INFULUENCE OF LABORATORY SHORT TERM AGING ON TENSILE STRENGHT OF POROUS ASPHALT MIXTURE CONTAINING BUTON GRANULAR ASPHALT

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Abstract— This study purposes to study the influence of laboratory short term aging on the tensile stress-strain relationship of porous asphalt concrete mixtures using Buton Granular Asphalt (BGA) as partial replacement for petroleum asphalt. The experimental tests show that the Indirect Tensile Strength-vertical strains curve were similar for all mixtures. The application of BGA as partially replaced petroleum asphalt in the porous asphalt mixture improved the tensile strength and elastic modulus in comparison to porous asphalt mixture without BGA.

Keywords— Porous Asphalt, Buton Granular Asphalt, Tensile Strength, Strain, Stress.

I. INTRODUCTION

Some areas in southern Buton Island, Indonesia possess natural rock asphalt resources with deposit of approximately 60,991,554.38 ton (24,352,833.07 barrel oil equivalent). Natural rock asphalt composed of approximately 30% bitumen and 70% mineral. (BGA) is a granular type of natural rock asphalt product which is available in the market. Utilization of local material such as BGA has played an important role for securing stable infrastructure development. This demand will continue in future [1], In Indonesia, the heavy precipitation of high intensity rainfall always creates temporary flood on the surface road in the low land area up to several tens of minutes before flows into the drainage. The utilization of porous asphalt as a wearing course of pavement can overcome the temporary flood problem that occurred from rainfall.

Aquaplaning and temporary flood on the surface road in the low land area are generated by the heavy precipitation of high intensity rainfall. The employment of porous asphalt as a wearing course of pavement becomes an interesting solution to overcome the temporary flood problem that occurred from rainfall. Porous asphalt has been used in many countries such as in Netherland [7][9]. Porous asphalt consists mainly of open graded coarse aggregate with small amounts of fine aggregate and filler therefore the skeleton of the open graded aggregate create porosity and permeability within the porous. Its porosity can allow water to drain freely through it resulting in aquaplaning reduction [3].

The service life of asphalt pavements are largely reduced by ageing process[11]. This present research aims to study the suitability of BGA as additive to improve the capability of porous asphalt against short term aging this paper result. In many literatures related to aging explain that the short-term aging occurs during the construction phase, while the mix is hot. This is probably caused by volatilization of oxidation products. The short-term oven aging (STOA) can be carried out to simulate the aging of the mixture during the construction process [8]. The influence of laboratory short term aging on tensile strength of porous asphalt mixture containing buton granular asphalt.

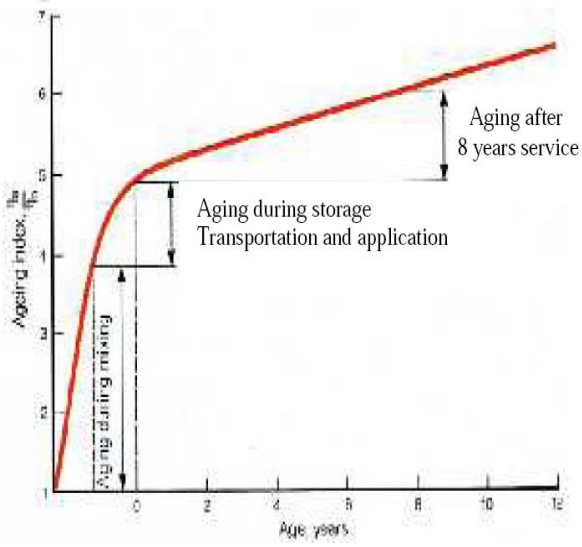


Fig.1. Ageing of bitumen during mixing, subsequently during storage, transportation and application and finally service (The Shell Bitumen Handbook, 2009)

II. MATERIALS AND METHODES

2.1. Buton Granular Asphalt (BGA)

Fig. 2 and Table I shows dimension of BGA and some properties of BGA, respectively. BGA has a relatively uniform grain size with a maximum grain size of 1.18 mm.



Fig.2. Buton Granular Asphalt BGA (dimension in mm)

Table1: Some Properties of Buton Granular Asphalt

Parameter	Value
Bitumen Content of BGA (%)	23.00
Asphalt Mineral Levels (%)	77.00
Water Content (%)	1.70
Flashpoint Before Extract (mm)	1.68
Melting Point of Bitumen BGA Extact (^{0}C)	86

2.2. Petroleum Asphalt

This paper used petroleum bitumen. Asphalt concrete mixtures in Indonesia generally use petroleum bitumen grade 60/70 as shown in Table 2.

Table2: Some Properties of Petroleum Bitumen Grade 60/70

Parameter	Value
Ductility (25^{0}C)	110
Spesific Gravity	1.01
Softening Point (^{0}C)	52
Flash Point (^{0}C)	310
Penetration (25^{0}C)	65
Weight (With TFOT) (%)	0.2
Penetration After TFOT (25^{0}C)	54

2.3. Aggregates

Crushed river stone and river sand were used as coarse aggregate and fine aggregate, respectively. These aggregates were from Jeneberang River, Gowa Indonesia. The physical properties of coarse aggregate and fine aggregate are presented in Table III.

Table3: Some Properties of Coarse Aggregate

Parameter	Value
Bulk Density	2.55
SSD Density	2.61
Apparent Density	2.72
Abrasion (%)	22.64
Particle flat and oval (%)	8.21
Absorption (%)	2.37

Table4: Some Properties of Fine Aggregate and Filler

Parameter	Value
Fine Aggregate	
Bulk Density	2.56
SSD Density	2.61
Apparent Density	2.70
Absorption (%)	1.89
Sand Equivalent Value (%)	83.9
Filler	
Bulk Density	2.55
SSD Density	2.61
Apparent Density	2.71
Absorption (%)	2.29
Sand Equivalent Value (%)	0.66

2.4 Asphalt Mixture and Aggregate Grading Combination

The total bitumen content of specimen without BGA was determined at 5% by weight of asphalt mixture and total bitumen content of specimen containing BGA was determined at 5.75% by weight of asphalt mixture. This research prepared Porous Asphalt mixture without BGA, Porous Asphalt mixture with 2,5% of BGA (contains bitumen from BGA 0.575% and petroleum bitumen 5.175% by mixture weight), and Porous Asphalt mixture with 4,5% of BGA(contains bitumen from BGA 1.035% and petroleum bitumen 4.715% by mixture weight). All mixtures used aggregates grading combination as shown in Figure 2. The aggregate grading combination met the requirement of mixture Porous asphalt with BGA [6]. Asphalt bitumen and aggregates of all Porous Asphalt mixtures were mixed at temperature of 160□C, and compacted into the cylindrical mold with capacity of 1,200 gram and diameter of 101.6 mm. The specimens were compacted with 50 blows each face by using Marshall compactor.

Table5: Asphalt Mixture Without BGA

Sieve	Coarse Aggregate	Fine Aggregate	Filler	Total
	Gram	Gram	Gram	Gram
¾"	0.00	0.00	0.00	
½"	29.01	0.00	0.00	29.01
3/8"	484.05	0.00	0.00	484.05
No.4	455.95	0.00	0.00	455.95
No.8	0.00	11.40	45.60	57.00
No.200	0.00	37.69	36.75	74.44
PAN	0.00	7.91	31.65	39.56
	Weight Aggregates			1140
	Petroleum Asphalt			60
	Total			1200

Table6: Asphalt Mixture With 2,5% BGA

Sieve	Coarse Aggregate	Fine Aggregate	Filler	Total
	Gram	Gram	Gram	Gram
¾"	0.00	0.00	0.00	0.00
½"	28.78	0.00	0.00	28.78
3/8"	480.23	0.00	0.00	480.23
No.4	452.35	0.00	0.00	452.35
No.8	0.00	11.31	45.240	56.55
No.200	0.00	37.39	36.46	90.00
PAN	0.00	7.85	31.40	0.00
	Weight Aggregates			1107.90
	Petroleum Asphalt			62.1
	Bitumen of BGA			6.90
	Mineral of BGA			23.1
	Total			1200

Table7: Asphalt Mixture With 4,5% BGA

Sieve	Coarse Aggregate	Fine Aggregate	Filler	Total
	Gram	Gram	Gram	Gram
¾"	0.00	0.00	0.00	0.00
½"	28.78	0.00	0.00	28.78
3/8"	480.23	0.00	0.00	480.23
No.4	452.35	0.00	0.00	452.35
No.8	0.00	11.31	45.240	56.55
No.200	0.00	37.39	36.46	71.52
PAN	0.00	7.85	31.40	0.00
	Weight Aggregates			1089.42
	Petroleum Asphalt			56.58
	Bitumen of BGA			12.42
	Mineral of BGA			41.58
	Total			1200

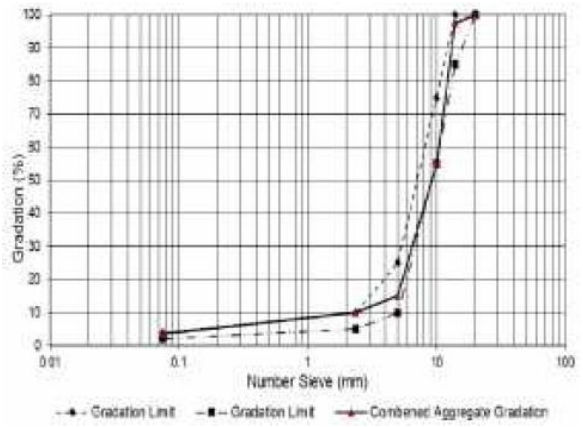


Fig.3. Combine Aggregate Gradation

2.5. Indirect Tensile Strength Test

Fig 4. Shows Indirect Tensile strength test was conducted according to ASTM D6931 – 12 [2].

Axial strain were derived via two linear variable differential transducers (LVDTs) measuring platen-to-platen displacement. Two LVDTs are mounted diametrically opposite one another to measure horizontal strain. The recording equipment consists of digital interface unit (data logger) connected to a computer that utilized to monitor and record data from the load actuator and LVDTs.

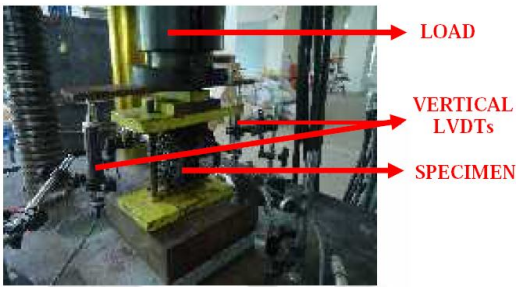


Fig. 4. Shows Equipment of Indirect Tensile Strength test

III. RESULTS AND DISCUSSION

3.1. Indirect Tensile Strength (ITS) Strain Curve of Asphalt

The vertical strains were measured up to the peak stress. The ITS-strain relationship of specimens subjected to short term monotonic tensile load are presented graphically in Fig. 5, 6,7,8,9, and Fig. 10.

ITS-vertical strains curve consists of two parts. The first part shows the linear zone that represents the elasticity arises up to approximately 80% of peak stress. The second part shows the nonlinear zone arise up to peak stress.

Before laboratory aging porous asphalt mixture without BGA, porous asphalt mixture with 2,5% of BGA and porous asphalt mixture with 4,5% of BGA had indirect tensile strength of 0.0949 MPa, 0.0913 MPa, and 0.1554 MPa, respectively. all samples failed when the vertical strain reached range between 0.03 and 0.04, respectively.

After laboratory aging porous asphalt mixture without BGA, porous asphalt mixture with 2,5% of BGA and porous asphalt mixture with 4,5% of BGA had indirect tensile strength of 0.1572 MPa, 0.1818 MPa, and 0.2687 MPa, respectively. All samples failed when the vertical strain reached range between 0.04 and 0.05.

Tensile strength test showed the value of asphalt porous mixture using BGA is higher than asphalt porous without BGA. The reason that makes the porous asphalt mixture with BGA can withstand higher tensile strength is the penetration of bitumen within BGA is high (16 mm) that contribute to the higher resistance to deformation caused by the short term monotonic tensile load.

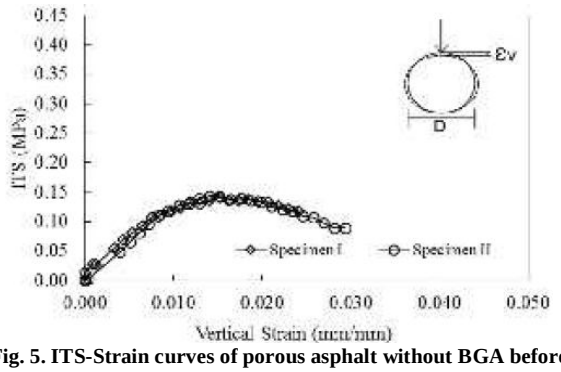


Fig. 5. ITS-Strain curves of porous asphalt without BGA before aging

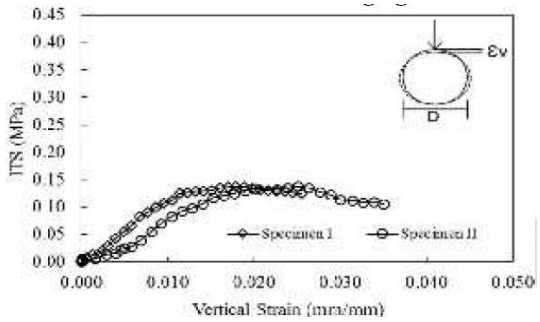


Fig. 6. ITS-Strain curves of porous asphalt with 2,5% BGA before aging

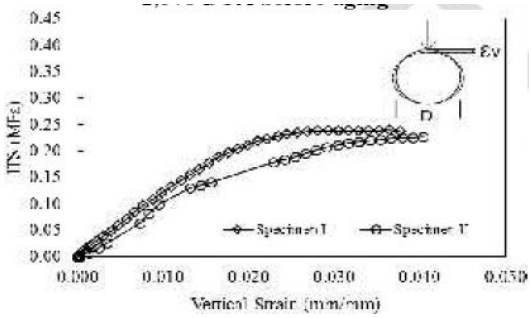


Fig. 7. ITS-Strain curves of porous asphalt with 4,5% BGA before aging

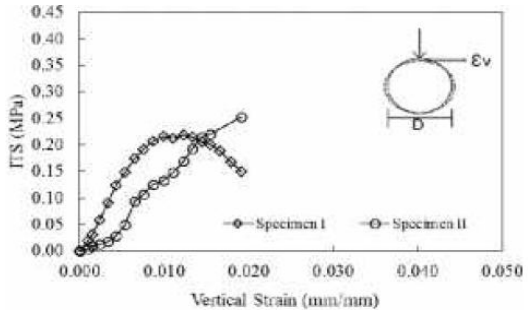


Fig. 8. ITS-Strain curves of porous asphalt without BGA after aging

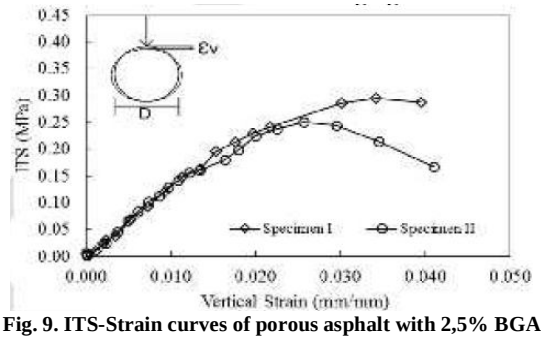


Fig. 9. ITS-Strain curves of porous asphalt with 2,5% BGA after aging

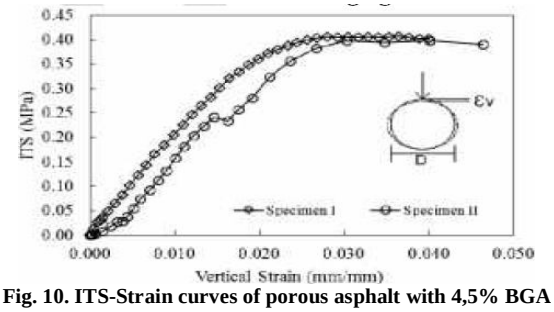


Fig. 10. ITS-Strain curves of porous asphalt with 4,5% BGA after aging

CONCLUSIONS

This present research aims to study the suitability of BGA as additive to improve the capability of porous asphalt against short term aging. The test result porous asphalt mixture containing BGA 4.5% demonstrated a better resistance to short term aging compared to porous asphalt mixture containing BGA 2.5% and without BGA.

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