The Aggregate Gradation in Road Reconstruction

Hakzah Hakzah, Andriansyah Andriansyah, Mustakim Mustakim, Jasman Jasman

Department of Civil Engineering, Universitas Muhammadiyah Parepare, Parepare, INDONESIA

E-mail: andriansyahandri282@gmail.com

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ABSTRACT

Reconstruction of the road section uses the flexible pavement method where aggregate material is the main component of the structure. Choosing the right aggregate gradation and meeting the specification requirements will greatly determine the quality of the road. This research aims to determine the characteristics of aggregate gradation sourced from stock files and compare the results of aggregate gradation analysis of job mix design planning consultants. The method uses laboratory testing. Aggregate wear test results 2-3 = 5.36%, 1-2 = 6.14%. The absorption value of aggregate 2-3 = 0.87%, 1-2 = 1.79%, 0.5 - 1 = 1.80% and stone ash = 2.27%. Values of dry specific gravity, SSD specific gravity, and apparent specific gravity of aggregate 2-3 = 2.73, 2.69, 2.66, 1-2 = 2.72, 2.64, 2.62 0.5- 1 = 2.70, 2.62, 2.58, rock ash = 2, 53, 2.59, 2.69. These values meet the requirements of the 2018 Bina Marga specifications, 2nd revision. The comparison of the results of the field aggregate gradation test analysis with the results of the job mix design analysis is the same because the aggregates tested come from the same stock file. The results of the sieve analysis test showed that the coarse aggregate fineness modulus of 2-3, 1-2, and 0.5 - 1 did not meet the specification standards, while the fine aggregate for stone ash did. The value that does not meet is caused by not paying attention to the additional note that the coarse aggregate retained on the 1" sieve is ±6%.

Keywords: reconstruction; characteristics; job mix design; comparison; additional.

INTRODUCTION

Construction of facilities and infrastructure in Pinrang Regency in recent years has been intensively carried out. Road conditions must be able to create safe conditions for drivers and pedestrians who use the road. The large number of road construction carried out in Pinrang Regency has caused the need for aggregate to also increase. From the results of observations, many road constructions were damaged and did not reach the predetermined design lifespan. One of the contributing factors is that the quality of the aggregate used does not match the specified specifications, which can reduce the quality of the road. To prevent road damage, you can test the quality of the foundation layer aggregate using the Bina Marga method which refers to the Indonesian National Standard (SNI) (Matulessy Nona et al., 2022).

Road pavement material is a mixture of coarse aggregate and fine aggregate as a binder used to serve traffic loads. The materials and materials that form the road surface layer are aggregates as the main material that influences the carrying capacity of the road surface layer. The aggregate used is crushed stone split stone or other materials. The carrying capacity and stability of the road surface layer are determined by the properties, grain shape, and gradation of the aggregate. (Fathurrozi & Sukmawan, 2020). Aggregate is the main component of the road pavement structure, namely 90-95% aggregate based on weight percentage or 75-85% aggregate based on volume percentage. The quality and properties of the aggregate greatly determine the quality of the road pavement in carrying traffic loads. The quality and properties of the aggregate are very important in carrying traffic loads, which if the quality and properties are good, is needed for the surface layer which will directly carry the traffic load and distribute it to the base layer (coarse base). Therefore, the aggregate to be used must be of good quality (Hakzah et al., 2022).

Quality is an important factor that can provide information as a benchmark as to whether the finished goods are as desired. In every road work, material quality control activities are always carried out, in this case, especially class A and class B aggregate materials, whether they meet the specified specification requirements. Several laboratory checks need to be carried out to determine the quality

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of class A aggregate. Material quality tests for class A aggregate foundation layer work on the quality of the foundation layer material in the pile of material in the stock file for the implementation of road pavement work (Fathurrozi & Gorang Sesiliana, 2015).

Reconstruction of the Pinrang - Rappang road section, Pinrang Regency, South Sulawesi Province using flexible pavement construction and only using class A aggregate foundation layers with a two-layer work technique with each layer being 15 cm thick so that the total thickness is 30 cm. So the material that must be used for the class A aggregate foundation layer on the project must really meet the specified specification standards. The problem of carrying out work using materials in the field must be considered by the executor, contractor and supervised by the supervising consultant so that the work results are better in accordance with the standards (Job Mix Design) set by the planning consultant. The aim of this research is to determine the characteristics of the aggregate used to produce the desired road quality according to the 2018 Bina Marga specification standards, 2nd revision.

Flexible pavement is a type of road structure that uses flexible materials so that it can adapt to changes in shape that occur due to traffic loads. In this pavement, the layers of material used work together to distribute the load from the vehicle wheels to the lower layers of the soil. One of the main materials in flexible pavement is asphalt, which has elastic properties that allow this pavement to adapt to changes in the soil conditions below it (Syaiful S, Rusfana H, 2022). On roads with moderate traffic density, flexible pavement is often the choice because the construction costs are relatively lower compared to rigid pavements that use concrete. Roads with moderate traffic usually consist of light to medium vehicles, such as passenger cars and light trucks, so they do not require a pavement structure that is too thick or strong as is required on roads with heavy traffic (Syaiful S et.al, 2022).

The design of flexible pavement on roads with moderate traffic takes into account several factors, such as the type and quality of the material used, the thickness of the layer, and the bearing capacity of the subgrade. The layers used in flexible pavement include the surface course which is usually made of an asphalt mixture, the base course, and the subbase course (Triyanto T et.al, 2020). The surface layer serves to withstand the direct vehicle load and protect the layer below from damage due to weather and water. Meanwhile, the upper and lower foundation layers serve to distribute the vehicle load to the subgrade. The advantages of flexible pavement are its ability to withstand deformation without cracking, as well as ease of maintenance and repair. If damage occurs such as holes or cracks, repairs can be done by patching the damaged part without having to dismantle the entire pavement. However, flexible pavement also has disadvantages, especially in terms of its service life which tends to be shorter than rigid pavement, especially if the traffic load exceeds the specified design capacity (Mubarak M et.al, 2020).

RESEARCH METHODS

The sampling location was at a quarry located in Pinrang Regency. Data collection preparation is a series of activities before starting data collection and processing. In this stage, a plan for activities that will be carried out in the research that needs to be carried out is prepared.

To carry out the research, several stages were carried out, namely: gathering information along with preliminary studies, sampling, preparation for testing, and testing in the laboratory. Data collection techniques are the methods used to collect data, both in the form of primary data (laboratory analysis) and secondary data (Job Mix Design), and then compare them based on SNI standard specifications.

1. Sieve analysis testing (SNI 03-1968-1990 /ASTM C-133-2012)

Sieve analysis is to determine the size of the aggregate, using certain standard sieve sizes indicated by the sieve hole (mm), and to determine its suitability for production. The formula is as follows:

a. Coarse aggregate

Percentage retained (%) = (Weight of retained specimen),(Σ weight of retained specimen) x 100 %

Cumulative percentage (%) = previous cumulative percentage + retained percentage

Pass percentage (%) = 100% - Cumulative Percentage

Fineness modulus (gravel) = (∑Cumulative % retained in No.100 sieve) ,100

b. Fine aggregate

Percentage retained (%) = (Weight of retained specimen)/(Σ weight of retained specimen) x 100%

Cumulative percentage (%) = Previous cumulative percentage + retained percentage

Pass percentage (%) = 100% Cumulative percentage

Fineness modulus (stone ash) = (∑Cumulative % retained in sieve No.100) /100

2. Testing the specific gravity and water absorption of aggregates (SNI 1970-2008)

The specific gravity of the coarse aggregate aims to determine the specific gravity of the aggregate in a saturated state with the surface dry water (SSD) and to determine the percentage of water weight contained (can be absorbed) by the coarse aggregate which is calculated against its dry weight. The formula is as follows:

Dry specific gravity = $\frac{C}{C-B}$

Surface dry weight = $\frac{A}{A-B}$

Apparent specific gravity = $\frac{C}{A-B}$

Absorption = $\frac{A-C}{C}$ x 100%

Information:

A= Weight of SSD test object (gr)

B= Weight of test object in water (gr)

C= Weight of oven dry test object (gr)

3. Coarse aggregate wear/abrasion testing (SNI 03-2417-1991)

Determining the resistance of coarse aggregate to wear using a Los Angeles machine. Wear is the ratio between the weight of the wear material and that passing through the No. sieve. 12 to the original weight in percent. In aggregate wear testing using a Los Angeles machine. The formula is as follows:

Aggregate war = $\frac{A-B}{A}$ x 100%

Information:

A = weight of the original test object (gr)

B = weight of the test object after abrasion (gr)

4. Testing aggregate mud content / sand equivalent (SNI 03-4428-1997)

This inspection is intended to determine the level of dust or mud or materials containing clay in the soil or fine aggregate. The maximum mud content value for fine aggregate is 5%. The percentage of mud content must not exceed the specified specification requirements because the greater the mud content, the greater the surface area of fine aggregate covered by mud. The formula is as follows:

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Sand equivalent = $\frac{(W1-W2)}{W1}$ X 100 %

Information:

W1 = Weight of oven-dry test object before washing (gr)

W2 = Weight of oven-dry test object after washing (gr)

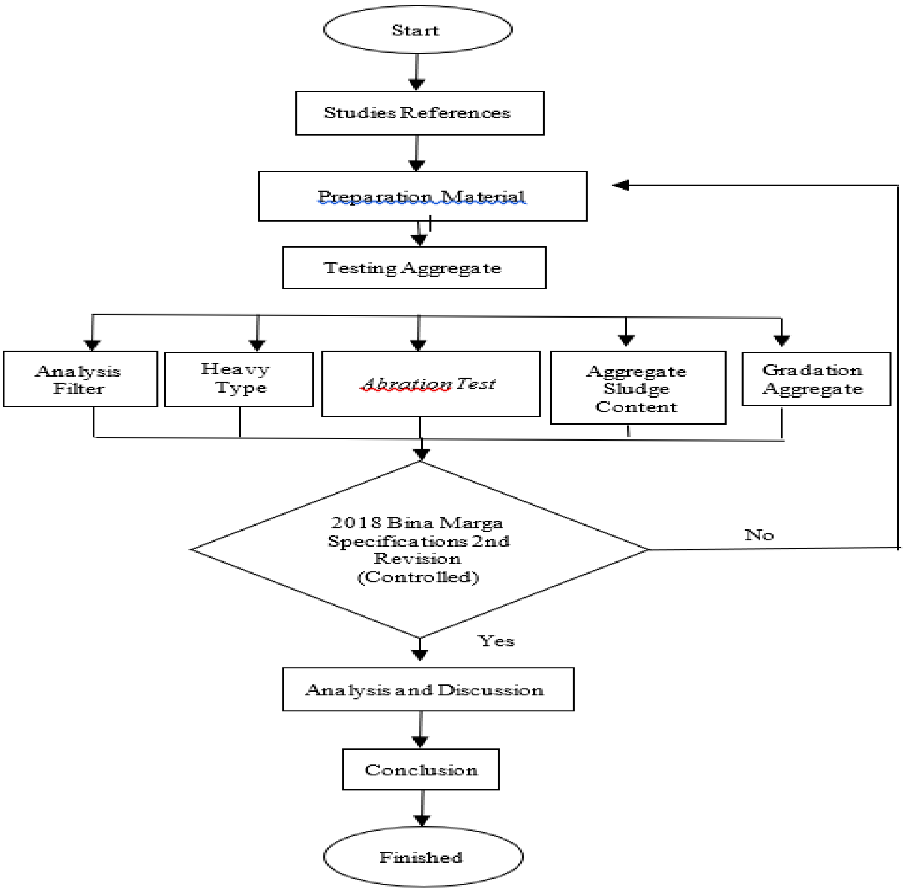

Figure 1. Research flow diagram

RESULT AND DISCUSSION

The test results are presented in several sections, namely (1) Aggregate sieve analysis test results, (2) Specific gravity and water absorption test results, (3) Coarse aggregate wear test results, (4) Sand equivalent test results, (5) Results of comparison of aggregate gradations used in the project with the job mix design by the planning consultant.

Aggregate sieve analysis

Table 1. Results of coarse aggregate sieve analysis

Sieve Hole (mm)	Split 2-3		Split 1-2		Split 0,5 – 1	
	% Restrained	% Passes	% Restrained	% Passes	% Restrained	% Passes
36,1 (1 1/2")	0,00	100,00				
25,1 (1")	30,40	69,6	0,00	100,00		
19,1 (3/4")	53,83	46,175	37,53	62,48		
12,7 (1/2")	94,10	5,9	67,93	32,07	0,00	100,00

9,52 (3/8")	99,675	0,325	91,93	8,07	0,55	99,45
No. 4	100	0	99,10	0,90	55,80	44,20
No. 8			100,00	0,00	85,50	14,50
No. 10					87,75	12,25
No. 16					100,00	0,00
Pan						
Fineness modulus	3,78		3,96		3,29	

Source: Laboratory analysis results

In table 1 the laboratory analysis results show the retained weight for analysis of 2-3 coarse aggregate sieves at #1" = 30.40%, 3/4" sieves = 53.83%, #1/2" = 94.10%, # 3/8" = 99.675%. Aggregate fineness modulus value for split material 2-3 = 3.78%, coarse aggregate 1-2 #3/4" = 37.53%, #1/2" = 67.93%, #3/8" = 91 .93%, #4" = 99.10%. Aggregate fineness modulus value for split material 1-2 = 3.96, coarse aggregate sieve analysis 0.5-1 # 3/8" = 0.55%, #4" = 55.80%, #8" = 85, 50%, #10" = 87.75%. The aggregate fineness modulus value for split material 0.5-1 = 3.29%. These three aggregates do not meet the standard specifications of between 5.5-7.1% (ASTM C-136-2012), a reference to the 2018 Bina Marga specifications, 2nd revision.

Table 2. Results of fine aggregate sieve analysis

Sieve Hole (mm)	Rock ash	
	% Restrained	% Passes
9,52 (3/8")	0,00	100,00
No. 4	1,20	98,80
No. 8	20,80	79,20
No. 10	28,80	71,20
No. 16	36,40	63,60
No. 30	53,30	46,70
No. 40	61,10	38,90
No. 50	72,20	27,80
No. 100	87,50	12,50
No. 200	92,90	7,10
Pan	100,00	0,00
Fineness modulus	3,61	

Source: Laboratory analysis results

In table 2 the laboratory analysis results show the retained weight for fine aggregate sieve analysis (stone ash) #4" = 1.20%, #8" = 20.80%, #10" = 28.80%, #16" = 36 .40 %, #30" = 53.30%, #40" = 61.10%, #50" = 72.20%, #100" = 87.50%, #200" = 92.90%, obtained The aggregate fineness modulus value for stone ash material is 3.61%, meeting the specification standards between 2.84-3.61% (ASTM C-136-2012).

Specific gravity and aggregate water absorption

Table 3. Specific gravity and aggregate absorption

Test type	Aggregate test results				Unit
	2-3	1-2	0.5-1	Rock ash	
Dry specific gravity	2.73	2.72	2.70	2,53	
Surface dry weight	2.69	2.64	2.62	2,59	gram
Apparent specific gravity	2.66	2.59	2.58	2,69	
Absorption	0,87	1.79	1.80	2,27	%

Source: Laboratory analysis results

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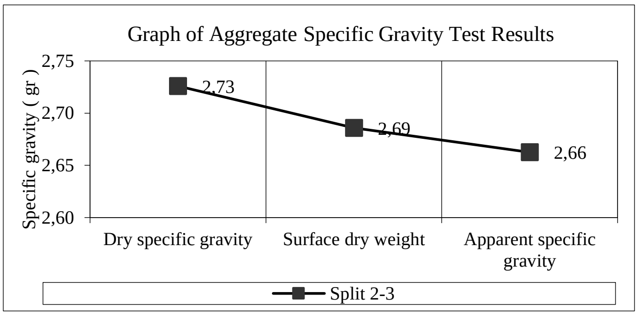

Figure 2. Results of split 2 – 3 specific gravity analysis

Figure 2. Results of split 2 – 3 specific gravity analysis show dry specific gravity (Bulk) 2.73 gr, saturated surface dry weight (SSD) 2.69 gr, apparent specific gravity 2.66 gr and absorption of 0.87% already meet the requirements specified ≤3% in the 2018 Bina Marga specifications, 2nd revision.

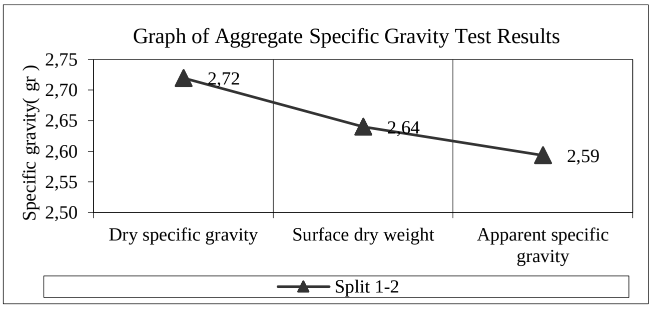

Figure 3. Results of split specific gravity analysis 1 – 2

Figure 3. Results of split 1 – 2 specific gravity analysis show dry specific gravity (Bulk) 2.72 gr, saturated surface dry weight (SSD) 2.64 gr, apparent specific gravity 2.59 gr and absorption of 1.792% which meets the requirements which has been determined to be ≤3 in the 2018 Bina Marga specifications, 2nd revision.

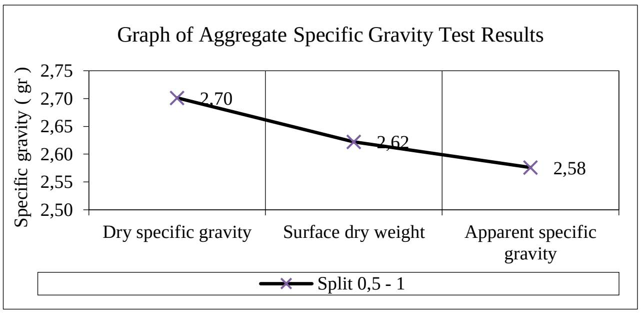

Figure 4. Split specific gravity analysis results 0.5 – 1

Figure 4. Results of analysis of split specific gravity 0.5 – 1 show dry specific gravity (Bulk) 2.70 gr, saturated surface dry weight (SSD) 2.62 gr, apparent specific gravity 2.58 gr and absorption of 1.80 % has met the requirements specified ≤3 in the 2018 Bina Marga specifications, 2nd revision.

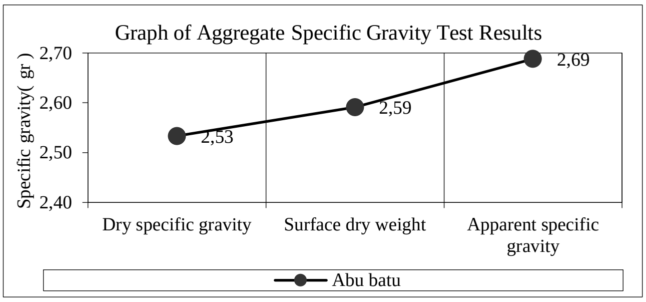

Figure 5. Results of analysis of specific gravity of stone ash

Figure 5. The results of the analysis of the specific gravity of stone ash show that the dry specific gravity (Bulk) is 2.59 gr, the saturated surface dry weight (SSD) is 2.53 gr, the apparent specific gravity is 2.69 gr and the absorption is 2.272%, which meets the stated requirements. specified ≤3% in the 2018 Bina Marga specifications, 2nd revision.

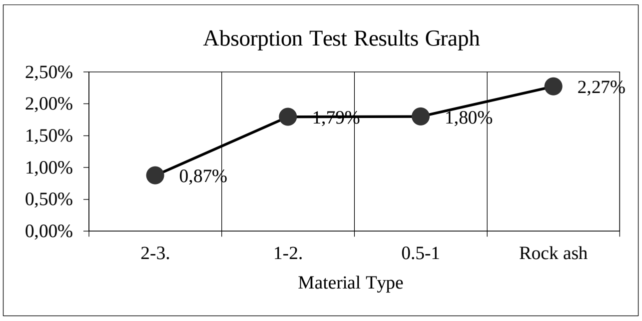

Figure 6. Absorption analysis results

Figure 6. The results of absorption analysis show that material 2-3 is 0.87%, material 1-2 is 1.79%, 0.5-1 is 1.80% and rock ash is 2.27%.

Coarse aggregate wear

Table 4. Coarse aggregate wear test results

Coarse aggregate	Weight before test (gram)	Heavy after test (gram)	Results (%)
Split 2-3	5000	4732	5.36
Split 1-2	5000	4693	6.14

Source: Laboratory analysis results

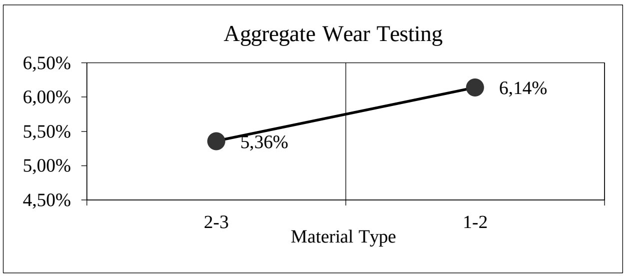

Figure 7. Coarse aggregate wear test graph

Figure 7. The results of the wear (abrasion) analysis show that the abrasion values obtained were 5.36% and 6.14%, meeting the Bina Marga 2018 Revision 2 specifications, a maximum of 8%, this shows that the aggregate is strong and resistant enough not to experience wear or tear. destruction during the mixing, spreading and compaction processes.

Aggregate sludge content / sand equivalent

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Table 5. Results of analysis of aggregate sludge content / sand equivalent

Testing	I	II	III
Clay Reading	10,20	10,40	10,20
Sand Reading	6,60	6,80	6,40
Results (%)	64,71	65,38	64,28
Average		64,28%	

Source: Laboratory analysis results

Table 5. The results of the aggregate mud content / sand equivalent analysis were obtained at 64.28%, meeting the requirements in the 2018 Bina Marga specifications, 2nd Revision (controlled).

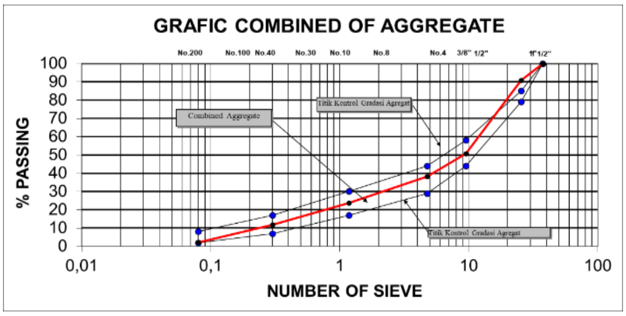
Comparison of aggregate gradations

Aggregate gradation testing results from laboratory analysis to determine the composition of the mixture with a comparison of the results determined by the planning consultant (job mix design).

Table 6. Results of combined gradation analysis of laboratory aggregates

Number of Sieve		1 ½''	1''	¾''	½''	3/8''	No.4	No.8	No.10	No.30	No.40	No.100	No.200
		37,5	25,4	19	12,5	9,5	4,75	2,36	1.18	0,6	0,3	0,15	0,08
Split 2-3	% Pass	100	69,60	69,60	5,90	0,33							
30,00	% Batch	30,00	20,28	20,88	1,77	0,10							
Split 1-2	% Pass	100	100	62,48	32,07	8,07	0,90						
21,00	% Batch	21,00	21,00	13,12	6,73	1,69	0,19						
Split 0,5-1	% Pass	100	100	100	100	99,60	44,20	14,50	12,25				
19,00	% Batch	19,00	19,00	19,00	19,00	18,92	8,40	2,76	2,33				
Rock ash	% Pass	100	100	100	100	100	98,80	71,20	71,20	46,70	38,90	12,50	7,10
30,00	% Batch	30,00	30,00	30,00	30,00	30,00	29,64	21,36	21,36	14,01	11,67	3,75	2,13
Combined aggregate		100	90,88	83,00	57,50	50,72	38,23	26,52	23,69	14,01	11,67	3,75	2,13
Specification		100	79-85	60-80	50-65	44-58	29-44	23-29	17-30	10-23	7-17	3-11	2-8

Source: Laboratory analysis results



Note: Add coarse aggregate retained on the sieve 1" ± 6%.

Figure 8. Graph of laboratory aggregate gradation analysis results

Table 6 and Figure 8. Results of laboratory aggregate gradation analysis show the process of using trial gradation by taking the aggregate composition by trial and error until it meets the appropriate portion for the aggregate mixture. It is known that the results of combining the aggregates for the retained coarse aggregate material #1" need to be added ± 6% to obtain the appropriate composition in the 2018 Bina Marga specifications, 2nd revision.

Table 7. Results of aggregate gradation analysis of job mix design

Number of Sieve		1 ½''	1''	¾''	½''	3/8''	No.4	No.8	No.10	No.30	No.40	No.100	No.200
		37,5	25,4	19	12,5	9,5	4,75	2,36	1.18	0,6	0,3	0,15	0,08
Split 2-3	% Pass	100	69,8	42,23	5,50	0,10							
30,00	% Batch	30,00	20,99	13,87	1,65	0,03							
Split 1-2	% Pass	100	100	61,48	4,53	0,30	0,25						
21,00	% Batch	21,00	21,00	12,91	0,95	0,06	0,05						
Split 0,5-1	% Pass	100	100	100	100	99,60	44,20	14,50	12,25				
19,00	% Batch	19,00	19,00	19,00	19,00	18,91	1,53	0,08	0,04				
Rock ash	% Pass	100	100	100	100	100	98,80	71,20	71,20	46,70	38,90	12,50	7,10
30,00	% Batch	30,00	30,00	30,00	30,00	30,00	29,76	23,55	22,02	12,84	10,41	3,45	1,98
Combined aggregate		100	90,99	75,78	51,60	49,01	31,34	26,63	22,06	12,84	10,41	3,45	1,98

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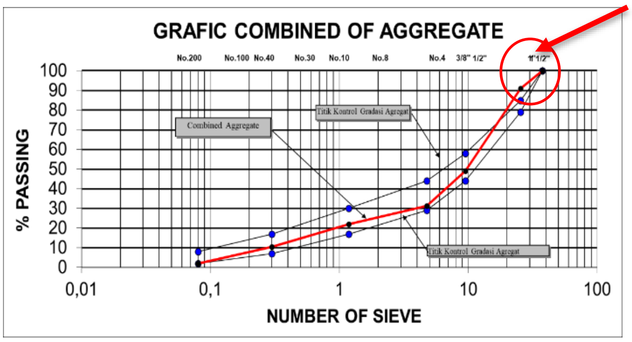
Specification	100	79-85	60-80	50-65	44-58	29-44	23-29	17-30	10-23	7-17	3-11	2-8

Source: Job mix design planning consultant



Note: Add coarse aggregate retained on the sieve 1" ± 6%.

Figure 9. Graph of aggregate gradation analysis results of job mix design

Table 7 and Figure 9. The results of the aggregate gradation analysis of job mix design planning consultants show the process of using trial gradation by taking the aggregate composition by trial and error until it meets the appropriate portion for the aggregate mixture. From the results of combining the aggregates, it is known that the coarse aggregate material retained in the 1" sieve needs to be added ± 6% to obtain the appropriate composition in the 2018 Bina Marga specifications, 2nd revision.

The results of the aggregate gradation composition analysis obtained from the laboratory with the planning consultant's job mix design are the same because the test objects or aggregates tested come from the same stock file, however, the job mix design gradation contains a note, namely adding the coarse aggregate retained in sieve no. 1 " ± 6% which is actually very important for the implementing party to pay attention to, in this case the contractor and supervising consultant, to be implemented in the field as a requirement so that the composition of the aggregate gradation mixture used can meet the requirements or provisions in the 2018 Bina Marga specifications, 2nd revision (controlled) and as determined by the planning consultant (job mix design).

CONCLUSION

Based on the results of laboratory test analysis, it show that the aggregate gradation used in the field has the same results as the job mix design aggregate gradation composition determined by the planning consultant because the aggregate material used is sourced from the same stock file. However, the notes that should have been taken into account in the field by contractors and field supervisory consultants regarding the addition of 1" coarse aggregate of ± 6% (figure 9) were not carried out. This indicates that the job mix design requirements are not being respected so that the coarse aggregate gradation in the 1" sieve does not meet the specification requirements which can reduce the quality of the construction which results in the road construction being quickly damaged or not lasting as long as the planned life.

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