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Effectiveness of Buton Granular Asphalt on Asphalt Emulsion Mixture Due to Aging Process

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Abstract : The objective of this study is to replaced of petroleum bitumen with local materials such as Buton granular asphalt (BGA) was blended with petroleum bitumen in the asphalt emulsion mixture, and to analyze the effect BGA of mixtures due aging process related to the stability, flow, and indirect tensile strength. The first method given a BGA partial substitution of the asphalt emulsion content with variations BGA content, while the second method to aging carried out in an accelerated manner in the experimental laboratory, by the sample being put into an oven at 85 °C with variations in aging time of 0, 1, 2, 3, 4, and 5 days. and checking the chemical content contained in the BGA. The results and analysis indicate that BGA at a level of 10% can be used as a substitute for part of the asphalt emulsion. Strain values increase after 1 day of aging, due to the influence of bituminous in the BGA in the mixture. Furthermore, after aging for 2, 3, 4, and 5 days, the values of strain was decreased, while the value of ITS was increased, because of the influence of mineral in the BGA in the mixture.

Keywords: aging; asphalt emulsion; Buton granular asphalt.

1. Introduction

Asphalt emulsion mixture is a mixture using asphalt emulsion to bind aggregates; it can be mixed and compacted at room temperature without the need for heating, because it has liquid physical properties and a low viscosity. The process without heating provides several advantages, namely, fuel saving and no air pollution. Pollution is caused by road infrastructure, besides coming from an increase in the number of vehicles, so a vehicle emissions increase is also caused by the process of making roads[1]. Asphalt hot mixing requires a certain temperature that is high enough for mixing and compaction, while the asphalt cold mix method does not use the heating process, so its energy use is also more efficient.

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Indonesia has natural asphalt found on Buton Island, Southeast Sulawesi, which is known as Buton asphalt. The natural asphalt available on Buton Island exists in a very large reserve. Buton asphalt deposits are around 60,991,554.38 tons, equivalent to 24,352,833.07 barrels of oil [2].

Buton asphalt is generally in a solid form that is formed naturally due to geological processes. The process of forming Buton asphalt originates in petroleum that is pushed to the surface, infiltrating between porous rocks [3]. One of the Buton asphalt products is Buton Granular Asphalt (BGA). BGA contains two main elements, namely, bitumen and minerals, shown in Figure 1.

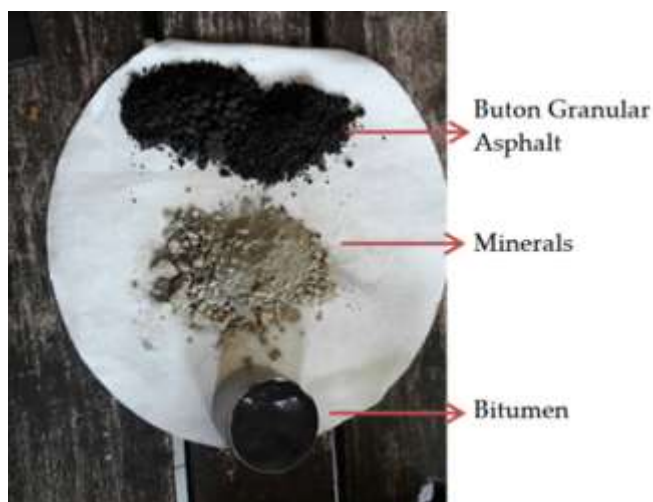


Figure 1. Buton Granular Asphalt (BGA) contents.

Natural stone asphalt formed by the impregnation of oil into limestone, which over time was changed to bitumen in stone. Bitumen content is usually around 10–35% of the weight of the rock, and is usually a chemical or commercial solvent extraction process is needed exploiting material. They can be found in France, Switzerland and Buton Island Indonesia [4]. Modification of asphalt emulsion and BGA can be done based on the required standards and based on previous studies [5–9].

Aging is a process of change due to time or age, the effect of aging on pavement needs to be considered in planning, based on the results of research [10] the quality of asphalt binders affect the age of the pavement so that it also affects the life-cycle cost and thus needs to be taken into account in contracts and construction management. Flexible pavement is a type of pavement that uses asphalt as a binder in the mixture, and it has a good level of elasticity so that it is comfortable to use. The performance degradation of the asphalt mixture in flexible pavement is due to the aging of the asphalt. Asphalt aging occurs when it is influenced by environmental factors (weather and temperature). Road asphalt pavement service will gradually deteriorates its performance due to repetition of vehicle and environmental loads factors [11].

Asphalt is a thermoplastic material, which has sensitivity to temperature changes. When the temperature decreases it will become hard or thicker, and if the temperature increases it will become soft or runny. The addition of Buton bitumen can make the asphalt harder and more durable to high temperatures, which is indicated by its increased softening point value and it becoming stronger against changes in temperature [12]. The temperature sensitivity in each type of asphalt varies so the aging time for each type of asphalt varies also. In research conducted on three types of asphalt modifications, differences were found in their aging resistance. The results showed different aging behaviors in different types of asphalt [13]. Asphalt is a binder in the mixture, so if aging occurs, the pavement will easily crack because its flexibility decreases, while the stiffness increases, affecting the performance of the mixture. Research shows that aging results in oxidation of the asphalt, resulting in increased stiffness [14]. The research [15] shows that during short-term aging, oxidation and aromatic

naphthene are transformed into resin until these resin production stops, and then during long-term aging the resin turns into asphaltenes.

2. Experimental

The making of the test object followed Indonesian National Standard (SNI)[16] beginning with weighing the composite components, namely, aggregate, asphalt emulsion, and BGA, according to the mix design. All materials were mixed at room temperature; then the mixture was put into a cylindrical mold that had been coated with filter paper on both sides. Then, the process of compaction of the mixture at room temperature was

completed with a pounder (weight 4.5 kg and fall height 45.7 cm) with 50 collisions for each field. After processing in cold conditions, the test object was cured in the mold for 24 hours; after 24 hours, the test object was removed from the mold and then put into the oven for 24 hours at 38°C. Asphalt specimens with optimal BGA content, with the interval of 2.5%, as a partial substitute of the weight of mixed asphalt emulsions, to obtain optimal BGA content. In the aging conditions, the returned specimens were heated at 85°C, for 1, 2, 3, 4, or 5 days.

The process of laboratory aging is carried out by referring to the recommendations of the results of a research on investigation of the relationship between field performance and laboratory aging properties of asphalt, that oven aging temperature at 85 ° C for 4 days is recommended to represent projects that are around 10 years old [17].

2.2. X-Ray Diffraction (XRD) Test

XRD (X-Ray Diffraction) is a tool to determine the chemical elements and compounds or structural characteristics of crystals contained in various types of materials by utilizing X-ray scattering.

2.3. Marshall Test

The Marshall test is a protocol used to examine the stability and flow value of an asphalt mixture with a maximum aggregate size of 2.54 cm. Stability of the asphalt mixture could defined as a resistance to permanent deformation of asphalt mixture due to a traffic load. Based on the flow value, the flexibility of the asphalt mixture can be measured by the change in sample diameter between the initial loads to the maximum load.

2.3. Indirect Tensile Strength (ITS)

The indirect tensile strength test (ITS) aims to determine the tensile strength characteristics of concrete asphalt and can be used as an indicator in conducting a study of cracking that occurs at the pavement layer [18].

3. Results and Discussion

3.1. XRD Testing Results

Figure 2 shows the relationship between the phase angles at 2 theta [°] with the intensity of the BGA type 20/25 specimen.

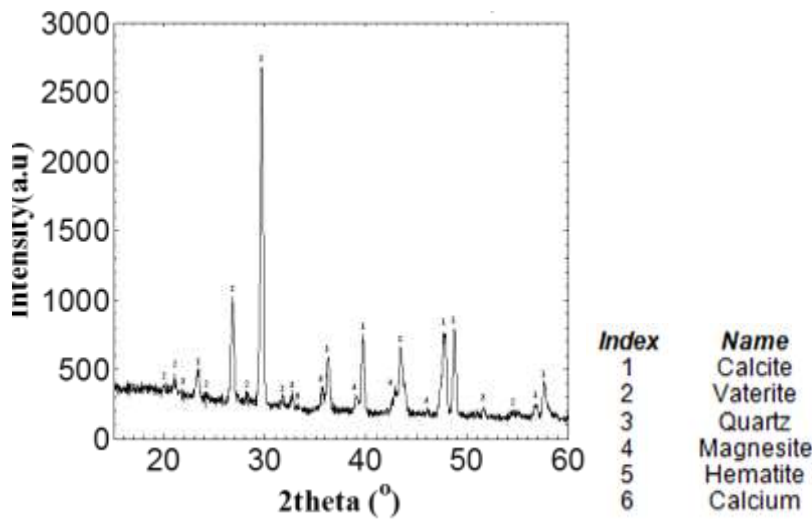


Figure 2.Relationship of phase angles with BGA intensity of 20/25.

Based on Figure 2 shows that there are Calcite compounds in each corner of the phase with different intensities. In general, Calcite compounds appear in the phase 30 phase 2 theta [°] with an intensity of 2700 au. this means that BGA type 20/25 has a large degree of gravity which makes the asphalt mixture stronger but the value of elasticity decreases so that Buton asphalt researchers reveal that Buton asphalt can improve the performance of asphalt mixtures but at optimum levels because if more will cause the mixture to become stiffer.

3.2. Determination of the optimum BGA content

Given a BGA partial substitution value 8.8% of the asphalt emulsion content, the Marshall test results showing the stability and flow values from the addition of BGA to the asphalt emulsion mixture are shown in Table 1.

Table 1.The results of the Marshall test.

BGA Content (%)	Stability (kg)	Flow (mm)
0	834.12	3.29
2.5	908.63	3.62
5.0	1030.47	3.82
7.5	1148.80	3.96
10.0	1273.08	4.03
12.5	1257.19	3.77

Figure3 shows the relationship between variation in the BGA level and the mixture stability and flow values; addition of BGA at levels of 2.5%, 5%, and 7.5% increased the values of the mixture stability and flow until the BGA level reached 10%, and the values decreased for a BGA level of 12.5%.

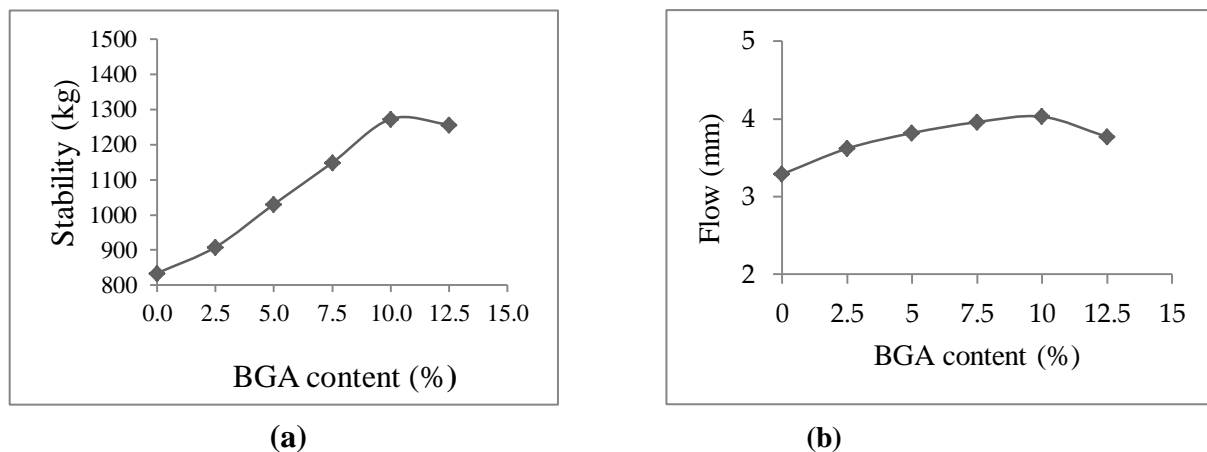


Figure 3.The effect of BGA content in the asphalt emulsion mixture based on Marshall test results:(a) Effect of BGA content on stability; (b) Effect of BGA content on flow.

The values of stability and flow were decreased by the addition of 12.5% BGA because BGA contains minerals that function as fillers in the mixture, as BGA levels increase, the levels of minerals from the BGA in the mixture also increase so that the ratio between filler and asphalt content moves outside the required limits and affects stability and flow.

The optimum values of stability and flow were obtained for a BGA level of 10%. The percentage increase in the value of stability between 10% BGA and without BGA is 52.626%. Based on the mixture composition of the total mixture is 1200 gr with 8.8% asphalt emulsion 10% BGA substitution can reduce 26.136% asphalt emulsion. BGA at a level of 10% can be used as a substitute for part of the asphalt emulsion while the mineral content of BGA can be used as a filler and substitute for part of the stone dust in the mixture.

3.3. Indirect Tensile Strength (ITS)

The increase in strain value occurs in oven aging 1 day, because of the heat so that the bitumen in the BGA becomes soft. The value of the strain shows the elasticity of a material, the higher the strain, the more elastic the mixture. The decrease in strain values in oven aging 2, 3, 4, and 5 days because of the effect of oxidation during aging makes the asphalt mixture increasingly stiffness.

Increased ITS value after aging 2, 3, 4, and 5 days because the mixture is getting stiffer so that the value of ITS is increasing. BGA contains lime found in minerals, causing the mixture to become hard so that the value of ITS increases. The relationship of the strain value with the indirect tensile strength without and with aging is shown in Figure 3. This affects the flexibility and adhesion of the asphalt and can cause the road to be easily damaged when receiving traffic loads [19].

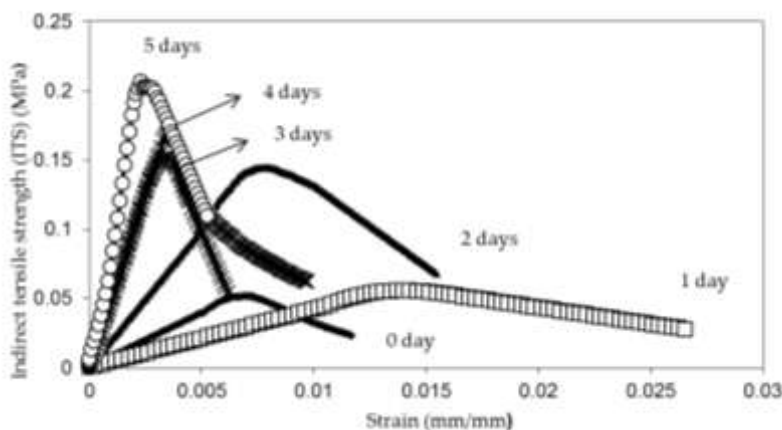


Figure 4.Relationship between strain and indirect tensile strength (ITS) for all variations of the aging process.

The value strain was increased after 1 day of aging because the heating that occurred made the bitumen contained in the BGA become active and cover the aggregate surface, causing the mixture to become stronger and more elastic. Furthermore, after aging for 2,3,4, and 5 days, the value strain was decreased, while the value of ITS were increased. This shows that due to the aging process, the mixture stiffness increases. This effect causes the liquid portion of the asphalt to evaporate due to hardening, so the asphalt becomes brittle and loses its adhesion.

4. Conclusions

The addition of 10% BGA to asphalt emulsion mixture can improve mixture performance. Percentage of BGA as partially substituted material with emulsion asphalt obtained the optimum value from the test results of 10%. Addition of 10% BGA to the asphalt emulsion mixture can improve mixed performance compared to the mixture without BGA.

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