PAPER NAME

17. Utilization of Igneous Rock as Coarse Aggregate in Asphalt Concrete Binder Course Mixture - GIES

WORD COUNT

3258 Words

CHARACTER COUNT

16043 Characters

PAGE COUNT

8 Pages

FILE SIZE

470.7KB

SUBMISSION DATE

Jan 19, 2023 1:41 AM GMT+8

REPORT DATE

Jan 19, 2023 1:41 AM GMT+8

14% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

- 2% Internet database
- 9% Publications database
- Crossref database
- Crossref Posted Content database
- 4% Submitted Works database

Excluded from Similarity Report

- Bibliographic material
- Quoted material
- Cited material
- Small Matches (Less then 15 words)
- Manually excluded sources

Utilization of Igneous Rock as Coarse Aggregate in Asphalt Concrete Binder Course Mixture

P R Rangan[1], M Tumpu[2] and Mansyur[3]

[1]Associate Professor, Civil Engineering Department, University of Christian Indonesia Toraja, Indonesia

[2]Lecturer, Civil Engineering Department, Fajar University, Indonesia

[3]Lecturer, Civil Engineering Department, SembilanBelas November University, Indonesia

pareausanrangan68@gmail.com, tumpumiswar@gmail.com, mansyurusn14@gmail.com

Abstract. Enrekang Regency, South Sulawesi Province, is an area that has a source of material in the form of river aggregate which was classified as igneous rock in Mata Allo River. However, the use of river stone so far has only been limited as to building materials and has not been used as coarse aggregate in asphalt mixtures. The use of river stone which had been underutilized is also based on the fact that there is no research on this aggregate. This study aims to determine the feasibility of Mata Allo River aggregate that can be used as coarse aggregate in the asphalt concrete binder course (AC-BC) mixture against the Marshall test. This research was conducted by testing the characteristics of coarse aggregate based on the standards of Highways, Indonesia. The composition of the AC-BC mixture as a result of aggregate gradation were 50.00% of coarse aggregate, 45.15% of fine aggregate and 5.85% of filler, respectively. AC-BC mixture were produced using petroleum bitumen of 60/70 grade penetration at variations in asphalt content of 4.0%, 4.5%, 5.0%, 5.5%, and 6.0%. Based on the results of the study, the Mata Allo River Aggregate which is classified as igneous rock is suitable for use as road material with flexible pavement construction for the AC-BC mixture resulting from laboratory testing, where the Marshall characteristic test results for the mixture meet the specifications of Bina Marga, Indonesia.

1. Introduction

Most of the road pavements that are often used were flexible pavements and the type of mixture used was Asphalt Concrete (AC). The structure of the surface layer consisted of a wear layer (Wearing Course) and binder layer (Binder Course) which were placed separately, therefore we need a road pavement that was environmentally friendly but also provided comfort for the rider [1-4].

Along with the increased in road construction, the need for aggregate was increased. To meet these needs, government and researcher need to take advantages of the natural resources around the road construction. The Ministry of Public Works and Public Housing (PUPR), Indonesia encouraged the used of local materials to take advantages of the natural potential of the area in Indonesia [5-8].

The Mata Allo River, which is located in Enrekang district in South Sulawesi Province, Indonesia is one of the sources of material in the form of igneous stone aggregate which was very adequate and has so far been used but not as widely and as fully as possible.

Considering the existence of quite a lot of material, the material should also be used as a road pavement construction material because aggregate played an important role in the formation of the pavement layer, where aggregate was the main material that affected the carried capacity. The road surface layer and asphalt as a binder of aggregate, so that the pavement layer was waterproof, so it was necessary to conducted research in the laboratory to determine whether the aggregate was feasible or not to be used as a pavement material.

There are several mixed characteristics that must be possessed by asphalt concrete, namely stability, durability, flexibility, fatigue resistance, surface roughness or shear resistance, water resistance and workability [9-11]. Based on several previous studies, it can be stated that igneous rock was generally suitable for used in the asphalt concrete binder course of hot asphalt mixture, because it meets of the specifications required by Bina Marga requirement, Indonesia on physical characteristics and mixed characteristics for Marshall values. Therefore, this study aims to analyzed the Marshall characteristics of the AC-BC mixture using igneous rock originated from Mata Allo River, Enrekang District, South Sulawesi province, Indonesia.

2. Materials and Method

2.1. Mixture Characteristics of Asphalt Concrete Mixture

One of the things that was quited influential on the properties of asphalt concrete was the mix design, be it during mixing, laying, compacting, or at the time of its use. A mixed design with certain proportions will produce certain mix characteristics.

2.1.1. Stability

Stability is the strength of the asphalt mixture to withstand deformation due to constant and repeated loads without happen collaps (plastic flow). Stability occured as a result of shearing between grains, inter-particle locking and good bonding power of the asphalt layer. Thus, high stability can be obtained by tryed to use, among others: good graded aggregate, dense, and had a small void of mineral aggregate (VMA).

2.1.2. Durability

Durability was the resistanced of the asphalt mixture to the effects of weather, water, temperature changes, and wear and tear due to vehicle wheel friction. The durability of asphalt concrete was influenced by asphalt film, Void in Mix (VIM) and Void in Mineral Aggregate (VMA).

2.1.3. Flexibility

Flexibility was the ability of the layer to follow the deformation that occured due to repeated traffic loads without cracking and volume changes. To achieve high flexibility required a large of VMA, small of VIM, and the use of asphalt with high penetration or by using open graded aggregate.

2.1.4. Skid Resistance

Skid Resistance, namely the ability of asphalt pavement to provide a surface that was sufficiently rough so that vehicles passed through it do not experience slippage, both when the road was wet or dry. The factors to get road roughness were the same as to get high stability, namely surface roughness of the aggregate grains, contact area between grains or grain shape, aggregate gradation, mixture density, and asphalt film thickness.

2.1.5. Impermeability

Impermeability was the ability of asphalt concrete to not enter water or air into the asphalt concrete layer. Water and air can accelerated the asphalt aging process, and peel of the asphalt film/cover from the aggregate surface. The number of pores remaining after the asphalt concrete has been compacted was an indicator of the watertightness of the mixture. The impremeability level of asphalt concrete was inversely proportional to its durability level.

2.1.6. Resistance to Fatigue

Resistance to fatigue was the ability of asphalt concrete to experience repeated loads without fatigue in the form of cracks or rutting.

2.1.7. Workability

Workability was the ease of a mixture to be spreaded and compacted so that results that meet the expected density were obtained.

2.2. Aggregate Pick-Up Point

The location where the material was taken from the Mata Allo river, Enrekang District, South Sulawesi Province, Indonesia. The distance from the aggregate collected from the center of Enrekang was ± 3 km. The material contained in the Mata Allo River is quite a lot to support development in the area. Figure 1 shows the aggregate pick-up point in Mata Allo river.

Figure 1. The aggregate pick-up point in Mata Allo river

2.3. Physical Properties of Coarse Aggregate

Table 1 shows the test method, specification standard and physical properties of coarse aggregate. Coarse aggregate in this research was taken from Mata Allo river. Coarse aggregate in this research is classified as igneous rock with a hardness level above 95%.

Table 1. Physical properties of coarse aggregate

No	Testing type	Testing method	Testing results	Spesification
1	Bulk specific gravity	SNI 1969 : 2016	2.58	Min. 2.5%
2	Saturated surface dry specific gravity	SNI 1969 : 2016	2.63	Min. 2.5%
3	Apparent specific gravity	SNI 1969 : 2016	2.70	Min. 2,5%
4	Water absorption	SNI 1969 : 2016	1.72	Max. 3%
5	Abrasion with los Angeles machine	SNI 2417 : 2008	13.66	Max. 40%
6	Impact test	SNI 03-4426-1997	16.60	Max. 30%
7	Sludge content	SNI 03-4428-1997	0.65	Max. 5%
8	Flatness index	ASTM D-4791 :10	4.64	Max. 10%
	Elongation index		7.79	
	Flatness and elongation index		4.95	

From the results of testing the characteristics of the Mata Allo River crushed stone, all test results meet the specifications for coarse aggregate required based on Bina Marga standards, Indonesia.

2.4. Physical Properties of Fine Aggregate

The results of testing the characteristics of sand as fine aggregate from the Mata Allo River are in accordance with the test method used and the required standard specifications are in Table 2.

Table 2. Physical properties of fine aggregate

No	Testing type	Testing method	Testing results	Spesification
1	Bulk specific gravity	SNI 1970 : 2016	2.66	Min. 2.5
2	Saturated surface dry specific gravity	SNI 1970 : 2016	2.69	Min. 2.5
3	Apparent specific gravity	SNI 1970 : 2016	2.75	Min. 2.5
4	Water absorption	SNI 1970 : 2008	1.21	Max. 3
5	Sludge content	SNI 03-4428-1997	3.30	Max. 5

From the results of testing the characteristics of the Mata Allo river sand as fine aggregate, all test results meet the fine aggregate specifications required based on the Bina Marga Standard, Indonesia.

2.5. Characteristics of Petroleum Bitumen Grade 60/70

The petroleum bitumen grade 60/70 asphalt penetration test results in this study, namely ductility test of 129.33 cm, specific gravity of 1.03, flash point of 290°C, burning point of 300°C, softening point of 50.75°C and weight loss of 0.175%.

2.6. Marshall Test Convensional

There are three stages of testing carried out from the Marshall Conventional method, namely measuring specific gravity, measuring stability and flow as well as measuring density and analyzed of voids. Before testing the test object, it is necessary to do the following things:

- The test object must be clean from organic impurities, oil and paper.
- Each test object was given an identification mark that characterizes the number of variations given.
- Measure the height of each test object using a caliper with an accuracy of 0.1 mm. The height of the test object is the average of three measurements.

Figure 2. Marshall convensional test of AC-BC mixture

3. Results and Discussion

3.1. Combined Aggregate Gradation

The results of combined aggregate gradation for the AC-BC mixture based on the combined aggregate gradation with the total aggregate and filler used in the 1200 gram asphalt mixture are in Table 3. From the results of combined aggregate gradation and filler for the AC-BC mixture, consisted of crushed stone from the Mata Allo River as the coarse aggregate fraction, sand from the Mata Allo River as the fine aggregate fraction and cement as the filler fraction with the composition of coarse aggregate by 50%, fine aggregate by 44.15% and filler 5.85%.

Table 3. Combined aggregate gradation

Sieve size		Sieve weight (gr)	Sieve weight + restrained (gr)	Restrained weight (gr)	Σ Restrained weight (gr)	Percent total restrained (%)	Percent pass (gr)
mm	Inch						
25	1"	495	495	0	0	0	100
19	3/4"	510	601	91	91	5	95
12.5	1/2"	550	669	119	210	11	89.50
9.5	3/8"	538	935	397	607	30.35	69.65
4.75	No. 4	310	703	393	1000	50.00	50.00
2.36	No. 8	302	465	163	1163	58.15	41.85
1.18	No. 16	320	479	159	1322	66.10	33.90
0.600	No. 30	350	523	173	1495	74.75	25.25
0.300	No. 50	308	456	148	1643	82.15	17.85
0.150	No. 100	278	424	146	1789	89.45	10.55
0.075	No. 200	357	451	94	1883	94.15	5.85
Pan		450	567	117	2000	100	0

3.2. Mixtures Design of AC-BC Mixtures

To find out the approximate asphalt content of the AC-BC mixture using the formula:

$$Pb = 0.035\ (\%CA) + 0.045\ (\%FA) + 0.18\ (\%FF) + K \quad (1)$$

Where :

Pb = approximate asphalt content
CA = coarse aggregate retained by sieve no. 4
FA = fine aggregate passing sieve no.4 retained by sieve no.200
FF = fine aggregate passes filter no. 200 (filler)
K = constant value, for AC 0.5 to 1.0

The approximate asphalt content (Pb) to be used for the design of the AC-BC mixture is:

Pb = 0,035 (50%) + 0.045 (44.15%) + 0.18 (5.85%) + 0.6
= 5.39%
= 5% (be rounded)

From the results of the estimated asphalt content (Pb) 5%, a test object was made with 5 variations of asphalt content, 2 asphalt content below Pb and 2 asphalt content above Pb with an interval of 0.5%, then variations in asphalt content were 4.0%, 4.5% , 5.0% , 5.5% and 6.0%. The weight of asphalt for each variation of the asphalt content of the AC-BC mixture is shown in Table 4.

Table 4. Aggregate weight and asphalt mixed weight of AC-BC mixture

Asphalt content variation	Aggregate weight (gr)	Asphalt weight (gr)	Total mixed weigth (gr)
4.0%	1200	50.00	1250.00
4.5%	1200	55.29	1255.29
5.0%	1200	63.16	1263.16
5.5%	1200	69.84	1269.84
6.0%	1200	76.60	1276.60

3.3. Marshall Characteristics of AC-BC Mixtures

Testing the Marshall characteristics of AC-BC mixture based on laboratory tests carried out on 3 samples of specimens for asphalt content of 4.0%, 4.5%, 5.0%, 5.5% and 6.0%. The total test specimens for the AC-BC mixture are 15 test piece. From the laboratory tests carried out on samples of the specimens for each variation of the asphalt content, the results of the average Marshall characteristic test of the AC-BC mixture are obtained as presented in Table 5.

Table 5. Marshall characteristics of AC-BC mixture

Marshall Test AC-BC Mixture (2 x 75) Collision						
Asphalt content variation (%)	VIM (%)	VFB (%)	VMA (%)	Stability (kg)	Flow (mm)	Marshall Quetiont (kg/mm)
4.0	4.97	65.64	12.08	848.00	3.19	277.12
4.5	4.66	65.17	12.92	862.29	3.23	267.24
5.0	4.97	65.83	14.31	867.02	3.26	265.24
5.5	4.61	69.52	15.08	844.02	3.28	258.03
6.0	4.82	70.58	16.33	839.54	3.33	251.96

Void in the mixture (VIM) is a parameter that indicates the volume of voids filled with air in the asphalt mixture, expressed in % by volume. VIM value for asphalt content of 4.0% - 6.0% meets the standards required by the 2018 Highways specification, namely min 3.0% and max 5.0%. If look at the VIM value that meets the requirements, the asphalt mixture will not be easily oxidized and the asphalt becomes brittle due to aging of the asphalt both at the time of making the mixture, implementation in field and service life.

VFB (Void filled bitumen) is part of the volume of voids in the aggregate (VMA) filled with effective asphalt, expressed in % VMA. The VFB value for asphalt content of 4.0% - 6.0% meets the standards required by the specifications of the Highways Requirement, Indonesia, which is min. 65%. The results of the VFB value that meet the specifications indicated that the asphalt mixture produced has high durability so that the possibility of bleeding is very small.

Void in Mineral Aggregate (VMA) is the volume of voids between the aggregate grains of a compacted asphalt mixture, including air voids and voids filled with effective asphalt, expressed in % by volume. VMA for asphalt content of 4.9% - 6.0% meets the standards required by the specifications of Bina Marga, namely min. 14%, while the asphalt content of 4.0% - 4.8% does not meet the standards required by the Bina Marga specification. It can be seen that the asphalt content of 4.0% to 4.8% VMA value does not meet the specifications, which is below the minimum specification limit. This can cause asphalt clumping on the surface.

Stability is the ability of an asphalt mixture to accepted a load until there is plastic melting which was expressed in kilograms or pounds. The stability value was obtained from the results of direct readings on the Marshall Test equipment while carryed out Marshall testing. The stability value for asphalt content of 4.0% - 6.0% meets the standards required by the Highways specification, Indonesia which is min. 800 kg. High stability can be obtained by seeking the use of, among others: good graded aggregate, dense, and has a small void mineral aggregate (VMA).

Flow is a change in the plastic shape of an asphalt mixture that occurs due to loads up to the failure limit expressed in mm or 0.01". The flow value for asphalt content of 4.0% - 6.0% meets the standards required by the Bina Marga specification, namely min. 2.0% and max. 4.0%.

Marshall Quotient is an approximate value that almost showed the stiffness value of an asphalt mixture under load. The MQ value is obtained from the comparison between the corrected stability value and the flow value, and is expressed in units of kg/mm or kN/mm. The resulting Marshall Quetiont meets the specifications of Bina Marga, namely min. 250 kg/mm. To achieve high flexibility required a large VMA, small VIM, and the used of asphalt with high penetration or by using open graded aggregate.

4. Concluding Remarks

Based on the results of the study, the Mata Allo River Aggregate which is classified as igneous rock is suitable for use as road material with flexible pavement construction for the AC-BC mixture resulting from laboratory testing, where the Marshall characteristic test results for the mixture meet the specifications of Bina Marga, Indonesia.

References

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

[2] 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.

[3] Rangan P. R. and Tumpu M. 2021. Marshall Characteristics of AC-WC Mixture With The Addition of Anti-Flaking Additives. ARPN Journal of Engineering and Applied Sciences, 2021, 16(3), pp. 340–344.

[4] Irianto and Tumpu M. 2021. Compressive Strength of Asphalt Concrete Wearing Course Mixture Containing Waste Plastic Polypropylene. ARPN Journal of Engineering and Applied Sciences, 2020, 15(17), pp. 1835–1839.

[5] Rangan P. R. and Tumpu M. 2021. Effect Of Calcium Hydroxide (Traditionally Called Slaked Lime) to Stabilization of Laterite Soil. IOP Conf. Series: Earth and Environmental Science

1088 (2021) 012105.
[6] Rangan P.R.. Grandy.. Esra. 2019. The Effect of Using Sugar Cane Drops as a Subtitute some Asphalt for AC-BC and AC-WC Concrete Asphalt Layer. Journal of Advanced Research in Dynamical and Control Systems, 2019, 11 (7), pp. 699-706.
[7] Rangan P. R., Tumpu M., Caroles L., Mansyur. Compressive Strength of high-strength concrete with cornice adhesive as a partial replacement for cement. IOP Conf. Series : Earth and Environmental Science 871 (2021) 012006.
[8] Caroles L., Tumpu M., Rangan P. R., & Mansyur. (2021). Marshall properties of LASBUTAG asphalt mixes with pertalite as a modifier. IOP Conf. Series: Earth and Environmental Science 871 (2021) 012064.
[9] Ministry of public works, Directorate general of highways, Specification hot mix asphalt with processing Asbuton. Jakarta (in Indonesia) 2006.
[10] Stephen B., The Shell Bitumen Handbook, University of Nottingham, May 2015.
[11] Standard National of Indonesia. Standard Test Method of Asphalt Mix with Marshall Test. SNI 06-2489-1991.

14% Overall Similarity

Top sources found in the following databases:

- 2% Internet database
- 9% Publications database
- Crossref database
- Crossref Posted Content database
- 4% Submitted Works database

TOP SOURCES

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	Franky E.P. Lapian, M. Tumpu. "Opportunity Utilization Tailings Waste ... Crossref	8%
2	LL Dikti IX Turnitin Consortium on 2019-11-21 Submitted works	<1%
3	core.ac.uk Internet	<1%
4	Institute of Graduate Studies, UiTM on 2013-12-26 Submitted works	<1%
5	ejurnal.its.ac.id Internet	<1%
6	Asian Institute of Technology on 2009-04-13 Submitted works	<1%
7	Ari Kusuma, Alpius, Sakaria Randepadang. "The used of rubber materi... Crossref	<1%
8	Universitas Diponegoro on 2016-05-13 Submitted works	<1%

9	Pasundan University on 2020-07-03 Submitted works	<1%
10	Thanaya, I. Nyoman Arya, I. Gusti Raka Purbanto, and I.G. Wikarga. "Pr... Crossref	<1%
11	inotera.poltas.ac.id Internet	<1%