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MARSHALL CHARACTERISTICS OF ASPHALTIC CONCRETE UTILIZING REFINE BUTONIC ASPHALT AS AN ASPHALT MODIFIER

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ABSTRACT

Refine Butonic Asphalt (Retona) is one of refined natural rock asphalts from Buton Island which is produced using extraction techniques so that it has better performance than commonly asphalt cement. The use of asphalt modifier in asphalt concrete mixtures is very limited in amount but contributes to considerable effects on the performance of asphalt as well as on the mixtures. This study aims to investigate stability and durability of asphalt concrete mixture containing Retona P6014 as an asphalt modifier. Research was conducted in four stages. Stage I was to determine physical properties of material, stage II was to find optimum asphalt content of asphalt, while stage III was to obtain mixture characteristics against content of Retona. Resistance to water damage then was conducted in stage IV. Results show that the use of Retona P6014 as an asphalt modifier produced a lower penetration value and softening point of original asphalt, which resulted in changes in characteristics of asphalt mixture. Utilizing Retona P6014 on asphaltic concrete was indicated to improve asphalt properties and asphalt concrete mixture at the right content. It was also shown that the asphalt concrete mixture with Retona seems to have a better performance in term of their stability, stiffness and resistance to water damage than those without it.

Keywords: Additive; Asphaltic concrete, Durability; Retona; Stability.

1. INTRODUCTION

Refine Butonic Asphalt or known as Retona, is one of refined natural rock asphalts from Buton Island, South East Sulawesi, Indonesia. Retona is produced using extraction techniques so that it has better performance than that of common asphalt cement. Two (2) types of Retona were produced by PT. Olah Bumi Mandiri, which consists of mastic form of Retona B6060 and a powder form of Retona P6014. The main potential of Retona lies in its chemical composition. It is rich in aromatic oil content, which contributes to overcome problems of waxy bitumen, which have low softening point and adhesiveness. This usually occurred in petroleum asphalt, due to the absence of certain types of oil used to enriched bitumen properties, because of the increasing need for certain types of oil, leaving a dried, hard and easily to oxidized asphalt.

One common usage of Butonic Asphalt, which is widely known as Asbuton, is to combine it into petroleum asphalt, so that a higher performance of asphalt is achieved due to its viscosity changes. The influence of viscosity changes and temperature susceptibility of asphalt on resistance to deformation of pavement mixture is significant. To increase a higher performance, to reduce the frequency of maintenance required, and to provide much longer service life for maintenance treatments at difficult sites,

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modified asphalt is commonly used. An asphalt modifier is commonly added or substitute to bitumen to modify its properties. One of the main purposes of using a modifier in the mixture is in improving resistance to permanent deformation of asphalt mixture at high temperature without losing its properties. This is obtained by either stiffening the bitumen so that the visco-elastic response of the asphalt is reduced or by increasing the elastic component of the bitumen, thereby reducing the viscous component, which results in a reduction in permanent strain (Brown, S 1990).

Many researchers had studied on performance of asphaltic mixture using a combination of petroleum asphalt and Butonic Asphalt (Asbuton). Ramli et al. (2001a) investigated characteristics of asphaltic mixture utilizing Butonic Mastic Asphalt (BMA). They extended to study durability of the BMA mixture in order to describe effect of water vapor cyclic phenomenon (Ramli et al. 2001b). Performance of a mixture utilizing Refined Butonic Asphalt (Retona) blend on asphaltic concrete wearing course (AC-WC) mixture has been conducted (Subagio et al., 2003; 2005; 2007). Subagio et al., (2009) focused on fatigue, plastic deformation, and stiffness modulus of the asphaltic mixtures. Utilizing liquid Asbuton as a partial replacement of petroleum asphalt bitumen on a Porous Asphalt mixture had also been presented (Ali et al., 2011). Study on the resistance of Asphalt Concrete with Butonic bitumen against water saturation had also been reported (Ali, 2013). However, Retona used as an asphalt modifier in bituminous mixture for surfacing layer of the road was only limited. This experimental study presents the Marshall characteristics and durability of asphaltic concrete specimens containing Retona P6014. Specimen preparation, procedures and data evaluation will be presented in the following discourse. Some results of the testing will be compared with previous studies.

2. STABILITY AND DURABILITY OF ASPHALT MIXTURE

Stability of the asphalt mixture could be represented as its ability to support the traffic load with the absence of deformation, known as a stability value. The Asphalt Institute, MS-2 (1991) defined that stability is a resistance to permanent deformation of asphalt mixture due to a traffic load. The stability value of asphalt mixture is affected by frictional resistance and interlocking between aggregates particles and cohesion of the mixture. On the Marshall test it demonstrates as a maximum load that the specimen can be restrained at the temperature of 140 ^{0}F with the consistence loading velocity of 2 inch per second. Stability of asphalt mixture is affected by interlocking and interparticle friction between aggregates which is correlated with densification of the mixture, and its value is formulated in the following formula (Equation.1).

$$S = f(p,k,t) \tag{1}$$

In which, S= stability of the mixture (lbs), p= value of stability reading from the Marshall device *marshall* (lbs), k= proving ring calibration of *marshall device, and* t= specimen depth correction.

Durability of mixture is defined as resistance of the mixture due to water existence and temperature disturbance, which is strongly related to the ability of water and air penetrated to the mixture. Durability of the mixture, then, is affected by densification and porosity of the mixture. Furthermore, the thickness of asphalt covering the

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aggregate, which is depend on the asphalt usage as a binder of the mixture, is also important factors of the durability of the asphalt mixture. The more amount of asphalt with the less void the more thickness of film asphalt and the higher durability of the mixture. In the laboratory, durability of the mixture is formulated as the retained strength after the specimen is 24 hour immersed under water with temperature of 60^{o}C. (Equation. 2).

$$r = \frac{S - S_{t)}}{S} x100\% \tag{2}$$

In which, r = index of retained strength/ stability, S= Stability value of Marshall standard test (lbs), S_t= Stability value of Marshall Immersion test.

3. EXPERIMENTAL WORKS

Laboratory program started with material testing for each individual component materials of the mixture, which consists of aggregates, asphalt and Retona P6014. The aggregates used in this study were obtained from Clereng, Yogyakarta, Indonesia and consisted of crushed gravel coarse, fine aggregates and filler. The individual sizes of aggregate were separated first and then recombined to meet the Binamarga specification at middle of the grading as shown in Table 1. The Asphalt Cement (AC 60/70) used in this study was provided by PT Pertamina Cilacap, and Retona P6014 was produced by PT. Olah Bumi Mandiri, (OBM), Jakarta, Indonesia. The Retona is extracted from Asbuton asphalt, rock asphalt from Lawele, Buton Island, Indonesia, where the properties of the Retona is showed by Table 2. It shows that the bitumen content of Retona additive was highly sufficient (55% –60%), and its bitumen properties was very soft (0 – 10 dmm).

Table 1. Aggregate Grading Design

Sieve size		Percentage of Passing (%)	
Inch	Mm	Specification*)	Design (Mid)
# 1	25	100	100
# ¾	19	90 – 100	95
# ½	12.5	74 – 90	82
# 3/8	9.5	64 – 82	73
# 4	4.75	47 – 64	55.50
# 8	2.36	34.6 – 49	41.80
# 16	1.18	28.3 – 38	33.15
# 30	0.600	20.7 – 28	24.35
# 50	0.300	13.7 – 20	16.85
# 100	0.150	4 – 13	8.50

*) Bina Marga (2010)

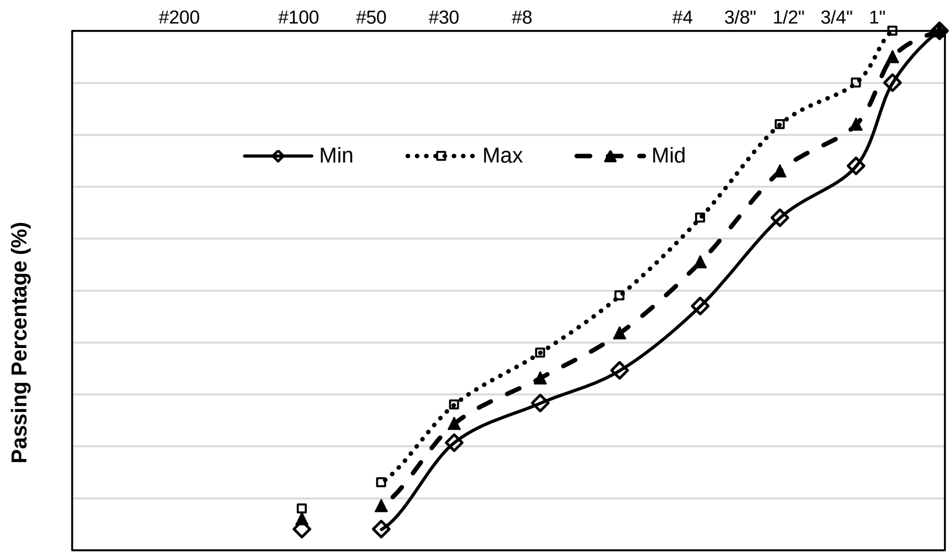

Figure 1. Aggregate Grading Specification and Design

Table 2 Characteristics of Retona P6014 material

Characteristics	Units	Value
Shape	-	Powder
Density	kg/lt.	1.45
Size	inch	20 mesh
Bitumen content	%	55-60
Mineral content	%	40-55
Mineral pass sieve #200 mesh	%wt	93
Penetration	dm m	0-10
Softening Point R&B,	˚C	130 min

Material properties including coarse aggregate, fine aggregate, filler, asphalt, and Retona was initially tested before preparing the specimen. The effect of utilizing Retona on the hardness and softening point of asphalt as well as the mixing and compacting temperature for each different contents of retona to reach the same viscosity with original asphalt (Pen 60/70) were also conducted. Specimen of asphalt with optimum Retona content was prepared and penetration tests as well as softening point tests of asphalt then were performed. From the data obtained the value of Penetration Index (PI) which represents a temperature susceptibility of asphalt could be carried out using formula derived by Brown (Brown, S, 1990).

Three specimens were then prepared for each of five asphalt contents from 4 to 6 percent, with the interval of 0.5 %, by total weight of the mixture, to obtain optimum asphalt content. The mixture mixing process complies with The AASHTO T 245-82 and ASTM D 1559-89 procedure. The specimens of Marshall standard test then were investigated. Next, five types of specimens with different content of Retona (from 0 to 15 percent, with the interval of 3 %, by total weight of asphalt content) were prepared and tested at optimum asphalt content in order to get optimum content of Retona.

Following this, resistance to water damage was conducted to measure loss of adhesion between aggregate and asphalt caused by the action of water on compacted asphalt mixture. Three specimens for each types of specimen containing Retona and those without Retona were prepared at optimum asphalt content. To obtain the asphalt mixture retaining stability, specimens were immersed in a water bath at 60^{o} C for 24 hours, and then the Marshall test was run. The Index of Retained Strength, which was define as a percentage of stability was obtained under immersion test to stability obtained under standard condition, which then was calculated (IRE-TRRL).

4. RESULTS AND DISCUSSION

Result of six types of asphalt concrete specimens with different Retona content of 0%, 3%, 6%, 9%, 12% and 15% of optimum asphalt content respectively will be discussed in the following discourse.

Figure 1 shows the effect of Retona content on the stability and flow of the specimen. As can be seen from the graph, stability was rising with the increasing Retona content until it reached maximum value, then, it was followed by decreasing the graph. The specimen containing Retona have a higher stability than those without it. Since the stability is represented by the resistance to deformation, this means that the resistance to deformation of the mixture was strongly affected by Retona content. The higher Retona content provides higher stability. This occurrence was likely because of the hardness of bitumen changes. The use of Retona as an additive provides the higher hardness in the bitumen. Higher penetration asphalt provides higher stability of the mixture. This is in consistence with the previous works (Afandi, 2010; Ali, 2010; Subagia et.al, 2009). They showed that the mixtures contains Retona have a higher stability, less value of flow and air void.

Asphalt containing Retona had a lower penetration value compared to the original asphalt. This means that an added Retona on the asphalt provides a more hardness on original asphalt and increases its viscosity, therefore mixing and compacting temperature were adjusted to reach the same viscosity with the original asphalt (Pen 60/70). It was also seen from the table that softening point of original asphalt was higher than those with Retona. These penetration and softening data lead to the temperature susceptibility of asphalt which could be indicated by penetration index (PI). It is shown that asphalt containing Retona had a lower PI (high temperature susceptibility) than those without it. Temperature susceptibility of the asphalt is one of the parameters influencing the deformation value (flow) of the asphalt mixture.

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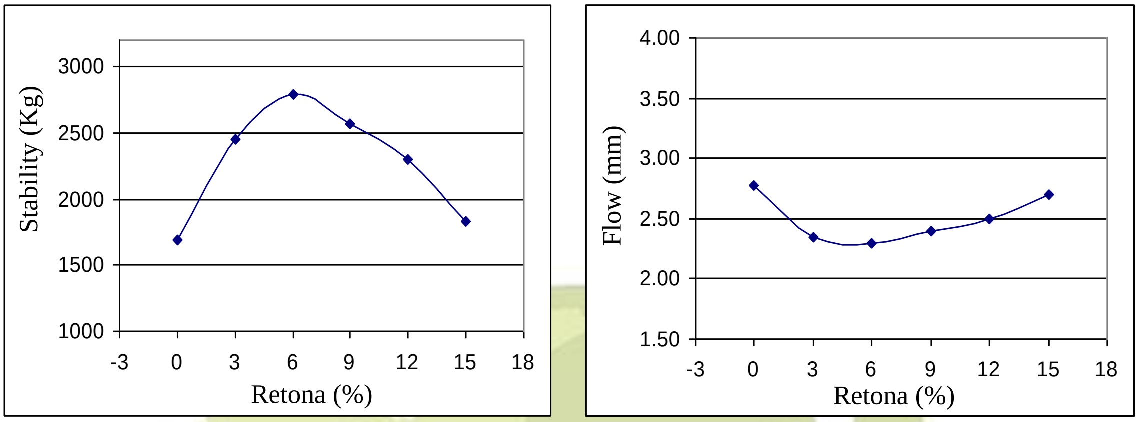

Figure 1 Stability and flow of mixture at different Retona content

As shown on Figure 2, the value of flow was ascending with the increasing of Retona content. The flow represented the deformation of the asphalt mixture. This indicated that the increasing Retona content on the mixture will increase its deformation. Previous research obtained that the mixture made with lower penetration bitumen caused lower deformation. The rising in hardness of the asphalt caused by Retona decreased its workability leading to the increasing of void in the mixture. This seems to prove the reason of this phenomenon as mentioned in the previous paragraph (Table 4).

The changes of voids in total mixture (VITM) and voids filled with asphalt (VFWA) corresponding to the Retona content is depicted in Figure 2. It is observable from the graph that the higher the Retona content the lower VITM, but the higher VFWA. The specimen made with higher content of Retona had less voids than those with less Retona. The use of Retona results in a higher volume of bitumen resulting decreasing voids in the mix and a increasing voids filled with asphalt.

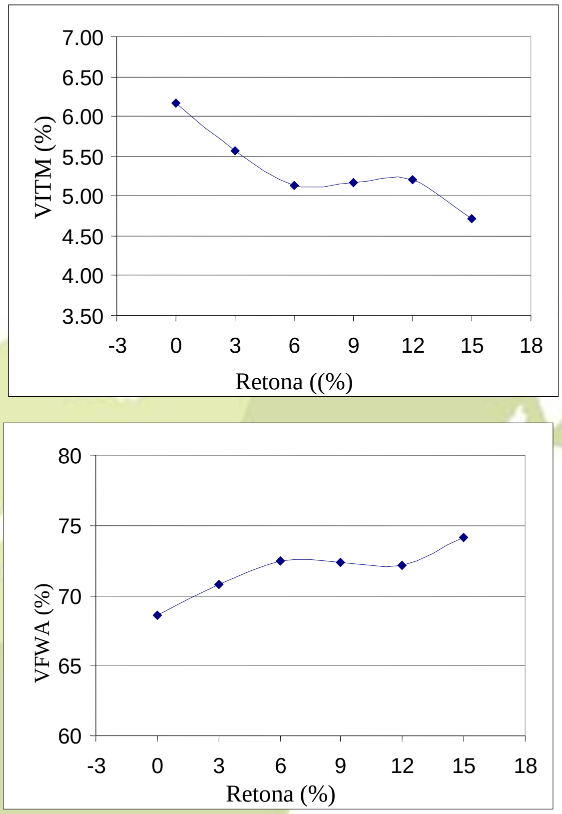

Figure 2. Relationship between Retona content versus VITM and VFWA

Figure 3 presents the relationship between Retona content versus density and Marshall Quotient. As shown from the graph that density of the mixture was climbing with the ascending of the Retona content. Since density reflects a unit weight of the mixture, the results point out that the higher Retona content leads to the higher unit weight. It was because the voids of the mixture with lower Retona content was less than those of with the higher Retona as a result of better lubrication effect on compaction phase of less hard asphalt.

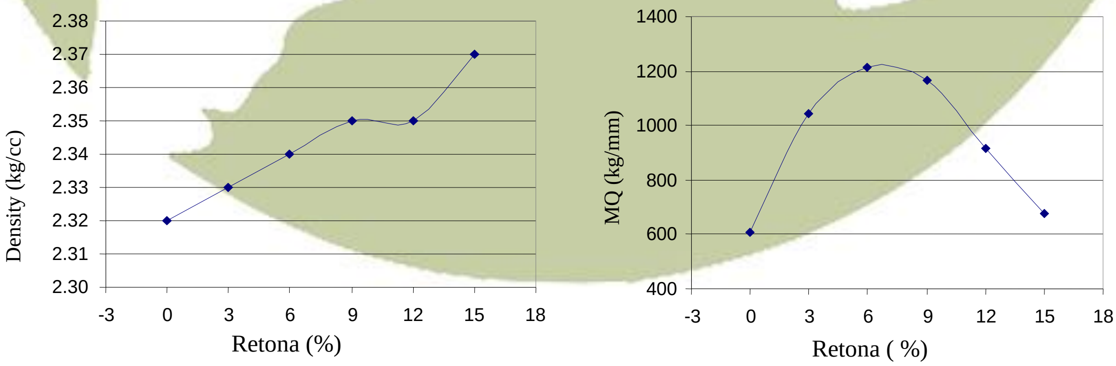

Figure 3. Density and Marshall Quotient of mixture at different percentage of Retona

Marshall Quotient (MQ) is a ratio of stability and flow. It indicates flexibility of the asphalt mixture. As plotted in the Figure 3, MQ was rising with the increasing of the Retona content until it reached maximum value which is followed by the falling of the curve. This indicates that the higher Retona content leads to the lower flexibility of the mixture. This was because the added of Retona provides a stiffening of the asphalt, so that the visco-elastic response of the asphalt is reduced, which results in a reduction of its flexibility. The falling of the stiffness was likely to occur because of the rising of voids filled with asphalt that in turn decreases its stiffness.

Retained stability of specimen prepared at optimum asphalt content containing Retona optimum content was relatively higher than the corresponding value for specimen prepared without Retona (Table 4). This means that specimen containing Retona have a higher resistance to water damage compared to those without it. This was because specimen containing Retona gives a lower VITM, a higher VFWA and a bigger density of the mixture, as a result of the more volume of asphalt-Retona. Furthermore, the most component of the RETONA, potassium, the very light metal which was reactive to water, formed a potassium oxide. Since Binamarga requires that the retained of stability should be equal to or greater than 75 % of that obtained without immersion, both of the specimens with and without Retona meet the specification.

Table 4. Index of retained strength of specimen with and without Retona

Characteristics	Original mixture		Mixture Containing Retona	
	Standard	Immersion	Standard	Immersion
Stability (kg)	1690,64	1557,06	1903,63	1811,06
Indeks of Retained strength (%)	92,098		95,13	

Table 5 presents results of penetration and softening point, and penetration index of asphalt with and without Retona. As can be seen from the table, asphalt containing Retona had a lower penetration value compared to the original asphalt. This means that an addition of Retona on the asphalt provides a more hardness on original asphalt. It was also seen from the table that softening point of original asphalt was higher than those with Retona. From these penetration and softening data we can get the temperature susceptibility of asphalt, which could be indicated by penetration index (PI). It is shown that asphalt containing Retona had a lower PI (high temperature susceptibility) than those without it. Temperature susceptibility of the asphalt is one of the parameters influencing the deformation value (flow) of the asphalt mixture.

Table 5. Penetration, softening point and Penetration Index of Asphalt with and without Retona *)

No	Parameter	Original Asphalt	Asphalt with Retona
1	Penetration (0.1 mm)	71,3	44,5
2	Softening Point (°C)	56	55
3	Penetration Index (PI)	1.13	-0.03

5. CONCLUSION

Based on the data obtained and analyses carried out the following conclusion might be drawn from this experimental study. The use of Retona on the specimen increased resistance to permanent deformation and descending the value of deformation (flow).

The higher the Retona content the higher the stability but the lower the flow. The voids and density of specimens were influenced by the use of Retona. The higher the Retona content the lower VITM and density, but the higher VFWA. From the value of Marshall Quotient it was shown that the higher the Retona content the greater stiffness of the specimen occurred, which was followed by the decreasing value. The specimens containing Retona were relatively more resistant to water damage (more durable) than those without it. The hardness of asphalt containing Retona was higher compared with that of original asphalt. It was also shown that asphalt containing Retona had a higher temperature susceptibility than those without it.

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