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The Effect of Aggregate Micro and Macrotexture on Pavement Skid Resistance in UTHM Campus Pagoh

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Abstract

Skid resistance is crucial for driver safety, as the friction force between a vehicle's tires and the road surface prevents sliding. Road accidents are a global issue, resulting in millions of deaths and injuries annually, often due to inadequate pavement skid resistance. This issue is exacerbated in wet weather conditions. This study aims to examine the effect of aggregate micro and macro texture on pavement skid resistance at UTHM Campus Pagoh. The British Pendulum Test and Sand Patch Method, following ASTM E303 and ASTM E965 standards respectively, were employed. The skid resistance values were analyzed against the JKR index, which requires a minimum skid resistance of 65 for both wet and dry conditions and a macrotexture depth above 0.5 mm. The best sand patch result was 344 mm, with the highest value on turning lane block E. The results indicate that the pavement on campus meets the JKR index, confirming that it is safe for use. The skid resistance value is a vital factor in road safety.

1. Introduction

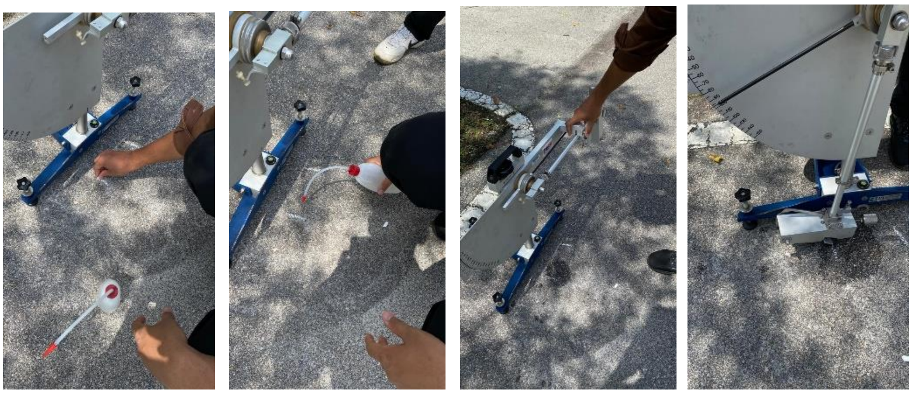
The condition of road pavement is one of the most important aspects to determine safety in public areas, such as shopping malls and playgrounds [1]. Sand patch method is used to assess the surface texture depth that is the average depth daily or long journeys. There are ways to determine its level of safeness to ensure the road is kept up to date to guarantee a safe road. British Pendulum Test (BPT), which is highly known for its ability to determine or study problems in the design and maintenance of public highways, and to test the frictional resistance of new roads, road markings and iron works. Pavement texture detection technology can provide the basis for skid resistance prediction, construction uniformity analysis, traveling severity classification, and tire-pavement noise evaluation[2].

2. Methods

To understand the research status of asphalt pavement texture, the related achievements and progress of pavement surface texture were systematically sorted out from three aspects: the characterization of pavement surface texture, the texture measurement and evaluation, and the relationship between texture and the skid resistance [3]. Two methods were used to figure out the amount of skid resistance. There are ways to determine its level of safeness to ensure the road is kept up to date to guarantee a safe road [4]. British Pendulum Test (BPT), which is highly known for its ability to determine the skid resistance value and to study problems in the design and maintenance of public highways, and to test the frictional resistance of new roads, road markings and iron works. Sand patch method is used to assess the surface texture depth that is the average depth daily or long journeys. Fig.1 depicts the researched study's flowchart.

2.1 British Pendulum Test (ASTM E303)

British Pendulum Test is an easy method to determine the skid resistance for pavement. The index for skid resistance test is ASTM E303 [5]. BPT can be used to identify the pavement microtexture and pavement friction with the tire. The texture of pavement can be classed by four levels. For example, mega-texture, macrotexture, micro texture and roughness with wavelengths scope; >50 mm, 0.1¬50mm, 0.1¬20 mm, 1¬500 nanometer[3]. Pendulum Test Value (PTV) can be affected by temperature, pavement conditions and roughness and surface regularity. The friction of pavement can be determined by its regularity. Relatively, small friction values were obtained for surfaces with small irregularities [6]. Two conditions of pavement surface are wet and dry that give the main aspects for the changed value of friction coefficient. The friction coefficients were significantly higher on the dry surfaces than on the wet surfaces [4]. The wet condition of the pavement surface decreases the friction coefficient plus the BPN. The pavement microtexture mainly depends on the surface texture of the aggregate, which is affected by factors such as the particle shape, angularity and texture characteristics of the aggregate. [1]



(a) (b) (c) (d)

Fig 1 *British Pendulum Test; (a) Mark the road; (b) Pour water on the road for wet condition; (c) Lock the stopper; (d) Release the stopper*

2.2 Sand Patch Method

Applying a known amount of glass beads or sand on a textured surface and spreading it outward into a circle is the test's method. The mean texture depth (MTD) is determined by averaging the measurements of the circle's diameter on each of the four axes. The diameter of the circle is measured on four axes and the values are averaged. The value is then used to calculate the mean texture depth (MTD) [7]. The pavement's skid resistance is then ascertained using the MTD. The sand patch test is for determining pavement skid resistance and assessing the effectiveness of different building materials and techniques. The research advances pavement texture analysis and provides a technologically advanced and useful substitute for conventional sand patch techniques [8]. With a rectangular patch used in place of the circular one to allow for direct comparison with MTD determined using point cloud data. Standard sand is filled into a measuring cylinder, then the sand is gradually poured onto the desired area, distributed with a disc tool, and the corners are smoothed with a steel ruler. Next, using the volume of sand that remains, the final MTD is computed. The efficacy of the proven pavement macro-texture Finite Element model in this research setting is assessed using the sand patch method as a baseline [6].

(a) (b) (c) (d)

Fig 2 *Sand Patch; (a) Clean the road; (b) Pour the road; (c) Flatten the sand using hockey puck; (d) Measure the diameter of the sand*

3. Result and Discussion

The test was carried out to the effect of aggregate micro and macro texture on pavement skid resistance of UTHM Campus Pagoh using British Pendulum Test and Sand Patch Method.

3.1 Microtexture Measurement

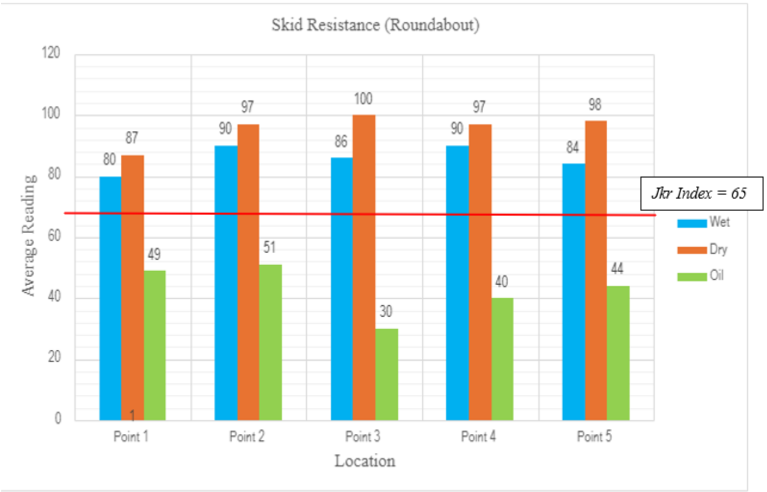
Microtexture measurement was carried out to obtain skid resistance value according to ASTM E303-83 standard and further analysis is shown in subsequent sections. The effect of pavement wheel track deformation on pavement texture was considered, and different data calibration methods and reference plane definitions on MTD calculations were compared [9].

3.1.1 Microtexture Measurement at Roundabout

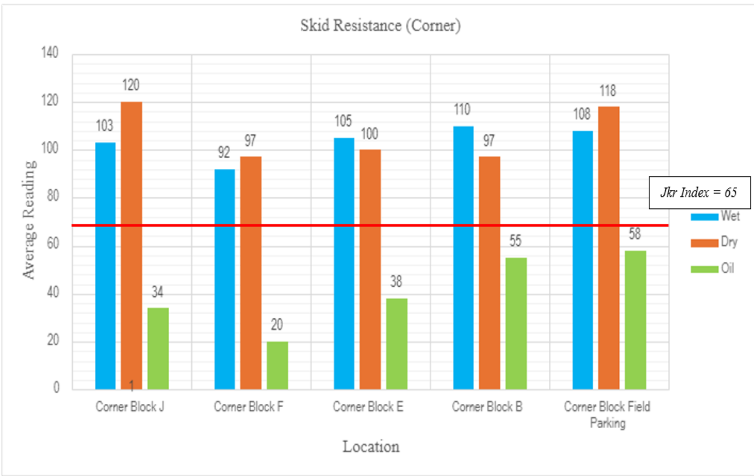
These are graphs of skid resistance tests that have been conducted at the roundabout for five checkpoints. The dry condition on all 5 points shows a considerable amount of skid resistance where all of it passes the index required in between or greater than 55 and 65. Hence, it is proposed that the minimum value of SRV for safe riding conditions on Malaysian roads is 55 SRV [5]. Based on figure Fig 3 (a), these amounts show that the skid resistance at the roundabout is at optimum condition and can still be used for a longer period. For this test we took three different road conditions namely wet, dry and oily. Looking at the picture below shows the reading of the first roundabout recorded the lowest reading for wet and dry road conditions which are 80 and 87. While for the greasy road area the lowest is the third reading which is 30. The highest reading for dry road is point 3 of 100 and wet at points 2 and 4 as much as 90. As for the highest level of oily road surface at point 2, 51. However, the condition of this road does not affect the road in UTHM Pagoh and is still good.

3.1.2 Microtexture Measurement at corner

These are graphs of skid resistance tests that have been conducted at the corners for five checkpoints. All five of the dry conditions exhibit a reasonable level of skid resistance, passing the necessary index in between or greater than 55 and 65. Hence, it is proposed that the minimum value of SRV for safe riding conditions on Malaysian roads is 55 SRV [5]. Fig 3 (b) demonstrates that the roundabout's skid resistance is in optimal condition and has more time to be useful. For this test we took three different road conditions namely wet, dry and oily. Looking at the picture below shows that corner block F recorded the lowest reading for wet, dry and oily road conditions which are 92, 97 and 20. The highest reading for dry conditions is at corner block J which is 120. While for the wet road surface it is at corner block B which is 110. However, it does not affect the condition of the road because it exceeds the set JKR index which is 65 and above.



(a)



(b)

(c)

Fig 3 *Average skid resistance value for 5 spots; (a) at the roundabout; (b) at the corners; (c) at the T Junction*

3.1.3 Microtexture Measurement at T-junctions

These are graphs of skid resistance tests that have been conducted at T junctions for five checkpoints. The dry condition on all five points demonstrates a significant amount of skid resistance, with all passing the needed index in between or greater than 55 and 65. Hence, it is proposed that the minimum value of SRV for safe riding condition on Malaysian roads is 55 SRV [5]. Fig 3 (c) indicate that the roundabout's skid resistance is in good condition and can be used for an extended period. For the condition of the road in the T junctions' area, it was found that the lowest reading in the T junction block F area for dry surface is 103 and for wet surface in Block E is 93. For the lowest value for oily surface is 30 in the T junction parking area. Looking at the highest value at T junction share facilities which is 115 for dry surface while wet surface at T junction parking and gym, 100. As for oily surface it is at T junction block E which is 78 and the highest in every reading. This is likely due to road conditions as rough or textured surfaces may still provide resistance despite the presence of oil.

3.2 Macrotexture Measurement

From the data that were collected, the mean diameter of sand (mm) was calculated and has been formed into a bar chart to present the value of it. The JKR specification for macrotexture measurement based on ASTME965.

3.2.1 Macrotexture Measurement at Roundabout

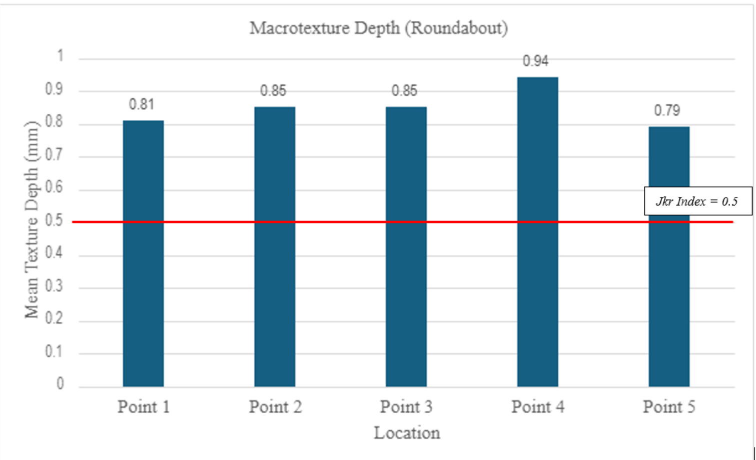
This is the table that was made based on macrotexture measurement values that were obtained for five checkpoints at roundabout. Based on Fig 4, Average Mean Texture Depth (MTD) value for the first point is 280 mm,the second point is 273.75 mm,the third point which is 273.4 mm,the fourth point is 254 mm and the last point which is 285 mm. All of it was under open texture classification. The texture depth for all of the points were above 0.79 which passes the index that JKR provided which is above 0.5. Minimum threshold value of MTD is 0.45 [5]. Based on the values that were obtained the condition for macrotexture measurement at roundabout is consistent and was under a great condition.

3.2.2 Macrotexture Measurement at Corner

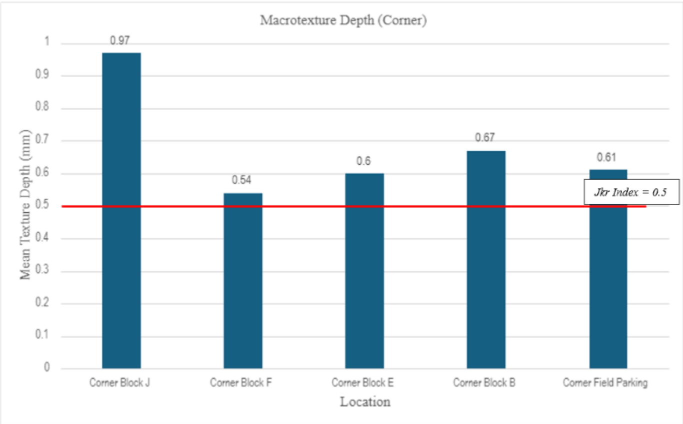
This table was created using the macrotexture measurement values that were collected for each of the five roundabout checkpoints. Based on Fig 5, the first point has an average Mean Texture Depth (MTD) value of 265.25 mm, followed by the second point at 344 mm mm, the third point at 324.75 mm, the fourth point at 308.25 mm, and the final point at 324.25 mm. Everything falls under the description of open texture. All of the texture depth values for 5 locations passing the JKR-provided index are above 0.5. Minimum threshold value of MTD is 0.45 [10]. The macrotexture measurements at corners are in a consistently good condition, based on the results that were obtained.

3.2.3 Macrotexture Measurement at T-junctions

The macrotexture measurement values that were gathered for each of the five T Junctions checkpoints were used to construct this table. Based on Fig 6, the average Mean Texture Depth (MTD) value for the first point is 277.75 mm, and the values for the next, third, fourth, and final points are 318.75 mm, 277.5 mm, 311.25 mm, and 307.75 mm, respectively. Everything was described as having an open texture. which gives the values of 0.83 mm, 0.63 mm, 0.83 mm and 0.66 mm and 0.67 which all of it passes the JKR-provided index which is above 0.5. Minimum threshold value of MTD is 0.45 [5].



(a)



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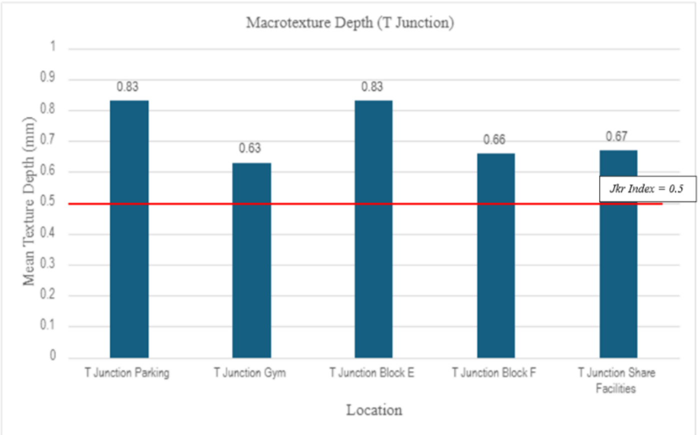

(c)

Fig 4 *The mean diameter of sand (mm) value for 5 spots at the, a) Roundabout, b) Corners and c) T Junctions*

Conclusion

The purpose of this study was to use ASTM E303-22, ASTM 965, and JKR standards to assess the micro and macro texture of pavement in dry, wet, and greasy circumstances. Five readings for skid resistance and four readings for sand patch were taken during the test, which was carried out at three separate places on the UTHM Campus Pagoh. The findings indicated a positive correlation between sand diameter and skid resistance values, indicating that higher skid resistance values are seen on road surfaces with deeper texture. This shows that rougher surfaces could provide cars more traction and grip, which would increase road safety. Both the wet and dry road conditions met the JKR criteria; the coarse surfaces, which are appropriate for roundabouts and wet climates, give a better skid resistance. The best sand patch result was 344 mm, with the highest value on turning lane block E. The road inside UTHM Campus Pagoh is still in good condition and does not need maintenance in the near future.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author confirms sole responsibility for the following: ***Study conception and design:*** *Muhammad Aidil Fikri Bin Safuan, Iqbal Akmal bin Idurus, Muhammad Fareez Syahmi bin Jamaluddin. Data collection: Muhammad Aidil Fikri Bin Safuan, Iqbal Akmal bin Idurus, Muhammad Fareez Syahmi bin Jamaluddin.* ***Analysis and interpretation of results:*** *Muhammad Aidil Fikri Bin Safuan, Iqbal Akmal bin Idurus, Muhammad Fareez Syahmi bin Jamaluddin and* ***Draft manuscript preparation:*** *Muhammad Aidil Fikri Bin Safuan, Iqbal Akmal bin Idurus, Muhammad Fareez Syahmi bin Jamaluddin.* ***Finalist manuscript preparation:*** *Hazirah binti Bujang.*

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