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The Effect Of Red Brick Powder And Teak Wood Ash Powder Fillers On Marshall Characteristics

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Abstract

Road pavement really needs a mixture of asphalt that has good durability and stability, because roads have an important role in the transportation system to support economic growth and community mobility. This study aims to analyze the effect of the use of Red Brick Powder and Teak Wood Powder Ash as a substitute for fillers on AC-WC asphalt mixtures. With the increasing amount of red brick powder and teak wood powder ash and has not been utilized optimally, there is a need for innovation in the use of environmentally friendly alternative materials. The method used in this study is Marshall testing to determine the characteristics of the mixture, such as stability, flow, VIM, VMA, and VFA with different filler content variations. The filler variation used in this study was 0%, 5%, 7% with a ratio of 80 : 20. The results showed that the 7% filler variation provided the most optimal mixture characteristics with a VIM value of 4.89% and a VMA of 15.89% which still met the required specifications. In addition, the values of stability, flow, VFA, and Marshall Quotient are also within the standard limits. Based on these results, red brick powder and teak wood ash have the potential to be used as filler alternatives to AC-WC mixtures that are more environmentally friendly.

Keywords: *Teak Wood Ash; AC-WC; Filler; Red Brick Powder*

Abstrak

Perkerasan jalan sangat membutuhkan campuran aspal yang memiliki daya tahan dan stabilitas yang baik, karena jalan memiliki peran penting dalam sistem transportasi untuk menunjang pertumbuhan ekonomi dan mobilitas Masyarakat. Penelitian ini bertujuan untuk menganalisis pengaruh penggunaan Serbuk Bata Merah dan Abu Serbuk Kayu Jati sebagai pengganti filler terhadaap campuran aspal AC – WC. Dengan meningkatnya jumlah limbah serbuk bata merah dan abu serbuk kayu jati serta belum dimanfaatkan secara optimal, sehingga diperlukannya inovasi pemanfaatan material alternatif ramah lingkungan. Metode yang digunakan pada penelitian ini adalah pengujian Marshall untuk mengetahui karakteristik campuran, seperti stabilitas, flow, VIM, VMA, dan VFA dengan variasi kadar filler yang berbeda. Variasi filler yang digunakan pada penelitian ini yaitu 0%, 5%, 7% dengan perbandingan 80 : 20. Hasil penelitian menunjukkan bahwa variasi filler 7% memberikan karakteristik campuran yang paling optimal dengan nilai VIM sebesar 4,89% dan VMA sebesar 15,89% yang masih memenuhi spesifikasi yang dipersyaratkan. Selain itu, nilai stabilitas, flow, VFA, dan Marshall Quotient juga berada dalam batas standar. Berdasarkan hasil tersebut, serbuk bata merah dan abu serbuk kayu jati berpotensi digunakan sebagai alternatif filler pada campuran AC-WC yang lebih ramah lingkungan.

Keywords: *AC WC; Filler; Serbuk Bata Merah; Abu Serbuk Kayu Jati*

INTRODUCTION

Roads often experience an increase in traffic flow and volume every year. [1] And roads are one of the main infrastructures that have an important role in the transportation system that supports economic, social and community mobility activities. Smoothing the flow of distribution of goods and services in various regions is the main factor for the existence of adequate roads. The coating supports the smooth flow of transportation that is safe, comfortable, and efficient for all road users. [2]
Road pavement is a pavement structure located on the ground (Subgrade). The function of the pavement layer is to distribute the load from the vehicle's wheels so that there is no deformation on the subsoil during the planned life. [3]
Along with the increase in road use, the need to improve the quality of road construction is becoming more and more urgent. The development of road transportation infrastructure must be designed economically, but still consider the suitability of the life of the plan that has been set. [2]

One of the causes of damage and reduced strength in bending pavement is the strength and durability in the wear layer and the fastening material on the road pavement is very low [4]. To avoid this, the aggregate selection must be appropriate and meet the requirements to achieve the success of road construction or maintenance. [5]
In general, the AC-WC mixture consists of several materials, namely coarse aggregate, fine aggregate, asphalt, and filler [6]. Asphalt or bitumen is a material that will melt when it is hot, and will harden again when the temperature drops or cools. [7]
Flexible pavement consists of a surface layer or AC-WC has a minimum thickness of 4 cm. [8], the layer is a layer that is directly related to the wheels of the vehicle and has a smoother texture than other pavement layers that function as a protection for the lower layer from damage due to the influence of water or weather. [9]

As time goes by, the use of additives in fillers as a substitute for conventional fillers is starting to be widely used to anticipate the availability of materials that are usually used is getting thinner [10], so innovation is needed by using alternative filler substitutes such as red brick powder waste and wood powder ash whose amount of waste is still not optimally utilized. [11] Wood sawdust is organic waste from the mechanical processing process of wood into various sizes. If used as a filler or cavity filler in asphalt mixtures, it can help increase asphalt's resistance to deformation and extend its fatigue period at various temperatures.[12]

In this study, wood powder waste is used by first heating under the sun, then in the oven for one to two days and after drying, wood powder is burned until it becomes ash. [13]
Chemically, brick ash has a similar composition to cement compounds and belongs to the pozzolan group due to its high silica content. This silica plays an important role in reducing the need for asphalt content while strengthening the mixed structure, resulting in asphalt pavement that is more stable and resistant to traffic loads and weather influences. [2]

Several previous studies have discussed the use of red brick powder waste or wood powder ash as fillers in asphalt mixtures. However, in previous studies, it generally only used one type of waste, so not many have discussed the effect of using the combination of the two materials in the AC-WC mixture. In addition, previous studies have not discussed the composition of the most optimal filler mixture for marshall characteristics. Therefore, further research is needed on the effect of the filler combination on the AC-WC asphalt mixture.

This study used a combination of 80% red brick powder and 20% teak wood powder ash from the total filler mixture in each variation of filler content. The comparison is used because red brick powder has a more dominant silica content so it is expected to improve the stability of the mixture, and wood powder ash is used as an additional material to help improve the density of the mixture and to avoid a decrease in stability.
0%, 5%, and 7% filler variations were used for the purpose of determining the effect of increased filler content on marshall characteristics. For the 0% variation, it is used as a normal mixture, while the 5% variation and 7% variation are used to evaluate the effect of using fillers on stability, flow, VIM, VMA, and VFB until the optimum level can be determined that produces the best mixed performance.

Both the chemical composition and particle size of this material have the potential to strengthen or even decrease the stability of the asphalt mixture, depending on the ratio of the mixture. Therefore, research is needed to obtain results or understanding related to the effect of the use of brass red brick powder and teak wood powder ash on the AC-WC layer.

METHODS

This research was carried out in the laboratory and the method used in this study is the experimental method, this study was conducted to determine the effect of the variation in the use of red brass brick powder waste filler and teak wood powder ash on the characteristics of Marshall in the AC-WC laston mixture. Each mixed variation is tested with reference to the 2018 General Specification of Highway Revision 2 as well as several SNI and ASTM testing standards related to road pavement. The materials used in this study are coarse aggregates, fine aggregates, fillers, and asphalt. The filler is obtained from red brick powder waste and teak wood powder ash. The asphalt used is asphalt with a 60/70 penetration because this type of asphalt is commonly used in AC-WC mixtures.

Red brick powder is obtained by crushing red brick fragments until they are fine and passing the No. 200 sieve. Meanwhile, wood powder ash comes from sawdust that is sun-dried in the sun or ovened for a day or two, then burned to ashes and sifted so that the particles are smoother. This study used a combination of 80% red brick powder and 20% teak wood powder ash from the total filler mixture in each variation of filler content. The comparison is used because red brick powder has a more dominant silica content so it is expected to improve the stability of the mixture, and wood powder ash is used to fill cavities in the asphalt mixture. The variations used in this study were 0%, 5%, and 7% of the total mixed fillers. 0% variation for normal mixtures without fillers, 5% and 7% variations were used to see the effect of the addition of alternative fillers on marshall characteristics.

The research stages are carried out starting from SPGR (Specific Grafity) Testing, Job Mix Design, Marshall Testing, and Geotechnical Material Model (GMM) Testing.
The job mix process is carried out at a temperature of 150°C-160°C, and the compaction process is carried out at a temperature of 140°C-150°C. The test specimen was grown with a total impact of 75 times on the upper side and 75 times on the lower side using a marshall compactor tool. Each filler variation is made in 3 samples so that the test results can be compared.

This test uses the Marshall method to determine the value of stability, flow, VIM, VMA, VFA. This test aims to reduce red brick waste and teak wood powder ash that is wasted and has not been optimally utilized in road pavement construction.
This research was carried out directly in the laboratory in stages, starting from coarse aggregate testing, stone ash fine aggregate testing, filler to Marshall testing on AC-WC asphalt mixture.

After obtaining data from laboratory testing, the next steps will be summarized in a table and visualized through graphs to analyze whether or not the mixture complies with the Bina Marga 2018 Revision 2 specifications. And the final result is used to determine the filler variety that can provide the best performance to the Marshall characteristics of the AC-WC asphalt mixture. This study uses Microsoft excel software to assist in data analysis, the results are then analyzed by comparing the value of each mixed variation in the marshall characteristics to the requirements of the 2018 Revised 2018 General Specification of Highways 2. And from these results, it can be known the optimal filler variation in the AC-WC asphalt mixture.
The following are the steps in the implementation of the research:

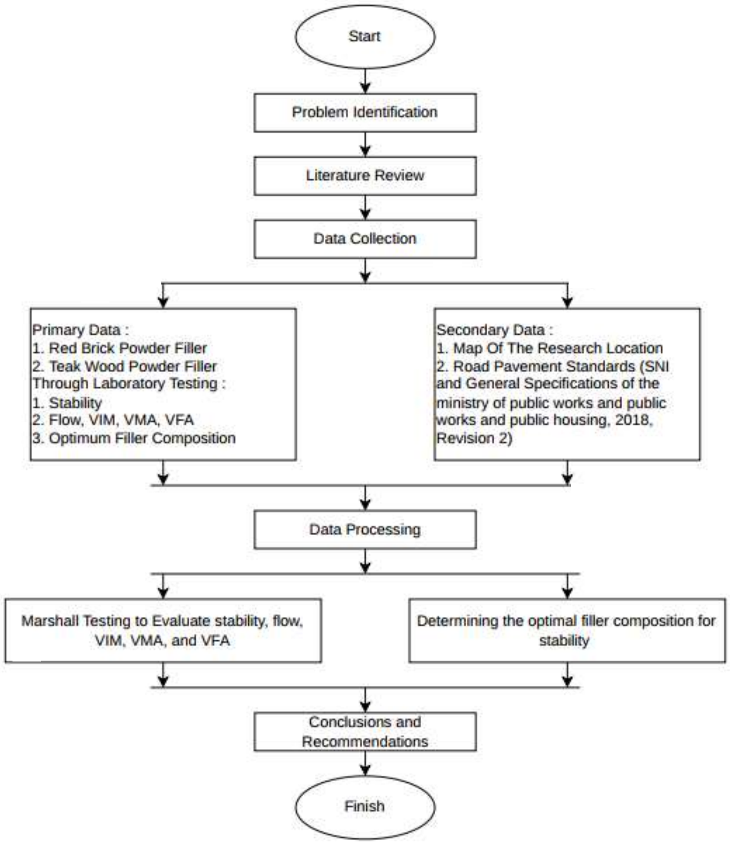

Figure 1. Research Steps

RESULTS AND DISCUSSION

Based on the purpose of this study, which is to determine the influence of Marshall Characteristics with the addition of Red Brick Powder and Teak Wood Powder as an alternative filler to asphalt mixture. The research data was obtained from the results of experiments in the laboratory. After the data of the results of the experiment in the laboratory is obtained, it can be processed and displayed in the form of tables and graphs. The following are the results of the data analysis:

SPGR (Specific Gravity) Filler

SPGR testing aims to ensure the quality of the aggregates to be used in concrete or asphalt mixtures, and can help ensure the quality of materials.

Figure 2. Specific Gravity *of Filler (*Red Brick Powder)

No.	Job Items	Filler	
1.	Piknometer Identification	A	B
2.	Piknometer Weight + Sample	107,7	107,7
3.	Piknometer Weight	57,7	57,7
4.	Sample Weight	50	50
5.	Temperature ºC	25ºC	25ºC
6.	Piknometer Weight + Water + Sample	191,6	191,3
7.	Piknometer Weight + Water	162,9	162,9
8.	Soil Specific Gravity	2,347	2,315
9.	Average Soil Specific Gravity - Average	2,331	

Figure 3. Heavy Weight *Filler (* Wood Powder Ash)

No.	Job Items	Filler	
1.	Piknometer Identification	A	B
2.	Piknometer Weight + Sample	107,7	107,7
3.	Piknometer Weight	57,7	57,7
4.	Sample Weight	50	50
5.	Temperature ºC	25ºC	25ºC
6.	Piknometer Weight + Water + Sample	193	193,1
7.	Piknometer Weight + Water	162,9	162,9
8.	Soil Specific Gravity	2,513	2,525
9.	Average Soil Specific Gravity - Average	2,519	

Based on the table of specific gravity of red brick powder fillers, an average value of 2.331 was obtained, while in the table the specific gravity of teak wood powder ash obtained an average value of 2.519. It can be concluded that teak wood powder ash has a higher specific gravity and is able to fill the cavities in the mixture so that the mixture becomes denser. While red brick powder has a lighter specific gravity.

GMM (Geotechnical Material Model)

Geotechnical Material Model (GMM) testing aims to determine the characteristics of the material or determine the specific gravity of the mixture without air cavities as the basis for calculating VIM and VMA values.

The data from GMM testing results are as follows:

Figure 4. GMM Filler Testing Data 0%

Asphalt Rate	= 5.4%				
Total Agg	= 94.6%				
GMM Test Lab	=2,443				
Bj. Asphalt	=1,032				
Bj. Eff Agg	= 2,650				
Asphalt Content	4,5 %	5,0 %	5,5 %	6,0 %	6,5 %
GMM	2,476	2,458	2,440	2,422	2,405

Figure 5. GMM Filler 5% Testing Data

Asphalt Rate	= 5.4%				
Total Agg	= 94.6%				
GMM Test Lab	=2,384				
Bj. Asphalt	=1,032				
Bj. Eff Agg	= 2,576				
Asphalt Content	4,5 %	5,0 %	5,5 %	6,0 %	6,5 %
GMM	2,414	2,397	2,380	2,364	2,348

Figure 6. GMM Filler Testing Data 7%

Asphalt Rate	= 5.4%				
Total Agg	= 94.6%				
GMM Test Lab	=2,462				
Bj. Asphalt	=1,032				
Bj. Eff Agg	= 2,673				
Asphalt Content	4,5 %	5,0 %	5,5 %	6,0 %	6,5 %
GMM	2,494	2,476	2,458	2,440	2,423

The results of the GMM test showed a change in the maximum specific gravity value in each filler variation, namely in the 5% filler variation there was a lower GMM value than the 0% and 7% fillers. This shows that the addition of 5% filler can cause the mixture to be denser so that the air cavity in the mixture is smaller.

Meanwhile, in the 7% filler variety, the GMM value increased again.

Marshall Test Results

The purpose of this Marshall test is to determine resistance or strength (stability) to fatigue (flow). Here are the results of Marshall's testing:

Figure 7. Marshall Test Result 0%

Parameters	Asphalt Rate				
	4,5	5	5,5	6	6,5
VIM (%)	6,14	5,13	3,99	2,96	1,61
VMA (%)	15,32	15,48	15,53	15,69	15,57
VFA (%)	59,97	66,87	74,34	81,1	89,66
Stability (kg)	1125	1289,7	1271,4	1207,4	1125
Flow (mm)	3,03	3,4	3,31	3,36	3,14
MQ (kg/mm)	371,9	308,07	402,6	360,11	358,49

Figure 8. Marshall Test Results 5%

No	Parameters	Units	Results	Requirements
1.	VIM	%	2,95	3,0% - 5,0%
2.	VMA	%	16,58	Min 15%
3.	VFA	%	82,26	Min 65%
4.	*Stability*	Kg	1321,7	Min 800 kg
5.	*Flow*	Mm	2,45	2 – 4
6.	*Marshall Quotient*	Kg/mm	537,80	
7.	*Marshall* stability remains	kg	110,73	Min 90%

Figure 9. Marshall Test Results 7%

No	Parameters	Units	Results	Requirements
1.	VIM	%	4,89	3,0% - 5,0%
2.	VMA	%	15,89	Min 15%
3.	VFA	%	67,75	Min 65%
4.	*Stability*	Kg	1257,7	Min 800 kg
5.	*Flow*	Mm	3,05	2 – 4
6.	*Marshall Quotient*	Kg/mm	412,90	
7.	*Marshall* stability remains	kg	111,27	Min 90%

No.	Parameter	Spesifikasi	Variasi			Analisis Perbandingan
			Filler 0%	Filler 5%	Filler 7%	
1	VIM (%)	3 – 5%	3,87	2,95	4,89	Filler 0% dan 7% memenuhi spesifikasi, sedangkan filler 5% berada sedikit di bawah batas minimum.
2	VMA (%)	Min 15%	15,22	16,58	15,89	Seluruh variasi filler memenuhi spesifikasi minimum 15%
3	VFB (%)	Min 65%	74,61	82,24	67,75	Semua variasi memenuhi spesifikasi, dengan nilai tertinggi pada filler 5%
4	Stabilitas (kg)	Min 800 kg	1394,9	1321,7	1257,7	Semua variasi memenuhi spesifikasi, namun nilai stabilitas menurun seiring penambahan filler.
5	Flow (mm)	2-4 mm	3,73	2,45	3,05	Seluruh variasi masih berada dalam rentang spesifikasi 2–4 mm.
6	*Marshall Quotient* (kg/mm)	-	375,46	537,80	412,90	Nilai tertinggi terdapat pada variasi filler 5%, menunjukkan campuran paling kaku.
7	Stabilitas *Marshall* Sisa (%)	Min 90%	93,44	110,73	111,27	Semua variasi memenuhi spesifikasi, dengan nilai tertinggi pada filler 7%.

Figure 10. Comparison of Marshall Test Results

Based on the comparison table of the three filler variations, the 5% filler variation has the highest stability value of 1321.7 kg. However, the VIM value in this variation is below the minimum specification, which is 2.95%. A VIM value that is too low indicates that the air cavity in the mixture is too small so that the mixture has the potential to bleed when receiving high temperatures and repeated traffic loads.

In the 7% filler variation, most of the parameters meet the specification of the clan, the VIM value of 4.89% is qualified and the VMA, VFB, flow stability, and MQ values also still meet the requirements.
Therefore, the 7% filler variety can be said to provide a more balanced mix performance compared to other variations.
Based on the results of the Marshall test, the following graph analysis was obtained:

Void In Mix (VIM)

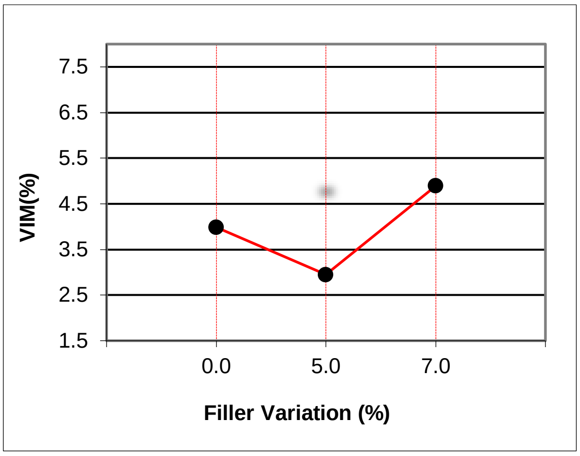

Figure 11. *Void In Mix*

The VIM value decreased from a 0% to 5% filler variation, then increased again to 7%. A 5% decrease in VIM value in fillers occurs because filler particles are able to fill the air cavities between aggregates until the mixture becomes denser. The smaller the air cavity in the mixture, the lower the VIM value.

However, when the filler level is increased to 7%, the VIM value increases again. This is thought to occur because too many fillers cause the mixture to be unevenly distributed and some fillers are not effective in filling the cavity. This results in the formation of new air cavities in the mixture so that VIM increases again.

Void In Minneral Aggregate (VMA)

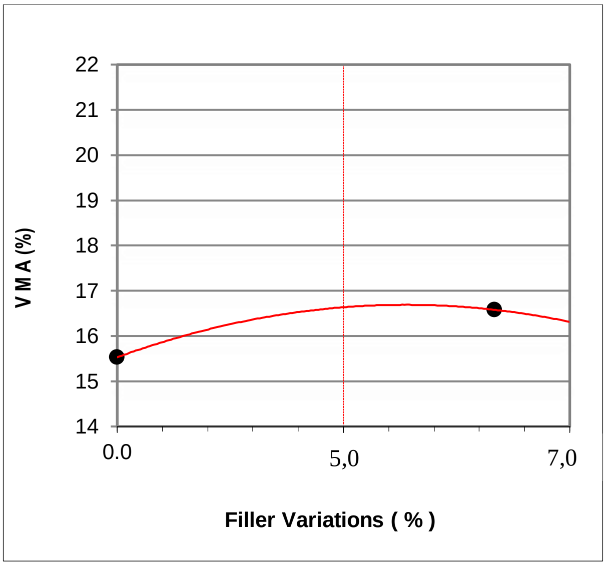

Figure 12. *Void In Mineral Aggregate*

The value of the VMA tends to increase from a 0% filler to about 5%, then decreases slightly at 7%. This suggests that the addition of fillers in a certain amount can increase the cavities between aggregates that can then be filled by asphalt. However, if the filler content is too high, the mixture becomes too dense so that the cavities between the aggregates decrease again.

Void Filled With Asphalt (VFA)

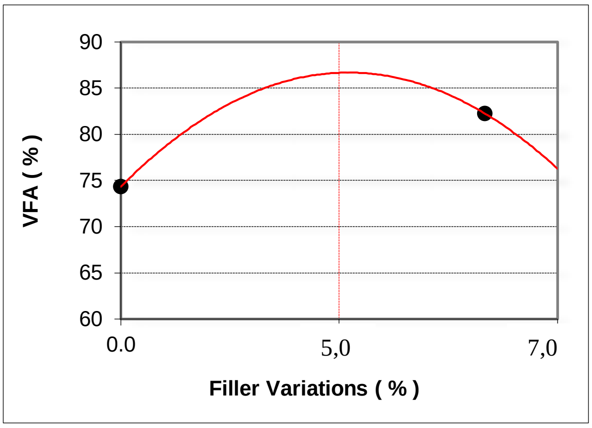

Figure 13. *Void Filled With Asphalt*

It can be concluded that the value of Void Filled with Asphalt (VFA) in the 5% filler variation increased to reach a value of 82.26%. This shows that the cavities in the mixture are filled with asphalt so that the mixture becomes denser. However, VFA values that are too high can also cause the mixture to become too plastic and potentially deform.

Meanwhile, in the 7% filler variation, the VFA value decreased to 67.75. This decrease occurs due to the increase in air cavities in the mixture so that the percentage of cavities filled by asphalt becomes smaller.

Stability

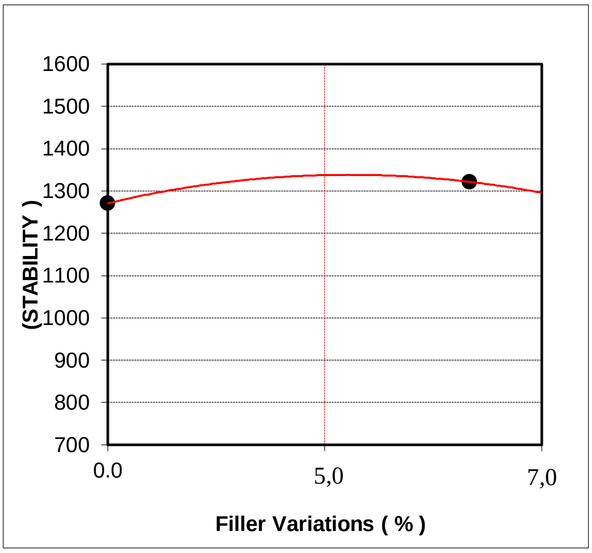

Figure 14. *Stability*

Based on the graph above, it can be seen that the stability value increased from 0% filler to 5% filler, then decreased in 7% filler. The highest stability is obtained at 5% of 1321.7 kg. This shows that the addition of fillers to a certain extent is able to increase the bonds between aggregates and make the mixture stronger against traffic loads.

However, when filler is added up to 7%, the stability value decreases. This condition is suspected to be due to too much filler causing the mixture to become stiffer and the aggregate distribution less than optimal so that the binding strength of the aggregate decreases. However, the stability value of the 7% filler still meets the specification of the highway, which is above 800 kg.

CONCLUSION

Based on the test results, *the characteristics of the* Marshall AC-WC mixture with the addition of ash fillers, teak wood powder, and red brass brick powder have an influence on the characteristics of the asphalt mixture. This effect can be seen from changes in the values of VIM, VMA, VFA, stability, flow, Marshall Quotient (MQ), and residual Marshall stability in each filler variation used.

The results of this study show that the 5% filler variation produces the highest stability value of 1321.7 kg. However, the VIM value in this variation is 2.95% so it is still below the required specification limit. Meanwhile, in the 7% filler variation, most of the marshall parameters have met the general specifications of the 2018 Revised 2 Highway, namely the VIM value of 4.89%, the VMA of 15.89%, the VFA of 67.75%, the stability of 1257.7 kg, the flow of 3.05 mm, the Marshall Quotient of 412.90 kg/mm, and the stability of the remaining marshall of 111.27%.

Based on the results of the evaluation of all marshall parameters, the 7% filler variation can be said to provide optimal results compared to other variations because all parameters meet the required specifications.

Suggestions for further research are suggested using different types of asphalt mixtures to find out how much effect red brick powder fillers and teak wood powder ash have on other types of mixtures such as AC-BC.

It is necessary to carry out additional testing on the durability properties of asphalt mixtures to determine the resistance of the mixture to the influence of water and traffic loads.

The mixing and compaction process should be carried out with more careful control so that the test results are more consistent and closer to the conditions in the field.

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