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The characteristics of Asphalt Concrete – Wearing Course (AC-WC) mixture using Buton Rock Asphalt (BRA) with Oily Sludge (OS) as a rejuvenator

Y Astor, A M S Sufanir and W Z Utari*

Department of Civil Engineering, State Polytechnic of Bandung, Bandung, West Java, Indonesia

*wahdiah.zunda.mtri17@polban.ac.id

Abstract. Indonesia is a country that has an abundant supply of natural asphalt, namely Buton Rock Asphalt (BRA). The problems faced by the BRA pavement as a binder is the quality of asphalt concrete produced cannot yet compete the oil asphalt pavement as a binder. Therefore, researchers use Oily Sludge (OS) as a BRA rejuvenator. In this study, a test is conducted to identify the behavior and characteristics of Marshall and dynamic stability on the mixture of Asphalt Concrete – Wearing Course (AC-WC) with the use of BRA as a binder and an OS as the rejuvenation material of BRA. The variation of asphalt content used are 4,5%, 5%, 5,5%, 6%, and 6,5%. Based on the result of the test, the dynamic stability value of asphalt and BRA mixture that has been rejuvenated has a higher dynamic stability value than the mixture without BRA.

1. Introduction

Oily Sludge (OS) is a waste that occurs in processing, distributing, and storing petroleum. In general, OS is produced by the deposition of fine particles from fuel oil. The deposits are increasingly piling up in the lower part of the storage tanks or in the oil distribution pipes. Based on the Government Regulation No.85 Jo PP 18 of 1999, OS is categorized as a hazardous and toxic waste (B3). Therefore, an action is needed to handle this waste problem which is in line with environmental aspects.

On the other hand, Indonesia is a country that has an abundant supply of natural asphalt. Buton Rock Asphalt (BRA) on Buton Island has a natural asphalt content that is not less than 650 million tons, with vary contents of buton asphalt between 10-35% that is equivalent to 170 tons of oil asphalt [1]. However, the use of buton asphalt has not been used optimally. The problem that is faced by the buton asphalt pavement as a binding material is the quality of the asphalt concrete produced cannot yet compete the pavement with oil asphalt as a binder. This is because buton asphalt is a natural asphalt that still contains aggregate and water that is need to be processed to get the quality which is near to oil asphalt.

One of the buton asphalt processing is by rejuvenating through the process of buton asphalt softening or dissolving with rejuvenator. In 2015, Hermadi, Ronny, & Yamin conducted research about the use of OS as a rejuvenating material of Buton Rock Asphalt (BRA) for cold mixture [2]. The result of the study indicate that OS can be used as an buton asphalt rejuvenator, the 5/20 bitumen modifier type also has better characteristic than MC-800 cold mixture from 60 pen asphalt. In 2017, Putra, Wibisono, & Malik conducted research about the utilization of waste OS for mixture of lataston asphalt (thin layer of asphalt concrete) with marshall testing [3]. From this research, the addition of OS reduces the quality of the asphalt mixture, but still meets the specifications except the penetration value and kinematic viscosity

which decreases. In 2018, Sarwono, Suryoto, & Rahmawati conducted research about the characteristics of buton asphalt emulsion extract using modified solar flakes with asphalt penetration 60/70 [4]. The review used in this study is the mixing time of asbuton and diesel to obtain optimum levels of solubility of buton asphalt variations in composition of buton asphalt modified with asphalt penetration 60/70.

This study used a test to investigate the behavior and characteristics of Marshall, and the dynamic stability in Asphalt Concrete – Wearing Course (AC-WC) mixture with the use of Buton Rock Asphalt (BRA) as a binder and OS as an BRA rejuvenating material. The variation of contents that is specified in this study are 40%, 42.5%, 45%, 47.5%, and 50%. The determination of content variations is based on the previous research.

2. Methodology

2.1. Material

The material used in this study is shown in Figure 1: Coarse Aggregates and Fine Aggregates from Subang, Jawa Barat; 5/20 BRA from Buton Island; OS from around Cikarang, Jawa Barat; and asphalt with pen 60/70. All materials used are tested based on Direktorat Jendral Bina Marga 2010. Spesifikasi Umum Direktorat Jendral Bina Marga Edisi 2010 Revisi 3 Divisi 6.

Figure 1. Materials: (a) coarse aggregate and fine aggregate; (b) 5/20 bra; (c) oily-sludge; (d) asphalt with pen 60/70.

2.2. Machine and specimen

Technical characteristics testing is conducted based on Direktorat Jendral Bina Marga 2010. Spesifikasi Umum Direktorat Jendral Bina Marga Edisi 2010 Revisi 3 Divisi 6. In 5/20 BRA and OS, extraction and recovery are conducted first and then the properties are tested. After 5/20 BRA and OS are extracted and recovered, rejuvenating or mixing are conducted to the bitumen from 5/20 BRA and heavy oil from the OS are investigated to identify how much the percentage (%) of heavy oil to the content of bitumen needed in order to get the result that is equivalent or close to asphalt with pen 60/70. The variation level determined in this study are 40%, 42.5%, 45%, 47.5%, dan 50%. Furthermore, test object is made and a test using Marshall instrument is done as can be seen in Figure 2. Marshall testing is conducted to identify Optimum Asphalt Content. Then, a calculation is done to find out the value of Marshall parameter, such as VIM, VMA, VFB, stability, and flow.

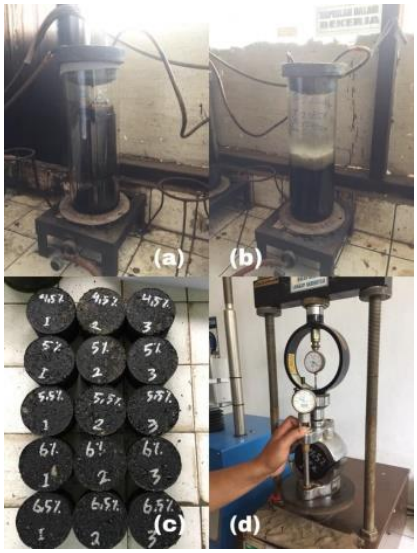

Figure 2. (a) 5/20 BRA extraction; (b) OS extraction; (c) test object; (d) marshall testing.

3. Test results

3.1. BRA characteristics + OS

The results of test that has been conducted on the characteristics of BRA + OS that will be used in buton asphalt mixture can be seen in Table 1 below:

Table 1. The variation of BRA + OS.

Type of testing	Method	Specification	Results	Units
Bitumen penetration at 25 °C, 100g, 5 second	SNI 2456-2011	Min. 50		0.1 mm
40%			38	
42.5%			48	
45%			60	
47.5%			67	
50%			69	
52.5%			73	
55%			80	

It can be seen from table 1 that the BRA + OS mixing test results are start from 45% to 55% of penetration values, and meet the requirements of Spesifikasi Umum Direktorat Jendral Bina Marga Edisi 2010 Revisi 3 Divisi 6. Then, properties testing of 50% heavy oil variation is conducted on the asphalt weight with 69 pen value to investigate the characteristics of the asphalt. The results can be seen in Table 2 below:

Table 2. The characteristics of BRA + OS.

Characteristics	**Specification**	**Results**	**Information**
Penetration	Min. 50	69	Qualified
Softening point	≥ 53 °C	54.3	Qualified
Specific gravity	≥ 1.0	1.027	Qualified
Ductility	≥ 100 cm	1.25	Not qualified

From table 2, it can be seen that BRA + OS used in this study has met the requirements of Spesifikasi Umum Direktorat Jendral Bina Marga Edisi 2010 Revisi 3 Divisi 6. Because the ductility does not meet the requirements, the researchers try to add latex to the BRA + OS mixture, and it is obtained the ductility of 3.75 cm and still does not meet the requirements. The results of ductility obtained are still not good because the type of OS used is paraffinic instead of asphaltic. Therefore, when the test object is made, the amount of asphalt with pen 60/70 will be more dominant than the amount of BRA.

3.2. The comparison of 60/70 pen asphalt and BRA

The comparison of 60/70 Pen Asphalt and BRA can be seen in table 3:

Table 3. The characteristics of asphalt with pen 60/70 and BRA.

Characteristics	Specification		Results		Information	
	Pen 60/70	**BRA**	**Pen 60/70**	**BRA**	**Pen 60/70**	**BRA**
Penetration	60 – 70	Min. 50	63	69	Qualified	Qualified
Viscosity	≥ 300 cST	-	360	-	Qualified	-
Softening point	≥ 48 °C	≥ 53°C	51.1	54.3	Qualified	Qualified
Specific gravity	≥ 1.0	≥ 1.0	1.033	1.027	Qualified	Qualified
Density	≥ 100 cm	≥ 100 cm	> 140	1.25	Qualified	Not qualified

Table 3 shows the characteristics comparison of asphalt with pen 60/70 and BRA. The penetration value of asphalt with pen 60/70 is 63 and the penetration value of BRA is 69. From each results, the penetration value obtained from BRA is greater, which means the BRA is slightly better than asphalt with pen 60/70 if it is seen from the penetration value. The softening point of asphalt with pen 60/70 is 51.1 and the softening point of BRA is 54.3. From each results of softening point, the softening point obtained from BRA is greater, which makes the BRA is slightly better than asphalt with pen 60/70 if it is seen from the softening point. The density of asphalt with pen 60/70 is 1,033 and the density of BRA is 1,027. From each results of the density, asphalt with pen 60/70 is considered better than BRA if it is seen from the density value. The ductility value of asphalt with pen 60/70 is >140 and the BRA ductility is 1,25. Based on each results of ductility value, a greater ductility value is obtained by asphalt with pen 60/70, so asphalt with pen 60/70 is better than BRA if it is seen from the ductility value. The ductility value obtained from BRA is very far from the specification because the OS used in this research is paraffinic rather than asphaltic, so the asphalt that is produced become stiff. The ductility value of BRA before added by OS is 0,25 cm, and after it is added by OS become 1,25 cm. When the OS is mixed into BRA, it does not have much effect on the ductility value because it only increases by 1 cm.

3.3. Resume of optimum asphalt content

Optimum Asphalt Content is obtained by testing the Marshall method. The analysis of Marshall testing produces values from several parameters, which are flow, Marshall Quotient (MQ), Density, Stability, Voids in the Mix (VIM), Voids in Mineral Aggregate (VMA), and Voids Filled with Bitumen (VFB).

Table 4. The characteristics resume of optimum asphalt content on each level of BRA.

Mixed characteristics	Mixed type			Requirements	
	0% BRA	10% BRA + 0,1% latex	10% BRA	Min.	Max.
Optimum asphalt content (%)	5.90	6.25	6.10	-	-
Ratio to asphalt	1.1	1.1	1.1	0.6	1.4
Density (ton/m^3)	2.330	2.328	2.330	-	-
VMA (%)	16.7	17.1	16.90	15	-
VIM-Marshall (%)	3.83	3.45	3.58	3	5
VIM-PRD (%)	2.71	2.29	2.45	2	-
VFB (%)	76.9	79.71	78.65	65	-
Stability (kg)	1045.3	1042.0	1046.0	1000	-
Flow (mm)	3.31	3.47	3.40	2	4

It can be seen from table 4 that the mixture of asphalt with pen 60/70 + 10% BRA + 0,1 % latex has Optimum Asphalt Content of 6,25%, the mixture of asphalt with pen 60/70 + 10% BRA has 6,10%, and the mixture of asphalt with pen 60/70 without BRA has 5,90 %. Based on the Optimum Asphalt Content, a calculation of other mixture characteristics is conducted to identify the optimum BRA content. The criteria which is necessary to be used in the next step is the mixture of asphalt with pen 60/70 with BRA that have high stability values. By paying attention to these factors, a mixture of optimum asphalt with pen 60/70 and BRA obtained is a mixture of asphalt with pen 60/70 + 10% BRA with Optimum Asphalt Content value is 6,10%.

3.4. The analysis of asphalt with pen 60/70 with BRA mixture comparison

There are six characteristics of asphalt mixture tested, which are density, Voids in Mineral Aggregate (VMA), Voids in the Mix (VIM), Voids Filled with Bitumen (VFB), stability, and flow. Below is the analysis on the characteristics of mixture asphalt with pen 60/70 with BRA:

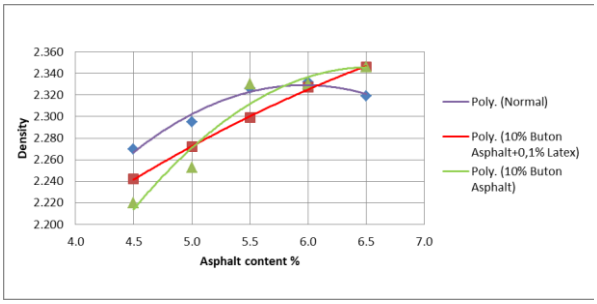

Figure 3. Density value.

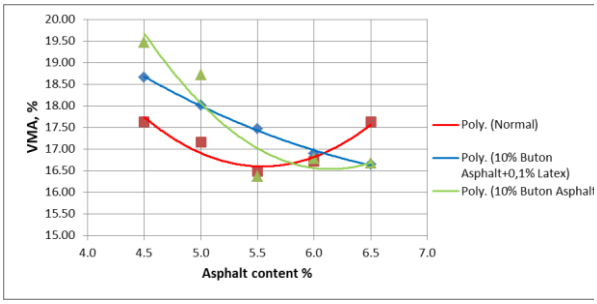

Figure 4. VMA value.

Figure 3 shows the relationship between various variations of asphalt content with density. The density value of asphalt will show a positive trend along with the increasing of asphalt content. In the mixture of asphalt + 10% BRA, the density value signifies a decrease, while the density value shows an increase in 6,5% asphalt content. The higher the density value, the asphalt mixture will be denser.

Figure 4 connects the relationship between several variations of asphalt content with VMA. Voids in Mineral Aggregate (VMA) shows how much the percentage of cavities available to be filled by asphalt. In the mixture of asphalt with pen 60/70 + 10 % BRA + 0,1% latex and the mixture of asphalt with pen 60/70 + 10% BRA, the VMA value is greater than the mixture of asphalt without BRA. However, there is a decrease of VMA value in the 6% asphalt content. The desired VMA value is the minimum possible value but still within the limits of VMA value according to the specification used.

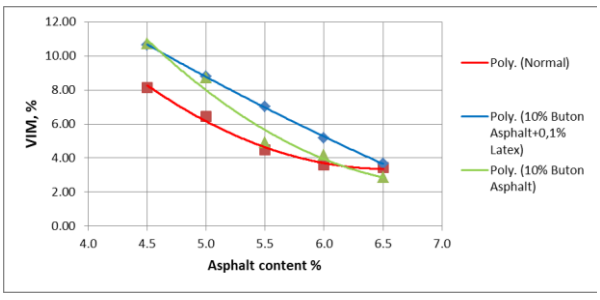

Figure 5. VIM value.

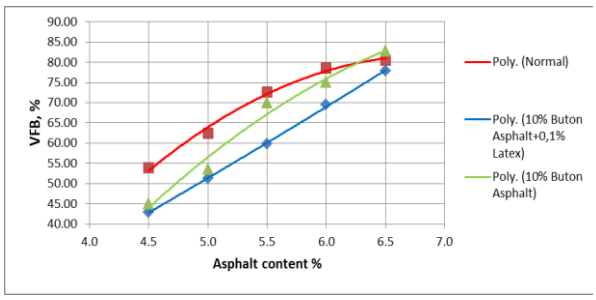

Figure 6. VFB value.

Figure 5 describes the relationship between several variation of asphalt content with VIM. VIM value is very necessary for mixture to give enough spaces for compaction due to traffic loads and also the impact of temperature increasing. It can be seen from Figure 5 that the addition of BRA increase the

VIM value. A decreasing of VIM value can indicate the resistance of mixture to deformation because the aggregate pore is well filled.

Based on Figure 6, it can be concluded that there is a relationship between several variations of asphalt content with VFB. Voids Filled with Bitumen (VFB) affects the durability of the mixture asphalt. VFB value is a percentage of VMA value after being reduced by VIM. In the figure of asphalt with pen 60/70 + BRA mixture, the VFB value is lower than the asphalt without BRA mixture.

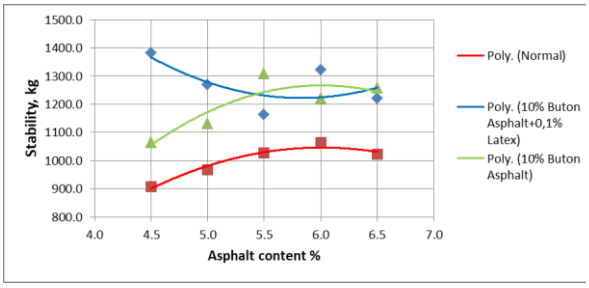

Figure 7. Stability value.

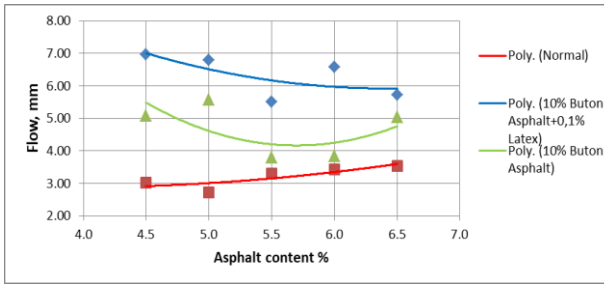

Figure 8. Flow value.

As can be seen in Figure 7, there is a relationship between several variations of asphalt content with stability. Stability shows the ability of asphalt mixture to accept traffic loads without changing the forms such as waving, grooving, and bleeding. In the stability figure of the asphalt with pen 60/70 + BRA mixture, it is greater than the stability in the mixture of asphalt without BRA.

From Figure 8, it can be seen that there is a relationship between asphalt content with flow. Flow is a parameter to determine the flexibility or plastic form change of asphalt caused by loads. In the figure of asphalt with pen 60/70 mixture + 10 % BRA + 0,1% latex and asphalt with pen 60/70 + 10% BRA, the flow value is increasing. This shows that the asphalt + BRA mixture is more stiff and vulnerable to cracking.

4. Conclusions

Based on the result of the study on the characteristics of 5/20 BRA Buton asphalt with OS as rejuvenator, it can be concluded as follows:

- Based on the analysis of Optimum Bitumen Content, the mixture of asphalt + 10% BRA reaches the optimum condition with Optimum Bitumen Content value of 6,10%.
- The dynamic stability value of the mixture of asphalt + 10% BRA + 0,1% and asphalt + 10% BRA, it has a higher value than the mixture without BRA.
- The flow value of the mixture of asphalt + 10% BRA + 0,1% latex and asphalt + 10% BRA, the flow value increases efficiency. It shows that the mixture of asphalt + BRA is more stiff and vulnerable to cracking. It is caused by the OS used is paraffinic instead of asphaltic.

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