

The effect of contaminant on skid resistance of pavement surface

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Abstract. Skid resistance of the pavement surface is the force generated by the movement of the wheels of the vehicle on the surface of the pavement. Contaminants are materials that cover the surface of the pavement affecting the skid resistance of the pavement surface. The contaminant acts as a coating interface or direct contact of the pavement surface with the wheels of the vehicle which can cause adverse effects, such as the decreasing value of skid resistance of the pavement surface. This study aims to analyze the effect of some types of contaminants on skid resistance of pavement surfaces. The contaminants that used in this study were water, sand, salt, and lubricating oil. The study was conducted by direct testing on two types of pavement: flexible pavement and rigid pavement. The measurements of the skid resistance were made using the British Pendulum Tester with British Pendulum Number for two conditions: before and after the pavement surface was covered with contaminants. The results showed that there was a contaminant effect on skid resistance of pavement surface. Skid resistance of pavement surfaces decreased after the contaminants were covered in water, sand, salt, and lubricant by 20.1%, 22.8%, 37.1% and 50.5% respectively.

1. Introduction

In a dry season, pavement surface has a large and adequate skid resistance value. While in the winter, when the surface covered with a layer of mud, snow, ice, or others, so the skid resistance value is inadequate [1]. Environmental conditions are factors that greatly affect the skid resistance value of pavement surface and the wheels of the vehicle [2]. The skid resistance value of asphalt pavement surface is highly influential when the pavement surface is covered by contaminants [3]. This research will discuss contaminant and its effect on skid resistance value of pavement surface. How is the skid resistance value of the pavement surface before being exposed to contaminants and how does the contaminant affect the skid resistance value of the pavement surface? The measuring instrument used to determine the skid resistance value of pavement surface was British Pendulum Tester (BPT) with unit British Pendulum Number (BPN). Contaminants that were used are water, sand, salt, and lubricating oil. Measurement of skid resistance value was done for two types of pavement: flexible pavement and rigid pavement. This research used the regulation of SNI 4427: 2008 which is Way of Pavement Surface Pavement Test Using British Pendulum Tester (BPT) Tool [4].



2. Literature Review

Skid resistance is a force that withstands the relative motion between the wheels of the vehicle and the surface of the pavement. This resistance force is produced by the wheels' rotation or glide over the pavement surface (Figure 1).

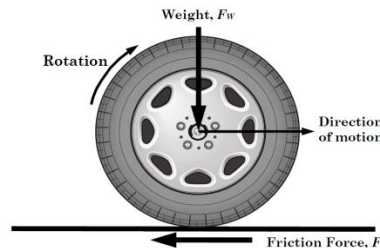


Figure 1. Diagram of force that occurs in vehicle rotation [2]

The pavement surface has sufficient skid resistance value if the frictional resistance between the tire and the road surface is sufficient and the surface is not slippery, so that dry or wet conditions do not result in smooth tires easily slip. Wet pavement surfaces are more dangerous for vehicles with smooth tire surfaces than dry surface conditions. The skid resistance scores are presented in Table 1. Factors affecting skid resistance of pavement surfaces are presented in Table 2.

Table 1. The recommended minimum skid resistance value [5].

Category	Type Location	Skid resistance value
A	Difficult locations such as:	65
	1. Roundabout	
	2. Finger turns <150 m on the highway.	
	3. Tilt, 1:20 or more steep, with length > 100 m	
B	4. Signal intersection of the intersection on the highway.	55
	Main/fast, continuous roads and 1st class roads and heavy traffic roads in urban areas (> 2000 vehicles per day)	
C	Other locations	45

Table 2. Factors affecting pavement skid resistance [6].

Characteristics of Pavement Surfaces	Parameters of Vehicle Operations	Ban Proofs	Environmental
• Micro Texture • Macro Texture • Mega texture or unevenness • Material Properties • Temperature	• Slip Speed - Speed of vehicle - Braking motion • Driving maneuvers	• Foot Print • Site Design and Condition • Rubber composition and hardness • Air pressure • Expenses • Temperature	• Climate - Wind - Temperature - Water (rain, condensation) - Snow and ice • Contaminants - Anti skid material (salt, sand) - Land, sand, ruins

The British Pendulum Tester (BPT) is a tool used to measure the skid resistance value of a pavement surface, equipped with a swing or pendulum at a certain position. The testing method consists of a

pendulum type tester mounted with a standard launching rubber to determine the skid resistance of tested pavement surface.

3. Research Methods

The method that was used in this research was experimental research method. The location of the study was chosen based on two types of pavement surface that were flexible pavement on Dr. A. Sofian Street (in USU Campus) and rigid pavement on Sisingamangaja XII Street.

3.1 Sample

The number of sample points were 10 sample points on each of the four types of contaminants provided. So, total sample point used 40 points. In the test, five sample points were taken for one type of contaminant on each segment of the road that became the location of the study. The five sample points were 70 cm from the edge of the pavement for flexible pavement, 20 cm away from the edge of the pavement for rigid pavement, and one another 40 cm longitudinal direction of the pavement. At each sample point, five repeated reading were performed : five repeated reading of skid resistance values of pavement surfaces before expose to contaminants and five repeated reading of skid resistance values of pavement surfaces after expose to contaminants. Selection of the number of sample points and the treatment of contaminant conditions per road segment was made referring to previous research on the value of skid resistance and the influence of contaminants. From that research, the skid resistance value of pavement surface was examined before (zero covered) and after (all covered) exposure to contaminant.

3.2 Contaminant Materials

The type of contaminants were selected and determined as follows : the water was from PDAM, the sand was sand that passed screen No.16 and stucked in screen No.30, the salt was salt which was passed screen the No.16 and stucked in screen No.30, and the lubricating oil was Castrol Go lubricating oil with viscosity SAE 20W-40.

3.3 Laying of Contaminant Materials

3.3.1 Before exposure to contaminants (zero covered).

The testing of skid resistance value of pavement surface before exposure to contaminants (Figure 2).

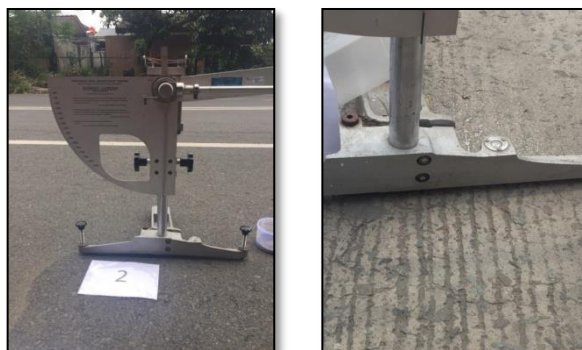


Figure 2. Pavement Surfaces before exposure to Contaminant

3.3.2 After exposure to contaminants (all covered).

Testing the skid resistance value when the pavement surface has been exposure to contaminants. Contaminants in the form of liquids (water and lubricating oil) were placed above the test surface and flattened using a brush, so that it covers all areas (Figure 3). On the other hand, the contaminants in the

form of solids (sand and salt) were placed above the test surface and flattened with a brush with a thickness of 1.0 mm based on the size of the passing material screen No.16 as 1.18 mm (Figure 4).



Figure 3. Pavement surfaces affected by water and lubricating oil contaminants



Figure 4. Pavement surfaces affected by sand and salt contaminants

The methods and stages used in data processing were as follows :

- Find the Skid Resistance Value Before and After Exposure to Contaminants. The test of the skid resistance of each sample point were repeated five times for the reading. The skid resistance value used was the average of the five repetitions of the reading. Similarly, the skid resistance value of the pavement surface that have been exposure to contaminants.
- After the skid resistance value for each sample were obtained, then the data were described using statistical description by calculating the average value and the percentage of skid resistance decrease value.
- The percentage of the decrease in the skid resistance value was calculated using the equation:

$$\text{The percentage decrease} = \left(\frac{\text{Skid Resistance Decrease Value}}{\text{Initial Skid Resistance Value}} \right) * 100\% \quad (1)$$

- Find the the influence of contaminants on pavement surfaces between the two variables : the contaminant (independent variable) and the skid resistance value (dependent variable) using Two Way Anova test method with SPSS 15.0 software [7]. The purpose of the Two Way Anova test (Anova Two Directions) was to determine whether there was an influence between the provision of contaminants to the skid resistance value on two types of pavement surface.

4. Results and Analysis

4.1 Skid Resistance Test Result

The average of skid resistance value from the five sample points (BPN) before and after exposure to contaminants can be seen in Table 3.

Table 3. The average of skid resistance value (BPN) before and after exposure to contaminants.

No.	Type of contaminants	Average of skid resistance value (BPN)			
		Flexible Pavement		Rigid Pavement	
		Before	After	Before	After
1	Water	51.76	41.92	59.92	46.96
2	Sand	52.60	40.96	67.76	51.84
3	Salt	56.84	36.04	59.24	36.92
4	Lubricant Oil	54.60	28.04	60.00	28.64
	average	53.95		61.73	

Before exposure to contaminants, the average of skid resistance value (BPN) on Dr. A. Sofian Street with flexible pavement type was 53.95 and Sisingamangaraja XII Street with rigid pavement type was 61.73. Based on Table 1, the minimum skid resistance value for flexible pavement type with category C is 45 and for rigid pavement type with category B is 55. So, those values were still adequate. After exposure to water, sand, salt and lubricating oil contaminants, the skid resistance value on Dr. A. Sofian Street with bending pavement types were 41.92, 40.96, 36.04, and 28.04, respectively. On the other hand, the skid resistance value on Sisingamangaraja XII Street with rigid pavement type were 46.96, 51.84, 36.92, and 28.64. Based on the minimum skid resistance value, those values were inadequate.

The average percentage of skid resistance decrease value affected by contaminants has shown in Tabel 4.

Table 4. The average percentage of skid resistance decrease value because of contaminants.

No.	Type of Contaminants	Average percentage of decrease (%)	
		Flexible Pavement	Rigid Pavement
1	Water	19.0	21.6
2	Sand	22.1	23.5
3	Salt	36.6	37.7
4	Lubricant Oil	48.6	52.3

The average percentage of the skid resistance decrease value on flexible pavement surface affected by water contaminant was 19.0%, sand contaminant was 22.1%, salt contaminant was 36.6%, and lubricant contaminant was 48.6%. On the other hand, the average percentage of the skid resistance decrease value on rigid pavement surface contaminated by water was 21.6%, sand was 23.5%, salt was 37.7%, and lubricating oil was 52.3%.

The contaminants that gave the effect of the skid resistance decrease value from the smallest to the greatest were water, sand, salt, and lubricating oil (Figure 5).

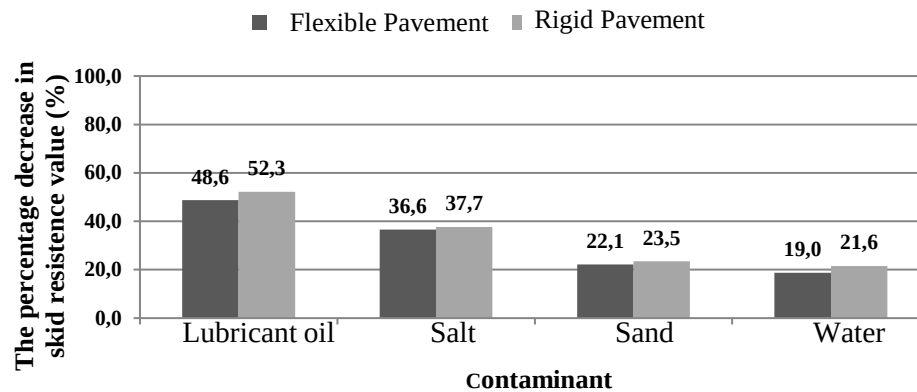


Figure 5. The average percentage of skid resistance decrease value

4.2 Statistical Test Results

Based on Kolomogorov-Smirnov Test, at significance level $\alpha = 5\%$ or 95% confidence level obtained p-value of 0.343. Because of the p-value ($=0.001$) $> \alpha$ ($=0.05$), it means the distribution of data was normally then continued with the next test. The results of differential influence analysis of research factors using Two Way Anova Test, for contaminant type factor at significance level $\alpha = 5\%$ or 95% confidence level obtained p-value of 0.001. Because of the p-value ($=0.001$) $< \alpha$ ($=0.05$) then there was influence of contaminant type factor for the data at 5% significance level. Or in other words, it can be concluded that the type of contaminant of water, sand, salt and lubrication have given influence significantly to the skid resistance value of the pavement surface.

5. Conclusion

Based on the results of the research there are some conclusions as follows: (1) Based on minimum skid resistance value, the skid resistance value on flexible and rigid pavement before exposure to contaminants were still adequate, but after exposure to contaminants were inadequate; (2) There was an effect on the skid resistance value on the pavement surface with water, sand, salt, and lubricating oil as contaminant on the surface of flexible and rigid pavements; (3) The contaminants that gave the effect of the skid resistance decrease value from the smallest to the greatest were water, sand, salt, and lubricating oil.

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