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Comparison Of Marshall Test Value Using Tulungagung Marble Waste Coarse Aggregate And Kediri Local Coarse Aggregate As AC-WC Concrete Asphalt Mixture

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ABSTRACT

Seiring dengan meningkatnya volume kendaraan di Indonesia, maka kebutuhan jalan akan terus mengalami peningkatan. Pada dasarnya agregat setiap wilayah memiliki sifat dan karakteristik yang berbeda. Oleh karena itu, dilakukan penelitian terhadap karakteristik agregat kasar dari dua *quarry* berbeda yang nantinya akan digunakan sebagai campuran aspal beton lapis permukaan atau *Asphalt Concrete - Wearing Course* (AC-WC). Penelitian ini dilakukan untuk mengetahui pengaruh perbandingan agregat kasar dari dua *quarry* berbeda, yaitu *quarry* berasal dari kabupaten Tulungagung dan Kediri. Pengujian campuran aspal beton ini menggunakan metode *marshall test* yang mengacu pada aturan - aturan yang terdapat dalam SNI dan Spesifikasi Umum Dinas Pekerjaan Umum Bina Marga Provinsi Jawa Timur Tahun 2018. Pembuatan benda uji menggunakan campuran aspal lapisan AC-WC kemudian diuji dengan menggunakan metode *marshall*. Hasil penelitian ini menunjukkan bahwa nilai kadar aspal optimum (KAO) agregat kasar Tulungagung berada pada kadar aspal 6,64%, sedangkan untuk agregat kasar Kediri berada pada kadar aspal 6,71%. Dari hasil perbandingan dapat disimpulkan bahwa campuran aspal dengan agregat kasar Kediri cocok digunakan pada lalu lintas dengan beban kendaraan yang berat dan intensitas yang rendah, sedangkan campuran aspal dengan agregat kasar Tulungagung cocok digunakan pada lalu lintas dengan beban kendaraan yang ringan dan intensitas yang tinggi. Berdasarkan hasil uji Anova dua arah, didapatkan nilai P-Value sebesar 0,66 yang artinya nilai P-Value ≥ alpha (α=5%), sehingga dapat disimpulkan bahwa tidak terdapat pengaruh perbedaan agregat kasar Tulungagung dan Kediri terhadap kekuatan pada aspal beton lapis aus (AC-WC).

ABSTRACT

As the volume of vehicles in Indonesia continues to increase, the road demand will also keep rising. Essentially, each region's aggregate possesses different properties and characteristics. Therefore, research was conducted on the characteristics of coarse aggregates from two different quarries, which will later be used as a mixture for Asphalt Concrete - Wearing Course (AC-WC). This study was conducted to determine the effect of comparing coarse aggregates from two different quarries, specifically those from Tulungagung and Kediri districts. The testing of this asphalt concrete mixture used the Marshall test method, referring to the rules contained in SNI (Indonesian National Standard) and the General Specifications of the East Java Province Public Works Office in 2018. The test specimens were made using AC-WC layer asphalt mixture and then tested using the Marshall method. The results of this study showed that the optimal asphalt content (KAO) for Tulungagung coarse aggregate was at 6.64%, while for Kediri coarse aggregate it was

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at 6.71%. From the comparison, it can be concluded that the asphalt mixture with Kediri coarse aggregate is suitable for use in traffic with heavy vehicle loads and low intensity, while the asphalt mixture with Tulungagung coarse aggregate is suitable for traffic with light vehicle loads and high intensity. Based on the two-way ANOVA test results, a P-Value of 0.66 was obtained, meaning that the P-Value ≥ alpha (α=5%), so it can be concluded that there is no significant effect of the differences between Tulungagung and Kediri coarse aggregates on the strength of the Asphalt Concrete - Wearing Course (AC-WC).

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1. INTRODUCTION

In social life, of course, the important role of a road cannot be separated. Roads are important in supporting various community activities, both mobilization and distribution of goods and services [1]. A highway can be interpreted as a route that is useful for passing traffic from one place to another. Highways function as connecting facilities, so that smooth and safe traffic can be achieved which meets technical and economic requirements by the function and characteristics of the traffic [2]. As the volume of vehicles in Indonesia increases, the need for roads will continue to rise, so road pavement structures must be well planned [3]. Indonesia is expected to achieve its medium term strategic plan, which is to become one of the high income countries, with a per capita income of 14.250 – 15.500 USD. To accomplish this plan, efforts are made by developing and improving the existing road infrastructure so that economic growth is not hindered and can proceed smoothly [4].

Asphalt concrete is a layer of flexible pavement whose constituent material consists of a mixture of hard asphalt and continuously graded aggregate which is then mixed, spread, and compacted hot at a certain temperature [5]. Based on its function, asphalt concrete layer consists of three types, one of which is asphalt concrete layer as a wear layer usually called Asphalt Concrete - Wearing Course (AC-WC). asphalt concrete as a wear layer (AC-WC) is a layer that experiences direct contact with vehicle wheels and weather changes, making it prone to damage [6]. Laston (asphalt concrete) is generally used for heavy traffic, so a high-quality layer is needed to withstand the relatively large vehicle loads. Therefore, to achieve a high-quality pavement structure, good materials are required, as materials are the main component of a pavement construction [7]. The marble processing industry produces waste in the form of marble fragments every day. Some of the marble fragment waste is used as landfill material and some is simply thrown away because it is considered less economical. Marble is a rock that has coarse grains with an interlocking texture and contains quartz and chlorite [8]. Several AMP companies in Tulunggagung Regency still use aggregates from outside Tulungagung as materials for road pavement construction, one of which is aggregated from Kediri Regency.

The use of aggregate from outside Tulungagung results in higher production costs. Moreover, the limitations of river stone material for pavement mixtures will gradually decrease, so that marble waste can be used as an alternative as a substitute for coarse aggregate in asphalt concrete mixtures [9].

This research was carried out because basically the aggregates of each region have different properties and characteristics. Therefore, research was carried out on the characteristics of coarse aggregates from Tulungagung and Kediri which were used as a mixture for surface layer asphalt concrete or Asphalt Concrete - Wearing Course (AC-WC). This research was carried out to konow the values of stability, flow, Marshall Quotient (MQ), Void in Mix (VIM), Void in Mineral Aggregate (VMA), and Void Filled with Asphalt (VFA) in the comparison of coarse aggregates in Tulungagung Regency. and Kediri at the optimum asphalt content (KAO) value. From these results, it can be seen that the coarse aggregate is better used as a mixture for Asphalt Concrete Wearing Course (AC-WC), so that it can be determined that the coarse aggregate meets the standards, is of good quality, strength, and economy which can later be used as an asphalt concrete mixture for flexible pavement construction in the future.

2. METHOD

2.1 Research Plan

This research uses an experimental method by comparing coarse aggregate from two different quarries originating from Tulungagung and Kediri Regencies as a mixture of Asphalt Concrete Wearing Course (AC-WC) by conducting tests at the Road Materials Laboratory of Universitas Pembangunan Nasional “Veteran” Jawa Timur. This research is guided by the General Specifications of the East Java Province Public Works Department of Highways 2018 Revision 2 (Division 6 Asphalt Pavement) and several rules contained in SNI (Indonesian National Standards). This test is carried out by making a test object in the form of Asphalt Concrete - Wearing Course (AC-WC).

2.2 Mixed Aggregate Composition

This test was carried out using the middle limit value in the combined aggregate gradation table as a mixture of Asphalt Concrete - Wearing Course (AC-WC). The weight of the test object in this study was 1200 grams. Determining the weight of the aggregate composition used the middle limit method to minimize the possibility of errors in the aggregate composition of the test object. Aggregate composition planning using the middle limit value method is shown in table 1 as follows :

Table 1. Asphalt Mixture Aggregate Grading

Sieve Size		Specification	Middle Limit Passed	Middle Limit Stuck	weight
ASTM	mm	%	%	%	gram
3/4"	19	100	100	0	0
1/2"	12,5	90 - 100	95	5	60
3/8"	9,5	77 - 90	83,5	11,5	138
No. 4	4,75	53 - 69	61	22,5	270
No. 8	2,36	33 - 53	43	18	216

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No. 16	1,18	21 - 40	30,5	12,5	150
No. 30	0,60	14 - 30	22	8,5	102
No. 50	0,30	9 - 22	15,5	6,5	78
No. 100	0,15	6 - 15	10,5	5	60
No. 200	0,075	4 - 9	6,5	4	48
PAN	< 0,075		0	6,5	78
Total				**100**	**1200**

2.3 Estimated Asphalt Content

After obtaining the gradation results for the aggregate mixture, the next step is to determine the estimated asphalt content used as the AC-WC mixture. Determining the estimated asphalt content used as a mixture refers to SNI 03-1737-1989 where the percentage of asphalt weight to the mixture weight ranges from 4% to 7%. The estimated calculation of asphalt content is presented in equation 2.1 as follows :

$$Pb = 0{,}035\,(\mathrm{A}) + 0{,}045\,(\%\,B) + (K \times C) + F \quad \text{.......} (2.1)$$

3. RESULTS AND DISCUSSION

3.1 Sieve Analysis of Coarse and Fine Aggregates

Sieve analysis tests are carried out to determine the distribution of grains (gradations) in coarse aggregate using a sieve shake. From the results of the weight percentage that passes through the coarse aggregate, the aggregate is mixed to determine the percentage of aggregate in the asphalt concrete mixture. This test was carried out using the middle limit value in the combined aggregate gradation table as a mixture of Asphalt Concrete - Wearing Course (AC-WC). The purpose of using the middle limit value method is to minimize the existence of errors in making the aggregate composition of the test specimen. Based on the combined aggregate gradation results shown in table 2, a combined aggregate gradation analysis graph can be made as shown in figure 2 as follows :

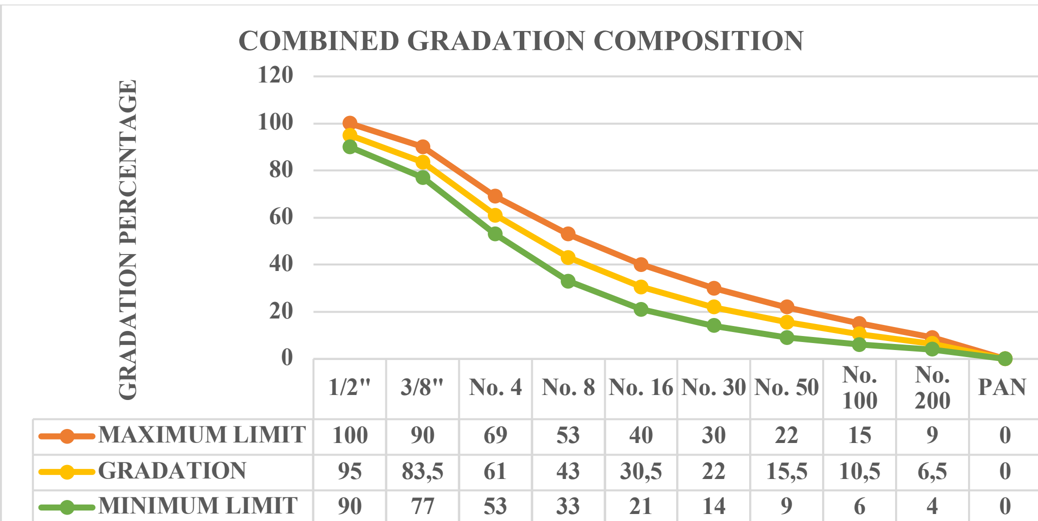

Figure 2. Aggregate Combined Gradation Analysis Chart

3.2 Specific Gravity and Absorption Testing of Coarse and Fine Aggregates

Specific gravity and absorption testing are important tests in mix planning. The purpose of this test is to obtain bulk specific gravity, saturated surface dry, apparent and absorption values for aggregate. The results of the specific gravity and aggregate absorption tests are as follows :

Table 2. Test Results for Specific Gravity and Absorption of Coarse Aggregate

Material	Specific Gravity	Tulungagung	Kediri
Aggregate Size 10-15 mm	Bulk (gr/cm3)	2,58	2,61
	Saturated Surface Dry (gr/cm3)	2,61	2,64
	Apparent (gr/cm3)	2,66	2,71
	Absoption (%)	1,29	1,41
Aggregate Size 5-10 mm	Bulk (gr/cm3)	2,56	2,58
	Saturated Surface Dry (gr/cm3)	2,59	2,61
	Apparent (gr/cm3)	2,65	2,65
	Absoption (%)	1,36	1,14

Table 3. Test Results for Specific Gravity and Absorption of Fine Aggregate

Material	Specific Gravity	Result
Aggregate Size ≤ 5 mm	Bulk (gr/cm3)	2,61
	Saturated Surface Dry (gr/cm3)	2,65
	Apparent (gr/cm3)	2,72
	Absoption (%)	1,55

3.3 Asphalt Test Result

In this research, the asphalt testing carried out included penetration testing, softening point testing, flash point and burning point testing, and specific gravity of asphalt. This research is guided by the General Specifications of the East Java Province Public Works Department of Highways 2018 [10]. The asphalt test results are shown in table 3.3 as follows:

Table 3. Asphalt Test Result

Test Type	Specification	Result
Asphalt Penetration (mm)	60-70	65,15
Asphalt Flash Point (°C)	Min. 232	356
Asphalt Burn Point (°C)	Min. 232	360
Asphalt Softening Point (°C)	Min 48	52,5
Asphalt Specific Gravity (gram/cm)	Min. 1	1,043

3.4 Determination of Planned Asphalt Content

Determining the planned asphalt content in this research uses the Asphalt Institute approach method. The results of the asphalt content used are as follows :

Table 4. variations in asphalt content

Coarse Aggregate	Variation	Percentage (%)	Weight (gram)
Tulungagung	Pb - 1	5,14	67,85
	Pb - 0,5	5,64	74,45
	Pb	6,14	81,05
	Pb + 0,5	6,64	87,65
	Pb + 1	7,14	94,25
Kediri	Pb - 1	5,09	67,19
	Pb - 0,5	5,59	73,79

	Pb	6,09	80,39
	Pb + 0,5	6,59	86,99
	Pb + 1	7,09	93,59

3.5 Marshall test results to determine the Optimum Asphalt Content of Tulungagung Coarse Aggregate

Determining the optimum asphalt content uses a graphic method by establishing Marshall parameter value limits that meet the specifications. The parameters for determining optimum asphalt content consist of Void In Mix (VIM), Void In Mineral Aggregate (VMA), Void Filled with Asphalt (VFA), Stability, Flow, and Marshall Quontient (MQ) values. The average Marshall test results for Tulungagung coarse aggregate are shown in Table 5 as follows:

Table 5. Marshall Test Results of Tulungagung Coarse Aggregate

Marshall Parameters	**Specification**	**Variations in Asphalt Content**				
		5,14	**5,64**	**6,14**	**6,64**	**7,14**
Stability (Kg)	Min. 800	1235,99	1371,75	1514,06	1604,33	1652,12
Flow (mm)	2-4	2,31	2,46	2,57	2,6	2,7
Marshall Quotient (kg/mm)	Min. 250	540,05	562,02	597,6	618,98	619,53
VIM (%)	3-5	8,62	6,53	4,95	4,3	3,33
VMA (%)	Min. 15	19,23	18,3	17,84	18,18	18,24
VFA (%)	Min. 65	55,37	64,32	72,25	76,42	81,8

3.5.1 Stability Of Tulungagung Coarse Aggregate

Based on table 5, a graph of the average stability results of Tulungagung coarse aggregate is presented which is shown in figure 3 as follows :

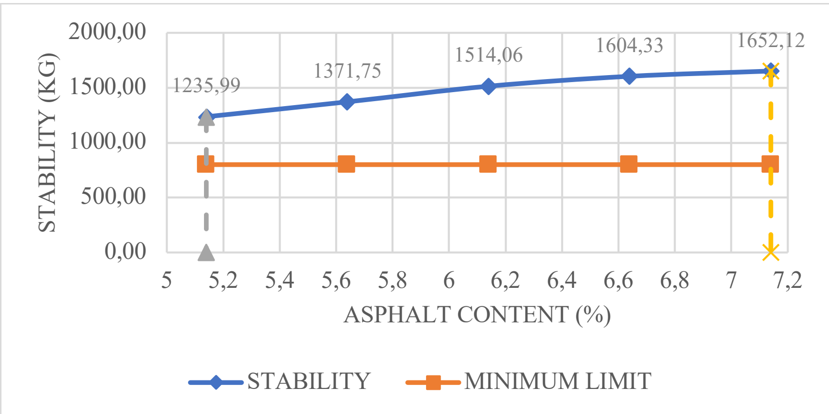

Figure 3. Graph of Tulungagung Coarse Aggregate Stability Results

3.5.2 Flow Of Tulungagung Coarse Aggregate

Based on table 3.5, a graph of the average flow results of Tulungagung coarse aggregate is presented which is shown in figure 3 as follows :

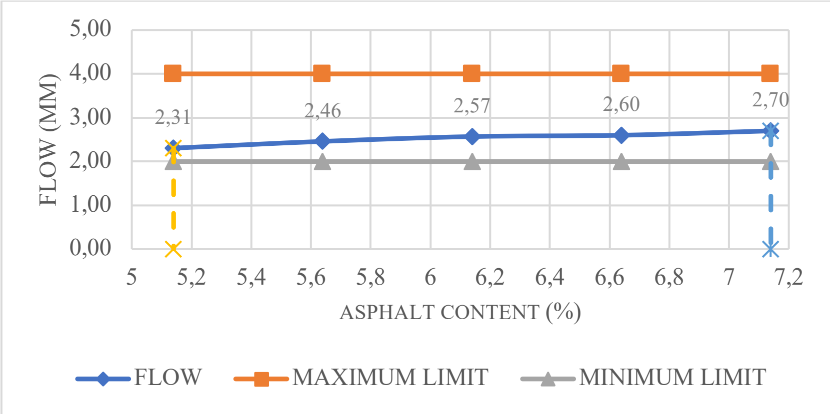

Figure 3. Graph of Tulungagung Coarse Aggregate Flow Results

3.5.3 Marshall Quotient (MQ) Of Tulungagung Coarse Aggregate

Based on table 5, a graph of the average Marshall Quotient (MQ) results of Tulungagung coarse aggregate is presented which is shown in figure 4 as follows :

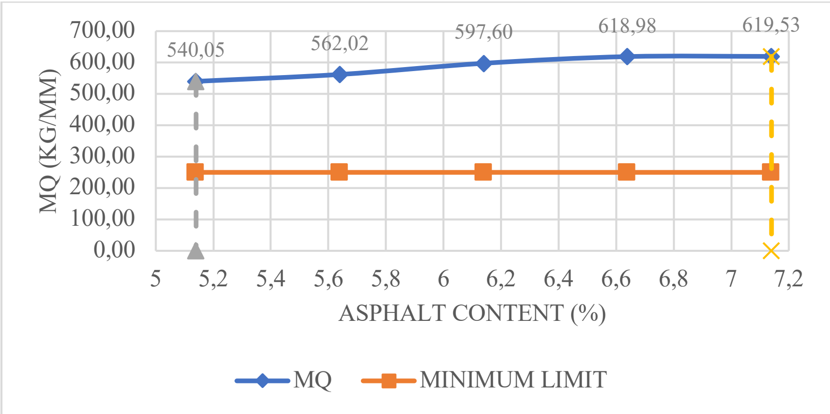

Figure 1. Graph of Tulungagung Coarse Aggregate MQ Results

3.5.4 Void In The Mix (VIM) Of Tulungagung Coarse Aggregate

Based on table 5, a graph of the average VIM results of Tulungagung coarse aggregate is presented which is shown in figure 5 as follows :

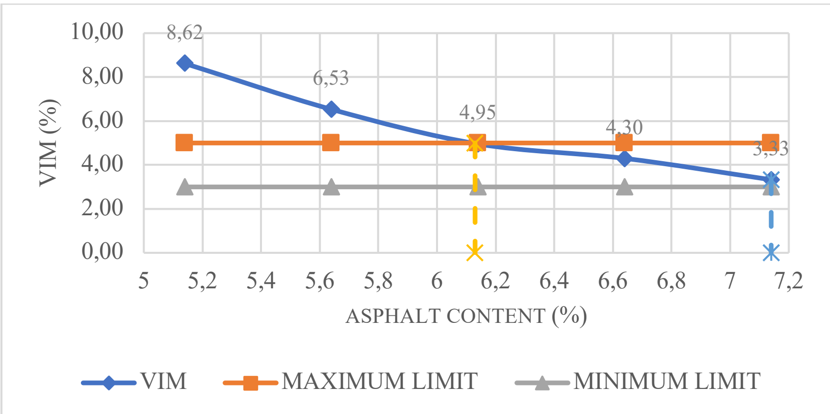

Figure 2. Graph of Tulungagung Coarse Aggregate VIM Results

3.5.5 Void In Mineral Aggregate (VMA) Of Tulungagung Coarse Aggregate

Based on table 3.5, a graph of the average VMA results of Tulungagung coarse aggregate is presented which is shown in figure 3.6 as follows :

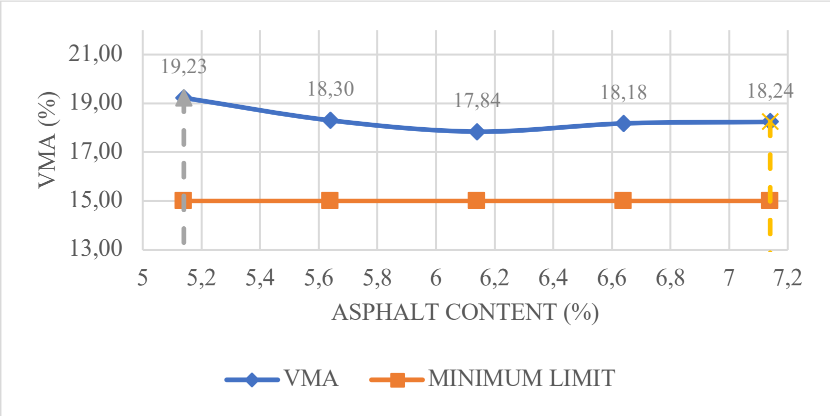

Figure 3. Graph of Tulungagung Coarse Aggregate VMA Results

3.5.6 Void Filled With Asphalt (VFA) Of Tulungagung Coarse Aggregate

Based on table 3.5, a graph of the average VFA results of Tulungagung coarse aggregate is presented which is shown in figure 7 as follows :

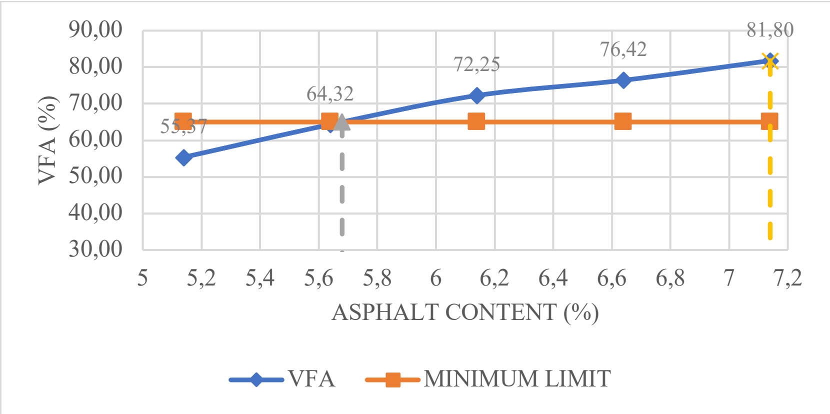

Figure 4. Graph of Tulungagung Coarse Aggregate VFA Results

3.5.7 Results Of Optimum Asphalt Content Tulungagung Coarse Aggregate

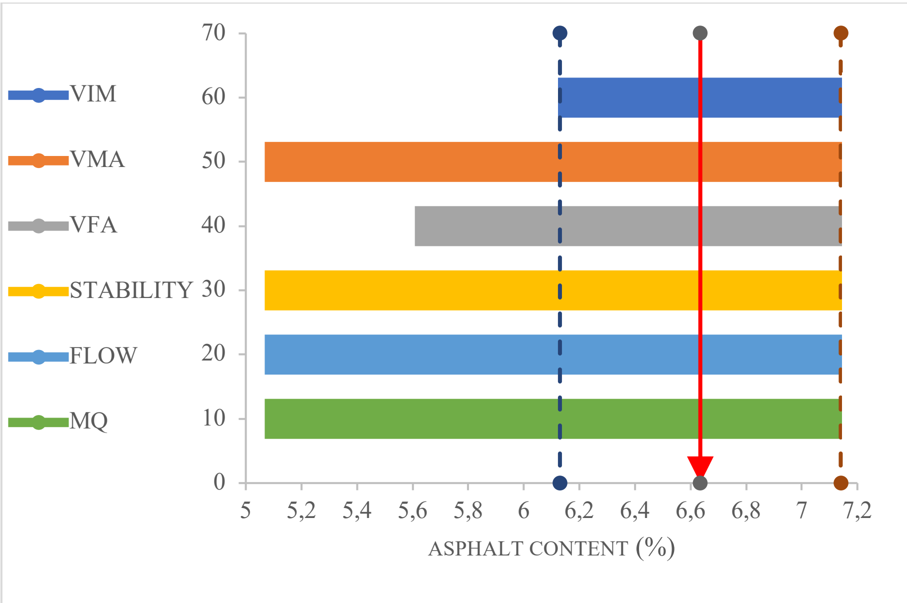

Figure 5. Tulungagung Coarse Aggregate Optimum Asphalt Content Graph

3.6 Marshall test results to determine the Optimum Asphalt Content of Kediri Coarse Aggregate

Determining the optimum asphalt content uses a graphic method by establishing Marshall parameter value limits that meet the specifications. The parameters for determining optimum asphalt content consist of Void In Mix (VIM), Void In Mineral Aggregate (VMA), Void Filled with Asphalt (VFA), Stability, Flow, and Marshall Quontient (MQ) values. The average Marshall test results for Kediri coarse aggregate are shown in Table 6 as follows:

Table 1. Marshall Test Results of Kediri Coarse Aggregate

Marshall Parameters	**Specification**	**Variations in Asphalt Content**				
		5,09	**5,59**	**6,09**	**6,59**	**7,09**
Stabilitas (Kg)	Min. 800	1342,3	1406,77	1506,08	1628,69	1677,63
Flow (mm)	2-4	2,8	2,97	3,03	3,27	3,32
Marshall Quotient (kg/mm)	Min. 250	483,82	491,8	501,95	504,82	506,52
VIM (%)	3-5	9,15	7,53	5,6	4,27	3,16
VMA (%)	Min. 15	19,64	19,12	18,34	18,11	18,05
VFA (%)	Min. 65	53,86	61,38	69,74	76,44	82,54

3.6.1 Stability Of Kediri Coarse Aggregate

Based on table 9, a graph of the average stability results of Kediri coarse aggregate is presented which is shown in figure 9 as follows :

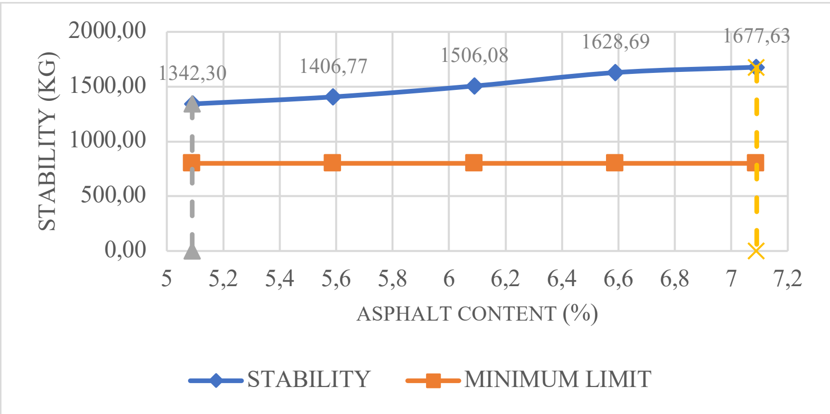

Figure 6. Graph of Kediri Coarse Aggregate Stability Results

3.6.2 Flow Of Kediri Coarse Aggregate

Based on table 10, a graph of the average flow results of Kediri coarse aggregate is presented which is shown in figure 3.10 as follows :

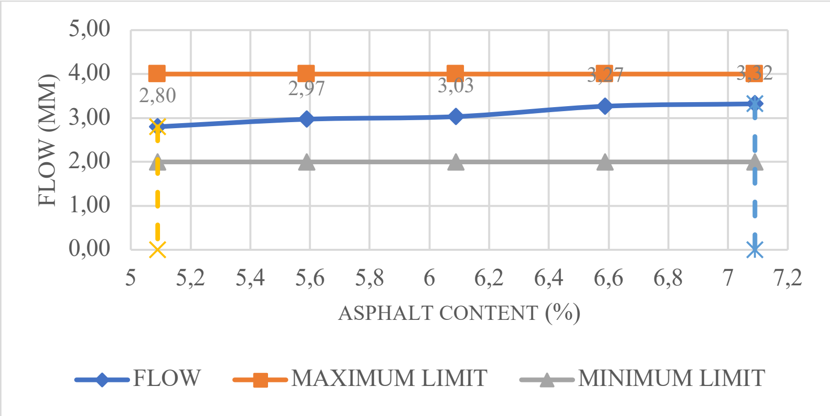

Figure 7. Graph of Kediri Coarse Aggregate Flow Results

3.6.3 Marshall Quotient (MQ) Of Kediri Coarse Aggregate

Based on table 11, a graph of the average Marshall Quotient (MQ) results of Kediri coarse aggregate is presented which is shown in figure 11 as follows :

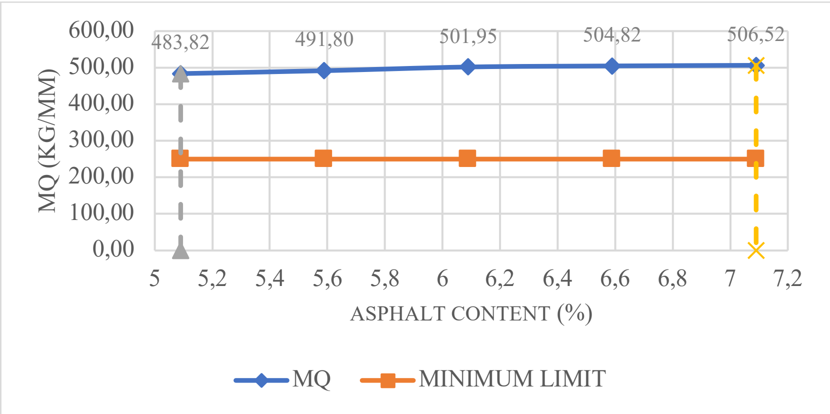

Figure 8. Graph of Kediri Coarse Aggregate MQ Results

3.6.4 Void In The Mix (VIM) Of Kediri Coarse Aggregate

Based on table 12, a graph of the average VIM results of Kediri coarse aggregate is presented which is shown in figure 12 as follows :

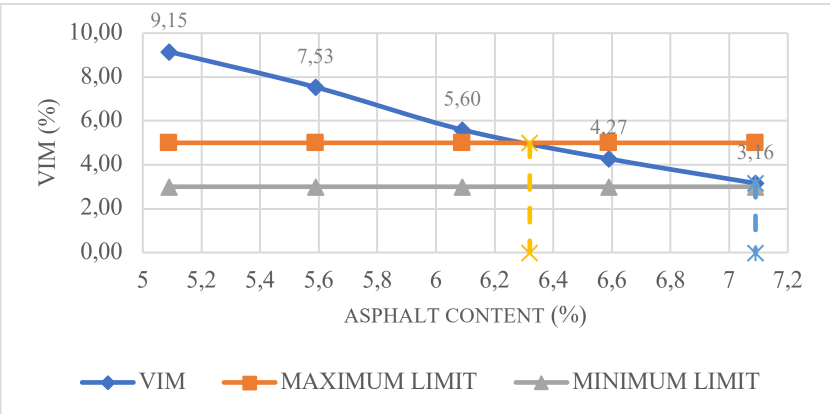

Figure 9. Graph of Kediri Coarse Aggregate VIM Results

3.6.5 Void In Mineral Aggregate (VMA) Of Kediri Coarse Aggregate

Based on table 13, a graph of the average VMA results of Kediri coarse aggregate is presented which is shown in figure 13 as follows :

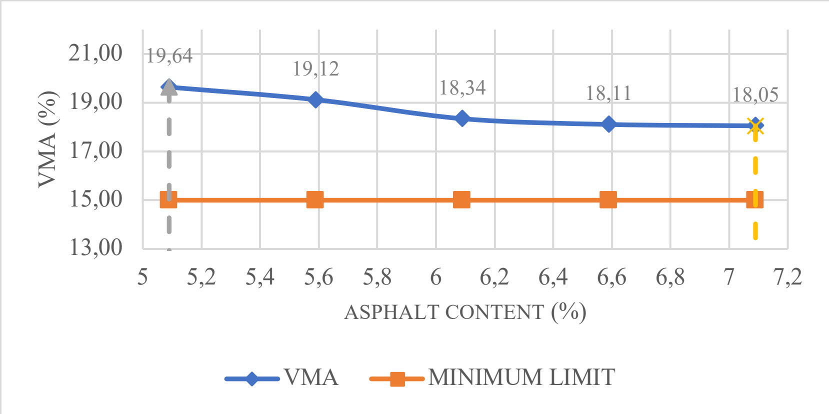

Figure 10. Graph of Kediri Coarse Aggregate VMA Results

3.6.6 Void Filled With Asphalt (VFA) Of Kediri Coarse Aggregate

Based on table 14, a graph of the average stability results of Kediri coarse aggregate is presented which is shown in figure 14 as follows :

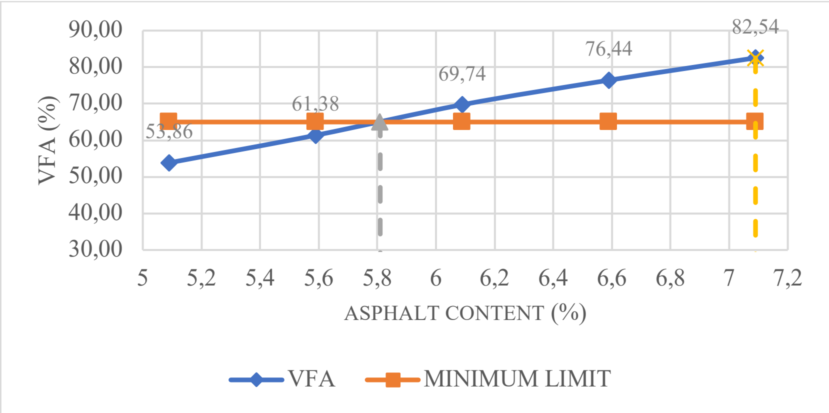

Figure 11. Graph of Kediri Coarse Aggregate VFA Results

3.6.7 Results Of Optimum Asphalt Content Kediri Coarse Aggregate

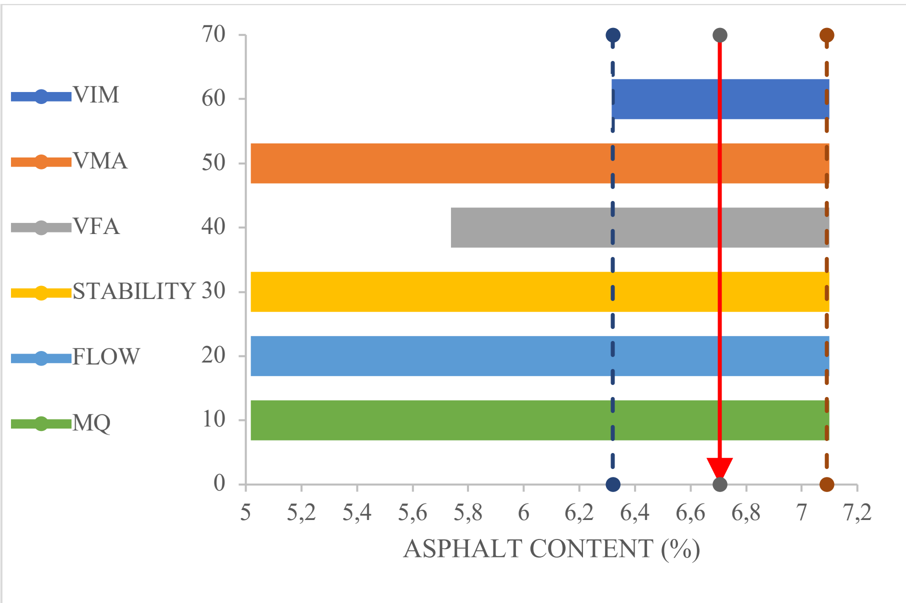

Figure 12. Kediri Coarse Aggregate Optimum Asphalt Content Graph

3.7 Comparison Results of Marshall Testing on Optimum Asphalt Content of Tulungagung and Kediri Coarse Aggregate

The comparative results of the Marshall test on the Tulungagung coarse aggregate obtained an optimum asphalt content value of 6.64%, while on the Kediri coarse aggregate the optimum asphalt content value was obtained at 6.71%. The comparative results of the Marshall test on optimum asphalt content are shown in table 7 as follows:

Table 2. Marshall Test Comparison Results on Optimum Asphalt Content

Marshall Parameter	Specification	Coarse Aggregate		Percentage (Increase/Decrease)
		Tulungagung	Kediri	
Stability (Kg)	Min. 800	1622,85	1665,34	2,55
Flow (mm)	2-4	2,64	3,3	20
MQ (Kg/mm)	Min. 250	636,05	523,57	-21,48
VIM (%)	3-5	4,07	3,16	-28,55
VMA (%)	Min. 15	17,89	17,36	-3,05
VFA (%)	Min. 65	77,35	81,81	5,45

4. CONCLUSION

Based on the results of research regarding the comparison of Marshall test values using Tulungagung marble waste coarse aggregate and local Kediri coarse aggregate as a mixture of AC-WC, it can be concluded that the optimum asphalt content obtained in Tulungagung coarse aggregate is 6.64%, Meanwhile, for the Kediri coarse aggregate, the optimum asphalt content value was 6.71%. For Tulungagung coarse aggregate, the optimum asphalt content value obtained was a stability value of 1622.85 Kg, a flow value of 2.64 mm, a Marshall Quotient (MQ) value of 636.05 Kg/mm, a Void in Mix (VIM) value of 4, 07%, Void in Mineral Aggregate (VMA) was 17.89%, and Void Filled with Asphalt (VFA) was 77.35%. Meanwhile, for Kediri coarse aggregate, the optimum asphalt content value obtained was a stability value of 1665.34 Kg, a flow value of 3.30 mm, a Marshall Quotient (MQ) value of 523.57 Kg/mm, a Void in Mix (VIM) value of 3 .16%, Void in Mineral Aggregate (VMA) of 17.36%, and Void Filled with Asphalt (VFA) value of 81.81%. From the comparison, it can be concluded that the asphalt mixture with Kediri coarse aggregate is suitable for use in traffic with heavy vehicle loads and low intensity, while the asphalt mixture with Tulungagung coarse aggregate is suitable for traffic with light vehicle loads and high intensity. Based on the results of the two-way ANOVA test, P-Value of 0.66 was obtained, which means the P-Value ≥ alpha (α=5%). Thus, it can be concluded that there is no significant effect of the differences between Tulungagung and Kediri coarse aggregates on the strength of Asphalt Concrete - Wearing Course (AC-WC).

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