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STABILITY AND INDIRECT TENSILE STRENGTH OF ASBUTON MIXTURE WITH ADDITIONAL GONDORUKEM (REGINA COLOPHONIA)

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ABSTRACT

Indonesian natural rock asphalt is known as Asbuton (Buton asphalt) i.e. rock asphalt from Buton Island containing bitumen of approximately 10% to 30%. Semi extraction type of Asbuton product is available as known as modified Buton asphalt (MBA). Research and development have been conducted to obtain better quality of MBA based asphalt concrete. The utilization of Gondorukem (Regina Colophonia) is expected can increase several parameters such as Marshall stability and indirect tensile strength (ITS) of asphalt concrete. The national and regional road infrastructure development in Indonesia can be sustained by used MBA as binder and Gondorukem as additive in pavement material.

The aim of this study is to investigate the properties of asphalt concrete wearing course (AC-WC) mixture using MBA as binder and Gondorukem as additive. The result of Marshall stability and ITS tests showed the sufficient of Marshall stability and ITS can be established by proper aggregate interlocking and adhesive which developed due to the utilization of MBA and Gondorukem in AC-WC mixture.

Keywords: Modified Buton asphalt (MBA), Gondorukem, AC-WC mixture, Marshall stability, Indirect tensile strength (ITS)

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1. INTRODUCTION

Hot mix asphalt mixtures (HMA) is particulate composite material composed of aggregates, asphalt binder and air voids. Asphalt concrete mixtures vary significantly as a result of using different binder-aggregate combinations, aggregate gradations, and binder modification techniques [1, 2].

There is approximately 61 million tons of solid bitumen or natural rock asphalt resources in the Kabungka and Lawele districts of Buton regency in Indonesia. Utilizing local materials such as Asbuton products for road-infrastructure development has played an important role in improving sustainable development in Indonesia in recent decades [3]. Buton natural asphalt or Buton asphalt (Asbuton) consists of approximately 10% - 30% bitumen and 70% minerals. Thus, the utilization of Asbuton products is strongly encouraged in the development of road-infrastructure. During the last few decades, Asbuton with a granular shape has been investigated for use in road construction in asphalt concrete (AC) production. Asbuton can be refined to separate bitumen from the minerals and used extracted bitumen of Asbuton and petroleum bitumen to produce MBA. In recent years, there has been a growing interest in incorporating MBA as a main binder to produce asphalt concrete [4, 5, 6, 7, and 8]

It is well known the utilization of rubber as additive has positive effect on the mechanical properties of asphalt concrete [9, 10]. Gondorukem is a sap processing product of pine tree where Gondorukem is a material absorbs quickly heat or fire. The use of gondorukem rubber as an additive is expected can increase asphalt pavement layer resistance to damage caused by water and weather.

It is important to incorporate performance testing along with the empirical testing during the mixture design and quality control testing of asphalt concrete mixture. Marshall test is an empirical laboratory test that widely used to measure the stability of compacted asphalt concrete specimen [11]. As the wheel passes, tensile stress arises in the pavement structure. The tensile strength is conventionally used in pavement engineering practice as key parameter in the prediction or estimation the performance with related to the mechanical behavior of pavement structures [11]. M.R. Islam, et al [12] carried out ITS test to evaluate the influence of short-term laboratory aging (on loose mixture), long-term laboratory oven aging and field aging on the tensile strength of asphalt concrete. C. S. Du, [11] carried out ITS test to evaluate the cement influence on the tensile strength of asphalt emulsion mixture.

The present research is part of ongoing project that intends to study the suitability of MBA as binder and Gondorukem as additive in production of asphalt mixture. This paper reported the test results on the Marshall stability and ITS of the AC-WC mixture.

2. MATERIALS AND METHODS

2.1. Gondorukem (Regina Colophonia)

Gondorukem (Regina Colophonia) is a general term for the sap processing products of pine trees. The term Gondorukem originated from the use of sap as a patch of a leaking wooden ship. The world's Gondorukem industry began about 100 years ago. In the United States there was an industry in 1830. In Indonesia the Gondorukem industry began around 1938, with its first factory in Takengon (Aceh). Gondorukem is a cheap and easy material which is a natural resin obtained and distilled from pine resin and is a clear yellow to yellowish solid. The quality of the sap will determine the quality and yield of the resulting Gondorukem. Pine tree sap contains 70 -75% Gondorukem and 20-25% turpentine, respectively.

With the development of industrial technology, Gondorukem is used as additive, printing ink, chewing gum, tire industry and many more (Gondorukem and Turpentine Processing

Handbook - Industrial Division of Perum Perhutani). Table 1 shows some properties of Gondorukem.

Table 1. Some properties of Gondorukem (SNI 01-5009.12.2001)

No.	Parameter	Standard			
		X	**WW**	**WG**	**N**
1	Soft point of ring and ball method	≥78°C	≥78°C	≥76°C	≥74°C
2	Test colour with lovibond	as per example	as per example	as per example	as per example
3	Drops	≤ 0.02%	≤ 0.05%	≤ 0.07%	≤ 0.10%
4	Acid value	160 – 190			
5	Sponification value	170 – 220			
6	Iodine value	5 -25			
7	Ash content	≤ 0.01%	≤ 0.04%	≤ 0.05%	≤ 0.08%
8	Volatile oil content	≤ 2%	≤ 2%	≤ 2.5%	≤ 3%
Information : X (*Rex*) = The clearest color WW (*Water White*) = Clear colors like water WG (*Window Glass*) = Clear colors like window glass N (*Nancy*) = Yellow color - brownish brown					

2.2 Modified Buton Asphalt (MBA)

Table 2 shows properties of MBA. Commercial MBA was used as a prominent binder in this research. Properties of MBA are mostly similar to the petroleum bitumen.

Table 2. Properties of MBA

No.	Properties	Testing result
1	Penetration before weight loss (mm)	78.6
2	Softening point (°C)	52
3	Ductility in 25°	114
4	Flash point (°C)	280
5	Specific gravity	1.12
6	Weight loss	0.5
7	Penetration after weight loss (mm)	86

2.3. Properties of Coarse Aggregate and Filler

All material used were collected from Jeneberang river in Gowa. Two fractions of coarse aggregates derived from crushed river stone were used: one with aggregate diameter 5 - 10 mm and the other with crushed stone diameter 10 - 20 mm. Stone dust collected from the same stone crushed plant was used as filler. Some properties of coarse aggregates and filler are shown in Table 3 and Table 4, respectively.

Table 3. Properties of coarse aggregate

Properties	(Crushed stone)	
	Diameter 5 - 10 (mm)	**10 - 20 (mm)**
Water absorption, %	2.07	2.08
Bulk specific gravity	2.62	2.63
Saturated surface dry specific gravity	2.68	2.68
Apparent specific gravity	2.77	2.78
Flakiness index, %	20.10	9.38
Abrasion aggregate, %	25.72	24.36

Table 4. Properties of filler

<table>
<tr><td>Water absorption, %</td><td colspan="2">2.28</td></tr>
<tr><td>Sand equivalent, %</td><td colspan="2">69.57</td></tr>
<tr><td>Bulk specific gravity
2.59</td><td>Saturated
surface dry specific gravity
2.65</td><td>Apparent specific gravity
2.76</td></tr>
</table>

2.4. Mixtures Design

The combined aggregate gradation is shown in Fig. 1. The combined aggregate gradation was kept constant for all mixtures. The mixtures were all prepared in the laboratory. Based on the preliminary experiment the optimum content of asphalt MBA was obtained at 6.25% of the total weight of the mixture. Table 5 shows the mixture by weight of AC-WC mixture without Gondorukem and with 2.5, 5.0, 7.5 and 10% Gondorukem. The weight of the Gondorukem used is based on the weight of the asphalt. Gondorukem, MBA, aggregates and filler were mixed and compacted into the cylindrical mold with capacity of 1,200 gram and diameter of 101.6 mm. The specimens were compacted with 75 blows each face by using Marshall compactor. Mixing and compaction process were carried out at temperature of 150 °C.

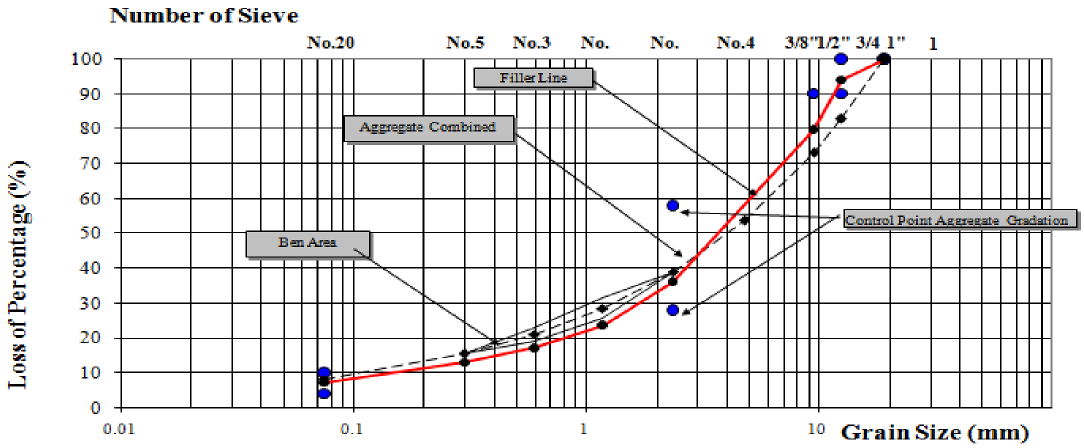

Figure 1. Combined Aggregates Gradation

Table 5. Asphalt mixture with and without Gondorukem (for 1,200 grams)

No	Description			Unit	Gondorukem content (%)				
					0.0	2.5	5.0	7.5	10.0
A	Gondorukem weight			gr	0.00	1.87	3.75	5.62	7.50
B	Modified Buton Asphalt (MBA) (6.25%)			gr	75.00	73.12	71.25	69.38	67.50
C	Aggregate combined gradation				Aggregate weight according to sieve size				
	Sieve	% loss	% restrained						
1	3/4"	100.00	0.00	gr	-	-	-	-	-
2	1/2"	96.00	4.00	gr	45.03	45.03	45.03	45.03	45.03
3	3/8"	86.93	9.07	gr	102.03	102.03	102.03	102.03	102.03
4	No. 4	63.90	23.03	gr	259.04	259.04	259.04	259.04	259.04
5	No. 8	43.56	20.34	gr	228.79	228.79	228.79	228.79	228.79
6	No. 16	28.62	14.94	gr	168.10	168.10	168.10	168.10	168.10
7	No. 30	20.76	7.87	gr	88.50	88.50	88.50	88.50	88.50
8	No. 50	15.60	5.16	gr	58.05	58.05	58.05	58.05	58.05
9	No. 100	10.79	4.80	gr	54.02	54.02	54.02	54.02	54.02
10	No. 200	8,.3	2.37	gr	26.65	26.65	26.65	26.65	26.65
11	PAN	6.06	0.00	gr	94.79	94.79	94.79	94.79	94.79
	Total		100.00	gr	1,125	1,125	1,125	1,125	1,125
D	Test piece weight (A + B + C)			gr	1,200	1,200	1,200	1,200	1,200

2.5. Marshall Stability and Indirect Tensile Strength

The Marshall stability test was conducted on AC-WC mixture with and without Gondorukem specimens according to SNI 06-2489-1991 [12]. Figure 2 shows the Marshall stability test equipment.

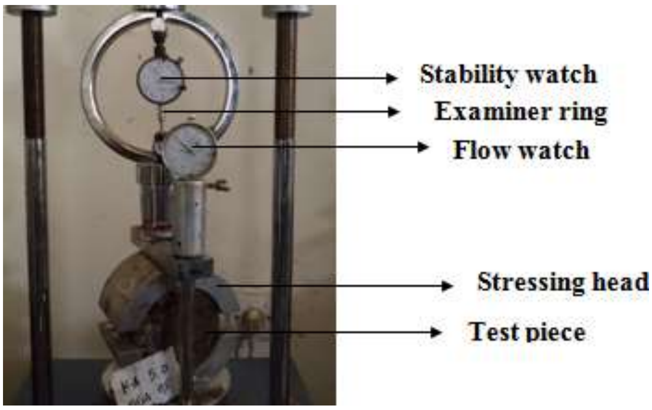

Figure 2. Marshall stability test equipment

ITS test was conducted on asphalt with and without Gondorukem specimens according to ASTM D6931-12 [13]. Figure 3 show ITS equipment.

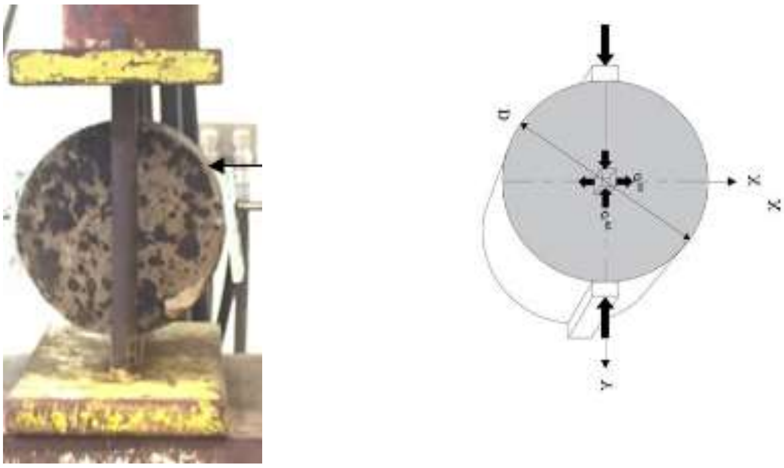

Figure 3. Indirect tensile strength (ITS) equipment

3. RESULTS AND DISCUSSION

3.1. Stability of AC-WC Mixture with and without Gondorukem

Fig. 4 shows the relationship between Gondorukem content with stability value. Three nominally identical companion specimens were produced for each AC-WC mixture under investigation to ensure repeatability of result. Each value in the Table 7 is average of three similiar specimens. After compaction, the stability of the AC-WC mixture can be established due to the proper coalesces of MBA with Gondorukem so that there is an increase in the grip strength of the binder that covers the aggregate. Figure 4 indicates that the Marshall stability of AC-WC mixture increases initially, reaches a maximum value at 7.5% of Gondorukem content with corresponding with stability value of 2,884.52 kg and then decreases with increasing of Gondorukem content. This result shows that the excessive Gondorukem cannot coalesce with MBA and led to decrease the adhesive binder and particle aggregates.

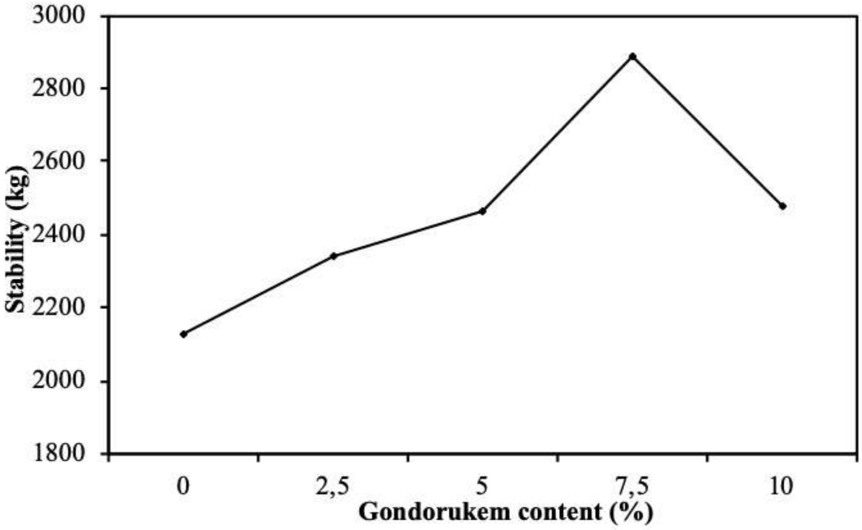

Figure 4. Relationship between Gondorukem content with stability value

3.2. Indirect Tensile Strength (ITS)

A series of ITS tests were performed on AC-WC with different Gondorukem content. ITS test for each mixture is repeated three times in order to verify experimental result.

Visual observation on every specimen was carried out prior to ITS test. Visual observation result on compacted specimens shows that no piling of bituminous material and filler at the lower end of the specimens. Also no bleeding occurred. These results indicate that all materials are well mixed and the compaction process allowing particles aggregate to be bound.

Fig. 5 shows relationship between Gondorukem content with ITS value. ITS of mixture without Gondorukem and mixture with 2.5%, 5%, 7.5% and 10.0% Gondorukem were 0.598 MPa, 0.678 MPa, 0.807 MPa, 0.807 MPa and 0.697 MPa and 0.1013, respectively. ITS percentages increases were 13.37%, 34.94%, 34.94% and 16.55% with 2.5%, 5%, 7.5% and 10.0% Gondorukem, respectively, compared with the corresponding value on the without Gondorukem.

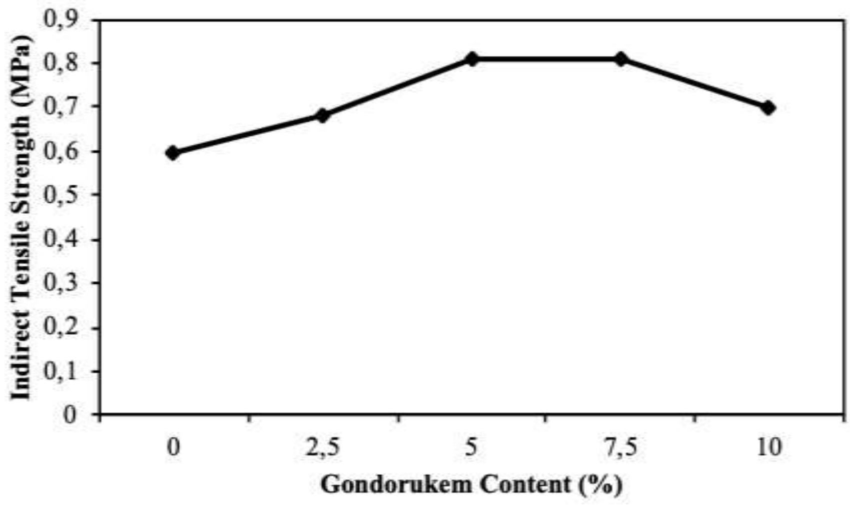

Figure 5. Relationship between Gondorukem content with ITS value

When MBA containing petroleum bitumen and Gondorukem were blended to produce a mixture, the chemical components of MBA and Gondorukem bitumen have a rearrangement, and a layer of membrane is formed to cover aggregate. As a result, AC-WC mixture containing MBA and Gondorukem had the sufficient stability with resistance to deformation and the sufficient strength to withstand the tensile load.

4. CONCLUSIONS

1. The utilization of Gondorukem with content from 2.5% to 10.0% increased the stability from 9% to 36% in comparison with the mixture without Gondorukem.
2. The increase in ITS was from 13.37% to 34.94% by the utilization of Gondorukem with content from 2.5% to 7.5%.

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