A Preliminary Study: Utilization Red Brick Powder as Filler in Asphalt Mixture

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Abstract. Filler has the smallest percentage of asphalt pavement's aggregate gradation but has a significant role. In addition, mineral filler stone dust, is very difficult to obtain. Therefore, there is a need to make an innovation by substituting filler with other materials, such as red brick powder. This study will discuss red brick powder as a filler substitution in the Hot Rolled Sheet – Wearing Course (HRS–WC) asphalt mixture. Variation of filler content used 0%, 25%, 50%, 75%, and 100% with optimum asphalt content of 6.75%. Furthermore, the Marshall test was carried out on all test objects to determine their characteristic values. The results showed that using red brick powder filler with a content of 75% obtained the optimum increase in stability aspects, equal to 61.29 kg. The value of flow and Void Filled With Asphalt (VFWA) will increase with the addition of filler content. While the Marshall Quotient, Void In Mix (VIM), and Void In Mineral Aggregate (VMA) values occur on the contrary, namely will decrease with the addition of filler content but still meet the specifications required by the Bina Marga 2018 Highways General Specification. This analysis shows that red brick powder can be used as a filler in the HRS asphalt mixture. – WC and need to be tried on a porous asphalt mixture that can drain water well and is suitable for application in tropical countries such as Indonesia.

Keywords: Red Brick Powder · Filler · Asphalt Mixture · HRS-WC First Section

1 Introduction

Filler has a significant role in an asphalt mixture [1]. The amount of filler in the asphalt mixture is very limited. Most fillers, so the mixture will be very stiff and crack easily, besides requiring a lot of asphalt to meet workability. On the other hand, the lack of mixture filler material becomes very flexible and easily deformed by vehicle wheels, resulting in bumpy roads [2]. The natural filler used in asphalt mixtures is stone dust [3], but stone dust is very difficult to obtain. It takes a lot of aggregates to crush. This will have an impact on rock mining which has the potential to cause environmental damage [4]. For this reason, an effort is needed to overcome this problem by looking for substitute materials that have as much positive value as possible in various aspects,

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such as strength, availability, environmental friendliness, or cost. Different alternative materials can be used as filler substitutions, such as fly ash [5], bottom ash [6], red brick powder [7], pine flower [8], areca nut ash [9], coconut coir [10], bagasse ash [11], rice husk ash [12], glass powder [13] and green mussel powder [14]. In this study, it will be tried to use red brick powder as a filler substitution in Hot Rolled Sheet Wearing Course (HRS–WC).

Red brick contains SiO_2, Al_2O_3, and Fe_2O_3 more than 70%, so it is classified as an active pozzolan [15]. In addition, red bricks have 47% silica and 47% alumina, where silica in asphalt mixtures can increase the potential for stability and durability of asphalt mixtures [16]. Red brick is a material that is easy to find because it is commonly used in various building constructions. Red brick has abundant availability, considering making it is also quite easy. However, there must be material left over from production that cannot be sold in every production. In addition, red brick waste is also often found in building demolition waste.

In the writer's research, at the optimum bitumen content (OBC) of 6.75% by total weight of the aggregate and the filler substitution content of 75% by the total weight of the filler, which is the most optimum content, the red brick powder can increase the stability of 6129 kg in the HRS–WC with other aspects remaining meet specifications [4]. Red brick powder also recorded in previous studies, could positively impact asphalt mixtures by increasing stability with other parameters while still meeting the required specifications. Asphalt Concrete Wearing Course (AC–WC) with 5.4% asphalt content and filler substitution of 6% of the total weight of the filler, the results show that the strength parameters can meet the specifications [7]. Another study also showed that red brick powder could increase stability with 50% filler substitution and optimum asphalt content of 5.5% for AC-WC [17]. Asphalt Concrete Binder Course (AC–BC) with filler substitution content of 6.5% and asphalt content of 6.5% showed that the stability value increased and met the specifications [18].

Meanwhile, the opposite result was obtained in a study with 35/50 Polish penetration asphalt: using red brick powder as a filler will begin to negatively impact the 50% substitution level [19]. This study aims to determine Marshall Properties HRS-WC using red brick powder as a filler substitution. Therefore, this research will be further developed to be new research and adopted to other mixture methods, namely porous asphalt with Australian Gradation, which could drain water better and is suitable for application in tropical countries such as Indonesia.

2 Materials and Method

2.1 Materials

This study will use the red brick powder as filler substitution, coarse aggregate, fine aggregate, and 60/70 penetration asphalt, as seen in Fig. 1, 2, 3 and 4. Asphalt testing consists of specific gravity, penetration, and softening point. Coarse aggregate testing involves abrasion using Los Angeles Machine, soundness, specific gravity, and absorption. Meanwhile, fine aggregate testing consists of sand equivalent, specific gravity, and absorption.

Fig. 1. Red Brick Powder

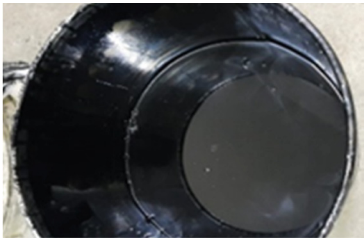

Fig. 2. Asphalt

Fig. 3. Coarse

Fig. 4. Fine Aggregate

2.2 Methods

This research is experimental by conducting experiments on making test objects using red brick powder filler with optimum asphalt content of 6.75% [20]. Variations in filler content used were 0%, 25%, 50%, 75%, and 100% substitution of the total weight of conventional filler with three specimens for each variation. Furthermore, Marshall testing will be carried out to determine the characteristics of the asphalt mixture. This research consists of 4 stages:

Stage I: Preparation of tools and materials testing. The preparation tools used include a set of asphalt testing tools, a set of coarse and fine aggregate testing tools, a group of Marshall hammers, and a set of Marshall testing tools. The materials used are coarse aggregate, medium aggregate, and fine aggregate originating from Clereng, Klaten Regency. The red brick powder was obtained from Ngadirejo, Sukoharjo Regency. At the sametime, asphalt is obtained from PT. Pancadharma Puspawira Ngasem, Karanganyar Regency.

Stage II: Materials Testing. Materials testing is used to determine the value of the characteristics of the material following the applicable terms and conditions. This testing includes coarse aggregate, fine aggregate, and asphalt testing. Coarse aggregate testing consists of specific gravity, abrasion with Los Angeles machine, and soundness. Fine aggregate testing consists of absorption, specific gravity and sand equivalent. Asphalt testing consists of specific gravity, penetration, and softening point. These testing is presented in Fig. 5, 6, 7, 8, 9, 10, 11 and 12.

Fig. 5. Coarse Aggregate Specific Gravity Test

Fig. 6. Abrasion Test

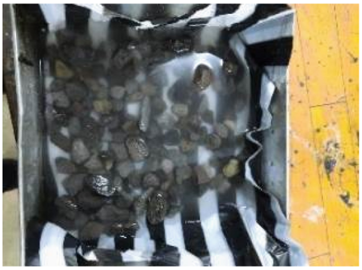

Fig. 7. Soundness Test

Fig. 8. Fine Aggregate Specific Gravity Test

Fig. 9. Sand Equivalent Test

Fig. 10. Asphalt Specific Gravity Test

Fig. 11. Asphalt Penetration Test

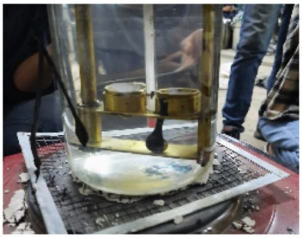

Fig. 12. Softening Point Test

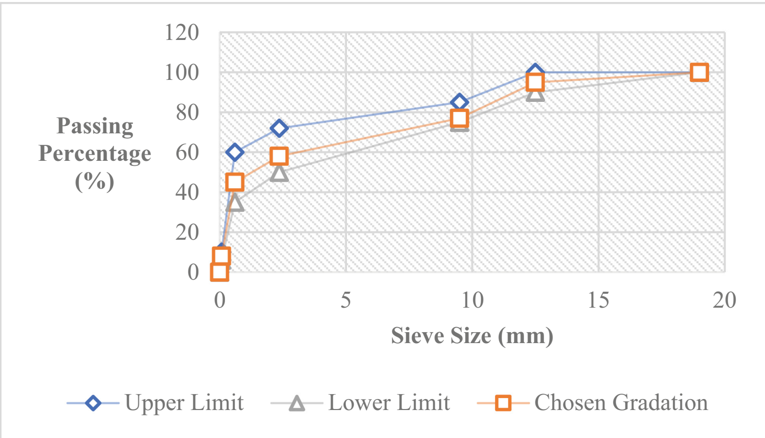

Fig. 13. Envelope Gradation of HRS –WC

Stage III: Aggregate gradation planning for HRS – WC according to Bina Marga Specifications (2018). The envelope gradation of HRS-WC is presented in Fig. 13.

Stage IV: Making test specimens and Marshall testing with optimum asphalt content for each red brick powder material variation, which is 6.75% for each variation of filler content. Variations in filler content used are 0%, 25%, 50%, 75%, and 100%, with 3 samples each. The procedure for making specimens uses the Automatic Asphalt Mixer according to the mix design calculation. Marshall's test can be seen in Fig. 14.

Fig. 14. Marshall Test

Table 1. The Result of Coarse and Coarse Aggregate Testing

Type of Testing	Results	Specification	Description
1. Coarse Aggregate			
Coarse Aggregate Wear (%)	30	40	meet specifications
Bulk Density	2.52	-	meet specifications
SSD Density	2.546	-	meet specifications
Apparent Density	2.586	-	meet specifications
Water Absorption (Absorbtion) (%)	1.007	3	meet specifications
Aggregate Weathering (Soundness) (%)	2.80	12	meet specifications

Table 2. The Result of Coarse and Fine Aggregate Testing

Type of Testing	Results	Specification	Description
2. Fine Aggregate			
Bulk Density	2.584	-	meet specifications
SSD Density	2.703	-	meet specifications
Apparent Density	2.933	-	meet specifications
Water Absorption (Absorbtion) (%)	4.603	3	meet specifications
Sand Equivalent (%)	70.0	50	meet specifications

3 Results and Discussion

3.1 Materials Testing Result

The results of material testing are presented in Table 1 and 2 (Table 3).

Table 3. The Result of Asphalt Testing

No.	Type of Testing	Testing Method	Condition	Results		Description
				Non Filler	Red Brick Powder Filler	
1	Penetration at 25 °C (0.1 mm)	SNI 06-2456 -1991	60–70	66.8	64	meet specifications
2	Softening Point (°C)	SNI 2434 :2011	48	49.5	52.5	meet specifications
3	Specific gravity	SNI 2441 :2011	1.0	1.08	1.09	meet specifications

Table 4. The Result of Mix Design Calculation

Material	(%)
Coarse Aggregate	17.75
Fine Aggregate	68.63
Aggregate Fillers	6.88
Asphalt Content	6.75

3.2 Mix Design Result

Aggregate blending/mix design HRS-WC is carried out using an analytical method with a gradation envelope according to Bina Marga Specifications (2018) [21], as shown in Table 4.

3.3 Marshall Test Result

The results of the Marshall test to determine the Marshall characteristics (Stability, Flow, MQ, VFWA, VMA, and VIM) are presented in Table 5.

3.4 Stability

The relationship between stability and red brick powder filler according to the test results is presented in Fig. 15.

Based on Fig. 15. We can see that all variations of filler substitution of red brick powder have met the specifications of the Bina Marga (2018), which are more than 800 kg [21]. In addition of red brick powder as a filler, substitution can increase the stability of the Hot Rolled Sheet – Wearing Course (HRS–WC). An increasing effect

Table 5. Marshall Test Result

Filler (%)	Stability	Flow	VFWA	VMA	VIM	MQ
	(kg)	(mm)	(%)	(%)	(%)	(kg/mm)
	Specification					
	>800	>3	>68%	>18%	4–6%	>250
0%	1469.02	3.00	71.04	18.50	5.73	489.67
25%	1498.30	3.07	70.97	18.51	5.75	488.58
50%	1504.04	3.10	72.71	18.15	5.33	485.17
75%	1530.31	3.67	71.10	18.49	5.71	417.36
100%	1265.61	3.60	74.33	17.83	4.95	351.56

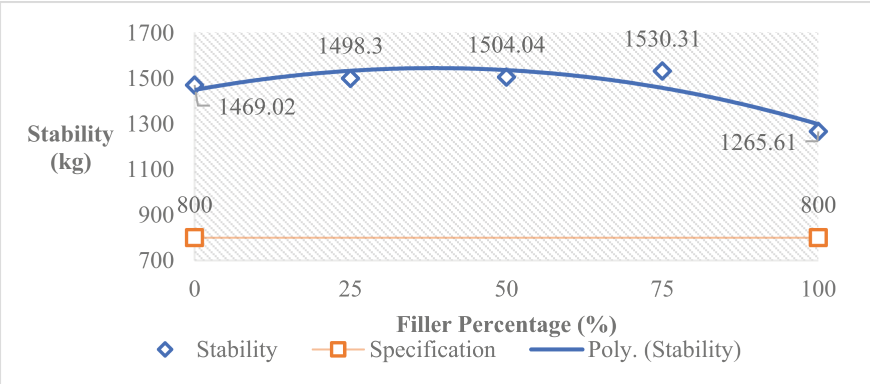

Fig. 15. Graph of Relationship between Red Brick Powder Filler and Stability

began to appear at a level of 25%, which continued to increase to a level of 75%, where the best stability value was obtained, which increased by 61.29 kg at a level of 75%. However, at 100% usage rate, the stability starts to decrease drastically due to the ability to fill space, and the absorption capacity of red brick is smaller than stone dust so that when used 100% as a filler, the stability will decrease drastically less than the use of ordinary stone. This follows the results of the mixture void (VIM), which is also significantly reduced. In previous research [22] also stated that the use of red brick powder as a filler substitution could increase the stability of the Malaysian-graded porous asphalt mixture.

3.5 Flow

The relationship between flow and filler content of red brick powder according to the test results is present in Fig. 16.

From Fig. 16 we can see that flow at each substitution level has met the specifications required by Bina Marga (2018) [21] by more than 3 mm. The use of red brick powder as

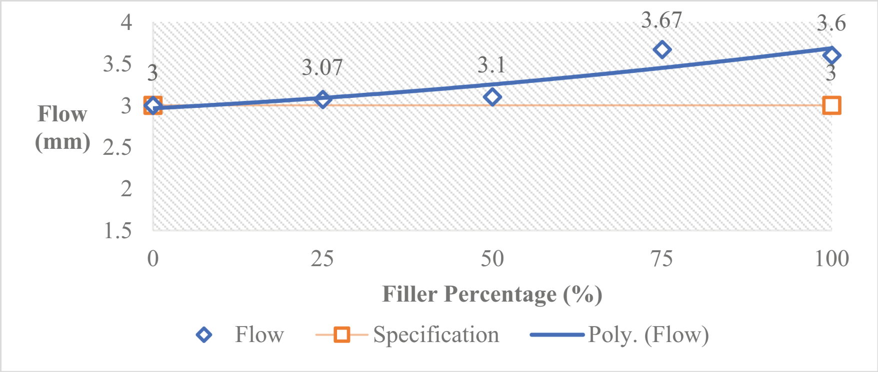

Fig. 16. Graph of Relationship between Red Brick Powder Filler and Flow

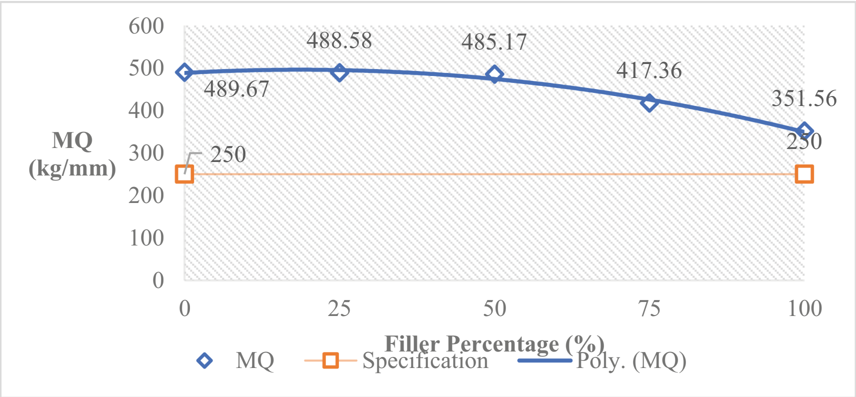

Fig. 17. Graph of Relationship between Red Brick Powder Filler and Marshall Quotient

a filler substitution in the Hot Rolled Sheet – Wearing Course (HRS–WC) will increase flow as the filler content is added. This is because the red brick powder is not good at filling asphalt-filled cavities and has a high absorption capacity than stone dust, so more asphalt enters the mixture and the plastic melt in the mixture becomes high. In line with previous research, the results also show that using red brick powder as a filler substitution in the Malaysian-graded porous asphalt mixture will make the flow value higher than using stone dust as a filler [22]. The use of red brick powder as a filler substitution in the Asphalt Concrete – Wearing Course (AC–WC) is also obtained, which will make the flow value higher than natural stone dust filler [23].

3.6 Marshall Quotient

The test results show the relationship between the Marshall Quotient and filler content of red brick powder is present in Fig. 17.

Based on Fig. 17. We can see that Marshall Quotient at each substitution level has met the specifications required by Bina Marga (2018) [21] by more than 250 kg/mm.

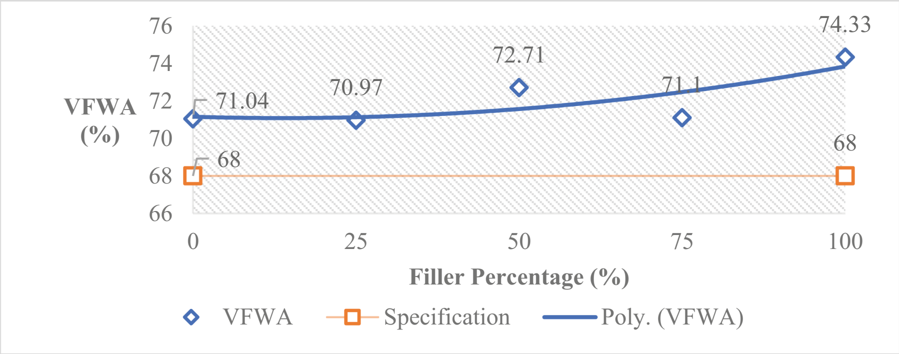

Fig. 18. Graph of Relationship between Red Brick Powder Filler and VFWA

The use of red brick powder as a filler substitution in the Hot Rolled Sheet – Wearing Course (HRS – WC) causes the Marshall Quotient value to decrease by adding filler content. The value of stability and flow influences the Marshall Quotient value. In this study, it was obtained that the stability value decreased at 100% filler substitution while the flow value increased to 100%, so the Marshall Quotient value decreased as well. The lower the stability value in the mixture and the higher the flow value in the mixture, the Marshall Quotient value decreases and vice versa.

3.7 Void Filled with Asphalt (VFWA)

The relationship between Void Filled with Asphalt (VFWA) and the content of red brick powder filler according to the test results is present in Fig. 18.

Based on Fig. 18. We can see that the VFWA at each substitution level has met the specifications required by Bina Marga 2018 [21] by more than 68%. The use of red brick powder as a filler substitution in the Hot Rolled Sheet – Wearing Course (HRS–WC) causes the VFWA to increase with the addition of filler content. This is because the red brick powder is not good at filling voids filled with asphalt and has a higher absorption capacity, so more asphalt enters the mixture and causes the void filled with asphalt to increase. In previous studies, the same thing also happened when applied to an Asphalt Concrete – Wearing Course (AC–WC); using red brick powder as a filler substitution would increase the VFWA value along with adding red brick powder substitution levels [24].

3.8 Void in Mix (VIM)

The relationship between Void In The Mix (VIM) and the filler content of red brick powder according to the test results is present in Fig. 19.

Based on Fig. 19, we can see that the VIM value at each substitution level has met the specifications required by Bina Marga 2018 [21], which is between 4–6%. However, using red brick powder as a filler substitution in the Hot Rolled Sheet – Wearing Course (HRS–WC) will cause the air void value in the mixture to always decrease with the

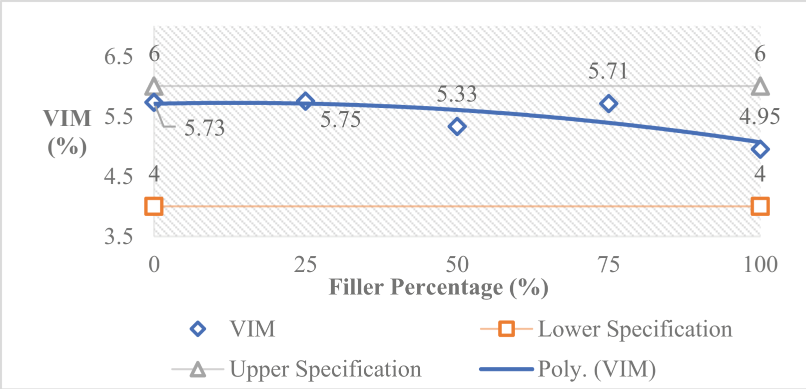

Fig. 19. Graph of Relationship between Red Brick Powder Filler and VIM

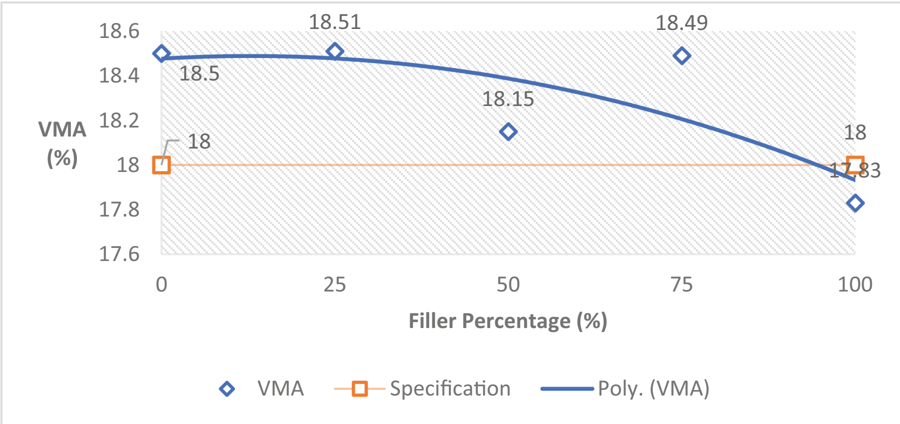

Fig. 20. Graph of Relationship between Red Brick Powder Filler and VMA

addition of filler content. This is because the red brick powder is not good at filling voids and has a high absorption capacity than stone dust so more asphalt might enter the mixture. The higher the VIM value, the less dense the mixture will be. In previous studies regarding the use of red brick powder as a filler substitution in another mixture, namely Asphalt Concrete – Wearing Course (AC–WC) it was also found that the value of air voids in the mixture or VIM will decrease with the addition of filler substitution levels [24]. So from this it can be concluded that the use of red brick powder filler has a good impact on the VIM value because the mixture becomes denser.

3.9 Void in Mineral Aggregate (VMA)

The relationship between Void In Mineral Aggregate (VMA) with filler content of red brick powder according to the test results is present in Fig. 20.

Based on Fig. 20. We can see that the VMA value at the substitution level of 0%–75% met the specifications required by Bina Marga 2018 [21], which is more than 18%. However, at 100% substitution, the VMA value did not meet the specifications. In addition, the VMA value with the substitution of red brick powder in the Hot Rolled Sheet – Wearing Course (HRS–WC) will decrease as the filler content is added. This is because the void in the mixture (VIM) with red brick powder filler gets smaller as the filler content is added. The VMA value is directly proportional to the VIM value so if the air void value decreases, it will have the same impact on VMA. In previous studies, the red brick powder was used as a filler substitution in the Asphalt Concrete – Wearing Course (AC – WC) mixture, which means that the VMA value will be lower than the use of stone dust as a filler [24, 25].

4 Conclusion

The utilization of red brick powder as a filler substitution affects the HRS-WC mixture characteristics. Through Marshall test, it is known that the stability value gets the optimum increase at a 75% level of 61.29 kg. Then the value of flow and VFWA will increase with adding filler content. While the value of Marshall Quotient, VMA, and VIM, the opposite occurs, namely the value will decrease with the addition of filler content. Based on the result, this study/research can be further developed to be new research and adopted to other mixture methods, namely porous asphalt with Australian Gradation, which could drain water better and is suitable for application in tropical countries such as Indonesia.

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