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Utilization of Buton Granular Asphalt (BGA) as Asphalt and Filler Content Substitution Material - in Asphalt Concrete Mixture- Wearing Course

Hujiyanto[1*], Hado Hasina[2], Indra Siolimbona[3]
[1,2,3] Civil Engineering Dept, University of Sulawesi Tenggara, Kendari, Indonesia

ABSTRACT: Roads are one of the infrastructure that is urgently needed in improving the accessibility of an area and has a crucial role as a connecting infrastructure that facilitates the transportation of people and goods. This road must be able to handle the volume of traffic according to the plan, so planning must ensure smooth transportation. Asbuton can be used as a binding material on road pavements. However, the use of buton asphalt as a road construction material in Indonesia has not had a significant impact on infrastructure development carried out by the government. The purpose of this study is to analyze the characteristics of Marshall's test value using Buton Granural Asphalt as a substitute for filler and Fine Aggregate in the mixture of Asphalt Concrete – Wearing Course (AC – WC). The type of data used is primary data obtained from laboratory test results and secondary data obtained from SNI Bina Marga 2018 rev.2. The results showed that with the addition of 19% BGA (Buton Granular Asphalt) as a filler and fine aggregate material, the stability of the mixture could be increased up to 2369,8 kg with the addition of BGA, when compared to aggregate without BGA, the stability value was higher. Based on the test of the characteristics of the 0% BGA mixture marshall obtained a density value of 2,304 t/m³, stability of 1240,6 kg, fatigue of 3.4 mm, Marshall Quotient (MQ) of 366,0 kg/mm, VMA of 16,3%, VFB of 76.2%, VIM of 3.9%. Marshall testing on a mixture of 19% BGA obtained a density value of 2325,0 t/m³, Stability of 2369,8 kg, Fatigue of 3.4 mm, Marshall Quotient(MQ) of 697,1 kg/mm, VMA of 15,4%, VFB of 80,0%, VIM of 3.1%.
All test parameters meet the standards set out in the 2018 General Bina Marga specification for revision 2 road and bridge construction work, so that AC-WC asphalt concrete with 0% and 19% BGA substitution can be used.

KEYWORDS: Buton Granural Asphalt, Bitument, Filler Substitute, Marshall Test

INTRODUCTION

The government continues to carry out infrastructure development, development aims to create a just, prosperous, and prosperous society. The development process is expected to trigger change and growth in the region that contributes to the progress and improvement of welfare for the community (1). One of the infrastructure developments that can have a significant influence in efforts to improve community welfare is the development of highway infrastructure. In Indonesia, highway construction generally uses local natural materials, one of the materials in road construction is asphalt, both oil asphalt and natural asphalt. The natural asphalt mining material is mostly located on the island of Buton, Southeast Sulawesi Province, so it is often called Buton Asphalt (Asbuton). This buton asphalt has a fairly large deposit, reaching 650 million tons (2). Buton asphalt is natural asphalt that is in rock deposits, in general the asphalt content contained in asbuton ranges from 10% to 40% depending on the origin of the quarry or the origin of the deposit. With the largest Asbuton reserve of 638.2 million tons, the largest is located in Buton Regency and a deposit of 24.2 million tons is located in North Buton Regency, Southeast Sulawesi province.

In the use of buton asphalt as a road construction in Indonesia has not had a significant influence on the development of highway infrastructure, one of the obstacles is that the area causes obstacles in the transportation of its products. In addition, the tendency of the government and contractors to continue to rely on imported oil asphalt from other countries is still dominant, making the use of Buton Asphalt seem to be only an alternative or reserve option in efforts to develop road infrastructure that is being emphasized by the government (1).

As an additional material or substitution material, natural asphalt has been widely used in road construction. In this study, the researcher innovated to compare two different variations of asphalt mixture, between a natural asphalt mixture (Buton Granular Asphalt) with a BGA percentage of 0% and an asphalt mixture with a BGA percentage of 19%. The BGA (Buton Granular Asphalt) used is type B50/30. Buton Granular Apal (BGA) is a substitute for Filler and bitumen in the Asphalt Concrete Wearing Coarse (AC-WC) Mixture.

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A. Road Pavement

Road pavement construction is a combination of aggregates and fastening materials designed to accept the traffic load of vehicles. The aggregate used can be crushed stone, split stone or river stone. Sedangkan untuk bahan pengikatnya meliputi aspal, semen, atau lempung. In road construction, the road surface layer is the top layer of the flexible pavement, which directly functions to withstand the weight of the vehicle. In other words, it is the layer that first receives pressure from the wheels of the vehicle passing through it.

Asphalt Concrete Wearing Coarse (AC-WC) is a pavement layer located at the top that functions as a wear layer. As a natural asphalt filler material, it is very important to modify the gradation of fine aggregate in the paved mixture so that the density is increasing, the asphalt is more efficient and can extend the service time of the road itself (3). Pavement construction consists of 2 types, namely Flexible Pavement Construction and Rigid Pavement Construction (Rigit Pavement). In Indonesia, these two types of construction are widely used. These two constructions have different characteristics, as presented in table 1.

Table 1. Difference between flexible pavement and rigid pavement

No	Purpose	Bending pavement	Rigid Pavement
1	Binding Materials	Asphalt	Cement
2	Material Repitation	Rutting (deflection) on the wheel track	Cracks appear on the surface
3	Subgrade of Groundland	Bumpy road (following the subsoil)	It is a block/beam on the laying
4	Temperature Changes	Modulus of stiffness changes, Small internal tension arises	Modulus of stiffness does not change, Arises large internal tension

Source: (4)

According to (5) the load of the vehicle working on the flexible pavement structure consists of :

1) Evenly divided load is the repetitive load of the vehicle's wheels. Sliding force due to the friction of vehicle tires during braking.
2) Vibration from a moving vehicle.
3) Vibration due to earthquakes.
4) Movement as a result of large land shrinkage.

B. Concrete Asphalt Layer

Concrete asphalt layer in road construction is a mixture of oil asphalt and aggregate that has a gradation in accordance with the provisions, mixed, laid out and compacted in hot conditions at a specified temperature. The aggregate material consists of a mixture of coarse aggregate, fine aggregate, and filler with good distribution, which is mixed with oil asphalt with a certain percentage level with the type according to the plan, such as the 60/70 penetration type. Its main strength comes from the locking between aggregates and also part of the fine material / sand, filler, and asphalt as the binding material (6). To increase the quality of asphalt, addictive materials or other materials can also be added, for example polyamide (7). In addition to new pavement construction, asphalt road construction can also use the results of recycling old materials from dismantling/waste, the use of this recycling can be done by means of heat recycling techniques (8). The use of asphalt can have a bad impact on the surroundings, such as it can cause environmental pollution, one of the efforts to reduce the impact on the environment, namely using asphalt pavement from recycling (RAP) (9).

Research (10) concludes that the use of recycled materials for road construction will provide benefits for the sustainability of development, For example, as waste utilization, reduction of raw materials from natural resources, reduction of transportation impacts, improvement of performance and effectiveness of financing in road construction. According to (11) the performance examination of concrete asphalt mixtures is generally carried out using Marshall testing tools. Where in this test the test results can be obtained according to the set test parameters.

In highway construction, the concrete asphalt layer consists of 3 types of mixtures, including:

1) Asphalt Concrete -Wearing Course (AC – WC), with a minimum thickness of 4 cm.
2) Asphalt Concrete- Binder Course (AC – BC) This layer has a minimum nominal thickness of 6 cm.
3) Asphalt Concrete – Base (AC – Base) This layer has a minimum nominal thickness of 7.5 cm

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C. Buton asphalt processed products

There are several types of buton asphalt production that are processed and used for additional materials in road work, namely Buton Granular Asphalt (BGA) type asbuton, Lawele Granular Asphalt (LGA) granular asbuton and semi-extraction asbuton.

Asphalt Granular Buton (BGA), is used as a substitution additive on Concrete Asphalt pavement, where in general it is used with a percentage of 5% - 10% of the total weight of the concrete asphalt mixture. This BGA grain asbuton consists of several types that are stated for the characteristics of the large penetration value and bitumen content, the types of BGA include B50/30, B50/20, 5/20, 15/20, 20/25.

Lawele Granular Asphalt (LGA), this type of Asbuton is generally used for Pavement of Makadam Asbuton Coating (LPMA) with the use of LGA up to 100%. This pavement is only used for low-traffic highways, LGA characteristics are produced with type B40/25.

Semi-Extraction Asbuton, This type of asbuton is generally for modifying and improving the quality of oil asphalt, namely for high temperature resistance. The use of this asbuton is a percentage of 20% of the overall use of asphalt. The pavement with this combination of semi-extracted asphalt and oil asphalt can be used for light as well as heavy traffic.

There are several advantages of asbuton, namely the relatively cheap price (depending on the distance), can be packaged in sacks so that mudh is transported, besides that it can be worked on hot mixtures, warm mixtures and cold mixtures (12). Buton Granural Asphalt is a processed asbuton product that plays a role in the mixture to increase optimization and rigidity, with a limit of flexibility that is able to reduce damage due to traffic loads and minimize unplanned damage. The main advantage of Buton Granural Asphalt is its resistance to temperature changes as it has a higher melting point than oil asphalt (13). Buton Granural Asphalt has been produced and ready-to-use natural asphalt with high quality has been processed, so that the asphalt can reach the surface of the grain. Buton asphalt granules contain a certain amount of asphalt and are in the form of fine granules. Buton Granural asphalt is one type of asphalt, which has various advantages compared to the existing used oil asphalt, and its price continues to increase in the international market in line with the rise in world oil prices. Residual Stability Index (ISS) analysis is an immersion testing method used to evaluate the durability of asphalt mixtures (14).

D. Material Basic Testing and hot asphalt mixture test standards

The grading requirements for the Asphalt Concrete -Wearing Course (AC-WC) Layer have certain limitations (grain size) with the aggregate size distribution used in the mixture, which is stipulated in the Bina Marga 2018 rev.2 specification. The upper and lower limits for each sieve size determine how much aggregate of each size is allowed in the mixture. These specifications are important to ensure that the resulting asphalt mixture has the desired quality and strength. The aggregate grading standard is set according to table 2.

Table 2. Combined aggregate gradation for asphalt mix.

Sieve Size		% Weight Passed Against Total Aggregate
Inch	(mm)	Laston AC WC
¾”	19	100
½”	12,5	90 – 100
3/8”	9,5	77 – 90
No. 4	4,75	53 – 69
No. 8	2,36	33 – 53
No. 16	1,18	21 – 40
No. 30	0,600	14 – 30
No. 50	0,300	9 – 22
No. 100	0,150	6 – 15
No. 200	0,075	4 – 9

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Basic testing of materials includes bituminous content testing and gradation of BGA, coarse aggregate wear testing, coarse and fine aggregate specific gravity and absorption testing, sieve analysis testing of all coarse and fine aggregates, BGA moisture content testing. The test parameters of the concrete asphalt mixture include testing stability values, volume weight, asphalt content, plastic melt (flow), VIM, VMA, asphalt absorption, asphalt layer thickness (asphalt film), effective asphalt content, and Marshall quotient. The standard test parameters based on the 2018 Bina Marga Specification revision 2 are set as in table 3.

Table 3. Specification of Test Parameters

no.	Test parameters	BM Standard 2018 Rev.2
1	VIM (%)	3 - 5
2	VMA (%)	>15
3	VFB (%)	>65
4	MQ (kg/mm)	>200
5	Stability	>800
6	Residual stability (%)	90
7	Flow	2 - 4

METHODOLOGY

This research was carried out from April 2024 to June 2024 at the UPTD Construction Laboratory of the Water Resources and Highways Office, Southeast Sulawesi Province. Testing Techniques, Material testing procedures based on Indonesia National Standards (SNI) and Bina Marga 2018 specifications rev.2. The raw materials for coarse and fine aggregates for research are local materials, processed from the production of stone crushers of mountain stones ex. Moramo, South Konawe district. For Buton Granular Asphalt (BGA) material sourced from PT. Buton Asphalt Indonesia (PT. BAI) while the oil asphalt material used is 60/70 type oil asphalt. From the results of the analysis of fine aggregate filters, coarse aggregates and asbutone minerals are mixed with a certain percentage until a qualified mixture gradation is obtained according to table 2. The data analysis technique used is analysis based on laboratory tests with a descriptive approach, namely by collecting data related to the problem being researched. The collected data is then compiled systematically. Tests include Material Base testing to ensure materials are qualified and density testing and marshall tests of bricket samples. The variables used in the study for AC-WC concrete asphalt can be seen in the following Table 4.

Table 4. Research Variables

No	Elements Under Review	Indicators	Parameters
1	Asphalt Content Using Filler and Fine Aggregate Buton Granural Asphalt	Optimum Asphalt Content Testing	BGA Percentage: - 0% BGA. And - 19% BGA
2	Characteristics of asphalt from Asbuton material	Density Test and Marshall test	1. VIM 2. VMA 3. VFB 4. MQ 5. *Density* 6. Stability 7. *Flow*

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RESULTS AND DISCUSSION

From the results of the basic testing of the material, an abrasion value of 28.36% was obtained, and the bitumen content at BGA was 18.81%. For the determination of the value of Optimum asphalt content, the characteristics of asphalt concrete mixture were tested with 2 variations of the mixture, namely 0% asphalt BGA and 19% BGA with asphalt content of 5%, 5.5%, 6%, and 6.5% and 7%, respectively. The results, from the testing of the two variations, can be seen in table 5 and table 6.

Table 5. Density and Marshall testing with 0% BGA Mix Variation

Test parameters	Asphalt content plan (%)				
	5	5.5	6	6.5	7
Density (g/cm³)	2.293	2.3	2.302	2.301	2.291
Voids in the aggregate (VMA) (%)	`15.87	16.05	16.43	16.91	17.69
Voids in the Mixtures (VIM) (%)	5.5	4.53	3.78	3.15	2.87
Void Filled of Bitument (VFB) (%)	65.37	71.77	77	81.43	83.77
Stability (Kg)	1055.5	1165.9	1262.9	1229.2	1136.6
Flow (mm)	3.2	3.3	3.5	3.7	4.3
Marshall Quotient (MQ) (Kg/mm)	333.25	357.54	364.49	335.85	265.06

Based on the test results according to the parameters, it is depicted in the form of a graph for the determination of the Optimum Asphalt Content value as presented in figure 1.

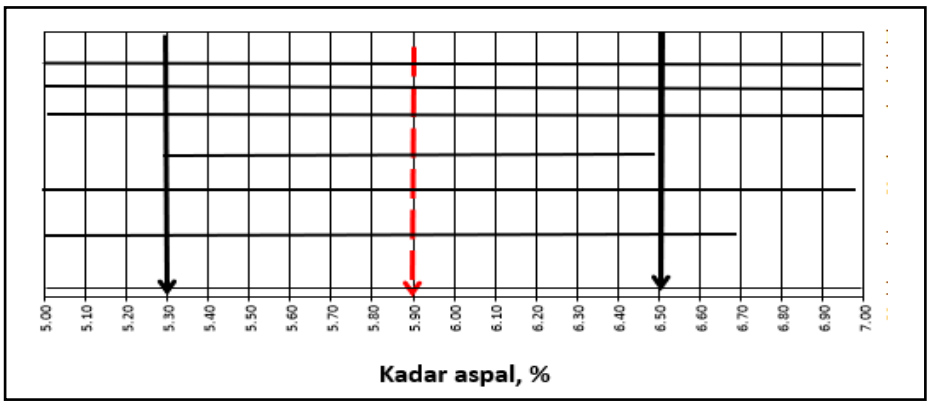

Figure 1. Graph of Results of Optimal Asphalt Rate setting with 0% BGA

The results of the above test show that the AC-WC concrete asphalt mixture with 0% BGA obtained the Optimum Asphalt Content with a value of 5.90%.

Table 6. Density and Marshall testing with 19% BGA Mixture Variation

Test parameters	Asphalt content plan (%)				
	5	5.5	6	6.5	7
Density (g/cm³)	2.338	2.336	2.315	2.316	2.306
Voids in the aggregate (VMA) (%)	14.2	14.75	15.93	16.37	17.17
Voids in the Mixtures (VIM) (%)	3.62	3.05	3.21	2.52	2.26
Void Filled of Bitument (VFB) (%)	74.51	79.34	79.9	84.62	86.82

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Stability (Kg)	3738.51	2024.42	2963.57	1153.44	1077.66
Flow (mm)	3.1	3.3	3.5	3.6	3,9
Marshall Quotient (MQ) (Kg/mm)	1191.78	613.69	856.26	320.18	287.08

The results of the above test show that the AC-WC concrete asphalt mixture with BGA of 19% obtained the Optimum Asphalt Content with a value of 5.80%.

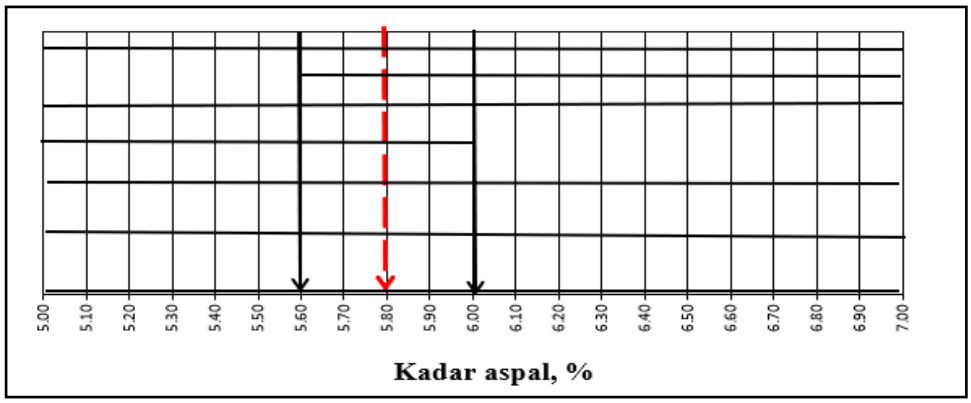

Figure 2. Graph of Results of Optimal Asphalt Rate setting with BGA 19%

From the two variations, the percentage of BGA usage of 0% and 19% is summarized in the test parameters based on the Optimum Asphalt Content value as presented in table 7.

Table 7. Recapitulation of the calculation results from the optimum asphalt content of 5.90% and 5.80%

No	Parameter	Hasil		Spesifikasi Bina Marga 2018
		0% BGA	19% BGA	
1	Density (g/cm³)	2,304	2,325	-
2	Voids in the aggregate (VMA) (%)	16,3	15,4	> 15
3	Voids in the Mixtures (VIM) (%)	3,9	3,1	3 - 5
4	Void Filled of Bitument (VFB) (%)	76,2	80,0	> 65
5	Stability (Kg)	1240,6	2369,8	> 800
6	Flow (mm)	3,4	3,4	2 - 4
7	Marshall Quotient (MQ) (Kg/mm)	366,0	697,1	-

CONCLUSION

Based on the results of testing and discussion as well as analysis of the use of BGA (Buton Granular Asphalt) as a substitute for filler and fine aggregate in the mixture of AC-WC (Asphalt Concrete- Wearing Course) layers, it can be concluded:

a. The results of the AC-WC (Asphalt Concrete- Wearing Course) test with 0% BGA obtained a density value of 2.304t/m³, a stability value of 1240.6kg, a fatigue value of 3.4mm, a Marshall Quotient value of 366.0 kg/mm, a VMA value of 16.3%, a VFB value of 76.2%, and a VIM value of 3.9%.
b. The results of the AC-WC (Asphalt Concrete- Wearing Course) test with 19% BGA obtained a density value of 2325.0 t/m³, a stability value of 2369.8 kg, a fatigue value of 3.4 mm, a Marshall Quotient value of 697.1 kg/mm, a VMA value of 15.4%, a VFB value of 80.0%, and a VIM value of 3.1%.
c. Performance results of asphalt mixture with the Utilization of Asphalt Granular Buton as a Substitute for Filler and Fine Aggregate in Asphalt Concrete - Wearing Course (AC-WC) Mixture can be used, because all test parameters meet the specifications.

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