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Marshall Characteristics of Hotmix Cold Laid Containing Buton Granular Asphalt (BGA) with Modifier Oil Base and Modifier Water Base

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ABSTRACT

The need of asphalt mixing plant (AMP) in the hot mix asphalt (HMA) production resulting in the construction of hot rolled asphalt (HRS) is restrained mostly at the areas that possess AMP. Many remote areas or remote islands cannot possess AMP hence the construction of HRS cannot be optimized at those areas. Natural rock asphalt that deposited in Buton Island, Southeast Sulawesi in Indonesia is crushed to produce Buton granular asphalt (BGA). BGA and cold modifier were utilized to produce hot mixture that can be laid at cold temperature of 50^{O}C to 27^{O}C. The employment of hotmix cold laid mixture containing BGA and cold modifier as pavement mixture is one solution to substitute hot rolled asphalt application in the remote and distance areas. The experimental results to investigate the Marshal Characteristic showed the hotmix cold laid containing BGA and cold modifier can attain an adequate compaction. At an optimum bitumen content of 8% within BGA, no significant differences on VIM, VMA and VFB were observed when the storing and compaction time were extended from 3 to 7 days. The stability value and tend to decline and the flow value increased with the extension of the storing and compaction time.

Keywords: Hotmix Cold Laid, Buton granular asphalt (BGA), Marshall parameters, cold modifier

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1. INTRODUCTION

Over several decades Indonesia government have supporting the exploitation and of the natural rock asphalt deposit that existed in large quantities in Buton Island, South-East Sulawesi, Indonesia. The natural rock asphalt is named Buton Asphalt or Asbuton that considered as significant economic material. Many researches and developments have been done during the last decades with the purpose of improving the mechanical properties of mixture containing Buton Asphalt with granular shape (Buton Granular Asphalt, BGA)[1][2][3][4][5][6].

The need of AMP in the hot mix asphalt (HMA) production is to make hot rolled asphalt (HRS) that can be rolled and compacted at hot temperature of approximately 100^{O}C. The construction of HRS cannot be optimized at the remote areas since difficulty arises on the need of AMP. The employment of hotmix cold laid containing BGA and modifier can be proposed as an alternative to substitute the hot rolled asphalt (HRA) pavement construction in the remote and distance areas.

Currently, the use of BGA with hot modifier and cold modifier for hotmix cold laid pavement is in the research and evaluation phase. The hot modifier should be heated prior mixing with other mixture materials. The cold modifier is used without heating prior mixing with other mixture materials. Cold modifier was used in this research. The purpose of this study is to develop a new hotmix asphalt containing BGA that can be laid and compacted at 27^{O}C to 50^{O}C through utilization of cold modifier that contains modifier oil base and modifier water base. The Marshall properties (stability, void in mineral (VIM), void mixture aggregate (VMA), void filled bitumen (VFB) and flow) were investigated to analysis the mixture containing BGA and cold modifier.

2. Materials and experimental methods

A. Physical Properties of Aggregates

Standard laboratory tests were carried out to determine the physical properties of aggregates. In this study, aggregates testing were done prior the mix design and analysis. Crushed river stone, river sand and fine filler from Jeneberang river in Sulawesi Island, Indonesia. Table 1 and Table 2 show some physical properties of fine aggregate and coarse aggregate, respectively.

Table 1. Some mechanical properties of fine aggregate

Testing	Result
Fine aggregates (%)	85,74
Angularity (%)	52

Table 2. Some mechanical properties of coarse aggregates

Properties	Value	Range
Soundness of aggregate by use of sodium sulfate or magnesium sulfate(%)	2,62 %	Max. 12 %
Abrasion (%)	24,09 %	Max. 40 %
Adhesion (%)	> 95%	Min. 95 %
Angularity (%)	97/95	95/90
Flat and elongated particles (%)	6,00 %	Max. 10 %
Passing Sieve No.200 (%)	0,37 %	Max. 1 %

B. Combined aggregate gradation in hot mix design

Table shows grain size distribution used in this study. The mineral within BGA was taken into account when analysis the mixture composition and grain size distribution. Hot mix Cold Laid Asbuton with according to gradation size distribution Asbuton hot mix cold Laid Asbuton [7].

Table 3. Gradation size distribution in this study and limit.

Sieve	Passing (%)	Limit (%)
1” (25 mm)	-	-
3/4 ” (19 mm)	100	100
1/2” (12,5 mm)	93	90 – 100
3/8 ” (9,5 mm)	-	-
No.4 (4,76 mm)	55	45 – 70
No.8 (2,36 mm)	32	25 – 55
No.50 (0,300 mm)	14	5 – 20
No.200 (0,075 mm)	5	2 – 9

C. Some properties of buton granular asphalt

Natural rock asphalt is crushed to reduce its granular size to 9.5 mm maximum size in order to produce BGA. BGA is from Lawele area and produced by the national asphalt Buton plant. It is available in the market. Table 4 shows some properties of BGA with bitumen contain of 25.47%, which means it contains 75% minerals. BGA has grains smaller than 9.5mm and with a water content of 0.81%.

Table 4. Some properties of BGA

Properties	Value
Bitumen content; %	25,47
Passing sieves 3/8″ (9.5mm); %	100
Water content , %	0,81
Asphalt mineral level,%	74,53
Penetration of bitumen, (dmm)	36
Melting point of bitumen, ^{O}C	59
Flash point before extract, ^{O}C	198

D. Mixture Preparation

The stages of mix the aggregates, filler (dust stone), modifier and BGA are as follow:

Table 5. Bitumen within BGA

Bitumen within BGA (%)	6	7	8	9	10
(%) BGA by weight by mixture	23,5	27,5	31,4	35,3	39,3

1. Before adding to the mixture, aggregates were heated to 170^{O}C for a period of approximately 1800 seconds. The weight of aggregates for each sample was 1,200 gr.
2. The cold modifier was 3.5% by weight of aggregates content in all mixtures. Without heated, cold modifier was added in the mixture of aggregates and filler.
3. The mixing of aggregates, filler and modifier were blended at a temperature 130±5^{O}C for around 60 seconds minutes prior to blending with BGA.
4. BGA was added into the mixture and blended with other materials for about 120 seconds.

The mixture composition and the investigation work were conducted according to the test matrix shown in Table 5 and Table 6. As shown in Table 5, the percentage of the added BGA in the mixture was varied from 6% to 10% in order to investigate the influence of the bitumen and mineral within BGA on the Marshall characteristic of mixture.

Table 5 shows the percentage of added BGA and bitumen within it. Table 6 shows the composition of aggregates, filler and mineral of BGA. Bitumen within BGA it calculated as bitumen content of the mixture.

E. Marshall Characteristic analysis

Marshall method was used for determining optimal bitumen content for stability and flow of specimen. Experimental programs consist of two parts. The first part focused to determine VIM, VMA, and VFB of the specimen whilst measured the stability and flow to determine the optimum BGA content. There identical samples were produced for the compaction stage of the process with 75 blows applied to the top and bottom side of specimens at temperature of 50^{O}C. Stability was tested in dry condition without immersed the specimens in the water.

Table 6.Composition of aggregates, filler and mineral of BGA

Bitumen within BGA (% by weight)	crushed stone 1-2cm (%)	crushed stone 0,5-1cm (%)	Filler (%)	Mineral of BGA (%)
6	30	35	17.45	17.55
7	30	35	14.52	20.48
8	30	35	11.59	23.41
9	30	35	8.66	26.34
10	30	35	5.74	29.26

The second part was done after obtained the optimum BGA content. The influence of curing and compaction time on stability was investigated by utilized the specimen with optimum BGA content. After storing the mixture up to 3 and 7 days, specimen were compacted into the mould by using the Marshall compactor with 75 blows applied to the top and bottom side of mixture at room temperature of 27^{O}C. The specimen with diameter of 100mm and height of approximately 60 mm were used to investigate the stability of mixture.

3. RESULT AND DISCUSSION

A. Determination of optimum BGA content for mixture by Marshall Method

The influence of BGA content on VIM, VMA, stability, flow and VFB are shown in Fig.1 to Fig.6. The increase in BGA content led to increase the bitumen and filler within the mixtures, as mention in Table 5 and Table 6. Fig.1 shows increasing the BGA content in the mixture tend to decrease the VIM value, but all VIM value can provide a sufficient asphalt binder to coat the aggregate particle. Fig.2 displays all VMA values increased by increasing the BGA content and led to an increase in the film thickness on aggregate particles.

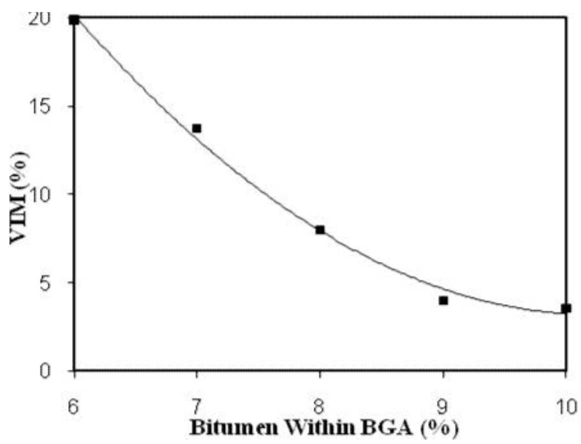

Fig.1. Relationship between bitumen within BGA and VIM

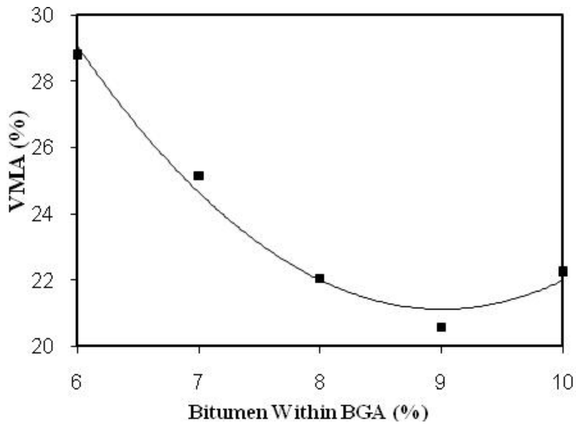

Fig.2. Relationship between bitumen within BGA and VMA

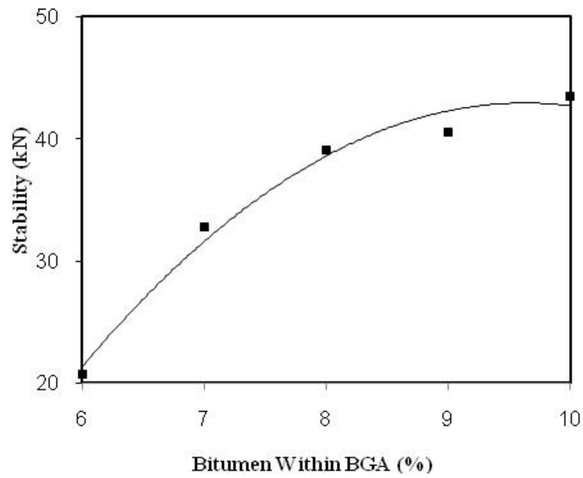

Fig.3. Relationship between bitumen within BGA and stability

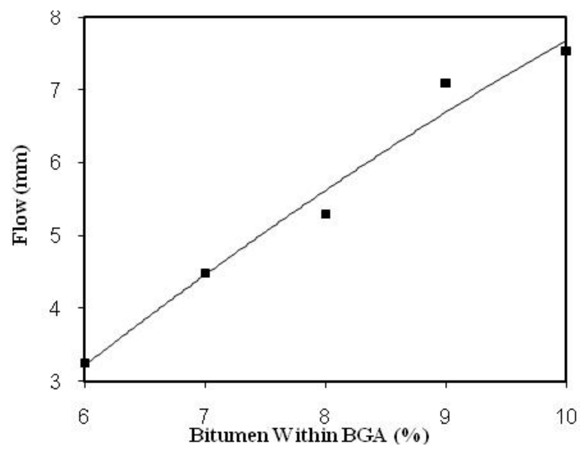

Fig.4. Relationship between bitumen within BGA and flow

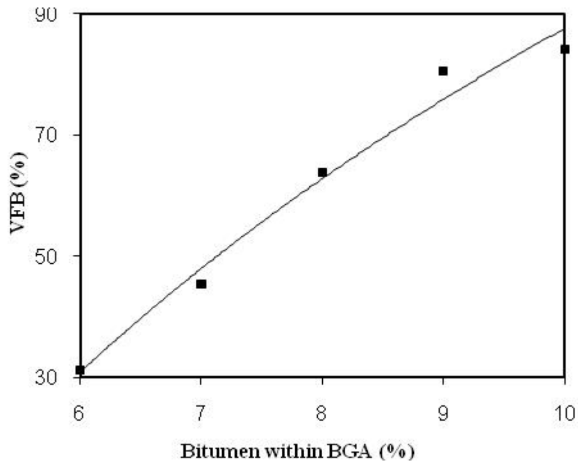

Fig.5. Relationship between bitumen within BGA and VFB

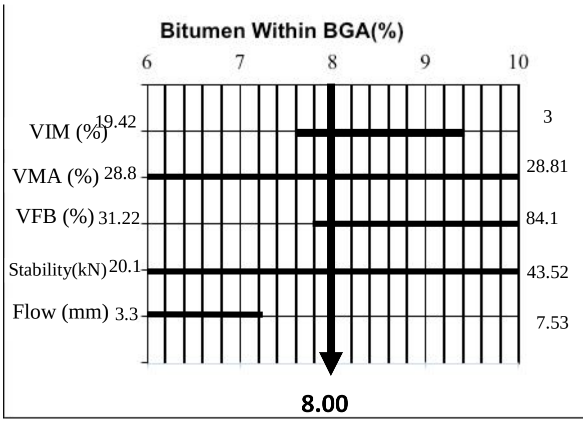

Fig. 6. Optimum bitumen content

Fig.3 displays Marshall stability depend on BGA content addition. After adding BGA, the stability value tend to increase until it reached the maximum value which was approximately 9% of the used BGA content and correspond to the stability value 17.2kN, and then stability value will decrease. Fig.4 displays a high percentage of BGA content increased the flow value, this result can create the formation of a flexible mixture. Fig.5 displays the effect of the BGA addition on VFB at different BGA content. In general, VFB value tend to increase with the addition of BGA content.

Fig. 6 displays the optimum bitumen content with in the mixture. All flow values exceeded 3 mm and the VFB value of 64.77% was reached by 8% bitumen within BGA, therefore the optimum content was determined as 8% bitumen within BGA with equal to 31.4% (by weight) BGA content in the mixture.

B. Influence of storing and compaction time on Marshall Parameters

Table 7 displays the influence of storing and compaction time on Marshal Parameters. When the storing and compaction time were extended to 3 and 7 days the mixture still can maintain its compaction ability at 27^{O}C. No significant differences on VIM, VMA, and VFA were resulted from an adequate compaction of mixture. The stability value at 3 and 7 days were 27 and 17.3 kN, respectively. The flow value at 3 and 7 days were 3.3 mm and 5.3 mm, respectively. The increasing in flow value reflects a continuous decline of cohesive and adhesive of bitumen with modifier and resulting in decrease in the stability value.

4. CONSLUSION

Based on the results obtained from this research, the following conclusion can be drawn:

1. An adequate compaction of mixture can be attained at temperature of 27^{O}C to 50^{O}C.
2. At 8% bitumen content within BGA, no significant differences on VIM, VMA, and VFB whilst stability value decrease and flow value ere observed when the storing and compaction time were extended from 3 to 7 days.

Table 7. Influence of storing and compaction time on Marshal Characteristic

Storing and Compaction (days)	Marshall Characteristic				
	VIM (%)	VMA (%)	VFB (%)	Stability (kN)	Flow (mm)
3	8.31	22.3	62.77	27.7	3.3
7	8.34	22.3	62.67	17.3	5.3

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