

The Measurements of Vehicle Braking Performance in Wet Asphalt Road Conditions

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Abstract

Tyres are fundamentally important to vehicle braking performance since they provide grip between the vehicle and the road. If the tyres do not work properly due to damage or wear, or when the road surface is contaminated, braking safety can be compromised. The purpose of this study was to determine the vehicle braking distance and deceleration on wet asphalt surface conditions. The asphalt surface used during the test is adhered to the ISO standard which is specially made for braking testing in wet road conditions. With its characteristics a maximum of 20 mm aggregate roughness. The value of skid resistance according to the BS ISO 23671: 2006 regulation is (50 ± 10) BPN as measured by a British Pendulum Tester (BPT). The type of vehicle to be used is the MPV (Multi Purpose Vehicle). SRTT (Standard Reference Test Tyre) is a tyre that is produced, controlled and stored in accordance with the ASTM (American Society for Testing and Materials) standard. This test will compare the wet braking performance of 2 (two) types of test tyres, namely SRTT tyre as reference tyre with candidate test tyre (spec A). From the results of the test data for asphalt skid resistance the value is 68 BPN. The wet braking performance data, the reference tyre (SRTT) average braking distance is 27,25 meters, while the candidate test tyre (spec A) is 25,69 meters.

Keywords: Tyres, SRTT (Standard Reference Test Tyre), Vehicle, Braking System, ISO Braking Asphalt, Skid Resistance, British Pendulum Tester (BPT)

1. INTRODUCTION

Tyres play important role in the vehicle braking system since they are in contact with the road surface which produce dynamic reaction forces to stop the vehicle. If the tyres are damaged or worn, and the road surface is contaminated, braking safety is compromised (as is the whole vehicle safety). The braking system of any road vehicle is subjected to extensive legislative standards and requirements in many

regions of the world. European Union (UN) Legislation and Regulations states that all road vehicles are required to have a working braking system that meets the legislative requirements. Included in the braking system requirements are 'service' and 'secondary' braking systems so that the vehicle can be safely brought to rest even in the event of the failure of one part of the system, and a 'parking brake' that can hold the vehicle safely on a specified incline [1, 2].

A Since braking system is one of the most important active safety means of a vehicle, brake designs and technology are continually being improved and supplemented with electronic systems that are helpful in controlling the vehicle under braking. According to a report from ECE, the need for regular and appropriate maintenance of any vehicles braking system must not be underestimated, 1.7 % of road accidents in Germany in 2009 were attributed to faulty brakes [2, 3].

From the explanation above, it can be concluded that the role of tyres is very important in vehicles. The condition of worn tyres can have an impact on the braking distance of a vehicle. Judging from the dangers posed by driving when the road conditions are wet, it is necessary to be alert for all motorists and other road users to always implement safety driving to prevent accidents from happening. The braking system and the condition of the vehicle tyres should also be checked regularly before we operate the vehicle.

The purpose of this study was to determine the relationship between the skid resistance of the asphalt surface and the vehicle braking distance on wet road surface conditions. The type of vehicle to be used is the MPV (Multi Purpose Vehicle). The SRTT (Standard Reference Test Tyre) will be used as a reference tyre to determine whether or not a candidate test tyre (Spec A) is good. This test will compare the wet braking performance of 2 (two) types of test tyres, namely SRTT tyre as reference tyre with candidate test tyres (spec A). In this test, the asphalt surface to be used is the ISO braking asphalt which is made for brake testing in wet road conditions. With its characteristics a maximum of 20 mm aggregate roughness. The value of skid resistance according to the BS ISO 23671: 2006 regulation is (50 ± 10) BPN as measured by a British Pendulum Tester (BPT) [4, 5].

2 METHODOLOGY

2.1 Vehicle and Speed Measurement Device Specification

The vehicle used by the author in this test is the Toyota Innova, with the specifications shown in Table 1. For a vehicle speed

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measuring device using the Racelogic VBOX, the specifications are shown in Table 2. [6].

Table 1. Car Specification

ITEM	SPECIFICATION
Engine Type	In-Line 4 Cylinder, 16-Valve, DOHC, VVT-i
Engine Capacity	1998 cc
Type of Fuel	Gasoline
Fuel Capacity (liter)	55
Transmission	Manual, 5 Speed
Steering (Power Steering)	With (Electric Power Steering)
Maximum Power (Ps/rpm)	138/5.600
Maximum Torque (Nm/rpm)	182/4.000
Fuel Intake System	EFI
Front Suspension	Double Wishbone
Rear Suspension	Multi-Link
Alloy Wheel Size	16 Inch
Tyre Size	205/65 R16 (Radial)
Dimension	4.735 x 1.830 x 1.795 mm

The condition of the vehicle that will be used in this test is carefully checked prior to testing. Careful examinations on engine condition, braking system, steering system and lighting systems are carried out.

The VBOX is one of the test instruments for non-contact distance and speed measurement. Using a powerful GPS / GLONASS engine, the VBOX records data 100 times per second and is equipped with a powerful 400 MHz PC processor. With IMU integration, USB and Bluetooth connectivity, compact flash card recording and audio functionality for voice tagging, the VBOX represents a flexible solution for a wide range of testing requirements. For accurate testing, even in areas where the view is obstructed, the VBOX has the ability to collect additional information from the IMU and combine it with GPS data in real-time to improve the quality of the parameters measured [6].

Table 2. Racelogic VBOX Specification

ITEM	SPECIFICATION
GPS (Maximum velocity)	1000 mph
GPS (Minimum velocity)	0.1 km/h
Update rate	100 Hz
Acceleration (Accuracy)	0.50 %
Acceleration (Maximum)	20 g
Compact Flash	Type I
Recording Time	Dependent on flash card capacity
Input Voltage Range	7 – 30 V DC
Power	Max. 5.5 Watts

2.2 Wet Braking Test Procedure

This test is conducted as a standard test at PT. Gajah Tunggal Tbk., and the wet braking test procedure are taken from the "Standard Wet Braking Test" belonging to the Proving Ground of PT Gajah Tunggal Tbk. The reference tyre to be used in this test is the SRTT (Standard Reference Test Tyre). SRTT is a tyre that is produced, controlled and stored in accordance with the ASTM (American Society for Testing and Materials) standard. This test will compare the wet braking performance of 2 (two) types of test tyres, namely SRTT tyre as reference tyre with candidate test tyres (spec A) [7].



Figure 1. Wet Braking Test Condition

In Figure 1, the conditions required for the wet braking test are as follows :

- a) The tracks must be wet 15 minutes before the test is carried out to ensure water depth
- b) Wind speed : ≤ 5 m/s
- c) Air temperature : $5^{\circ}\text{C} \leq \text{suhu udara} \leq 35^{\circ}\text{C}$

- d) Surface temperature : $5^{\circ}\text{C} \leq \text{suhu permukaan} \leq 55^{\circ}\text{C}$
- e) Soil temperature : temperature evolution of not more than 10°C during the test

Before starting the braking system test, warm-up must be carried out on ordinary vehicle tyres (wider or the same size as the test tyres). Perform 2 emergency brakes from a speed of 80 km/h to 0 km/h with 1 cooling of 1 km between 2 brakes. The braking points are marked with 6 cones as corridors and braking is carried out at the same point [7].

2.3 Asphalt Skid Resistance Testing

BPT is a dynamic pendulum type test instrument, used to measure the energy loss in the rubber under the tread of the pendulum rubbing against the surface being tested. This tool is intended for testing on a flat surface in the field or laboratory, and for measuring the polishing value on curved specimens. The unit of skid resistance value measured by the BPT tool is the British Pendulum Number (BPN), both for flat test surfaces or for polishing values for curved specimens. This value represents the properties of barriers or friction (frictional). The type of asphalt that the author will use in this test is "ISO Braking Asphalt". How to test asphalt skid resistance : The pendulum rod is lifted and placed in a locked position. The pendulum rod is released and allows the slide rubber to rub or touch the surface being tested, and immediately catch it again when the pendulum swings back in the opposite direction. The indicator needle points to the scale numbers printed on the measuring scale disc with BPN units. The more rigid the surface being tested, the greater the BPN reading. Each test is carried out four times when using natural rubber (British rubber), or five times when using synthetic rubber (AASHTO M 261) [8].



Figure 2. Test the roughness of asphalt with BPT

3 RESULTS

3.1. ISO Braking Asphalt Roughness Test Result

The ISO braking asphalt skid resistance data was collected at the Proving Ground of PT. Gajah Tunggal Tbk. This test method is in accordance with the standard of SNI 4427: 2008

concerning "The method of asphalt skid resistance test using the British Pendulum Tester (BPT)". The results of the ISO braking asphalt skid resistance test are shown in Table 3.

Table 3: ISO braking asphalt skid resistance test result

No	Temp (°C)	BPN					Average	Re-quire-ments	Re-marks
		1	2	3	4	5			
1	36	68	67	67	67	66	67	40 - 60	68
2	36	67	67	67	67	67	67		
3	36	68	68	68	68	68	68		
4	37	67	67	67	67	67	67		
5	37	70	71	69	70	71	70		
6	38	67	67	68	69	69	68		
7	38	69	69	69	69	69	69		
8	36	70	70	70	70	70	70		

From the results of the data collection above, there are 8 (eight) point areas on the ISO braking asphalt which are used as testing samples. This BPN test takes 5 times for each point of testing as the level of accuracy of the data. For the requirements of the skid resistance value in ISO braking asphalt in accordance with the BS ISO 23671: 2006 regulation is (50 ± 10) or 40 - 60 BPN. From the test results, we can see the average value of the ISO braking asphalt skid resistance is 68 BPN. From these data it can be concluded that the current BPN value is not in accordance with the predetermined standards.

3.2. Wet Braking Test Result

In this wet braking test the author will compare the wet braking performance of 2 (two) types of test tyres, namely SRTT tyre as reference tyre with candidate test tyres (spec A). The tyre size SRTT is P225 / 60 R16, while the candidate test tyre size (spec A) is 205/65 R16. The air pressure on both tyres is the same, the front and rear tyres is 220 kPa. The result of the wet braking test are as shown in Table 4.

Table 4: Wet Braking Test Result Data

SRTT Tyre Measurement	No	Braking Distance (m)	Average Deceleration (m/s ²)
	1	27,43	8,44
	2	27,42	8,44
	3	27,36	8,46
	4	26,99	8,58
	5	27,06	8,55

Spec A Tyre Measurement	No	Braking Distance (m)	Average Deceleration (m/s ²)
	1	25,58	9,05
	2	25,56	9,06
	3	25,93	8,93
	4	25,76	8,99
	5	25,61	9,04

From the results of the data collection above, the wet braking test was carried out with an initial speed of 80 km / h to a final speed of 20 km / h. This speed will be read on the Racelogic VBOX which we have set at a certain speed. For this test, the method used by the internal Proving Ground PT. Gajah Tunggal Tbk. namely the panic brake method, and data is taken 5 times of braking. The braking is carried out at the same starting point as indicated by the placement of the cone. The data above shows that the braking performance of the candidate test tyre (spec A) is better than the reference tyre (SRTT). The wet braking performance data, the reference tyre (SRTT) average braking distance is 27,25 meters, while the candidate test tyre (spec A) is 25,69 meters, so it can be concluded that the braking performance of the candidate test tyre (spec A) is good.

4 SUMMARY AND CONCLUSION

From the results of testing the data above, it can be concluded that the ISO braking asphalt (BPN) skid resistance value exceeds the standard requirements set by the BS ISO 23671:2006 regulation, which is 68 BPN. Meanwhile, the standard BPN value set should be 40 -60 BPN. This can have an impact on the results of the wet braking test, which results in good braking distance due to the high BPN value, so it is also better for a tyre's braking distance or has a high coefficient of friction. The wet braking test result data shows that the braking performance of the candidate test tyre (spec A) is better than the reference tyre (SRTT). The wet braking performance data, the reference tyre (SRTT) average braking distance is 27,25 meters, while the candidate test tyre (spec A) is 25,69 meters, so it can be concluded that the braking performance of the candidate test tyre (spec A) is good.

The hope of the next research is that improvement is needed in the ISO braking asphalt area, namely by asphalt polishing. It is hoped that the asphalt polishing can make the BPN value (skid resistance) decrease in order to obtain the BPN value according to the predetermined standards. It will also have an impact on the results of more accurate braking distances or in accordance with established regulations and for the development of better tyre products in braking performance on wet roads.

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