Jurnal Teknik Sipil: Vol 23, No. 2, May 2023, 299-306
Department of Civil Engineering, University of Tanjungpura.
ISSN: 1412-3576 (Print), 2621-8429 (Online), Indonesia

Constructions of UNTAN
Jurnal Teknik Sipil
Journal homepage: https://jurnal.untan.ac.id/index.php/jtsuntan

Characteristics of The Mixture of Lataston (HRS-WC) with Dolomite Limestone as A Filler in Asphalt Mixture

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Abstract

Indonesia is a country that has a lot of natural resources; one of the natural resources in Indonesia is lime. In Palembang, there is a large-scale dolomite lime-producing company that covers the territory of Indonesia. The content in the dolomite lime is Magnesium Oxide (MgO) ≥ 18% and Calcium Oxide (CaO) ± 30%. The purpose of this study is to utilize dolomite lime as a mixture of asphalt concrete layers and to find out changes in the characteristics of the HRS-WC mixture due to the use of dolomite lime as a filler. The experiment refers to Bina Marga 2018 revision II. The method used in this study is the experimental method, which is carried out by conducting experimental activities to obtain data. The aggregate specific gravity test obtained more than 2.5 gr/cm^3 results, which qualify the 2018 Bina Marga revision II specifications. Examination of the wear of the coarse aggregate yielded results that fulfil the 2018 Bina Marga revision II specifications. The filler used in this mixture is applied on combination with a percentage of 0% rock ash and 100% dolomite lime, then 25% rock ash and 75% dolomite lime, then 50% rock ash and 50% dolomite lime, then 75% rock ash and 25% dolomite lime, and 100% rock ash and 0% dolomite lime. %. The Marshall results from the percentage of 100% rock ash filler content and the percentage of 0% OAC dolomite lime filler content of 6.5% obtaine a stability value of 914.821 Kg, a flow value of 3.45 mm, and a Marshall Quotient value of 265.286 Kg/mm. The volumetric value of the percentage of 100% rock ash filler content and the percentage of dolomite lime filler content of 0 % OAC 6.5% deliver a VIM value of 4.153%, a VMA value of 18.391%, a VFB value of 79.671%.

Article history:
Submitted 15-02-2023
Revise on 15-02-2023
Published on 28-05-2023

Keyword:
Dolomite Lime, Asphalt, Bina Marga

DOI: http://dx.doi.org/10.26418/jtsft

1. Introduction

In the transportation sector, there needs to be innovation. Both carry out by academics and government agencies. One area that still requires development regarding the mixture of road pavements. Along with advances in science and technology, good ingredients and a balanced mixture are needed to obtain quality and efficient materials.

The constituent materials of asphalt pavement layers are coarse aggregate, fine aggregate, filler, and asphalt. The filler used must be of good quality according to the desired specifications. Filler or additional filler must contain material that passes sieve No. 200 at most 75% by weight.

In certain areas, alternative filler materials can be used as an asphalt mixture; in Palembang, there is a large-scale dolomite lime-producing company covering the territory of Indonesia. The content in the dolomite lime is Magnesium Oxide (MgO) ≥ 18% and Calcium Oxide (CaO) ± 30%. This study prepared 9 samples or specimens with dolomite lime filler content of 5%, 10%, and 15%. The Marshall results obtained have decreased from the standard asphalt mixture. From his research, the optimum bitumen content was obtained at 6.75%. From this fact, there is an idea of using dolomite lime as a filler in the Lataston or Hot Rolled Sheet (HRS) mixture in terms of the Marshall test, whether the use of dolomite lime can increase the stability of the pavement mixture.

2. Material and Methods

2.1 Theoretical Frame Work

Road pavement is a pavement layer located between the soil layer and the vehicle's wheels, which provides transportation facilities (Sukirman,2003). The function of the pavement is to carry the traffic load safely and comfortably before the planned age does not occur significant damage. Road pavements are made in layers for the pavement's adequate carrying capacity and durability but also to be economical. The top layer, the surface layer, is the best-quality layer. Beneath it is, which is over compacted subgrade.

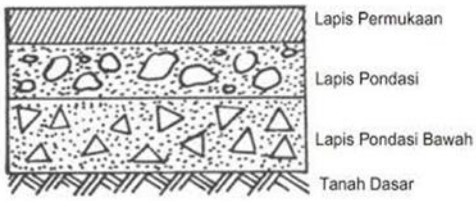

Figure 1. Pavement Layers

The structure of road construction pavement has 4 layers. Every layer is designed for each its functions. The thickness of layer is determined based on regulation of Bina Marga 2018 Revisi 2. The layers consist of surface course, base course, subbase course, and subgrade.

Generally road construction is divided according to binder material. It consists of flexible and rigid pavement.

- **Flexible Pavement**

The pavement uses asphalt as binder material. The character of the pavement layers is to carry and spread the traffic load to the subgrade.

- **Rigid Pavement**

This pavement uses Portland cement as binder material. Concrete slab with or without rebar is retrieved above subgrade layer or sub base layer. The most of traffic load is distributed by concrete slab.

- **Composite Pavement**

Composite pavement combines flexible pavement and rigid pavement with different positions. The first combination is the position of the flexible pavement above the rigid pavement. Meanwhile, the following combination, the flexible pavement position, is below the rigid pavement.

Indonesia uses 2 various of pavements, which are flexible pavement and rigid pavement. Those various pavements is applied with 3 mixtures of asphalt. There are LATASIR (Thin Layer of Asphalt Sand), LATASTON (Thin Layer of Asphalt Concrete, and LASTON (Layer of Asphalt Concrete). This research uses LATASTON as object.

According to the Ministry of Public Works (Highways 2018 revision II), the thin layer of asphalt concrete (LATASTON) is a cover layer consisting of a mixture of graded gap aggregate, filler, and hard asphalt in a specific ratio, which is mixed and compacted, with a solid thickness of 2.5 cm to 3 cm. HRS pavement construction in its use is divided into classes A and B. The difference in pavement constructions is found in the gradation aggregate used, traffic load, and terms of usage. The type of aggregate used consists of fine aggregate, coarse aggregate, and filler granules, while asphalt is used with a penetration of 60-70. Making asphalt concrete thin layer (LATASTON) aims to obtain a surface layer or interlayer on the highway pavement to provide donation capacity. Hot Rolled Sheet is flexible and has high durability. The HRS mixture with unequal gradations has a large enough cavity to absorb large amounts of asphalt (7-8%) without bleeding. In addition, HRS is compacted, so the resulting layer has high water and air.

2.2 Research Location

This study is conducted in Laboratory of Highway at Faculty of Engineering Pontianak.

2.3 Data

All data for this research is obtained from laboratory test results using following these material and equipment.

2.3.1. Asphalt

Asphalt or viscous liquid with hydrocarbon compound containing oxygen, sulfur, and chlorine. Asphalt, as a binder in flexible pavement, has viscoelastic properties. Asphalt is solid and liquid when heated. Asphalt is very complex, and chemically, it has yet to be well characterized. The main content of asphalt is saturated and unsaturated carbon compounds, aromatics having up to 150 carbon atoms per molecule, and aliphatic. The atoms other than hydrogen and carbon comprising asphalt are oxygen, nitrogen, sulphur, and others. Quantitatively, usually, 80% by mass of asphalt is carbon, 10% hydrogen, 6% sulphur, and the remainder oxygen and nitrogen, as well as trace amounts of iron, nickel, and vanadium. These compounds are often classified as asphaltene (with a small molecular mass) and molten (with a sizeable molecular group).

Asphalt usually contains 5 to 25% asphaltene. Most of the compounds in asphalt are polar compounds.

2.3.2. Filler

Filler is material or fraction of fine aggregate that passes sieve no . 200 (2.36 mm), a minimum of 75% of the total weight of the aggregate. Usually stone ash, lime ash, cement, and other materials are generally used. This filler does not have to be used for mixed asphalt concrete because, typically, each aggregate already contains filler when mixing in the field (AMP). If the filler content in the aggregate follows the specification plan, then no filler needs to be added, but if you want to use filler, it must meet the requirements.

2.3.3. Dolomite Limestone

Limestone is derived from fine white sedimentary rock containing the mineral calcium. The three main compounds that make up lime are calcium oxide, calcium carbonate, and calcium hydroxide. Lime can mix with a magnesium mineral called dolomite. Dolomite lime ($CaMg(CO3)2$) is commonly used to reduce soil acidity and add calcium ' as a plant nutrient. In addition, dolomite lime has an element of magnesium as a main, which is given to poor magnesium (Subandi, 2007).

2.3.4. Marshall Parameter

Marshall equipment is a device-equipped proving ring with a capacity of 22.5 kN or 5000 lbs. The proving ring is equipped with a gauge that is useful for measuring the stability of the mixture. In addition, there is a flow meter to measure plastic yield because the basic principle of the Marshall method is the examination of stability and flow, as well as the analysis of the density and pores of the formed solid mixture. Bruce Marshall invented mix design based on the Marshall method, which ASTM or AASHTO has standardized through several modifications, namely ASTM D 1559-76 or AASHTO T-245-90.

2.4 Analysis Method

In this study, the mixture characteristic of Lataston is examined using experimental method in laboratory. The goal of this study is to analyse the quality of Lataston using dolomite limestone as filler in HRS-WC mixture. The parameters of this research are mixture stability, flow, VIM, VMA, VFA, and MQ. Experiments include the making of sample test, and Marshall test.

2.4.1 Marshall Test

Testing with the Marshall tool was carried out following the 2018 revision II Bina Marga procedure. This test aims to determine the mixture's characteristics and the resistance or stability to the asphalt mixture's plastic melting (flow). The relationship between resistance (stability) and plastic melting (flow) is directly proportional. The greater the stability, the greater the flow value, and vice versa. So the more significant the stability, the more asphalt will be able to withstand the load, and vice versa. If the flow is higher, the asphalt be to withstand the load.

The mixture used in the Marshall test must meet some requirements. For mixture requirements for LATASTON can be seen in Table 1.

Table 1. Provisions for The Properties of LATASTON Mixture

Mixed Properties	Lataston specification (HRS -WC)
The number of collisions per field	50 times
Cavity in mix (VIM) (%)	4 ,0- 6,0 %
Cavity in aggregate (VMA) (%)	Min 1 8 %
Cavities filled with asphalt (VFA) (%)	Min 6 8 %
Marshall Stability (Kg)	Minimum 6 00 Kg
Marshall Quotient (kg/mm)	Minimum 250
Mixed Properties	Lataston specification (HRS -WC)
Marshall stability (%) after immersion for 24 hours, 60 ^{o}C	Minimum 90%

The calculation basis that is used as a reference in analyzing data refers to SNI 06-2489-1991 and The Asphalt Institute as follows:

- **Asphalt Density**

Asphalt specific gravity test in the laboratory (Specific Gravity Test) compares the weight of asphalt and distilled with the same content at a particular temperature (25˚C or 15.6˚C). This test is required during execution to convert weight to volume or vice versa.

Density = (C – A) × (B – A) – (D – C)

A is the mass of the pycnometer and cover. B is the mass of the pycnometer filled with water and cover. C is the mass of the pycnometer, cover, and sample. D is the mass of the pycnometer, cover, sample, and water.

- **Aggregate Density and Water Absorption**

Total aggregate consists of fine aggregate reactions, aggregate coarse, and filler, each of which has a different specific gravity: dry specific gravity and apparent specific gravity. Water absorption and effective specific gravity also differ between coarse and fine aggregates.

Coarse Aggregate

Dry Density

$$S_D = \frac{A}{(B-C)}$$

Bulk Density

$$S_B = \frac{A}{(A-C)}$$

Water Absorption

$$S_W = \left[\frac{B-A}{A} \times 100\%\right]$$

Effective Density

$S_E = \frac{S_a + S_d}{2}$

Fine Aggregate

Dry Density

$S_D = \frac{Bk}{(B+SSD-Bt)}$

Bulk Density

$S_B = \frac{Bk}{(B+Bk-Bt)}$

Water Absorption

$S_W = \left[\frac{SSD-Bk}{Bk} \times 100\%\right]$

Effective Density

$S_E = \frac{S_a + S_d}{2}$

S_D is dry density. S_B is bulk density. S_W is water absorption. Bk is weight of dry sand. B is weight pycnometer filled with water. BT is weight of pycnometer filled with sand and water. SSD is saturated surface dry.

- **Voids in The Mineral Aggregate (VMA)**

VMA is the percentage of spaces between particles on pavement including air voids of effective asphalt, excluding asphalt volume absorbed by aggregate. The percentage of VMA is calculated by this following formula:

$$VMA = 100 - \frac{(100 - \%Asphalt) \times Sample\ Density}{Aggregate\ Density}$$

VMA is voids in the mineral aggregate. Aggregate density is from effective mixture.

- **Voids in The Mixture (VIM)**

Voids in the mixture of asphalt pavement consists of voids between particles of aggregate covered by asphalt. The percentage of voids in the mixture can be calculated by this following formula:

$$VIM = 100 - \frac{100 \times Sample\ Density}{Maximum\ Theoretical\ Density}$$

$$Theoretical\ Density = \frac{100}{\frac{\%Aggregate}{Aggregate\ Density} + \frac{\%Asphalt}{Asphalt\ Density}}$$

- **Void Filled Bitumen (VFB)**

Air voids filled with asphalt or VFB (Void Filled Bitumen) is the percentage of voids between aggregate particles (VMA) filled with asphalt, excluding asphalt absorbed by the aggregate. The formula is as follows:

$$VFB = 100 \times \frac{VMA - VIM}{VMA}$$

2.4.2 Stability

Stability is the ability of the hard coating to withstand traffic loads without permanent deformation, expressed in kg. Stability measurement with Marshall is needed to determine the compressive and shear strength of the sample, which is retained on both sides of the pressure head. High enough stability is expected that the pavement can withstand traffic loads without destruction due to shear. For stability values indicated on the watch, it is necessary to convert against the Marshall tool. The reading on the stability watch must be multiplied by the value of the calibration proving ring used on the Marshall instrument. In this study, the Marshall tool used had a proving ring calibration value of 15.9. Furthermore, this value must also be adjusted with the correction number for the thickness of the specimen.

Table 2. Correction Number Based On The Thickness of Sample

Height of Sample (cm)	Correction Number
25,4	5.56
27	5
28,6	4.55
30,2	4,17
31.8	3.85
33,3	3.57
34,9	3,33
36.5	3.03
38,1	2.78
39,7	2,5
41,3	2,27
42,9	2.08
44,4	1.92
46	1.79
47,6	1.67
49,2	1.57
50,8	1.47
52,4	1.39

2.4.3 Marshall Quotient

This parameter is determined by the stability and the value of flow. The flow value is indicated with reading the clock hand on the Marshall tool. The values are already in mm units. The Marshall quotient is calculated with this formula below:

$$MQ = \frac{MS}{MF}$$

MQ is Marshall quotient. MS is Marshall stability. MF is the value of Marshall flow.

3. Results and Discussion

3.1 Material Testing

Material testing is conducted to all aggregates. All aggregates is tested to get the characteristics. This process is necessary thing to acquire the distribution for every aggregates.

3.1.1 Asphalt Characteristics Examination

The amount of asphalt used is just a little bit but it can give big impact in making of a mixture components. The asphalt used in this study is Aspal Pen 60/70. The test consists of softening point, flash point, burning point, asphalt penetration, ductility, density, and weight loss.

From the results examination in Laboratory of Highway, it acquires some data which fulfil the requirement in Spesifikasi Umum Bina Marga 2018 Revisi II. The results is presented in Table 3.

Table 3. Asphalt Examination Results

No	Descripstion	Requirement	Result	Unit
1	Penetration	60-70	61,7	0,1 mm
2	Density	≥ 1,0	1,029	gr/cc
3	Ductility	≥ 100	≥ 100	Cm
4	Softening Point	≥ 48	50,48	°C
5	Flash Point	≥ 232	285	°C
6	Burning Point	≥ 232	325	°C
7	Weight Loss	≤ 0,8	0,265	%

This test is to find out the level of the strictness of asphalt. The smaller penetration value shows the higher asphalt strictness & cohesion and the tougher asphalt. The purpose of the density test is to compare asphalt and distilled water at a temperature of 25˚C. Meanwhile, the ductility test is retrieved to acquire the level of asphalt elasticity or asphalt cohesion, which can describe the flexibility of the mixture. Flexibility shows the performance of the mix to restrain deflection without getting damaged.

The examination of softening point is to see the sensitivity of asphalt toward the temperature, which will get soft if the temperature is high. Checking the flash and burn points of asphalt aims to determine the temperature limit where the asphalt is still safe enough to be heated.

Weight loss testing aims to determine the evaporation of volatile materials in asphalt due to heating. From the results of the examination that has been carried out for asphalt penetration 60/70, there is a decrease of 0.267%, it shows that asphalt that is heated continuously or repeatedly will result in chemical elements in the asphalt will evaporate, and there will be a decrease in the weight of the asphalt so that the asphalt will undergo changes which result in the asphalt being slightly harder and will be brittle.

3.1.2 Coarse and Fine Aggregate Characteristics Examination

Coarse aggregate used is broken stone on field of laboratory of highway at Faculty Engineering Universitas Tanjungpura. The result of coarse and fine aggregate examination is shown in Table 4 and Table 5. Broken stone is filtered using sieve of No. ¾ “, No. ½ “, No. ⅜” and No. 8. The aggregate used consists of detained in sieve of No. ½ ”, No. ⅜” dan No. 8. The test consist of wear aggregate, bulk density, SSD density, apparent density, and water absorption. There are relevancy between density and water absorption. High density shows solid rock and strong toward abrasion test and low porosity. The other way, the rock with low density indicate low strength and high porosity.

Table 4. The Result of Coarse Aggregate Examination

No.	Checking Type	Specification	Result	Statement
1.	Aggregate Wear	Max 40 %	17,11%	Qualified
2.	Bulk Density	Min 2,5	2,702 g/cm^3	Qualified
3.	SSD Density	Min 2,5	2,715 g/cm^3	Qualified
4.	Apparent Density	Min 2,5	2,739 g/cm^3	Qualified
5.	Absorption	Max 3 %	0,50%	Qualified

The fine aggregate used is sand from field of laboratory of highway at Faculty of Engineering Universitas Tanjungpura. In fine aggregate, the sand equivalent test is carried out to determine relative comparison from disadvantage material toward aggregate passed sieve No. 4.

Table 5. The Result of Fine Aggregate Examination

No.	Checking Type	Specification	Result	Statement
1.	Sand equivalent	Min 95 %	95,35%	Qualified
2.	Bulk Density	Min 2,5	2,606 g/cm^3	Qualified
3.	SSD Density	Min 2,5	2,624 g/cm^3	Qualified
4.	Apparent Density	Min 2,5	2,652 g/cm^3	Qualified
5.	Absorption	Max 3 %	0,676 g/cm^3	Qualified

3.1.3 Filler Characteristics Examination

Filler used in this research is stone ash and dolomite limestone. The examination consists of density and absorption. The results are shown in Table 6 for stone ash and Table 7 for dolomite limestone.

Table 6. The Result of Stone Ash Examination

No	Checking type	Result
1	Bulk Density	2.636 g/cm^3
2	SSD Density	2.649 g/cm^3
3	Apparent Density	2.670 g/cm^3
4	Absorption	0.482 g/cm^3

Table 7. The Result of Dolomite Limestone Examination

No	Checking type	Results
1	Bulk Density	2.553 g/cm ^{3}
2	SSD Density	2.586g/cm ^{3}
3	Apparent Density	2.639g/cm ^{3}
4	Absorption	1.270g/cm ^{3}

3.1.4 Mixture Design

In calculating the proportions of the mixture design, first it has to analyse the sieve gradation for each aggregate. It is to adjudge the division of aggregate used in mixture. The mixture will be qualified if the gradation get into the interval for LATASTON (HRS-WC).

Table 8. Proportion Analysis for LATASTON (HRS-WC)

ASTM Sieve Size		CA (1/1)	MA (05)	FA (Sand)	Ash	Limestone	Proportion of Mixture					Amount	Specification
							CA (1/1)	MA (05)	FA (Sand)	Ash	Limestone	%	HRS-WC
inch/no	(mm)	% Passed	% Passed	% Passed	% Passed	% Passed	19,00%	20,00%	53,00%	4,00%	4,00%	100,00%	%
3/4	19	100	100	100	100	100	19,00	20,00	53,00	4,00	4,00	100,00	100
1/2	12,7	50,81	100	100	100	100	9,65	20,00	53,00	4,00	4,00	90,65	90-100
3/8	9,525	20,16	91,73	100	100	100	3,83	18,35	53,00	4,00	4,00	83,18	75-85
#8	2,36	2,65	40,87	99,67	83,97	100	0,50	8,17	52,83	3,36	4,00	68,86	50-72
#30	0,6	1,5	27,8	87,91	19,92	48,22	0,29	5,56	46,59	0,80	1,93	55,16	35-60
#200	0,075	1,5	16,37	3,1	4,91	3,33	0,29	3,27	1,64	0,20	0,13	6,35	6-10

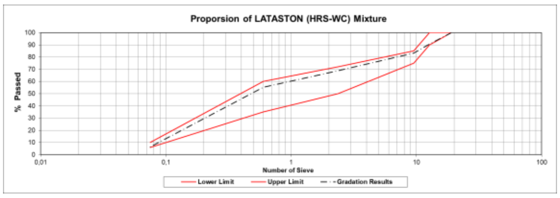

Figure 2. Proportion Graph of Mixture for LATASTON (HRS-WC)

3.2 Marshall Test

The sample is immersed in the water bath for 30 minutes at 60˚C. The Marshall value includes stability (P), VIM, VMA, VFB, and Marshall Quotient (MQ) analysis.

$$P = N \times O \times \text{Equipment Calibration}$$
$$= 0.817 \times 75 \times 12.998$$
$$= 796.453 \text{ kg}$$

$$VIM = \frac{100\,(D-I)}{D}$$
$$= \frac{100\,(2.436-2.308)}{2.436}$$
$$= 5.278\ \%$$

$$VMA = 100 - \left\{(100 - A) \times \frac{I}{B}\right\}$$
$$= 100 - \left\{(100 - 6) \times \frac{2.308}{2.654}\right\}$$
$$= 18.282\ \%$$

$$VFB = \frac{\left(A \times \left(\frac{I}{T}\right) \times 100\right)}{K}$$
$$= \frac{\left(6 \times \left(\frac{2.308}{1.029}\right) \times 100\right)}{18.282}$$
$$= 73.558\ \%$$

$$MQ = \frac{MS}{MF}$$
$$= \frac{796.453}{3.15}$$
$$= 252.842 \text{ kg/mm}$$

The test is conducted on many samples with different asphalt and filler content. Every asphalt content will produce optimum asphalt content. The connection graph between the value of stability, Flow, VIM, VMA, VFB & MQ, and asphalt content obtains it. The method used is asphalt Institute, which is based on Marshall test results. The content determined must be capable of restraining the load until plastic yields.

Table 9. The Results from Marshall Test on The Percentage 100% Dolomite Limestone and 0% Rock Ash

0% Rock Ash & 100% Dolomite Limestone							
% Asphalt	Stability	Flow	VIM	VMA	VFB	MQ	Density
5	586,982	3,900	4,629	15,576	73,484	150,508	2,356
	598,249	3,400	5,207	16,087	70,716	175,955	2,342
5,5	607,157	3,700	4,518	16,537	75,663	164,096	2,341
	599,556	3,200	4,432	16,462	76,077	187,361	2,343
6	733,858	3,200	5,015	18,011	74,848	229,331	2,312
	745,745	3,100	4,993	17,991	74,946	240,563	2,313
6,5	818,119	3,300	3,975	18,148	80,765	247,915	2,321
	877,360	3,200	4,253	18,385	79,495	274,175	2,314
7	890,310	3,850	3,761	18,989	82,716	231,249	2,309
	901,266	3,500	3,430	18,710	84,238	257,504	2,317

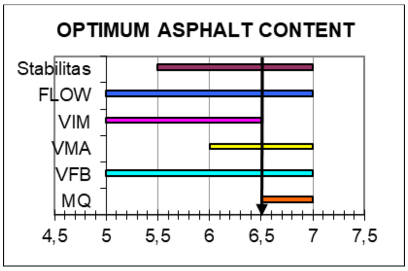

Figure 3. Optimum Asphalt Content with The Percentage of 100% Dolomite Limestone and 0% Rock Ash

Table 10. The Results from Marshall Test on The Percentage 75% Dolomite Limestone and 25% Rock Ash

75% Rock Ash & 25% Dolomite Limestone							
% Asphalt	Stability	Flow	VIM	VMA	VFB	MQ	Density
5	606,416	3,450	5,308	16,199	70,184	175,773	2,340
	599,164	3,500	5,546	16,409	69,107	171,190	2,334
5,5	574,324	3,400	4,790	16,797	74,311	168,919	2,336
	619,411	3,500	5,030	17,007	73,207	176,975	2,330
6	745,631	3,150	4,695	17,757	76,204	236,708	2,321
	767,754	3,100	5,280	18,262	73,642	247,663	2,307
6,5	887,978	3,560	3,909	18,115	81,002	249,432	2,323
	862,934	3,510	3,868	18,080	81,190	245,850	2,324
7	900,023	3,450	3,509	18,800	83,797	260,876	2,316
	896,708	3,650	3,538	18,824	83,664	245,673	2,315

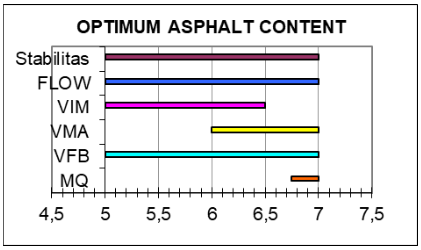

Figure 4. Optimum Asphalt Content with The Percentage of 75% Dolomite Limestone and 25% Rock Ash

Table 11. The Results from Marshall Test on The Percentage 50% Dolomite Limestone and 50% Rock Ash

50% Rock Ash & 50% Dolomite Limestone							
% Asphalt	Stability	Flow	VIM	VMA	VFB	MQ	Density
5	600,418	3,590	5,246	16,166	70,400	167,247	2,342
	586,747	3,660	4,907	15,866	71,988	160,313	2,351
5,5	546,561	3,450	5,193	17,172	72,409	158,423	2,327
	597,415	3,500	5,339	17,299	71,765	170,690	2,323
6	796,453	3,150	5,278	18,282	73,588	252,842	2,308
	795,600	3,100	5,254	18,262	73,688	256,645	2,308
6,5	891,618	3,150	3,839	18,078	81,255	283,053	2,326
	912,428	3,450	3,987	18,204	80,570	264,472	2,322
7	910,796	3,850	3,709	18,991	82,814	236,571	2,312
	913,266	3,500	3,561	18,866	83,490	260,933	2,316

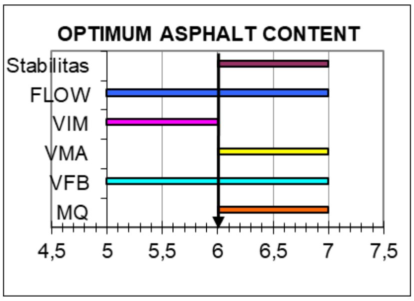

Figure 5. Optimum Asphalt Content with The Percentage of 50% Dolomite Limestone and 50% Rock Ash

Table 12. The Results from Marshall Test on The Percentage 25% Dolomite Limestone and 75% Rock Ash

25% Rock Ash & 75% Dolomite Limestone							
% Asphalt	Stability	Flow	VIM	VMA	VFB	MQ	Density
5	561,535	3,800	5,073	16,035	71,130	147,772	2,348
	610,075	3,100	5,064	16,027	71,174	196,798	2,348
5,5	594,685	3,100	5,427	17,398	71,320	191,834	2,322
	550,687	3,350	5,514	17,474	70,942	164,384	2,320
6	810,778	3,150	4,790	17,883	75,646	257,390	2,320
	826,030	3,100	4,850	17,935	75,379	266,461	2,319
6,5	892,028	3,350	4,126	18,345	79,865	266,277	2,320
	936,221	3,450	3,917	18,167	80,823	271,368	2,032
7	897,122	3,750	3,630	18,947	83,104	239,233	2,315
	915,112	3,500	3,674	18,984	82,903	261,461	2,314

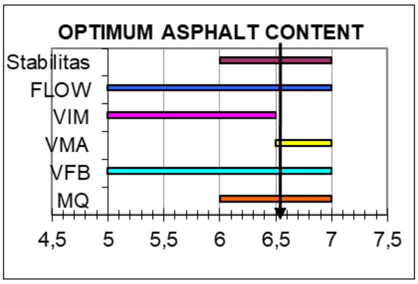

Figure 6. Optimum Asphalt Content with The Percentage of 25% Dolomite Limestone and 75% Rock Ash

Table 13. The Results from Marshall Test on The Percentage 0% Dolomite Limestone and 100% Rock Ash

100% Rock Ash & 0% Dolomite Limestone							
% Asphalt	Stability	Flow	VIM	VMA	VFB	MQ	density
5	603,422	3,600	5,507	16,441	69,087	167,617	2,338
	575,996	3,000	4,638	15,672	73,142	191,999	2,359
5,5	616,584	3,500	5,387	17,386	71,427	176,167	2,324
	602,526	3,700	5,036	17,079	72,980	162,845	2,332
6	828,818	3,050	4,740	17,863	75,803	271,744	2,322
	841,498	3,100	4,881	17,984	75,179	271,451	2,319
6,5	902,647	3,350	4,086	18,334	79,977	269,447	2,322
	926,996	3,550	4,221	18,449	79,366	261,126	2,318
7	905,133	3,600	3,598	18,943	83,183	251,426	2,317
	918,231	3,540	3,779	19,095	82,363	259,387	2,312

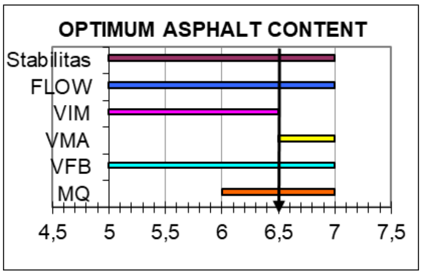

Figure 7. Optimum Asphalt Content with The Percentage of 0% Dolomite Limestone and 100% Rock Ash

From Figure 3, Figure 5, Figure 6, Figure 7, it can be determined optimum asphalt content for the mixture. There are four percentages, which are 6.5% with percentage of 100% dolomite limestone and 0% rock ash, 6% with percentage of 50% dolomite limestone and 50% rock ash, 6.5% with 25% dolomite limestone and 75% rock ash, and 6.5% with 0% dolomite limestone and 100% rock ash.

4. Conclusion

Based on the experimental results and analysis, the following conclusions can be drawn: Firstly, the specific gravity testing of the fine aggregate consisting of sand, stone ash, and dolomite lime resulted in values exceeding 2.5 gr/cm3. Similarly, the specific gravity of the coarse aggregate made of 1/1 stone and 0.5 stone also yielded values higher than 2.5 gr/cm3. These values meet the specifications outlined in the 2018 revision II Bina Marga guidelines.

Secondly, the examination of the wear of the coarse aggregate indicated a value of 17.11%, which falls within the acceptable range according to the 2018 revision II Bina Marga specifications, which require a deal below 40%. Thirdly, the asphalt parameter tests produced results that meet the requirements specified in the 2018 Bina Marga revision II guidelines. The filler used in the mixture consists of various combinations: 0% rock ash and 100% dolomite lime, 25% rock ash and 75% dolomite lime, 50% rock ash and 50% dolomite lime, 75% rock ash and 25% dolomite lime, and 100% rock ash and 0% dolomite lime.

The best marshall results are achieved using 100% rock ash filler and 0% dolomite lime filler. Four OAC (Optimum Asphalt Content) are obtained among the five combinations of filler mixtures, yielding values of 6.5% with percentage of 100% dolomite limestone and 0% rock ash, 6% with percentage of 50% dolomite limestone and 50% rock ash, 6.5% with 25% dolomite limestone and 75% rock ash, and 6.5% with 0% dolomite limestone and 100% rock ash.

The percentage of 100% rock ash filler content and 0% dolomite lime filler content resulted in an OAC value of 6.5%. When using the percentage of 100% rock ash filler content and 0% OAC dolomite lime filler content, the Marshall stability value obtained is 914.821 Kg, the flow value is 3.45 mm, and the Marshall Quotient value is 265.286 Kg/mm.

The volumetric analysis of the mixture with the percentage of 100% rock ash filler content and 0% dolomite lime filler content resulted in a VIM (Voids in Mineral Aggregate) value of 4.153%, a VMA (Voids in Mineral Aggregate) value of

18.391%, and a VFB (Voids Filled with Binder) value of 79.671%.

5. Acknowledgment

First, I want to show my gratitude to my parents for always being there for me and make sure that I could finish this research successfully. I wan to thank Mr. Said and Mr. Heri Azwansyah for providing suggestion and guidance so that this study delivers a creation that can be useful in pavement design. I would like to thank Jurnal Teknik Sipil UNTAN (JTS), who have agreed to publish this article so that it can become a valuable reference for everyone.

6. Author's Note

All of the content written in this article is original as it summarizes my studies with Mr. Said and Mr. Heri Azwansyah. The contents of this article were reviewed during my thesis defense at the Department of Civil Engineering, University of Tanjungpura.

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