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The Effect of Latex on The Characteristics of Asphalt Concrete Wearing Course

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Abstract
The Laston has a high degree of flexibility, located above the surface layer, this layer is susceptible to damage due to high temperatures, more. Asphalt as a pavement if spread will experience hardening, so that additional materials are added to make it flexible. The AC-WC mixture uses 60/70 penetration asphalt with the addition of latex. The purpose of knowing the characteristics of the marshall AC-WC mixture at the optimum asphalt content. The addition of latex 3%, 5%, 9% of the total volume of asphalt. The process is through heating asphalt and then adding latex, the proportion of aggregate is based on the ideal mixture gradation. Samples were made on hot mixture by Marshall test method. The results showed that the selected AC-WC mixture with a latex variation of 3% of the total, all asphalt properties were met. Stability 3201.1, Flow 2.4, MQ 1679,339kg, VIM 5% VMA 17.799%, VFA 74.426%.
Keywords: Latex Addtives, Asphalt, Marshall test.

1. Introduction

The flexible pavement the more used in Indonesia is asphalt concrete (laston). Laston has a high degree of flexibility so that it is located on the surface layer. This coating is susceptible to damage due to high temperatures and heavy traffic loads. The problem of AC-WC pavement as a flexible pavement layer, where asphalt works as an aggregate binder. The use of asphalt on AC-WC flexible pavement is very sensitive, if there is too much asphalt content there will be bleeding damage and if the asphalt content is too little then AC-WC flexible pavement will experience cracking damage.

Several cases that occur in road construction often experience damage before the service period ends. One of the efforts that can be done to improve service is to improve the quality of asphalt as a binder by using added materials. One of these additives is latex.

Latex (liquid natural rubber) is a natural resource that is widely produced in Indonesia, because Indonesia is the largest rubber producer in the world, so it is easy to obtain..

Therefore, research was conducted by comparing conventional asphalt and asphalt with the addition of latex as a mixture of asphalt using the Marshall test method. Determination of latex content with a standard reference content of latex mixture to asphalt, which is a minimum of 2% and a maximum of 7 to determine whether a value below or above the standard can be used. The addition of latex additives in this study with variations in latex content of 3%, 5% and 9% of the total asphalt mixture. The purpose of this study was to determine the optimum percentage of conventional asphalt that will be used as a reference for asphalt mixtures with latex using a penetration asphalt content of 60/70 and to determine the effect of adding Latex on Asphalt Concrete – Field Wear (AC-WC) mixture with Marshall test components, namely Stability, Stream, VIM, VMA, VFA.

Highway pavement is a part of the highway that is paved with a certain layer of the construction, which has a certain thickness, strength, stiffness, and stability in order to be able to safely transmit the basic traffic load on it to the ground. The pavement layer is located between the subgrade layer and the wheels of the working vehicle providing services to transportation facilities and during this period it is hoped that no significant damage will occur. (Hardiyatmo H., 2017)

Asphalt is a material which at room temperature is solid to slightly dense and is thermoplastic. The amount of asphalt in the pavement mixture ranges from 4% - 10% by weight of the mixture or 10-15% by volume. (((Nisumanti,S et al.,2020); (syahputra et al., 2020); (Carlina et al., 2019)))

Aggregate is a support which is the main component of the road pavement structure, which contains 90% - 95% percentage of aggregate by weight, or 75% - 85% of aggregate by volume. Thus the quality of the road pavement is also determined by the nature of the aggregate and the results of mixing the aggregate with other materials. (Setiawan et al., 2017)

Latex is a newly tapped sap with a dry rubber content (KKK) of about 30%. This garden latex is generally very attractive. Processing garden latex into concentrated latex requires high costs. Concentrated latex is a processed natural latex product which is concentrated by centrifugation or boiling from dry rubber content (KKK) 28% - 30%

to dry rubber content (KKK) 60%. Usually, concentrated latex is used for the manufacture of thin and high-quality rubber materials.(Suaryana et al., 2019)

Marshall test is a mandatory test for asphalt concrete, to find out and know the properties of concrete as we expect. From the marshall test, it will be known what percentage of asphalt content is needed for the planned rock gradation, which will produce the optimal compressive strength (called marshall expressed in Kg) of the embedded asphalt concrete cylinder (test object). for one hour at 60°C (Soehartono, 2014; Intari et al., 2019; Zhang et al, 2019).

Marshall testing is a volumetric analysis and flows analysis, the properties of the asphalt mixture can be seen from the marshall test criteria, including: (Nisumanti., S et al., 2020)

Stability is the ability of the asphalt mixture to withstand deformation due to workloads without undergoing permanent deformation such as groove waves. (Karami, 2017)

The flow values are the respective values indicated by the dial needle (in mm) when performing the Marshall test.

Marshall Quotient (MQ) is the result of a comparison between the currents used as an indicator of the potential flexibility of the train.

The voids filled with asphalt (VFB) is the volume between the aggregate particles filled with asphalt in the solid mixture, expressed in (%) to the total volume of the mixture.

The voids between mineral aggregates (VMA) are the empty spaces between the aggregate particles on the pavement, including air voids and the effective volume of asphalt (excluding the volume of asphalt that absorbs the aggregate).

The voids in the mixture (Va) or VIM in the asphalt pavement mixture consist of air spaces between the asphalt-covered aggregate particles. (Mochtar et al, 2019).

2. Material and Methods

2.1. Research Site

The research was conducted at the Laboratory of the Provincial Public Works Office of Bina Marga, South Sumatra Province.

2.2. Material

The materials used in this research are asphalt with pen 60/70 from PT. Bintang Selatan Agung, coarse aggregate in the form of split stone ½ and screen 1/1, fine aggregate from Lubuk Linggau South Sumatra, Latex From Kifazu Furniture Palembang, Filler from Semen Baturaja. The material Shows in figure 1.

Figure 1. Materials

2.3. Design Mix Formulas

The calculation of the design asphalt content in the Asphalt Concrete – Wearing Course using the Bina Marga method, then the design asphalt content is obtained, then the estimated asphalt content value is calculated to be used in determining the optimum asphalt content.

2.4. Research Procedures

The methodology of research is show in Figure 2

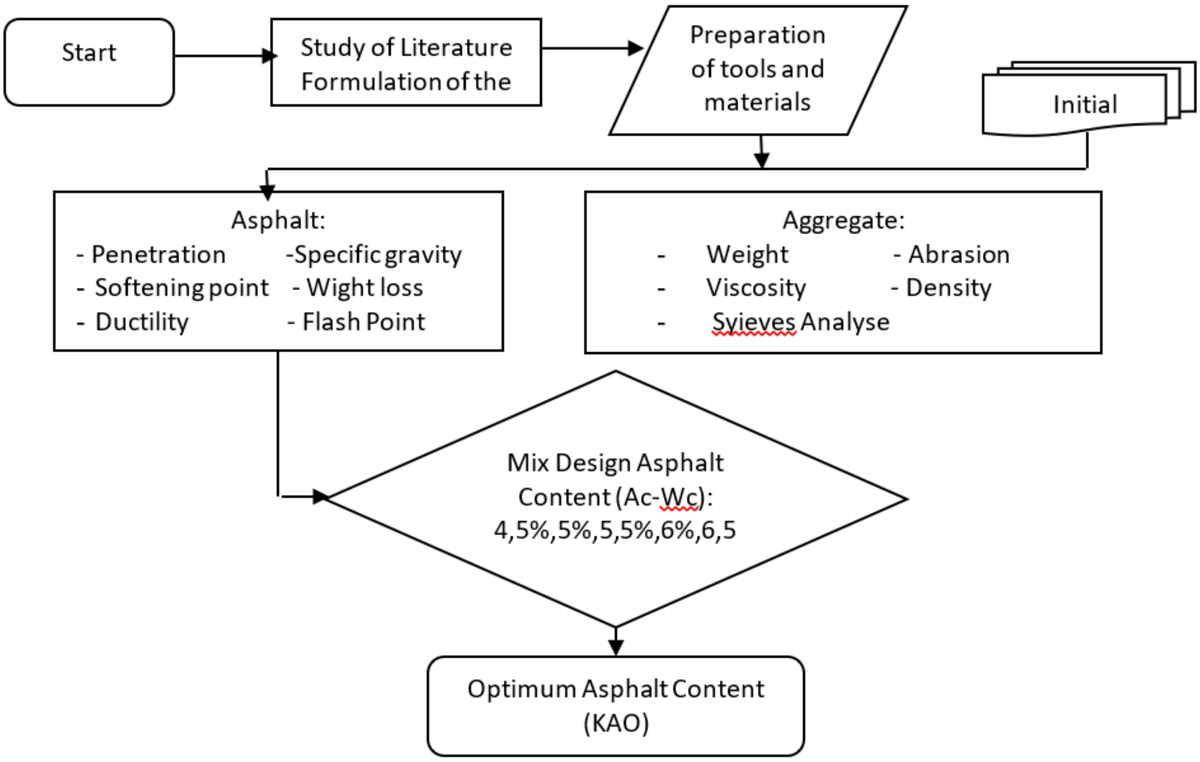

Figure 2. Research Procedures

Testing the physical properties of the material based on the specifications is then made a mixed design for each test object and Marshall testing is carried out in the following stages ((Direktorat Jenderal Bina Marga, 2015; Kementerian PU., 2020))

a. Aggregate test

   Sieve analysis of fine and coarse aggregates (SNI, 1968), Los Angeles machines are used to test for abrasion of aggregates, scales are used to test the specific gravity of aggregates, ovens are used to remove moisture in aggregates and pycnometers are used to determine specific gravity of aggregates and asphalt.(SNI 4804;2441;6893;2417;1969)

b. Asphalt test

   Asphalt testing is carried out to determine whether it is feasible or not when mixing.

   Penetration Testing, Flash Point and Burn Point Testing Softening point testing, ductility testing, Asphalt specific gravity testing. (SNI 2433;2439);(AASHTO T 245, 2015)

c. Make samples

   The making samples are used for conventional asphalt with asphalt content of 4.5%, 5.0%, 5.5%, 6.0%, and 6.5% to be used as a reference in latex mixtures. While the latex mixture with variations of 3%, 5%, and 9% with the optimum asphalt content (KAO) is 6%.

d. Marshall test

   Marshall test results obtained Marshall characteristic values, namely Stability, Flow, Void in Mix (VIM), Void in Mineral Aggregate (VMA), and Void Filled Asphalt (VFA). Marshall test shown in Figure 3

Figure 3. Testing Stage

3. Results and Discussion

3.1 Aggregate Characteristic Test

This test includes coarse aggregate, fine aggregate and filler whose results meet the characteristics of the specifications shown in the table. 1

Table 1. Results of Aggregate Characteristics

Characteristic	requirement	coarse aggregate		SNI	fine aggregate		SNI	Filler	SNI
		Split	Screen		Dust	Sand			
Bulk Density		2,45	2,53	1969:2008)	2,51	2,51	1970:2008		
SSD Density		2,58	2,57		2,60	2,58			
Specific gravity	Min 2,5	2,41	2,65		2,70	2,69			
Absorption %	Maks 3%	1,44	1,9		2,71	2,64			
Abrasion Los Angeles	Maks 40%	21,08	-	2417:2008	-	-			
Aggregate adhesiveness to bitumen	Maks 95%	95	95	2439:2011	-	-			
Syieve analys No. 200								100	1969: 2008
Free from organic ingredients								3,15	

Table 1 shows that coarse aggregate, and fine aggregate can be used for mixed material for the test specimens because they meet the requirements of the 2010 revision of the 3rd Highways specification.

3.2. Characteristics of Conventional Asphalt
The asphalt used for the mixture of test objects is asphalt penetration 60/70. The results of testing the characteristics of conventional asphalt can be seen in table 2

Table 2. Asphalt Characteristics

Asphalt Characteristics	Standard Test	requirement	Result
Specific gravity ($25^{\circ}C$)	SNI 2441-2011	Min 1	1,032
Penetration ($25^{\circ}C$, 100gr, 5 second)	SNI 06-2456-1991	60 - 70	66
Softening point	SNI 2434-2011	Min 48°C	50°C
Flash point	SNI 2433-2011	Min 232°C	310°C
Burn point	SNI 2433-2011	-	315°C
Ductility at $25^{\circ}C$	SNI 2432-2011	≥100	120

From table 3. Shows that the asphalt specific gravity, penetration, softening point, flash point, and burning point tests can be used as aggregate binders because they meet the requirements of the Revision 3 2010 Highway specification.

3.3. Mixed Composition with Envelope Gradient
The results of the calculation of the mixture composition using the envelope gradation method based on the Revision 3 Toll specification can be seen in Figure 4.

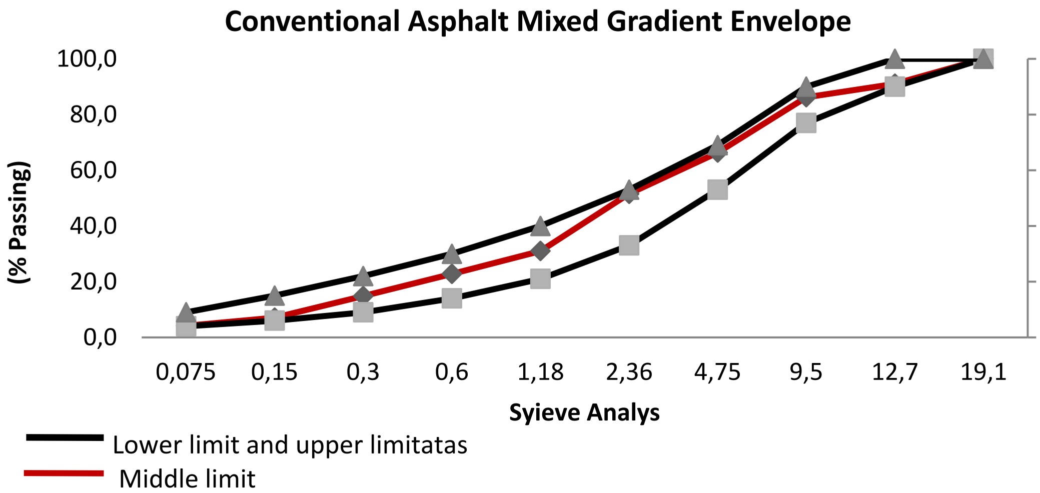

Figure 4. Gradition Mixed AC – WC

Figure 4 shows that the results of the mixture composition can be used for the manufacture of conventional asphalt specimens because the median gradation value of the mixture does not exceed or is not less than the lower and upper limits that have been set.

3.4. Conventional Marshall Test
Marshall test results obtained Stability, Flow, VIM, VMA, VFA, Density and Marshall Quotient (MQ) values. Marshall test results to determine the asphalt content of KAO. The KAO value is used in testing the characteristics of the AC-WC mixture with shown in table 3

Table 3. Conventional Marshall test Results

Asphalt content	Density	VIM	VMA	VFA	Stability	Flow	Marshall
4,5%	2,276	6,645	16,561	59,927	1076,5	2,70	398,818
5,0%	2,280	5,800	16,840	66,224	1127,2	2,86	394,426

5,5%	2,284	4,987	17,145	71,014	1166,5	3,05	382,852
6,0 %	2,288	4,145	17,439	76,304	1341,6	3,19	421,269
6,5%	2,282	3,729	18,093	79,482	1242,2	3,28	379,034

The results of the absolute density marshall test with the determination of the Optimum Asphalt Content are carried out with a bar chart, the Optimum Asphalt Content Value (KAO) is obtained from various types of variations in the planning of making test objects as shown in Figure 5.

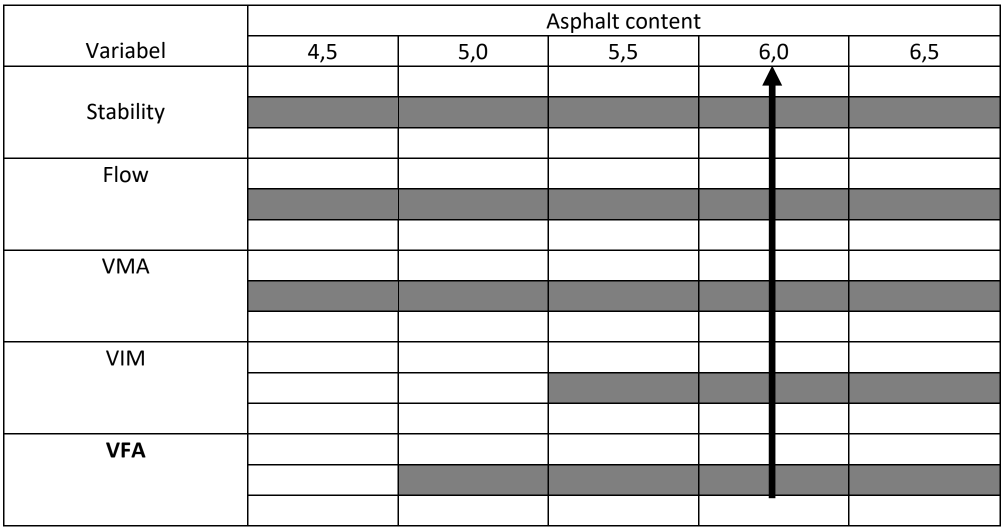

Figure 5. The optimum asphalt content value (K.A.O)

From figure 5. Shows the marshall parameters that meet the specifications are depicted in a bar graph to determine the optimum asphalt content limit.
The asphalt content value that meets the requirements of Laston AC-WC is located at the upper limit of 6.00%, the lower limit of 6.5% so that the optimum asphalt content value (K.A.O) of 6% is obtained which is used for asphalt AC-WC mixture

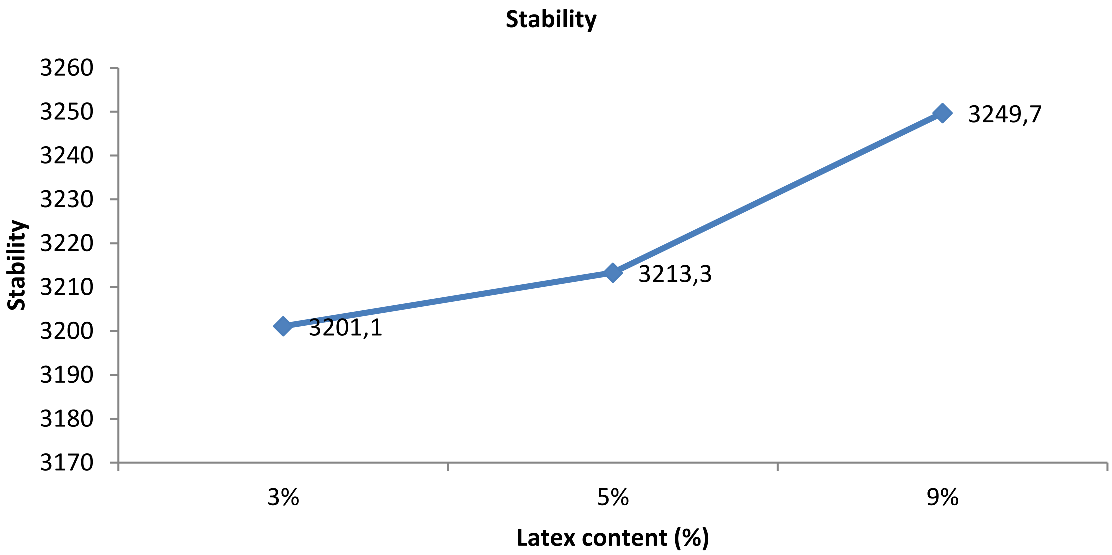

Figure 6. Stability Value

From Figure 6. The stability value of the test object for 3 variations of latex content meets the requirements according to the provisions, namely a minimum stability value of 900 kg.

The result of the highest stability value was 3249.7 on the test object with 9% latex content and the lowest value was 3201.1 with 3% latex content. This shows that the greater the latex content, the greater the Marshall stability value so that it can withstand excessive loads compared to conventional asphalt.

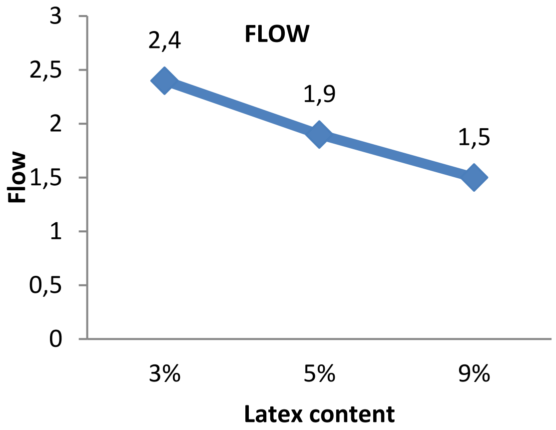

Figure 7. Flow value

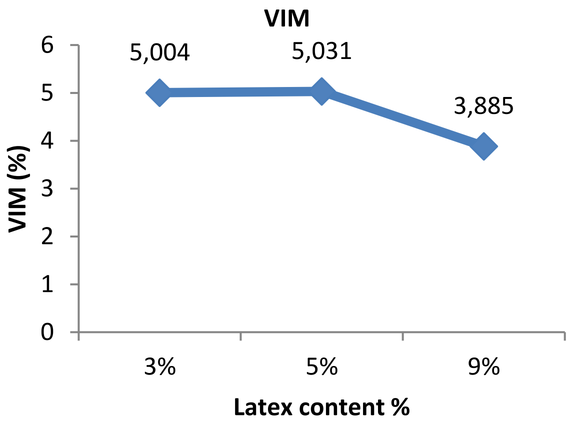

Figure 8. VIM value

As can be seen in Figure 7. The addition of latex to the asphalt will reduce the flow value.The addition of latex causes the mixture to tend to be harder than asphalt without latex.Latex 5% and 9% do not meet the specified specifications, namely min 2% and max 4%.3% latex content meets specifications

Figure 8. Shows the Void in mix (VIM) value with 5% latex content greater than the specified standardLatex levels of 3% and 9% have met the requirements, namely 3-5%.the best mixture is the content of 9% with a value of 3.8885.

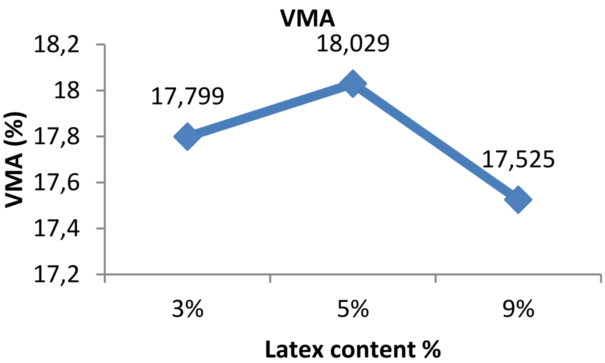

Figure 9. VMA value

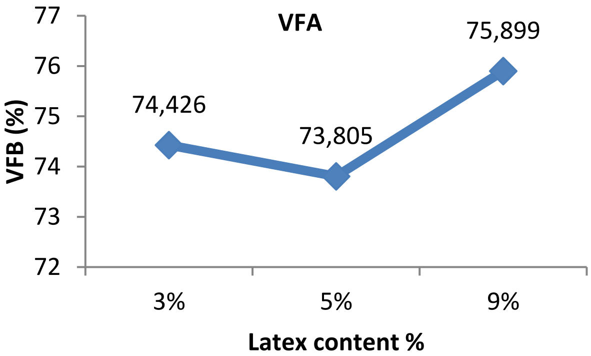

Figure 10. VFA value

Figure 9. Describes Voids in mineral aggregate (VMA) value the latex content of 3%, 5% and 9% was able to cover the aggregate well because the VMA value was not too small.The level of 5% has increased so that the aggregate blanket is not too good because it will make the mixture too soft.A good mixture to use is the content of 3% and 5%.

From figure 10. Show the highest Void filled with asphalt (VFA) value was found within the 9% latexs content with a VFA value of 75.899 and the lowest VFA value was 5% with a VFA value 0f 73,805.

This shows that the highest Void of asphalt content (VFA) value is found in latex content of 9% with a VFA value of 75,899 this is because the asphalt blanket value for aggregate is too small which will cause the asphalt to become soft. . While the lowest VFA value is 5% with a VFA value of 0f 73,805, the decrease occurs because the asphalt blanket is too large for the previous VMA value. The VFA value for each latex content was able to fill the cavity well because it had fulfilled the requirements, namely 65%.

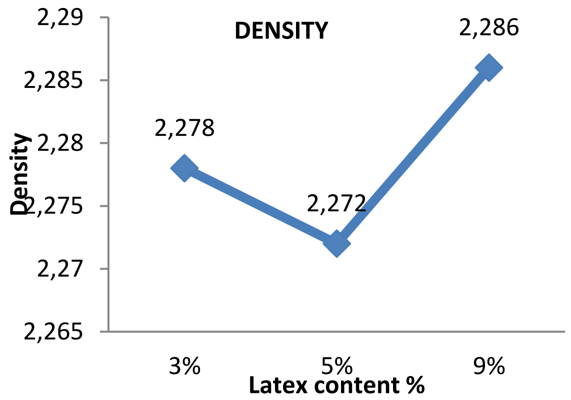

Figure 11. Density value

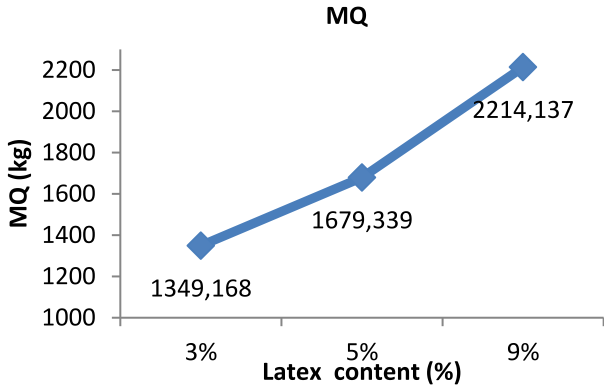

Figure 12. Marshall Quotient Value

From figure 11. shows the density value of each latex content that meets the specified requirements, namely at least 2%. The highest density value lies at 9% this is due to the high VFA value. While the latex content is low at 5%, the decrease is due to too much asphalt filling the cavities. The greater the density value, the greater the load-bearing ability.

Figure 12. it can be seen that the Marshall Quotient value for all sample with different variations in asphalt content, the results meet the requirements according to the provisions, namely the MQ ≥250.

The result of the highest MQ was found in the 5% latex content at 2214,137, whereas the lowest MQ was the 3% asphalt content at 1349,168.

The latex content of the MQ value will increase due to the high binding capacity of latex. The Marshall quotient value of each latex mixture is far above the specified conditions, Mixtures tend to be stiff, but can be used because they are able to withstand excessive loads.

4. Conclusions

Based on the analysis obtained the design asphalt content (Pb), the value of Optimum Asphalt Content (KAO) for conventional asphalt is 6% of the 5 variations of the test object. Marshall test analysis results from several variations obtained a mixture of latex asphalt with a content of 3% because the strength and flexibility of the mixture is better than conventional asphalt with Marshall parameter values namely stability 3101.1 kg/mm (Requirements > 800 kg/mm), Flow 2 ,4 mm (requirement > 2.0 – 4.0 mm), VIM 5.0% (requirement > 3.0 – 5.0%), VMA 17.799% (requirement > 15%), VFA 74.426% (requirement > 65%) and meet General Specifications Highway.

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