Analysis of stability of residue asphalt emulsion mixture containing Buton Granular Asphalt (BGA)

Bulgis¹, M W Tjaronge², S A Adisasmita² and M Hustim³

¹Doctoral Student, Civil Engineering Department, Universitas Hasanuddin, Makassar, Indonesia
²Professor, Civil Engineering Department, Universitas Hasanuddin, Makassar, Indonesia
³Associate Professor, Civil Engineering Department, Universitas Hasanuddin, Makassar, Indonesia

E-mail: bulgisgis@gmail.com

Abstract. The natural rock asphalt which available in abundance in the southeast of Buton Island, Indonesia was attempted to use in the production of cold mix asphalt. The purpose of this study is to replace petroleum bitumen with local materials such as natural rock asphalt. Small granular size of natural rock asphalt that referred to Buton granular asphalt (BGA) was blended with petroleum bitumen as droplet phase in the asphalt emulsion mixture. Mixture with 8.8% of asphalt emulsion mixture made with the cationic slow setting (CSS) that corresponded to the residue asphalt emulsion content was used as a mixture control. At residue asphalt emulsion content, bitumen of BGA was used for petroleum bitumen partial replacement in the asphalt emulsion mixture production. Test result revealed that utilizing BGA in asphalt emulsion mixture has proved for improving stability where the stability of all mixture with BGA super passed the stability of mixture without BGA.

1. Introduction
The asphalt emulsion mixture is one type of asphalt mixed with water and other emulsifiers. The emulsion is the dispersed phase of a liquid into another liquid [1]. Asphalt emulsion contains 40% to 75% hard asphalt, 0.1% to 2.5% emulsifier, 25% to 60% water and added with minor compositions such as Chloride Acid and Calcium Chloride [2]. The water is present in the asphalt emulsion, so it is necessary to consider the residual emulsion bitumen in the mixture to determine the bitumen content used. Buton Granular Asphalt is natural asphalt found in the Buton island, Indonesia, which in its development needs to be utilized in order to reduce the import of oil asphalt from abroad. Buton granular asphalt in its utilization can be used in a way as a partial replacement of oil asphalt [3-6]. Modification of Buton granular asphalt with asphalt emulsion based on mixed stability value. The purpose of stability testing is to know the ability of mix in receiving the load. The value of mixed stability can be obtained by Marshall testing according to SNI 06-2489-1991 standards [7].

2. Methodology

2.1 Material preparation
2.1.1 Characteristics of aggregates
The aggregates used for the asphalt emulsion mixture containing Buton granular asphalt are sourced from the Jeneberang River in Gowa. The aggregate size used for the mixed AC-WC type, crushed river stone with two fractions were used as coarse aggregate: one with aggregate diameter 5-10 mm and the other with crushed stone diameter 10-20 mm. Stone dust was obtained from the stone crushing process. Stone dust was defined as material passing a 0.075 mm sieve and sieve no # 30. The physical properties of coarse aggregates, stone dust is shown in table 1, table 2 and table 3. Aggregate combination to obtain mixed compositions that meet AC-WC mixed specifications [8]. Figure 1 shows the results of the sieve analysis for aggregate combination.

| Table 1. Properties of coarse aggregates. |
|-----------------------------------------|
| Properties                               | Crushed Stone                  |
|                                         | 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 2. Properties of stone dust (aggregate passing sieve no #30). |
|---------------------------------------------------------------|
| Water absorption, %                                           | 2.79   |
| Sand equivalent, %                                            | 89.66  |
| Bulk specific gravity                                         | 2.45   |
| Saturated surface dry specific gravity                        | 2.52   |
| Apparent specific gravity                                     | 2.63   |

| Table 3. Properties of filler.                                |
|---------------------------------------------------------------|
| Water absorption, %                                           | 2.28   |
| Sand equivalent, %                                            | 69.57  |
| Bulk specific gravity                                         | 2.60   |
| Saturated surface dry specific gravity                        | 2.65   |
| Apparent specific gravity                                     | 2.76   |

Figure 1. Combined aggregate gradation.
2.1.2 Buton Granular Asphalt (BGA)
The granules contained in the BGA were also a substitute for filler in the mix, BGA has a maximum grain size of 1.18 mm. Table 4 shows some BGA properties from laboratory results.

| Parameter                                      | Value   |
|------------------------------------------------|---------|
| Bitumen content of BGA (%)                     | 23.00   |
| Asphalt mineral content (%)                    | 77.00   |
| Water content (%)                              | 1.70    |
| Flashpoint before Extract (°C)                 | 168.00  |

2.1.3 Characteristics of asphalt emulsion.
Asphalt emulsion used is CSS-1h, the asphalt emulsion type which is cationic slow setting 1 hard which is kind of asphalt emulsion suitable for use in Indonesia. Investigation of asphalt emulsion characteristic in accordance with SNI 4978: 2011 standard [9]. Characteristics of asphalt emulsion are shown in table 5. Result of calculation of the percentage of nominal emulsion asphalt level by considering asphalt residue content. Based on the examination of CSS-1h asphalt emulsion residue content of 62.35% as shown in table 5, so as to obtain emulsion bitumen content in the ratio of the percentage of effective asphalt content with asphalt residue obtained 8.8%, that is the amount of water and asphalt residue of the total mix. Percentage value of asphalt emulsion level of 8.8% consisting of 3.3% water and 5.5% asphalt residue.

| Kinds of Testing                                      | Testing Result |
|-------------------------------------------------------|----------------|
| Viscosity, Saybolt Furol 25°C, s                       | 39             |
| Storage stability, 24-h, %                             | 0.6            |
| Elementary charge                                      | Positive       |
| Sieve test number, 20, %                              | 0              |
| Distillation                                           |                |
| Water content, %                                       | 36.65          |
| Oil content, %                                         | 2.0            |
| Residue content, %                                     | 62.35          |
| Residue penetration, 0.1 mm                            | 101            |
| Residue ductility, mm                                  | 1030           |
| Solubility in trichloroethylene, %                     | 99.4           |

2.2 Experimental works
The combined aggregate gradation was kept for all mixture without BGA and with 2.5%, 5%, 7.5%, 10%, 12.5% BGA. All materials are mixed in room temperature, then the mixture is inserted into a filtered cylinder mold on both sides. Then the mixing process of the mixture at room temperature was done by the pounder (weight 4.5 kg and the height fell 45.7 cm) with the number of collisions 50 times for each field. After cool conditions, the test specimen is cured in the mold for 24 hours, after 24 hours the test object is removed from the mold and then put into the oven for 24 hours at 38°C temperature.
2.3 Stability test
Marshall test is a protocol to examine the stability and flow value of an asphalt mixture with a maximum aggregate size of 2.54 cm. The Marshall tool is a compression device equipped with a 22.2 KN (5000 lbs) 22-2 KN (proving ring) tester. The proving ring is equipped with a measuring gauge that is useful for measuring the stability of the mixture. A flow meter to measure flow. Standard Marshall test specimen cylinders 4 inches in diameter (10.16 cm) and 2.5 inches (6.35 cm) and had a weight of approximately 1200 grams. The Marshall test apparatus is shown in figure 2. Based on the Marshall test results on the variation of Buton granular asphalt, the optimum variation values will be obtained and meet the required specifications.

![Stability watch](image)

**Figure 2.** Marshall equipment.

3. Result and discussions
Table 6 shows the Marshall value test results of the addition of BGA to the asphalt emulsion mixture to the stability and flow values. BGA percentage value is a substitute for asphalt emulsion content of 8.8%.

| BGA Content (%) | 0       | 2.5     | 5.0     | 7.5     | 10      | 12.5    |
|-----------------|---------|---------|---------|---------|---------|---------|
| Stability (kg)  | 934.12  | 1088.63 | 1190.47 | 1288.8  | 1373.08 | 1257.19 |
| Flow (mm)       | 2.29    | 3.72    | 3.92    | 4.09    | 4.33    | 3.77    |

**Figure 3.** Stability – BGA content relationship.

The effect of adding BGA with variations of 0%, 2.5%, 5%, 7.5%, 10%, 12.5% is shown in figure 3. In figure 3 shows the relationship of BGA addition to the stability value of the mixture, i.e. as the
addition of BGA can increase the stability value of the mixture to reach variation of 10% and decreased at 12.5% BGA increase. This is due to the addition of BGA so the amount of filler contained in the BGA also increased so that the composition of the mixture of the amount of filler does not meet.

4. Conclusions
Asphalt modification with BGA as petroleum bitumen partial replacement in the asphalt emulsion mixture production partial replacement was obtained at the addition of 10% BGA in an emulsion asphalt mixture with an asphalt content of 8.8% i.e. 5.5% residual asphalt and 3.3% was water contained in emulsion bitumen yielded higher stability compared to the mixture without BGA.

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