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Experimental Study on Determination of Optimum Asphalt Emulsion Content Using Bina Marga Indonesia Requirement

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Abstract. The development of road construction in Indonesia has recently increased. This results in the need for asphalt, which is one of the materials used in the pavement mixture, also increases. The emulsion spice in Indonesia has been applied, but only on the adhesive layer and the seam layer only. The Department Of Public Works Of The Directorate General Of Highways (Bina Marga) has issued several guidelines to guide the implementation of cold asphalt mix work. The use of low emulsion asphalt emulsion technology reduces emissions, reduces energy consumption and avoids oxidation. This study aims to analyze the value of optimum asphalt content (KAO) of emulsion asphalt mixture using Bina Marga method with reference to book 5 of Bina Marga Indonesia Requirement refer to ASTM. This study was experimented in laboratory. For Determining optimum asphalt content used stability, void in mix (VIM) and void in mineral aggregate (VMA). The results showed that based on the relationship between the content of emulsion asphalt content and all Marshall and volumetric parameters, the optimum content of the emulsion asphalt residue was 5.5%. Based on the relationship between the content of emulsion asphalt content and stability value, the content of optimum asphalt content was at 5.5%. The value of the test results is in accordance with the specification of effective asphalt level determination by Bina Marga Indonesia requirement.

INTRODUCTION

The development of road construction in Indonesia has recently increased. This has resulted in increased demand for asphalt, which is one of the materials used in the pavement mixture. Emulsion sponges in Indonesia have been applied, but only to the adhesive layer and the absorption layer. The Public Works Department of the Directorate General of Highways has issued several guidelines to guide the implementation of cold mix asphalt work. The use of emulsion asphalt mixture technology which has a low temperature will reduce emissions, reduce the amount of energy consumption and avoid oxidation [1-4].

Many researchers have developed emulsified bitumen via cold mix asphalt. Among the research on cold asphalt mixtures are as follows: the results of research by Yongjoo Kim and Hosin David Lee, (2011), show that the use of emulsion asphalt has a high level of effectiveness in the implementation of recycling of asphalt mixtures in the field; Shaowen Du, (2013), recommends a modified cement mix method with an emulsion asphalt mixture based on the optimum cement choice which results in increased asphalt binder stiffness and aggregate surface adhesion in practical applications; Abbas Al-Hdabi, et. al (2013), revealed that using waste ash in a cold asphalt mixture can increase the resistance of the material to water sensitivity and provide good resistance to fatigue [5-7].

The development of the amount of traffic load that will be received by the road results in a reduced service life of the pavement layer. Compressive load and tensile load are the two loads experienced by a pavement layer. For compressive load, the value can be obtained by direct Marshall test [8-13]. A number of regulations have been issued by Bina Marga, Indonesia requirement refer to ASTM to determine the characteristics of hot asphalt mixtures and cold mix asphalt, especially emulsion asphalt mixtures [14-21] . This study aims to analyze the value of the optimal asphalt content (KAO) of the emulsion asphalt mixture using the Bina Marga method with reference to

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Book 5 of Bina Marga, Indonesia requirement refer to ASTM (Cold Asphalt Mixture with Granular Asphalt with Emulsion Rejuvenator).

LITERATURE REVIEW

Asphalt Emulsion

The use of emulsion asphalt began in the early 20th century. Currently 5% to 10% of the grade of bitumen used is in emulsion form, but the use of emulsion asphalt varies greatly among countries. The United States is one of the world's largest producers of emulsion asphalt. The advantage of emulsified asphalt over hot asphalt is that it reduces the binder which can be associated with low temperature applications, compatibility with other water-based binders such as rubber latex, cement and reducing solvents. The role of emulsion asphalt components such as emulsifiers, acids or alkalis, and the additives in determining the physical properties and reactivity of the emulsion can be described. Classification of emulsion asphalt can be divided into several based on the value of reactivity, particle charge, and physical properties that can be described. In the last twenty years, it has been seen progress in understanding how the chemical effects of emulsion performance occur. As a result, formulations can be developed to optimize the performance of construction materials or construction processes not only to meet specifications standard but more than that, namely easy maintenance, quick drying and cold blended materials have better properties. Therefore, the emulsion asphalt mixture is a mixture that is not that difficult.

Emulsion asphalt is liquid asphalt produced by dispersing bituminous hard asphalt into water or vice versa with the help of an emulsifier. Emulsion asphalt is the result of evenly dispersing cement asphalt in water using an emulsifier which binds the asphalt molecules with water molecules. In an emulsion mixture, the asphalt content is generally in the range of ± 55-75% and the content of the emulsifier (emulsifier) ± 3%.

Emulsion asphalt can be classified according to the type of electric charge and according to the speed of hardening. Based on the electric charge contained, emulsion asphalt can be divided into: (1) Cationic emulsion asphalt or acid emulsion asphalt is emulsion bitumen which is positively charged; (2) Anionic emulsion asphalt or called alkaline emulsion asphalt is emulsion asphalt which is negatively charged and is widely used to coat alkaline rocks. (3) Monionic emulsion asphalt is emulsion asphalt, which is not electrically charged. (4) Emulsion asphalt or called alkaline emulsion asphalt is emulsion asphalt based on the speed of hardening, emulsion asphalt can be divided into: (1) Asphalt emulsion RS (Rapid Setting), is planned to have a fast reaction rate with the accompanying aggregate and the change of emulsion to asphalt. RS type will produce a relatively thick film layer. (2) Asphalt emulsion MS (Medium Setting), is planned to have a medium mixing level with coarse aggregate as a target. Since this type will not break when it comes to aggregates, a mixture using this type will still be able to lay out in a few minutes. (3) Emulsion SS (Slow Setting), this type is planned for mixing results that have high stability. This type is used with dense graded aggregate and contains high levels of fine aggregate.

Aggregate

Aggregate or rock, or granular material is a hard, compact grained material. The term aggregate includes, among other things, cobblestone, crushed stone, rock ash and sand. Aggregates have a very important role in transportation infrastructure, especially in this case on road pavements. The pavement bearing capacity is determined in large part by the characteristics of the aggregates used. The selection of the right aggregate that meets the requirements will determine the success of road construction or maintenance (Hot Asphalt Mixed Work Manual, Ministry of Public Works). The quality of an aggregate is greatly influenced by the properties it contains. Among the existing characteristics, it can be outline as follows: strength or strength, durability or durability, adhesiveness or adhesion to asphalt and workability or ease of implementation.

Asphalt Testing with the *Marshall* Method

The number of specimens prepared is determined from the purpose for which the Marshall test is performed. AASHTO determines a minimum of 3 specimens for each level of asphalt used. The basic principle of the Marshall method is stability and flow checks.

The mixed design based on the Marshall method was invented by Bruce Marshall, and has been standardized by ASTM or AASHTO through several modifications, namely ASTM D 1559-76, or AASHTO T-245-90. The basic principles of the Marshall method are stability and flow checks, as well as density and pore analysis of the formed solid mixture. The Marshall tool is a press device equipped with a proving ring with a 22.2 KN (5000 lbs) capacity and a flow meter. The probing ring is used to measure the stability value, and the flow meter to measure the plastic melt or flow. The Marshall specimen is a cylinder with a diameter of 4 inches (10.2 cm) and a height of 2.5 inches (6.35 cm). Marshall testing procedure follows SNI 06-2489-1991, AASHTO T 245-90 or ASTM D 1559-76. Broadly speaking, Marshall testing includes: preparation of specimens, determination of bulk density of specimens, checking of stability and flow values, and calculation of volumetric properties of specimens.

RESEARCH METHODOLOGY

General/Summary of Research Methodology

The method used in this study is an experimental method in the laboratory. Cold mix asphalt is produced using emulsion asphalt CSS-1h EA-60. Then do the assessment and stability testing with the Marshall Test. This research was carried out at the Laboratory of the Abepura National Road Center Laboratory, Jayapura. This research is planned to be carried out for 2 months starting from March to May 2018.

Research Materials

The materials/materials used in this study are as follows:

- Coarse aggregate, fine aggregate and rock ash are taken from a rock crusher around Abepura, Jayapura.
- Asphalt emulsion CSS-1h EA-60 was obtained from one of the emulsion asphalt producers in Indonesia.

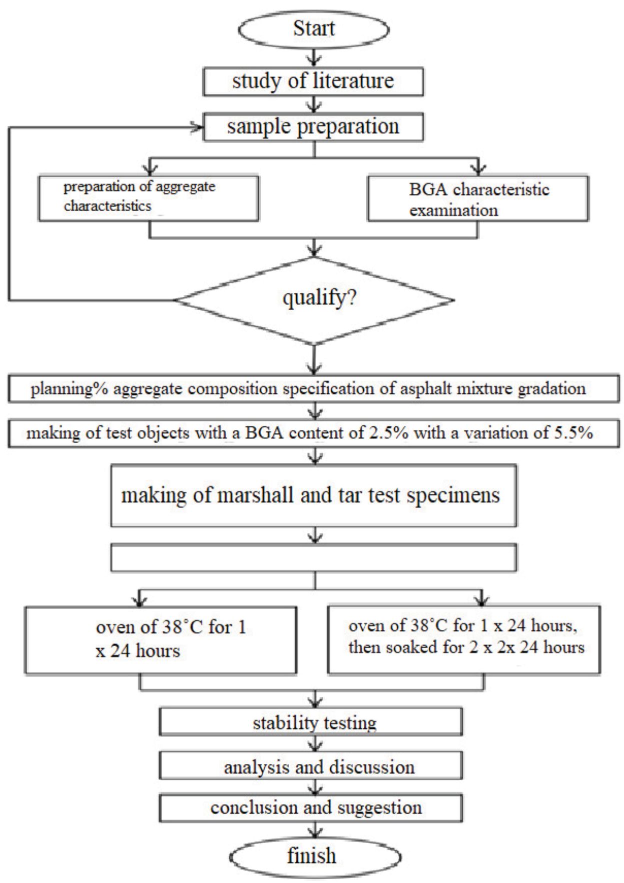

FIGURE 1. Research Flowchart.

Making Test Objects

The test objects made were 25 pieces for asphalt content of 4.5%, 5%, 5.5%, 6% and 6.5%. The manufacture of the test object refers to the SNI Marshall, begins with weighing the components of the mixture, namely aggregate, emulsion asphalt, according to the mix design.

All materials are mixed at room temperature. Next, the mixture is put into a mold cylinder which has been coated with filter paper on both sides. Then the process of compaction of the mixture at room temperature was carried out using a pulverizer (weight 4.5 kg and falling height 45.7 cm) with the number of collisions of 35 times, 50 times and 75 times for each plane. After cold conditions, the compacted specimen is removed from the mold using an ejector. Then the specimen is ovenized for 1 x 24 hours at a temperature of 38^0C (Normal) but previously it was left in the mold for 1 x 24 hours. Then again, the test object made is added by immersion process for 2 x 2 x 24 hours to obtain residual stability. But with a different curing process, the test object is left at room temperature for the specified time.

Research Flowchart

Figure 1 shows the flow chart of this research

Aggregate Characteristics Testing

Types of testing and testing methods for coarse aggregate (chipping), rock ash, and fillers are shown in Table 1 and Table 2. The types of testing and testing methods for coarse aggregate (chipping), rock ash, and filler are shown in Table 1 and Table 2.

TABLE 1. Coarse Aggregate Characteristics Testing

Testing	Testing Method
Water Absorption	SNI 03-1969-1990
Specific gravity	SNI 03-1969-1990
Flake Index	RSNI T-01-2005
Aggregate Wear	SNI 2417-2008

TABLE 2. Testing Methods of Rock Ash and Filler Characteristics

Testing	Testing Method
Water Absorption	SNI 03-1970-1990
Specific gravity	SNI 03-1970-1990
Sand Equivalent	SNI 03-4428-1997

RESULTS AND DISCUSSION

Results of Examination of Aggregate Characteristics

An examination of the aggregate characteristics is carried out to determine the suitability of the aggregate to be used. Tables 3 to 5 show the results of the aggregate characteristics testing that have been carried out. Based on the results of testing the characteristics of coarse and fine aggregates, it can be seen that the aggregates used meet the DGH specifications for the required road materials.

TABLE 3. Results of Coarse Aggregate Examination

Examination	(Crushed stone)	
	0,5 - 1 (cm)	1 - 2 (cm)
Water absorption,%	2.071	2.08
Bulk density	2.622	2.627
Saturated Surface Dry (SSD) Specific Gravity	2.677	2.682
Artificial density	2.773	2.779
Flakiness index,%	20.1	9.38
Aggregate wear,%	25.72	24.36

TABLE 4. Rock Ash Inspection Results

Water Absorbtion, %	2.792	
Sand Equivalent, %	89.66	
Bulk density	Specific Grafity Saturated Surface Dry (SSD)	Artificial density
2.449	2.518	2.629

TABLE 5. Filler Inspection Results

Water absorption,%	2.283	
Sand Equivalent,%	69.57	
Bulk density	Specific Grafity Saturated surface dry (SSD)	Artificial density
2.595	2.654	2.758

Result of Examination of CSS-1h Emulsion Asphalt Characteristics

The characteristics of emulsion asphalt type CSS-1h, namely emulsion asphalt type with positive charge with slow binding time with code EA-60 used in this study are shown in Table 6. Characteristics of emulsion asphalt used include furol saybolt viscosity at 25^0C, storage stability for 24 hours, particle electric charge, held sieve analysis no. 20, refining which includes moisture content, oil content and residual content, residue penetration, residual ductility and residue solubility in C_2HCl_3. In addition, it is clear that the testing method used is the Indonesian National Standard (SNI) where the test results obtained meet the required specifications so that they can be used as a binder in this study.

TABLE 6. Characteristics of CSS-1h EA-60 emulsion asphalt

Type of testing	Test method	Test result	Specification	Unit
The viscosity of saybolt furol at 25ºC	SNI 03-6721-2002	39	20 – 100	Second
24 hours storage stability	SNI 03-6828-2002	0.6	Max. 1	%
The electric charge of particles	SNI 03-2664-1994	Positive	Positive	-
Held filter analysis no. 20	SNI 03-3843-1994	0	Max 0.1	% Passes
Refinery	SNI 03-3642-1994			
• Water Content		36.65	-	%
• Oil Content		2.0	-	%
• Residue Content, Residue Penetration	SNI 06-2456-1991	62.35 101	- Min. 57	% 0.1 mm
Residual ductility	SNI 06-2432-1991	103	Min. 43	Cm
Residue solubility in C_2HCL_3	SNI 06-2438-1991	99.4	Min. 97.5	%

Mixed Gradation Determination

The gradation of the combined aggregate is shown in Figure 1. Comparison of the composition of the aggregate between the 1-2 cm coarse aggregate, the 0.5-1 cm of crushed stone coarse aggregate and the rock ash is 19%: 54%: 27% of the aggregate composition, the proportion of the combined aggregate. The results obtained are adjusted to the specification interval value of the Directorate of Highways (DGH) 2010. The combined aggregate design is between the upper and lower thresholds in the specification intervals of the Directorate of Highways for road materials in order to obtain an optimal mixture.

In Figure 1 it can be seen that the proportion of the planned aggregate is within the specification interval of Bina Marga Utilization of Asbuton Buku 5 (Cold Asphalt Mixture with Emulsion Rejuvenator Asbuton) for road materials so that the optimal mixture can be obtained.

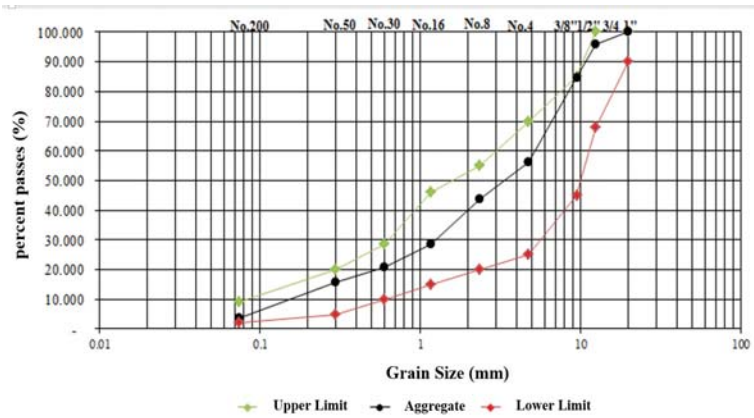

FIGURE 2. Compound aggregate gradation

Test Results of AC-WC Mixture Using Asphalt Emulsion Type CSS-1h As Binder Using the Marshall Method

Tests with each variation of the emulsion asphalt content using Marshall compactor with the number of collisions 75 times for each plane. The parameters obtained are stability and flexibility (flow) which indicates the measure of the resistance of a test object in receiving a load obtained from the analysis of the Marshall test. In addition, the volumetric value consisting of the cavity between the aggregate (VMA), the asphalt filled cavity (VFB), and the cavity in the mixture (VIM) is also characteristic of Marshall. Table 7 shows the results of the Marshall characteristics test.

TABLE 7. Marshall characteristics test results for all parameters

No	Emulsion asphalt content	VMA	VIM	VFB	Stability	Flow	MQ
1	4.50	21.49	12.39	42.37	732	2.98	245
2	5.00	21.36	11.18	47.81	806	3.40	237
3	5.50	17.94	6.19	65.86	1,558	3.70	421
4	6.00	17.73	4.82	72.84	2,131	3.90	546
5	6.50	17.44	3.33	81.10	1,986	4.13	480

The stability value obtained does not meet all the specifications stipulated by the 2010 Revision 3 Specification, Highways, which is ≥ 800 kg. The lowest stability value is in a mixture with an emulsion asphalt content of 4.5%, with a stability value of 732 kg and the highest stability value in a mixture with an emulsion asphalt content of 6% with a stability value of 2131 kg. Mixtures with emulsion asphalt content of 6.5% had a stability value of 1986 kg and mixtures with emulsion asphalt content of 5% with a stability value of 806 kg and mixtures with emulsion asphalt content of 5.5% had the greatest stability value of 1558 kg. Thus, we can see that the optimum emulsion asphalt content is between 6% and 6.5% emulsion asphalt content. Apart from stability parameters, other parameters are also such as flow, Marshall quotient (MQ), VIM, VMA and VFB which are known volumetric parameters to obtain Optimum Asphalt Content (KAO) using crushed stone from Quarry in Jayapura as a good aggregate. coarse aggregate and fine aggregate in this study.

The low stability of the emulsion asphalt mixture is due to the large flow that occurs and the thicker enveloped aggregate and in the end it will reduce the carrying capacity of the aggregates in the mixture when it is loaded. The reduction of the bond between the aggregates will reduce the stability of the mixture, but the increase in the cavity between the mixtures can cause the stability value to decrease. The stability value shows the strength and resistance of the asphalt concrete mixture to changes in fixed shapes such as waves, grooves (rutting) and bleeding. The lower the value of the stability of the mixture, the lower the performance of the mixture in bearing the load on the wheels of the vehicle.

The flow values obtained did not meet all the specifications set by Bina Marga, namely 2 mm to 4 mm. The lowest flow value is the mixture with the emulsion asphalt content of 4.5%, with a flow value of 2.98 mm and the highest flow value in the mixture with an emulsion asphalt content of 6.5% with a flow value of 4.13 mm. The mixture containing the emulsion asphalt content 6% had a flow value of 3.90 mm which was relatively greater than the mixture containing emulsion asphalt content of 5.5% with a flow value of 3.70 mm and the mixture containing emulsion asphalt content of 5% with a flow value of 3 40 mm. Increasing the cavity between the mixtures and the use of high emulsion asphalt content can cause the plastic melt value (flow) to increase.

The Marshall quotient value obtained was not in accordance with the specifications set by Bina Marga, which was a minimum of 250 kg/mm. The lowest Marshall quotient value was in a mixture with an emulsion asphalt content of 5.0% of 237 kg/mm, and the highest Marshall quotient value was in a mixture with an emulsion asphalt content of 6.0% of 546 kg/mm. Mixtures with emulsion asphalt content of 6.5% have a Marshall quotient value of 480 kg/mm which is the same as 6% emulsion asphalt content with a Marshall quotient value of 480 kg/mm and a mixture containing emulsion asphalt content is 4.50% with a Marshall quotient value of 245 kg/mm.

The low value of the Marshall quotient emulsion asphalt mixture is due to the small stability and large flow and the thicker covered aggregates and in the end it will reduce the binding capacity between the aggregates in the mixture when it is loaded. The reduced bond between the aggregates will reduce the stability of the mixture which leads to an increased flow value. Based on the Marshall quotient value obtained, the emulsion asphalt mixture can be used for flexible pavement at emulsion asphalt levels of 5.5%, 6.0% and 6.5%, but apart from stability parameters (stability, flow and Marshall quotient) It is necessary to pay attention to the volumetric parameters (VIM, VMA and VFB) to obtain the Optimum Asphalt Content (KAO).

The correlation between emulsion asphalt content and VIM value. The VIM value required by the General Specification 2010, revision 3 is 3% to 5%. It can be seen that the emulsion asphalt content is 4.5%, 5.0%, 5.5%, 6.0%, 6.5%, the value of VIM (Void in Mix) respectively is 12.39%, 11.18%, 6.19%, 4.82%, 3.33%. Based on the VIM value obtained, it can be seen that the VIM value that meets the 2010 specifications, Revision 3 is the emulsion asphalt content, which is 6.0% and 6.50%, while the emulsion asphalt content is 4.5%, 5.0% and 5.5% does not meet specifications 2010, Revision 3.

TABLE 8. Analysis of determining the optimal asphalt content

Stability	4.5	5	5.5	6	6.5
VIM	4.5	5	5.5	6	6.5
VMA	4.5	5	5.5	6	6.5

General specifications 2010, Revision 3, Division 6 concerning Asphalt Pavement requires that the VMA value in the asphalt mixture is at least 15%, where the VMA value at 4.5% emulsion asphalt content is 21.49% which is relatively greater than the VMA value at emulsion asphalt content 5.0% of 21.36%. Meanwhile, the emulsion asphalt content of 5.5%, 6% and 6.5%, respectively, the VMA values were 17.94%, 17.73%, 17.44% and 17.33%. Therefore, all emulsion asphalt levels used in this study meet the specifications required by the General Specifications 2010, Revision 3, Division 6 concerning Asphalt Pavement.

Based on the 2010 General Specifications, Revision 3, Division 6 on Asphalt Pavement, the VFB requirement in asphalt mixtures is a minimum of 65%. The results of the volumetric test of asphalt mixture using crushed stone as aggregate and emulsion asphalt as a binder in the form of VFB parameters showed values of 42.37%, 47.81%, 65.86%, 72.84%, 81.10%, 88.42 % for each emulsion asphalt content, namely 4.5%, 5%, 5.5%, 6% and 6.5%. Therefore, all emulsion asphalt levels used meet the General Specifications 2010, Revision 3, Division 6 on Asphalt Pavement except at 4.5% and 5.0% emulsion asphalt content. The analysis of determining the optimum asphalt content using Book 5 of Bina Marga is shown in Table 8.

CONCLUSION

Based on the research results, it can be concluded that: (1) Based on the correlation between emulsion asphalt content and all Marshall and volumetric parameters, the optimum emulsion asphalt residue content was 5.5%. (2) Based on the correlation between the emulsion asphalt content and the stability value, the optimum asphalt content was obtained at 5.5%. This test result value is in accordance with the specifications for determining the effective asphalt content by the Ministry of Public Works in 2006.

REFERENCES

[1] AASHTO T 245-97 (ASTM D 1559-76). Resistance Plastic of Bituminous Mixtures Using Marshall Apparatus. *American Society for Testing and Materials.*

[2] A. James. 2006. *Overview of Asphalt Emulsion. Transportation Research Circular Number E-C102.* Washington: Transportation Research Board of National Academies.

[3] AkzoNobel. *Bitumen Emulsion.* Technical Bulletin. AkzoNobel.

[4] Annual Book of ASTM Standards, Section 4, volume 04.03, Road and Paving Materials; Pavement Management Technologies, (1994).

[5] Anonim, 1991. *SNI 06-2489-1991, Metode Pengujian Campuran Aspal Dengan Alat Marshall,* Badan Standar Nasional Jakarta.

[6] Anonim, 2011. *SNI 4798:2011, Spesifikasi Aspal Emulsi Kationik,* Badan Standar Nasional Jakarta.

[7] ASTM D2397. 2012. Standard Specification for Cationic Emulsified Asphalt. *American Society for Testing and Materials.*

[8] ASTM D977. 1998. Standard Specification For Emulsified Asphalt. *American Society for Testing and Materials.*

[9] Illyin A B, (2012). Produksi Aspal Dari Asbuton dengan Ekstraksi menggunakan Asam Asetat.

[10] Manual Pekerjaan Campuran Beraspal Panas Buku 1, 2006, Departemen Pekerjaan Umum.

[11] Pedoman Pembuatan Aspal Emulsi Jenis Kationik, No. 024/T/BM/1999, Lampiran No. 2 Keputusan Direktur Jenderal Bina Marga N0. 76/KPTS/Db/1999 Tanggal 20 Desember 1999, Departemen Pekerjaan Umum.

[12] Pedoman Pemanfaatan Asbuton Buku 1, 2006, Departemen Pekerjaan Umum.

[13] Ridwan Hadi Rianto, (2007). Pengaruh Abu Sekam Sebagai Bahan Filler Terhadap Karakteristik Campuran Aspal Emulsi Bergradasi Rapat (CEBR).

[14] Rosalina dan Mulizar, (2013). Penelitian Karakteristik Campuran Aspal Emulsi Bergradasi Rapat.

[15] Shell Bitumen, *The Shell Bitumen Hand Book*, Shell Bitumen, Nottingham, 1990.

[16] Nyoman Suaryana, (2008). Penelitian Pemanfaatan Asbuton Butir di Kolaka Sulawesi Tenggara-Indonesia.

[17] Transportation Research, Number E-C 102, (2006). *Asphalt Emulsion Technology*.

[18] Tumpu M. Tjaronge M. W.. Djamaluddin A. R.. Amiruddin A. A. and La One. 2020. Effect of limestone and buton granular asphalt (BGA) on density of asphalt concrete wearing course (AC-WC) mixture. IOP Conf. Series: Earth and Environmental Science 419 (2020) 012029.

[19] Tumpu M. Tjaronge M. W. and Djamaluddin A. R. 2020. Prediction of long-term volumetric parameters of asphalt concrete binder course mixture using artificial ageing test. IOP Conf. Series: Earth and Environmental Science 419 (2020) 012058.

[20] Irianto. Tumpu M. Compressive Strength Of Asphalt Concrete Wearing Course Mixture Containing Waste Plastic Polypropylene. ARPN Journal Of Engineering and Applied Science, Vol 15, No. 17, September 2020.

[21] Rangan P. R. Tumpu M. Marshall Characteristic of AC-WC Mixture with The Addition of Anti-Flaking Additives. ARPN Journal Of Engineering and Applied Science, Vol 16, No. 3, February 2021.