Effect of Asphalt Content on the Surface Texture of Asphalt Concrete-Wearing Course (AC-WC) Mixture

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ABSTRACT

Road preservation is carried out as an effort to improve road quality, evaluated through surface roughness levels, considering that adequate road texture is a crucial factor in ensuring rider safety and comfort. This study aims to analyze the relationship between variations in asphalt content and the Mean Texture Depth (MTD) value in asphalt mixtures. Surface roughness measurements obtained through the Sand Patch Method are expressed as MTD values representing average texture depth. Results for asphalt contents of 5%, 5.5%, 6%, 6.5%, and 7% yielded MTD values of 0.59 mm, 0.54 mm, 0.48 mm, 0.36 mm, and 0.26 mm for the upper side; 0.45 mm, 0.48 mm, 0.41 mm, 0.32 mm, and 0.24 mm for the lower side; and 0.52 mm, 0.51 mm, 0.45 mm, 0.34 mm, and 0.25 mm for the combined upper-lower sides. The relationship between MTD and asphalt content was analyzed using linear regression with the coefficient of determination (R^2) as the evaluation parameter. Asphalt content influenced texture depth by 66.34% (upper side), 47.3% (lower side), and 53.73% (combined sides). The Voids Filled with Bitumen (VFB) parameter significantly contributed to MTD variation, with influence levels of 41.3% (upper), 46.07% (lower), and 43.13% (combined). The analysis demonstrates that lower asphalt content produces rougher asphalt mixture surface textures. AC-WC mixture testing confirms that asphalt content affects MTD values.

Keywords: AC-WC, asphalt content, surface texture, texture depth, sand patch method

1. INTRODUCTION

Roads are transportation facilities that play an important role in various community activities in a region, both urban and rural. As stated in the Ministry of Public Works and Public Housing (PUPR) strategy, with one of the strategies being road preservation. Road preservation is the improvement of road quality measured by the average roughness index (IRI),[1]. The urgency of conducting road preservation is, according to the Central Bureau of Statistics updated in 2024, that the total number of accidents in Indonesia reached 139,258. This matter is related to traffic accident risk factors including physical environmental conditions like potholes, damaged roads, wet/slippery roads, darkness, rain, and weather conditions[2].

According to Hardiatmo (2007) in [3], the types of flexible pavement distress can be identified as follows: deformation, cracks, edge damage of the pavement, surface texture damage, potholes, patches, and utility cut patching [4]. This condition can occur due to various factors, including the determination of the type of asphalt used, asphalt content, voids in the mixture, mixing temperature, or compaction [5].

The quality of road pavement can be determined by several methods and evaluation parameters that cover both structural and functional aspects of the road surface. The asphalt content in the pavement mixture plays an important role in determining the functional characteristics of the pavement, including the resulting surface texture. This study aims to determine the effect of variations in asphalt content on the texture depth value (MTD).

2. THEORY AND METHODS

2.1 Theory of Texture Depth Measurement

The materials used in the asphalt mixture are aggregates sourced from PT. Sulenco Wibawa Perkasa, Peniraman Village, Mempawah Regency, West Kalimantan, and Shell Pen 60/70 asphalt as the binder. The research procedure is presented in Figure 1.

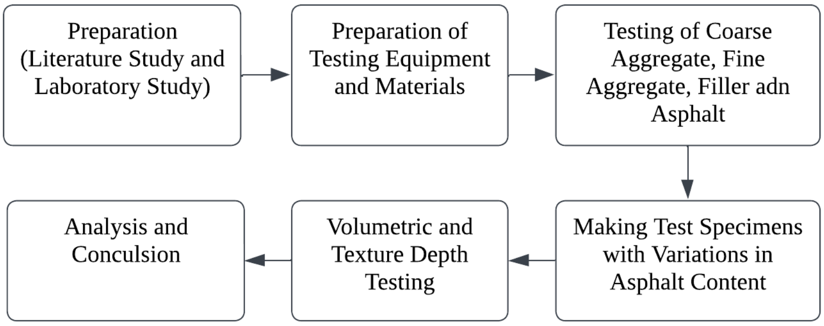


Figure 1. Research Flowchart in the Laboratory

The texture depth (MTD) measurement was performed using the Sand Patch Method.[6]. This method is a volumetric technique for measuring surface texture depth using sand with specific requirements [7]. This measurement refers to the standards of the Bina Marga General Specification 2018 Revision 2 and ASTM E695 [8].

2.2 Metode Penelitian Kedalaman Tekstur

For the measurement method of texture depth value (MTD), the Sand Patch Method is used with a rubber disc having a thickness of about 1 inch and a width of 2.5 to 3.5 inches, as shown in Figure 2.

Figure 2. Texture Depth Testing with the Sand Patch Method [9]

The test uses sand passing through sieve No. 50 with a size of 0.300 mm and retained on sieve No. 100 with a size of 0.150 mm

Macrotexture is evaluated to determine the surface texture variability of asphalt pavement, which is expressed by the Mean Texture Depth (MTD) using the following equation [10] :

$$MTD = \frac{4 \times V}{\pi \times D^2} \quad (1)$$

Keterangan :
MTD = Mean Texture Depth (mm)
V = Volume of sand (mm^3)

D = Average diameter (mm)

3. RESULTS AND DISCUSSION

3.1 Aggregate Test Results

The purpose of aggregate material testing is to ensure that fine aggregate, coarse aggregate, and filler materials meet the allowed specifications because aggregates constitute more than 90% of the mixture [11]. The feasibility testing is reviewed based on the results of aggregate specific gravity, absorption value, aggregate abrasion, and flakiness and elongation tests. The aggregate test results are presented in Table 1, Table 2, and Table 3.

Table 1. Coarse Aggregate Test Result

Test Type	Test Method	Specification		Test Result	Remarks
		Min.	Max.		
Bulk Specific Gravity	SNI 1969 : 2016	2.5	-	2.71	Passed
SSD Specific Gravity		2.5	-	2.72	Passed
Apparent Specific Gravity		2.5	-	2.73	Passed
Absorption (%)		-	3	0.29	Passed
Aggregate Abrasion (%)	SNI 2417 : 2008	-	40	0.00	Passed
Flakiness Test (%)	SNI 8287 : 2016	-	25	16.67	Passed
Elongation Test (%)		-	25	16.94	Passed

Table 2. Fine Aggregate Test Results

Test Type	Test Method	Specification		Test Result	Remarks
		Min.	Max.		
Bulk Specific Gravity	SNI 1969 : 2016	2.5	-	2.68	Passed
SSD Specific Gravity		2.5	-	2.70	Passed
Apparent Specific Gravity		2.5	-	2.73	Passed
Absorption (%)		-	3	0.72	Passed

Table 3. Filler Test Results

Test Type	Test Method	Specification		Test Result	Remarks
		Min.	Max.		
Bulk Specific Gravity	SNI 1970 : 2016	2.5	-	2.63	Passed
SSD Specific Gravity		2.5	-	2.65	Passed
Apparent Specific Gravity		2.5	-	2.69	Passed
Absorption (%)		-	3	0.92	Passed
Sand Equivalent (%)	SNI 03-4428-1997	65	-	68.657	Passed

In Table 1, Table 2, and Table 3, the laboratory test results indicate that the aggregates are suitable for use as a mixture in AC-WC asphalt. According to the Specification, the specific gravity of the aggregates must be greater than 2.5, the absorption value less than 3%, aggregate abrasion less than 40%, and flakiness and elongation less than 25% [12].

3.2 Asphalt Test Results

The purpose of asphalt testing is to ensure that the asphalt meets the specifications. Feasibility testing is reviewed based on the results of penetration, asphalt specific gravity, softening point, flash point, ductility, and weight loss tests. Pen 60/70 asphalt was used in this testing. The asphalt test results are presented in Table 4.

Table 4. Asphalt Test Results

Test Type	**Test Method**	**Specification**		**Test**	**Remarks**
		Min.	**Max.**	**Result**	
Penetration at 25°C (mm)	SNI 2456 : 2011	60	70	66,17	Passed
Asphalt Specific Gravity	SNI 2441 : 2011	1	-	1,054	Passed
Softening Point	SNI 2434 : 2011	48	-	48,20	Passed
Flash Point	SNI 2433 : 2011	232	-	325	Passed
Fire Point	SNI 2433 : 2011	232	-	347	Passed
Ductility at 25°C (cm)	SNI 2432 : 2011	100	-	143	Passed
Weight Loss (%)	SNI 06-2440-1991	-	0,8	0,054	Passed

In Table 4, the laboratory test results show that the asphalt is suitable to be used as a binder material in the AC-WC asphalt mixture. According to the Specification, the penetration value must be between 60 and 70, the asphalt specific gravity greater than 1, the softening point above 48°C, the flash point above 232°C, the ductility greater than 100 cm, and the weight loss less than 0.8%.

Viscosity testing was conducted using secondary data [6], The asphalt mixing temperature was obtained at 156°C and the compaction temperature of the mixture at 145°C, which were used during the asphalt mixture preparation process for the test specimens [13]. Laboratory testing is conducted to ensure that aggregate and asphalt materials comply with the Bina Marga General Specification 2018 Revision 2.

3.3 Preparation of Asphalt Mixture Test Specimens

In the production of asphalt concrete, the main components are asphalt binder and aggregates. A continuous gradation is used for the AC-WC mixture, as shown in Figure 2. The compaction results are presented in Figure 3, and the test specimens are shown in Figure 4 and Figure 5.

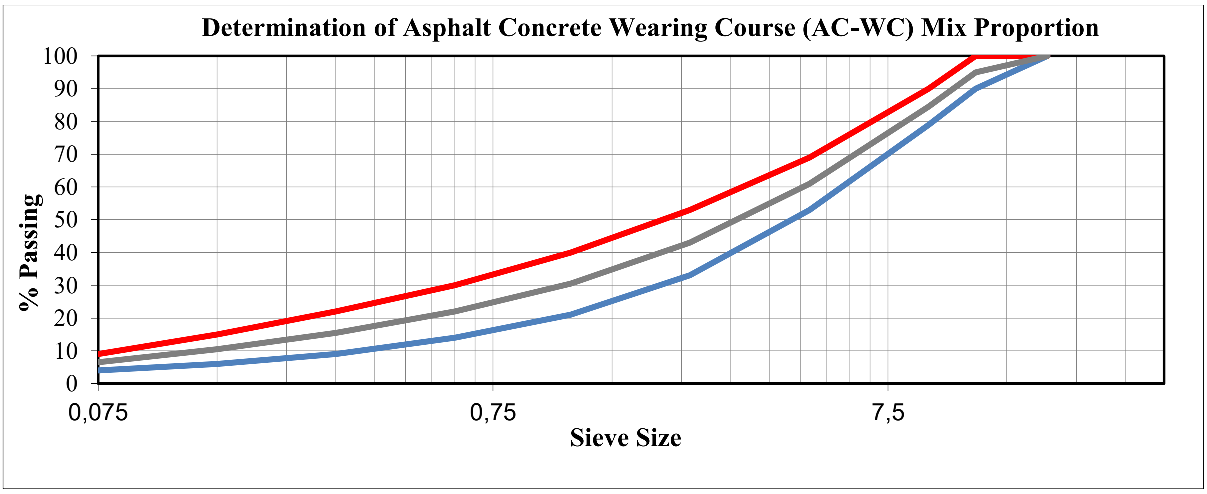


Figure 3. Gradation Envelope Graph of the (AC-WC) Mixture

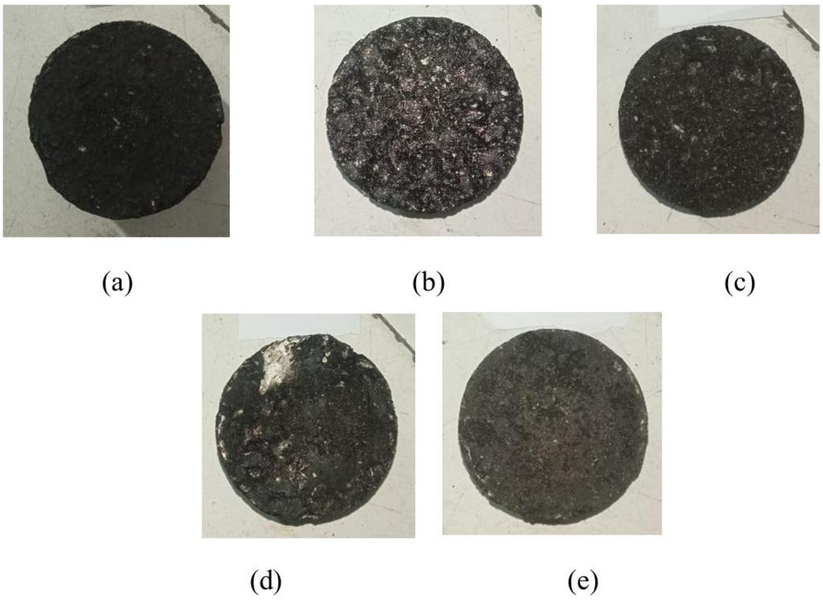


Figure 4. Top View of Samples with Asphalt Content of (a) 5%, (b) 5.5%, (c) 6%, (d) 6.5%, and (e) 7%

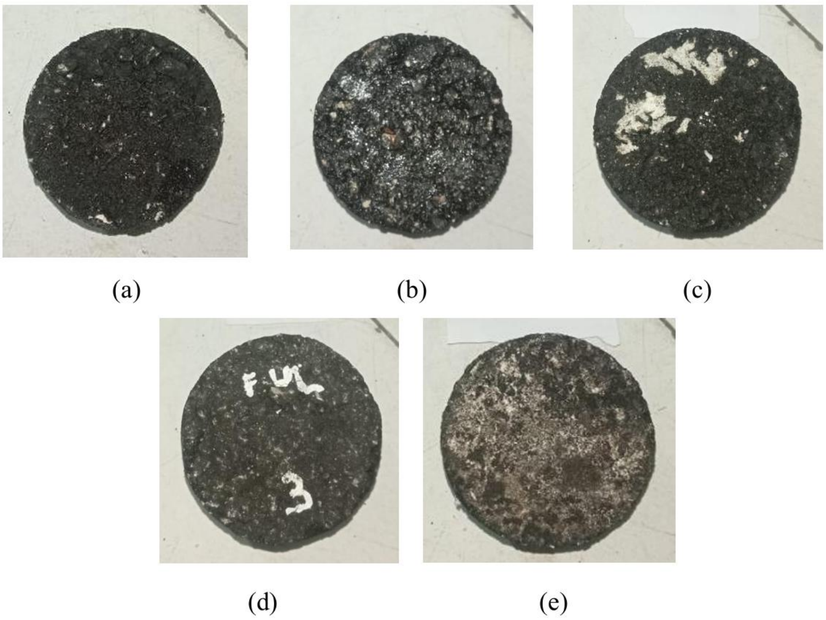


Figure 5. Bottom view sampel (a) 5% (b) 5,5% (c) 6% (d) 6,5% dan (e) 7%

The aggregate composition used consists of 39% coarse aggregate, 54.5% fine aggregate, and 6.5% filler, with asphalt content variations of 5%, 5.5%, 6%, 6.5%, and 7%. A total of 30 test specimens were made, with 6 specimens for each asphalt content variation.

3.4 Volumetric Test Results (VIM, VMA dan VFB)

Volumetric Properties (VIM, VMA, and VFA) as Variables Affecting the Strength of Asphalt Mixtures [6]. This study aims to examine the effect of volumetric properties on texture depth values by conducting volumetric testing. Bina Marga has established limits for volumetric values in the Asphalt Concrete Wearing Course (AC-WC) mixture type: 3–5%, VMA (Void in Mineral Aggregate): greater than 15%, and VFB (Voids Filled with Binder): greater than 65%. Based on the volumetric test results, the effect of volumetric properties on texture depth values was obtained. Furthermore, the relationship graphs are presented in Figures 6, 7, and 8:

Effect of Void in Mix (VIM) on Mean Texture Depth (MTD)

The effect of Void in Mix (VIM) on texture depth values is visualized in the graph, which has a coefficient of determination (R^2) of 0.2606. This means that VIM influences the texture depth of the mixture by 26.06%. The sharply rising trend line confirms that the lower the VIM value, the smoother the surface. The results are presented in Figure 6.

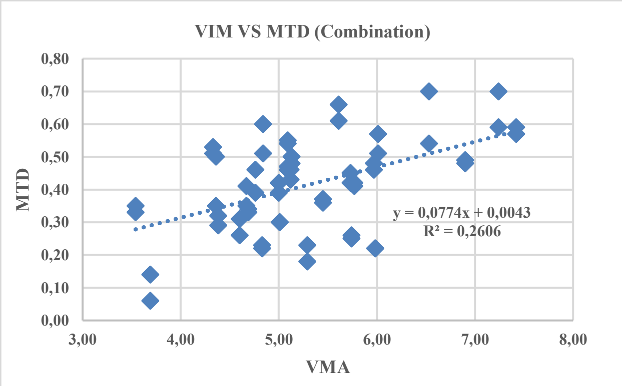


Figure 6. Graph of the Effect of Void in Mix (VIM) on Mean Texture Depth (MTD)

Effect of Void in Mineral Aggregate (VMA) on Mean Texture Depth (MTD)

The effect of Void in Mineral Aggregate (VMA) on texture depth values is visualized in the graph, which has a coefficient of determination (R^2) of 0.2704. This means that VMA influences the texture depth of the mixture by 27.04%. The sharply decreasing trend line confirms that the lower the VMA value, the rougher the surface. The results are presented in Figure 7

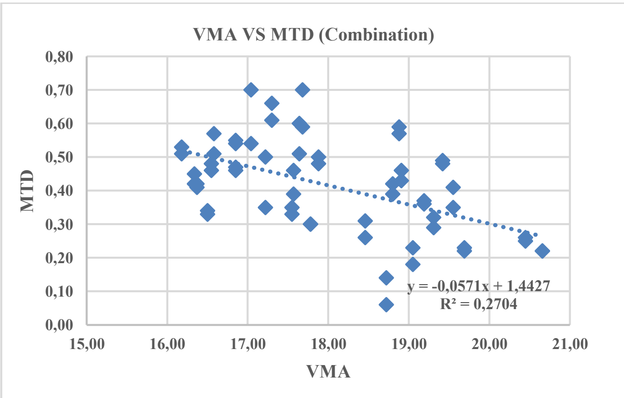


Figure 7. Graph of the Effect of Void in Mineral Aggregate (VMA) on Mean Texture Depth (MTD)

Effect of Voids Filled with Asphalt (VFB) on Mean Texture Depth (MTD)

The effect of Voids Filled with Asphalt (VFB) on texture depth values is visualized in the graph, which has a coefficient of determination (R^2) of 0.4313. This means that VFB influences the texture depth of the mixture by 43.13%. The sharply decreasing trend line confirms that the lower the VFB value, the smoother the surface. The results are presented in Figure 8.

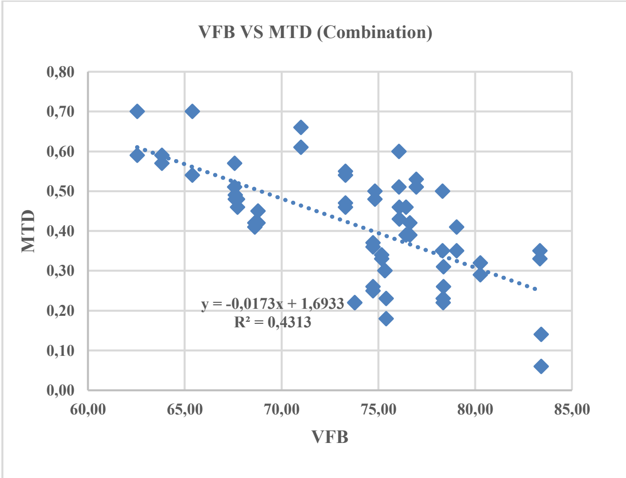
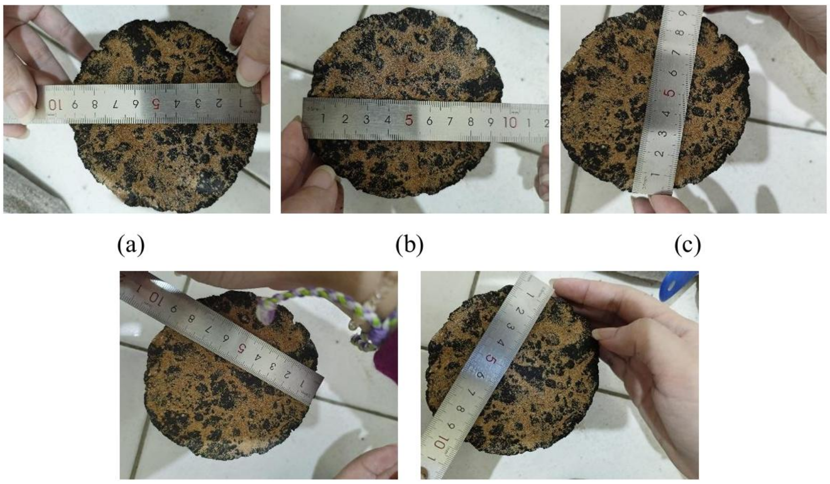


Figure 8. Graph of the Effect of Voids Filled with Asphalt (VFB) on Mean Texture Depth (MTD)

3.4 Results of Average Texture Depth (MTD) Testing

According to [14] Texture is a surface characteristic that has a broad impact on the functional quality of pavement. This study examines how aggregate type, asphalt mixture gradation, and optimum asphalt content affect the asphalt mixture. Macrotexture has a size range between 0.5 mm $\leq \lambda \leq$ 50 mm [15], The testing uses sand that passes through a No. 50 sieve with an opening size of 0.300 mm and is retained on a No. 100 sieve with an opening size of 0.150 mm, conducted in accordance with the American Society for Testing and Materials (ASTM E965-15) standard. Based on the texture depth test results, measurements were obtained for both the upper and lower sides using equation (1). The measurement images are presented in Figure 9.



(a) (b) (c)

(d) (e)

Figure 9. Sample Diameter Measurement (a) d1 (b) d2 (c) d3 (d) d4 (e) d5

The texture depth values are used to determine the relationship between asphalt content and the texture depth of the mixture (MTD). Furthermore, the relationship graphs are presented in Figure 10, Figure 11, and Figure 12.

Impact of Asphalt Proportion on the Mean Texture Depth (MTD) of the Upper Side

The relationship between bitumen content and the macrotexture value of the pavement surface is visualized in the graph, which has a coefficient of determination (R^2) of 0.6634. This means that asphalt content influences the texture depth of the mixture by 66.34%. The sharply decreasing trend line confirms higher asphalt concentrations lead to reduced surface roughness. The results are presented in Figure 10.

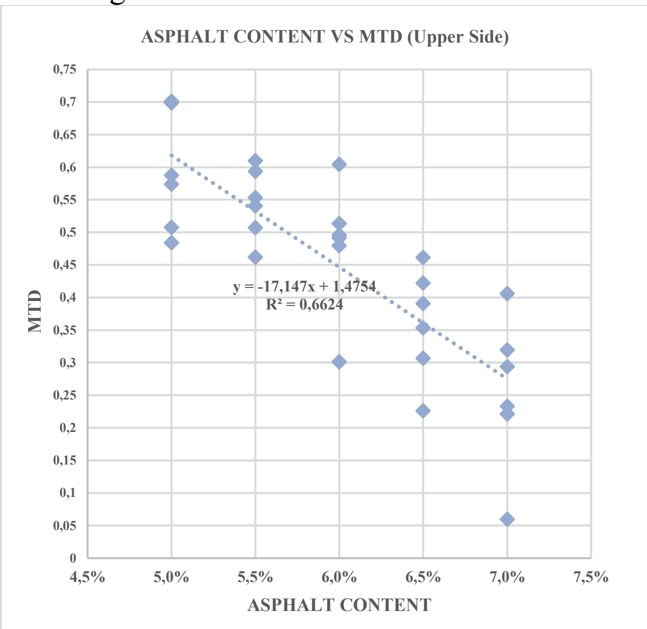


Figure 10. Graph of the impact of asphalt proportion on the MTD value of the upper side.

Impact of Asphalt Proportion on the Texture Depth (MTD) Value of the Bottom Side.

The relationship between bitumen content and the macrotexture value of the pavement bottom side is visualized in the graph, which has a coefficient of determination or R^2 value of 0.473, meaning that the asphalt content affects the texture depth of the mixture by 47.3%. The sharply decreasing trend line confirms higher asphalt concentrations lead to reduced surface roughness. The results are shown in Figure 11.

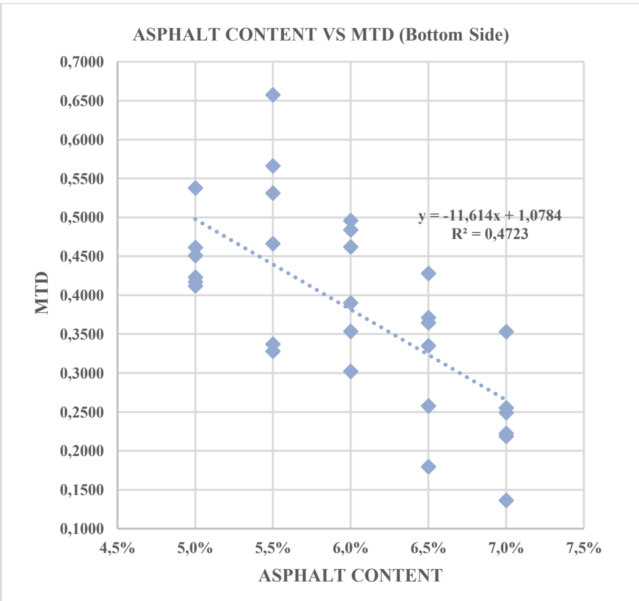


Figure 11. Graph of the impact of asphalt proportion on the MTD value of the bottom side

Impact of Asphalt Proportion on the Texture Depth (MTD) Value of the Combined Side

The relationship between bitumen content and the macrotexture value of the pavement combined side is visualized in the graph, which has a coefficient of determination or R^2 value of 0.5373, meaning that the asphalt content affects the texture depth of the mixture by 53.73%. The sharply decreasing trend line confirms higher asphalt concentrations lead to reduced surface roughness. The results are shown in Figure 12.

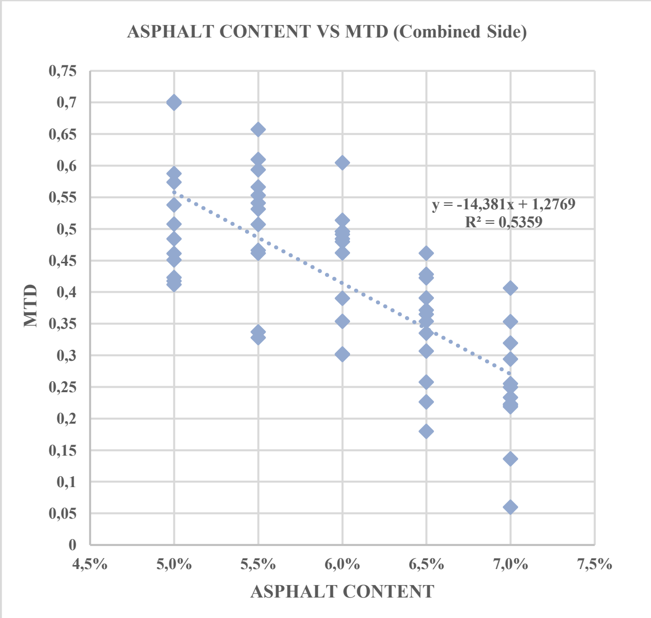


Figure 12. Graph of the impact of asphalt proportion on the MTD value of the combined side

4. CONCLUSIONS

This study proves that asphalt content has a significant effect on road surface roughness, which is measured by the Mean Texture Depth (MTD) value. The results show an inverse relationship: the lower the asphalt content, the higher the MTD value, meaning the surface is rougher. Regression analysis reveals that asphalt content explains 66.34% of the MTD variation on the upper side, 47.3% on the bottom side, and 53.73% for the combined sides. Additionally, the volume of voids filled with asphalt (VFB) also contributes to the MTD variation. Testing on the AC-WC mixture shows that the highest MTD occurs at 5% asphalt content (0.59 mm) and the lowest at 7% (0.26 mm). These findings confirm that a decrease in asphalt content increases surface roughness, which should be considered in asphalt mixture design to achieve a balance between safety and driver comfort.

5. ACKNOWLEDGEMENTS

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