Arah :	Marang - Kuala Terengganu

SAMPLE ID.	TEMPERATURE OF TEST SURFACE °C	BRITISH PENDULUM NUMBER (BPN)						
		MEASURED SRV						CORRECTED SRV AT 35°C
		1	2	3	4	5	MEAN	MEAN
1	37.3	53	51	51	50	51	51	52
2	39.7	47	45	45	44	46	45	47
3	40.6	50	49	49	49	49	49	51
4	38.4	50	49	49	47	47	48	50
5	37.6	40	42	42	41	41	41	42
6	37.7	45	40	45	40	43	43	43
7	40.7	45	47	45	45	44	45	47
8	40.5	50	42	45	50	49	47	49
9	40.6	47	45	45	45	46	46	47
10	39.0	46	46	47	45	46	46	47
AVERAGE								48

Figure 5: Sample of Data Collected for Skid Resistance Value

Note: British Pendulum Number (BPN) = Skid Resistance Value (SRV)

5.2 SAND PATCH TEST (VOLUMETRIC SPOT TEST)

The other important parameter with regards to the properties of wetted pavement surface is the texture depth. Picture 3 shows another personnel conducting the sand patch method to determine the mean texture depth of the pavement surface macrotexture. The test is conducted based on BS 598 Part 105 (1990).

Picture 3: Mean Texture Depth Being Measured At Site.

JKR MALAYSIA	BAHAGIAN KEJURUTERAAN FORENSIK PAKAR KEJURUTERAAN JALAN & JAMBATAN	No Dokumen:	
		No. Keluaran	
		No Pindaan	
		Tarikh:	
		Muka Surat:	

DETERMINATION OF AVERAGE TEXTURE DEPTH OF A PAVEMENT SURFACE USING THE SAND PATCH METHOD

Name:	Jalan Kuala Terengganu - Kota Bharu	Weather:	Cerah
Route:	F0003	From:	Bahagian Kejuruteraan Forensik
Section:	530.00	District:	Kuala Terengganu

Sample	Circle Diameter (mm)				Average diameter (mm)	Volume (cm3)	Texture Depth Average (mm)
	1	2	3	4			
1	190	180	170	180	180	25	0.98
2	180	190	190	190	188	25	0.91
3	185	195	500	200	270	25	0.44
4	180	190	190	190	188	25	0.91
5	145	150	155	155	151	25	1.39
6	165	155	155	160	159	25	1.26
7	165	160	150	165	160	25	1.24
8	185	180	180	185	183	25	0.96
9	180	180	190	190	185	25	0.93
10	200	175	185	190	188	25	0.91
					Mean Texture Depth (mm)		**0.99**

Figure 6: Sample of the Data Collected for Mean Texture Depth.

Figure 6 above shows the sample of the completed form containing data collected on the Mean Texture Depth. A minimum number of 10 point samples are tested for each test site and it is preferable that these points to be as close to the locations where the skid resistance values are being measured. For each sample, the average diameter of the circular sand patch is calculated by measuring the diameter at 4 different angles.

6.0 ANALYSIS AND FINDINGS

All the crash sites that were investigated are identified mostly through news media report and a few based on request by the District JKR throughout the country. An investigation team is send to these sites to execute the accident investigation procedures which include collecting data on skid resistance values and the mean texture depths. The type of pavement wearing course is identified by visual means. A total of 50 crash sites were investigated and 36% of them identified to be using ACW14 wearing course.

Bil	Jalan	Kod Jalan	Jenis Premix	SRV	MTD (mm)	SN
1	Jalan Pekan - Rompin	F0003	ACW14	52.7	1.36	32.39
2	Jalan Tanah Merah - Jeli	F0004	ACW14	54.3	1.38	34.17
3	Jalan Tanah Merah - Jeli	F0004	ACW14	48.9	0.94	27.00
4	Jalan Gambang - Kuantan	F0002	ACW14	47.0	0.66	23.73
5	Jalan - Kuantan Rompin	F0012	ACW14	51.4	0.86	29.17
6	Jalan Masuk Bandar Tun Razak	F2493	ACW14	58.0	1.96	40.22
7	Jalan Tampin - Gemas	F0001	ACW14	54.2	1.16	33.30
8	Jalan Kuala Terengganu - Kota Bahru	F0003	ACW14	48.0	0.99	25.91
9	Jalan Pantai Johor/Gunung Keriang/Jerlun	K2	ACW14	63.5	0.51	37.90
10	Jalan Kuantan - Segamat	F0012	ACW14	63.3	0.73	40.20
11	Jalan Ipoh - Lumut	F0005	ACW14	47.0	0.79	24.42
12	Menaiktaraf Jalan Tangkak - Jasin, Melaka (Pakej 1 : Tangkak ke Sempadan Negeri Melaka)	J21	ACW14	54.1	0.77	31.36
13	Projek Membina Dan Menaiktaraf Jalan Lingkaran Pulau Indah (Fasa1B & Fasa 2)	-	ACW14	65	0.67	41.68
14	Jalan Gapam / Seri Negeri, Daerah Melaka Tengah, Melaka	M12	ACW14	62.8	0.74	39.74
15	Jalan Seri Negeri / Semabok, Daerah Melaka Tengah, Melaka	F264	ACW14	60.4	0.57	35.77
16	Menaiktaraf Jalan Muar – Tangkak – Segamat, Johor (Fasa 1: Segamat – Tangkak) Pakej 1b	F0023	ACW14	67.4	0.39	39.33
17	Menaiktaraf Jalan Muar – Tangkak – Segamat, Johor (Fasa 1: Segamat – Tangkak) Pakej 2	F0023	ACW14	60.5	0.61	36.29
18	Menaiktaraf Jalan Dari Terowong (Selepas Tol Seremban) Ke Bandar Sri Sendayan, Laluan 195, Jalan Pusat Pelupusan Sisa Toksid, Seremban, Negeri Sembilan	F0195	ACW14	60.8	0.51	35.41
			AVERAGE	**56.6**	**0.87**	**33.78**

Table 3: Data Collection for ACW14.

Table 3 above is the list of sites where the wearing course is identified to be ACW14. There is a total of 18 locations encompassing both federal and state roads. Analysis on the data showed that the average value for Skid Resistance Value (SRV) is around 56.6 while the Mean Texture Depth (MTD) is 0.87 mm.

Bil	Jalan	Kod Jalan	Jenis Premix	SRV	MTD (mm)	SN
1	Jalan Cameron Highlands-Simpang Pulai	F0185	ACW20	58.0	1.28	37.80
2	Jalan Tanah Merah - Pasir Puteh	F0004	ACW20	51.5	0.99	29.87
3	Jalan Tampin - Gemas	F0001	ACW20	58.0	1.10	37.08
4	Jalan Pasir Puteh - Kota Bharu	F0003	ACW20	45.2	1.05	23.57
5	Jalan Kuala Kangsar - Gerik	F0076	ACW20	62.1	1.75	43.68
6	Jalan Gerik - Jeli	F0004	ACW20	56.3	1.12	35.38
7	Jalan Kulim-Baling	F0004	ACW20	59.0	1.21	38.59
8	Jalan Johor Bahru - Mersing	F0003	ACW20	51.9	1.24	31.18
9	Jalan Johor Bahru - Mersing	F0003	ACW20	55.8	1.32	35.59
10	Jalan Lekir - Setiawan	F0005	ACW20	56.9	1.22	36.41
11	Jalan Muar - Yong Peng	F0024	ACW20	59.0	1.25	38.26
12	Jalan Pekan - Rompin	F0003	ACW20	55.4	1.47	35.60
13	Jalan Ipoh - Gerik	F0076	ACW20	52.7	0.82	30.30
14	Jalan Kota Tinggi - Sungai Rengit	F0092	ACW20	53.4	1.39	33.20
15	Jalan Utama Jengka Utara/Selatan	F0083	ACW20	47.6	1.11	26.30
16	Jalan Gerik - Jeli	F0004	ACW20	49.8	1.12	31.56
17	Jalan Melaka - Muar	F0005	ACW20	59.5	0.88	37.46
18	Jalan BKE - Baling - Gerik	F0004	ACW20	71.4	1.16	51.40
19	Jalan Pasir Mas - Tanah Merah	F0129	ACW20	58.3	0.66	34.66
20	Jalan Johor Bahru - Mersing	F0003	ACW20	66.9	0.46	40.24
21	Jalan Gua Musang - Kuala Krai	F0008	ACW20	75.8	1.80	58.96
22	Jalan Temerloh - Jerantut	F0098	ACW20	56.0	1.30	35.74
23	Jalan Kuantan - Mentakab	F0087	ACW20	65.1	0.85	42.91
24	Jalan Changkat Jong	F0058	ACW20	70.3	1.56	52.07
25	Jalan Kepong - Kuala Selangor	F0054	ACW20	58.8	0.89	36.82
26	Jalan Simpang Pulai - Kinta	F3150	ACW20	57.3	0.99	35.83
27	Jalan Panglima Bayu - Rantau Panjang	F0196	ACW20	53.5	0.91	31.55
28	Jalan Setiawan - Kayan - Changkat Cermin	F0005	ACW20	52.2	1.25	31.53
29	Jalan Setiawan - Teluk Intan	F0005	ACW20	50.2	1.43	29.89
30	Jalan Kota Bharu - Pasir Mas	F0003	ACW20	52.2	1.23	31.47
31	Jalan Pintas Bandar Muar (Muar Bypass), Johor	F224	ACW20	60.1	0.48	34.37
32	Menyiapkan Kerja-Kerja Menaiktaraf Persimpangan Di Bandar Sultan Sulaiman / Pintu 2, Northport, Pelabuhan Klang,Selangor	-	ACW20	58	0.85	35.53
			AVERAGE	**57.4**	**1.13**	**36.40**

Table 4: Data Collection for ACW20.

Table 4 shows the crash sites where the pavement wearing course is identified to be ACW20. A total of 32 locations were selected on the number of federal roads. It was found that the average value for Skid Resistance Value (SRV) is 57.4 with the Mean Texture Depth (MTD) about 1.13 mm.

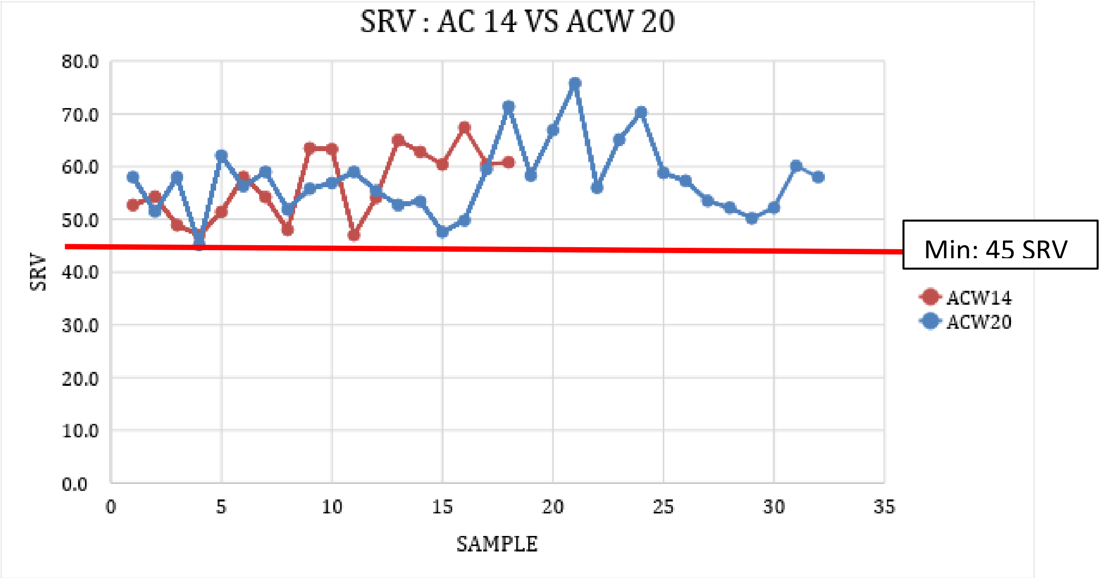


Figure 7: Comparison of Skid Resistance Values (SRV) for ACW14 and ACW20.

Skid Resistance values for both types of wearing course are plotted and is shown in Figure 7. All the data indicated that the values are all above the 45 SRV limit.

No.	SRV	AC 14	ACW 20
1	Mean	56.63	57.44
2	Standard Error	1.56	1.20
3	Median	56.15	57.10
4	Mode	47.00	58.00
5	Standard Deviation	6.62	6.79
6	Sample Variance	43.79	46.13
7	Kurtosis	-1.33	0.98
8	Skewness	-0.06	0.87
9	Range	20.40	30.60
10	Minimum	47.00	45.20
11	Maximum	67.40	75.80
12	Sum	1019.30	1838.20
13	Count	18.00	32.00
14	Confidence Level (95.0%)	3.29	2.45

Table 5: Analysis of Skid Resistance Value

Generally, analysis on the data showed that the mean SRV for ACW14 is only marginally lower than that of ACW20. However, the values are considered reasonably high as both are above the 55 SRV. The SRV values of ACW20 spreads out more (45.2 – 75.8) than that of the ACW14 which is a bit closer together (47.0 – 67.4).

The ACW20 wearing course has been used almost 20 years before the introduction of the ACW14. Some of the sites using ACW20 may have gone through much longer period of wear and tear by the daily moving traffic. This is attributed to the low value (i.e. 45.2) and wide range of the SRVs for ACW20 when compared to that of the ACW14. Whilst the higher range of the SRV (i.e. 75.8) may be due to the high proportion of the larger aggregate within the ACW20 matrix. Similarly, the wider range of the SRV for ACW20 may also be related to the wide envelope of the wearing course in the grading chart.

Analysis on the data showed that the average value of SRVs for both types of wearing course indicated no significant difference. Hence, based on SRV alone, the use of ACW14 may not be a factor for the high number of crashes.

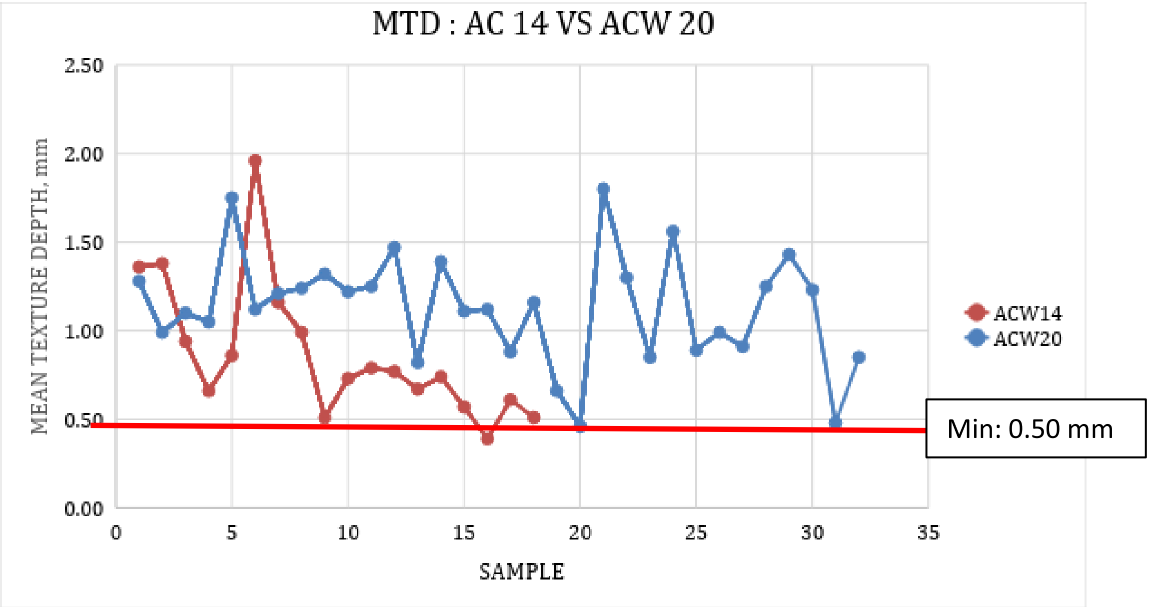


Figure 8: Comparison of Mean Texture Depth (MTD) for ACW14 and ACW20.

Figure 8 shows the plot of the Mean Texture Depth (MTD) values for both types of wearing course. Most of the values are above the 0.50 mm depth with a few points slightly less than the limit. However, the plot also indicated that MTD for ACW14 is much lower than that of ACW20.

No.	MTD	AC 14	ACW 20
1	Mean	0.87	1.13
2	Standard Error	0.09	0.06
3	Median	0.76	1.14
4	Mode	0.51	0.99
5	Standard Deviation	0.39	0.31
6	Sample Variance	0.15	0.10
7	Kurtosis	2.47	0.32
8	Skewness	1.49	-0.08
9	Range	1.57	1.34
10	Minimum	0.39	0.46
11	Maximum	1.96	1.80
12	Sum	15.60	36.14
13	Count	18.00	32.00
14	Confidence Level (95.0%)	0.19	0.11

Table 6: Analysis of Mean Texture Depth.

The analysis on the Mean Texture Depth (MTD) data is as shown in Table 6. The results indicated the average MTD for ACW14 is about 0.87 mm which is significantly lower (about 23%) than that of ACW20 which is 1.13 mm. However, both average MTD values for ACW14 and ACW20 complied with the minimum value required which is 0.50 mm.

The significant difference in average MTD may have marked effect on the capability of each type of pavement surface to drain out the water under the vehicle tyre. With lower MTD, ACW14 may be more likely to develop hydroplaning phenomena at high speed than that of ACW20.

7.0 CONCLUSIONS

Analysis on the data indicated that the difference in the average SRV values for ACW14 and ACW20 is very marginal and basically, insignificant. Hence, there is no strong evidence that ACW14 has lower skid resistance properties compared to ACW20 especially under normal dry condition.

Although, ACW14 has similar grading to ACW20, it contained slightly higher percentage of coarse aggregate of about 44% while ACW20 has 41.5% (see Table 4). The higher proportion of coarse aggregate may translate to stronger pavement due to the better interlocking action within the aggregate matrix. However, the higher proportion of the coarse aggregate in ACW14 does not have much influence on the SRV of ACW14.

Both wearing courses give MTD values around 0.8 mm and above which are quite good. The analysis showed that the ACW20 has much higher average MTD value when compared to that of ACW14. This may be largely due to the presence of larger aggregates (i.e. 14 & 20 mm) within its grading envelope. Better average MTD value basically means that ACW20 performs better in draining out the surface water runoff under the tyre during wet weather ride. In contrast, the lower average MTD value of ACW14 may have some negative impact in terms of the rate of draining out the water in the tyre-pavement interaction. Hence, ACW14 is much more likely to experience hydroplaning phenomenon than ACW20 during wet weather. High speed environment has higher risk of developing this and may cause skidding and out of control crashes. The comments that the use of ACW14 could have been the cause for the increase in the no. of road crashes may not be entirely unfounded, however, more research in this area is required.

8.0 RECOMMENDATION

a) Further study on skid resistance during wet weather is vital as it can provide better insight and understanding of pavement friction-tyre interaction.

b) More advanced testing method / equipment has been developed but local availability is very limited. Both the road authority and industry should push for latest testing technology. (Dynamic Friction Tester, Circular Texture Meter, Side-Force Friction Tester, Variable-Slip Tester)

c) Pavement age may affect skid resistance, as such further study on skid resistance of newly laid ACW14 is needed.

d) Camber value must be checked during construction in order to comply 2.5 % minimum to allow water run off flow out to the shoulder properly.

e) Data on SRV and MTD need to be continuously collected as and when accident forensic investigations are being conducted. More data would mean better analysis could be done with more accurate and convincing results.

9.0 REFERENCES

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