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Stress-Strain of Hotmix Cold Laid Containing Buton Granular Asphat (BGA) with Modifier Oil Base and Modifier Water Base as Wearing Course

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ABSTRACT
Buton granular asphalt (BGA) is produced from natural rock asphalt. The employment of hotmix cold laid containing BGA with modifier oil base and modifier oil base can substitute hot rolled asphalt (HRA) construction in the remote and distance 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 present study provides the information concerning the stress-strain pattern and compressive strength of hotmix cold laid containing BGA and Modifier Oil Base and Modifier Water Base at the storing and compaction time of 4 hours, 3 days and 7 days.
Keywords-Buton Granular Asphalt (BGA),Modifier Oil Base and Modifier Water Base,Stress-strain curve.

I. INTRODUCTION

Natural rock asphalt (Buton asphalt) resources are located in Butonisland, Indonesia. It is considered as significant economic material. Rock asphalt is crushed to reduce its granular size to 9.5 mm maximum size in order to produce Buton granular asphalt (BGA). There is a large resource of natural rock asphalt (sedimentary rock containing of high hydrocarbon substances) in South Buton Island, Southeast Sulawesi in Indonesia. The deposit of Buton rock asphalt resource are approximately 60.991.554.38 tons (24.352.883.07 barrel oil equivalent) [1]. The utilization application of BGA by mixing with aggregates in pavement construction is an alternative material that can increase domestic consumption of Buton asphalt. Furthermore, such utilization could reduce expenditures in using petroleum asphalt and improve national road infrastructure development. Many investigations have been undertaken over several decades with the purpose of improving the mechanical properties of mixture containing Buton granular asphalt (BGA). [2][3][4][5][6][7].

II. MATERIALS AND EXPERIMENTAL METHODS

2.1. Some properties of buton granular asphalt

BGA that used in this research is from Lawele area and produced by the national asphalt Buton plant, it is available in the market. Contain of bitumen is 25.47%, which means it contains of 75% minerals. BGA has grains smaller than 9.5mm and with a water content of 0.81%. BGA properties are shows in Table 1.

Table 1. Some properties of buton granular asphalt

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

2.2Physical Properties of Aggregates

Table 2 and Table 3 show some physical properties of fine aggregate and coarse aggregate, respectively. Crushed river stone and river sand were used as course aggregate and fine aggregate, respectively. In this study, aggregates testing were conducted prior the mix design and analysis.

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%

Table 3. Some mechanical properties of fine aggregate

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

2.3 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.

Table 4. Gradation size distribution in this study and limit (crushed stone, sand and filler).

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

Hot mix Cold Laid Asbuton with according to gradation size distribution Asbuton hot mix cold Laid Asbuton.[8]

2.4 Mixture Preparation

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

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.

Table 5.Composition of aggregates, filler, and BGA contain in the mixture

BGA by weight by mixture (%)	Bitumen within BGA (% by weight)	Mineral ofBGA (%)	crushed stone Ø 1 – 2 cm (%)	crushed stone Ø 0,5- 1cm (%)	Filler (%)
31.41	8	23.41	30	35	11.59

Table 6.Compaction Temperature at each Storing and compaction time

Storing and ompactionTime (days)	0 (4 hours)	3	7
Compaction Temperature (^{O}C)	50	27	27

2.5 *Compressive Strength Test*

Fig.1shows the compressive strength test equipment. Two external linear variable differential transformers (LVDTs) were attached to the specimen surface, and two LVDTs were attached to the specimen side, to measure the displacement.

The Marshall compactor with 75 blows applied to the top and bottom side of specimens at temperature of 50^{O}C. Compressive strength value were determined in cylindrical test specimen (Ø100 x 100±5mm). Test was done in according to the procedure listed in ASTM D1074 – 09. All specimens were tested in dry conditionwithout immersed the specimens in the water

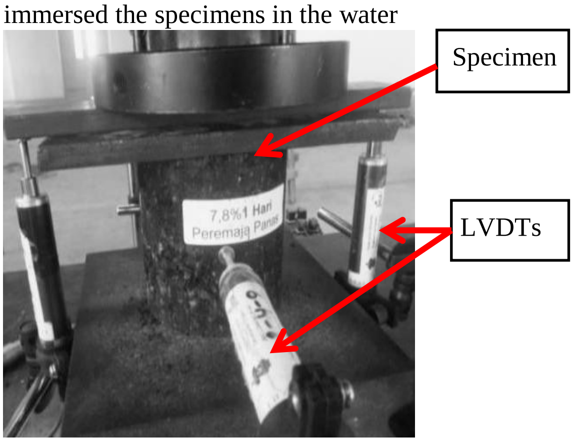


Fig.1.Compressive Strength test equipment (ASTM D1074 - 09)

III. RESULT AND DISCUSSION

3.1 Stress-Strain Curve

The stress-strain curves for each sample are given in Fig.2 to Fig.4. Vertical strains and horizontal strains patterns were similar for all specimens, irrespective of storing and compaction time. At storing and compaction time of 4 hours, the specimens reach their ultimate strength at vertical strain of about 0.49 and horizontal strain about 0.41, as shown in Fig.2. At storing and compaction time of 3 days, the specimen reach their ultimate strength at vertical strain of about 0.54 and horizontal strain about 0.64, as shown Fig 3. At storing and compaction time of 4 hours, the specimen reach their ultimate strength at vertical strain of about 0.75 and horizontal strain about 0.77, as shown Fig.4.At all storing and compaction day, under condition of this investigation, no significant change in vertical strains and horizontal strains at the peak compressive strength was observed in this compressive strength interval (1,68 – 2MPa) of hotmix cold laid mixture containing BGA with modifier oil base and modifier water base.

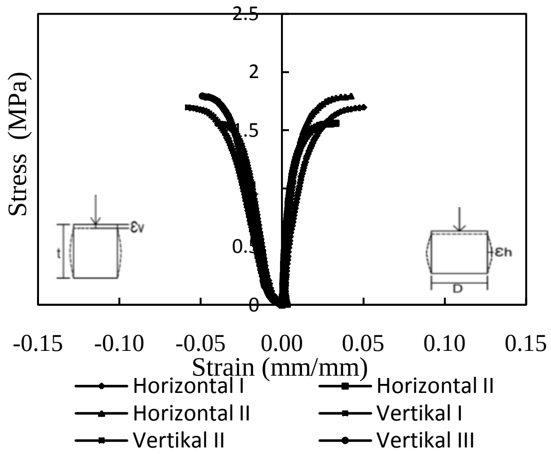


Fig.2. Stress-strain curve storing and compaction time 4 hours

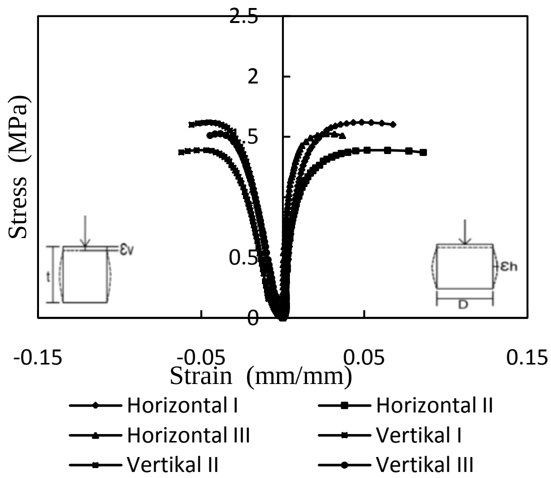
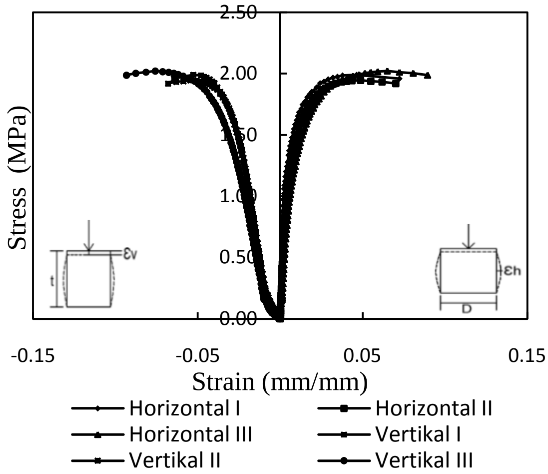


Fig.3. Stress-strain curve storing and compaction time 3 days



3.2 Relationship Between Storing and Compaction Day with Compressive Strength

Fig.5 shows the relationshipbetweenstoring and compaction time with compressive strength.

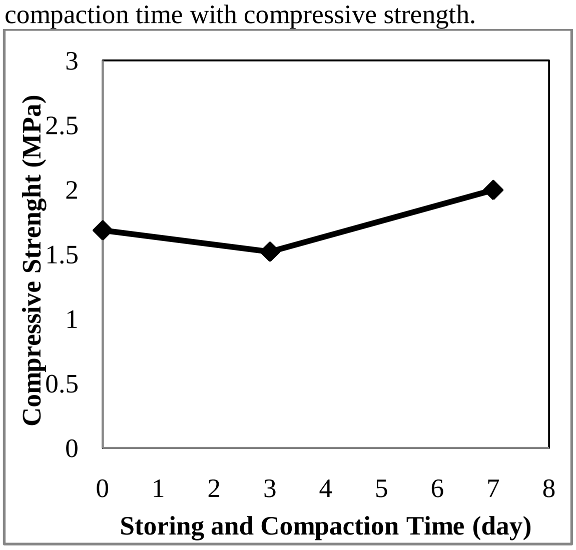


Fig.5.The relationshipbetweenstoring and compaction time with compressive strength

No significant difference on compressive strength was observed when the storing and compaction time were extended from 4 hours to 3 days. An increase in compressive strength was observed when the storing and compaction time were extended from 3 days to 7 days. When compared with compressive strength value at 3 days, the compressive strength value at 7 days was higher 40.9%.

IV. CONCLUSIONS

[1.] The work presented in this paper shows that a mixture made of BGA with Modifier Oil Base and Modifier Water Base could be compacted at temperature of 27 ^{O}C and 50 ^{O}C.

[2.] At storing and compaction time of 4 hours, 3 days and 7 days, the average horizontal strain value were 0.41, 0.64 and 0.77 respectively.

[3.] At storing and compaction time of 4 hours, 3 days and 7 days, the average vertical strain value were 0.49, 0,54 and 0.75 respectively.

[4.] The average compressive strength value was similar at storing and compaction time of 4 hours and 3 days. When compared with compressive strength value at 3 days, the compressive strength value at 7 days was higher 40.9%.

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