The Effect of Fineness Modulus of Fine Aggregate (sand) on Concrete Compressive Strength

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Abstract- Concrete is a buildings material made from a mixture of cement, sand, broken stone or gravel, and water. The fineness modulus is one of the physical properties of fine aggregates (sand). The Fineness Modulus (FM) of fine aggregates (sand) is an empirical figure obtained by adding the total percentage of the sample of a sand retained on each of a specified series of sieves and dividing the sum by 100. The fineness modulus of sand differs for each sand quarry. The purpose of this research is to analyze the effect of fineness modulus of fine aggregate (sand) on concrete compressive strength. The sand quarry taken in this study are from three sand quarry in Aceh Tamiang District. They are Johar quarry, Tanjung Karang quarry, and Alur Bamban quarry. The specimens of concrete used in the form of the cube measuring 150x150x150 mm amounted to 36 specimens. The compressive strength of concrete (fc') required is 21 MPa or K-250 with w/c ration 0.5. Concrete mix design using American Concrete Institute (ACI) method. The results showed that the fineness modulus of sand strongly influence the compressive strength of concrete. The classification of sand type is differentiated based on the results of fineness modulus test on each sand quarry. Sand fineness modulus (FM) of Johar quarry is 3.66 called medium sand (zone 2). Sand fineness modulus of Tanjung Karang quarry is 3.15 called mild sand (zone 3). And, Sand fineness modulus of Alur Bamban quarry is 2.52 called fine sand (zone 4). concrete compressive strength test results on johar quarry specimen is 21.1 MPa, tanjung karang quarry specimen is 22.1 MPa, and Alur Bamban quarry specimen is 21.5 MPa. Sand fineness modulus does not affect the concrete compressive strenght. The best classification of fine aggregate to increse concrete compressive strenght is mild sand (Tanjung Karang quarry).

Keyword: concrete, sand fineness modulus, ACI, compressive strength

I. INTRODUCTION

Concrete is a buildings material made from a mixture of cement, sand, broken stone or gravel, and water. Sand is one component of concrete mixing. The sand used for construction works in Langsa City area is taken from the quarry in Aceh Tamiang district. There are three quarry most used in Aceh Tamiang District, namely Johar quarry, Tanjung Karang quarry, and Alur Bamban quarry.

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. Usually commercial sand is obtained from river beds or from sand dunes originally formed by the action of winds. The usual particle size of sand grains is between 0.075 mm to 4.75 mm with further subdivision of coarse sand in range of 2 mm to 4.75

mm, medium sand in range of 0.42 mm to 2 mm and fine sand in between 0.075 mm to 0.42 mm [1].

The Fineness Modulus (FM) of fine aggregates (sand) is an empirical figure obtained by adding the total percentage of the sample of a sand retained on each of a specified series of sieves, and dividing the sum by 100. SNI-T-15-1990-03 divides 4 types of sand, i.e. coarse sand, middle sand, mild sand, and fine sand. The knowledge about the fresh and hardened properties of concrete is fundamental to ensure a good performance of buildings. The sieve analysis will show the smooth modulus of sand and gravel. The sieve anlysis of sand can be use for concrete and cement mortar. the studied dune sands are found to exhibit properties similar to aeolian sands from Kuwait, Saudi Arabia, Oman, Algeria, Australia and China. Dune sands can be used as fine aggregates in cement mortar mixtures whenever suitable sand materials are not economically available [2].

Fuller and Thompson first evaluated the significance of aggregate gradation in concrete proportioning in 1908 [3]. They developed an ideal gradation curve based on maximum density. Talbot and Richart conducted further advancement on aggregate gradation based on density in 1923 [4]. Subsequently, several other aggregate gradation concepts evolved including optimizing surface area, fineness modulus, minimizing particle interference and others. Modern concepts pertaining to aggregate gradation that have recently evolved include Shilstone method of workability and coarseness charts [5].

Donza et al. conducted research on high strength concrete with different fine aggregates and found that concrete with crushed stone sand results in higher strength than the corresponding natural sand concrete at all test ages. They also concluded that the shape and texture of crushed sand particles have an important effect on the interlocking of paste and aggregate particles, leading to an improvement of strength of concrete [6].

Divya Haritha and her team evaluated the use of crushed rock as fine aggregate in high strength concrete in comparison to the natural fine aggregate and concluded that the crushed rock as fine aggregate gives improved compressive strength of concrete. The split tensile strength of concrete also increases when fine aggregate is completely replaced with crushed rock [7].

The purpose of this research is to analyze the effect of fineness modulus of fine aggregate (sand) on concrete compressive strength.

Limitations of the problem in this study can be as follows:

a) The fine aggregate used comes from Johar quarry, Tanjung Karang quarry, and Alur Bamban quarry
b) Concrete mixing method using American Concrete Institute (ACI).
c) Concrete compressive strength performed at 7, 14, 21 and 28 days with the quality of concrete plan that is 21 MPa or K-250 with water cement factor 0.5
d) Coarse Aggregate used comes from Kuala Simpang, Aceh Tamiang District

II. DISCUSSION

Data collection is an influential and indispensable factor for determining compressive strength of concrete. In this study the required data were obtained from laboratory experiment.

The materials used are: Portland cement Type I, Coarse aggregate taken from Kuala Simpang quarry, fine aggregate taken from three quarry (Johar quarry, Tanjung Karang quarry, and Alur Bamban quarry), and clean water.

Table 1. Clasification of Fine Aggregate based on SNI-T-15-1990-03

Sieve Size (mm)	% Passing For			
	Grading Zone 1	Grading Zone 2	Grading Zone 3	Grading Zone 4
9,52	100	100	100	100
4,76	90-100	90-100	90-100	95-100
2,4	60-95	75-100	85-100	95-100
1,1	30-70	55-90	75-100	90-100
0,6	15-34	35-59	60-79	80-100
0,3	5-20	8-30	12-40	15-50
0,15	0-10	0-10	0-10	0-15
pan	0	0	0	0
Clasified	**Coarse Sand**	**Medium Sand**	**Mild Sand**	**Fine Sand**

Tests conducted in the form of sieve analysis test based on SNI 03-1968-1990 [8], testing of specific gravity and aggregate absorption base on SNI 03-1970-1990 [9], testing of moisture content, aggregate content weight testing SNI 03-4804-1998 [10], and mud (washing sand through sieve No. 200).

The test results of the sieve analysis of sand from the Johar quarry can be seen in table 2.

Table 2. Sieve Analysis of Johar Quarry

Sieve Size (mm)	Weight Retained (gr) sample 1	sample 2	mean	% Retained	% Total Retained	% Passing	Limits of Zone 2
9,52	0	0	0,00	0,00	0,00	100,00	100
4,76	7,15	7	7,08	0,71	0,71	99,29	90 - 100
2,4	59	74	66,50	6,65	7,36	92,64	75 - 100
1,1	125	135	130,00	13,00	20,36	79,64	55 - 90
0,6	361	349	355,00	35,50	55,86	44,14	35 - 59
0,3	280	282	281,00	28,10	83,96	16,04	8 - 30
0,15	150	135	142,50	14,25	98,21	1,79	0 - 10
pan	17,85	18	17,93	1,79	100,00	0,00	0
Total	**1000**	**1000**	**1000**		**366,45**		

The results of sieve analysis test show that the sand derived from Johar quarry is a category of medium sand (zone 2). This can be seen in Figure 1.

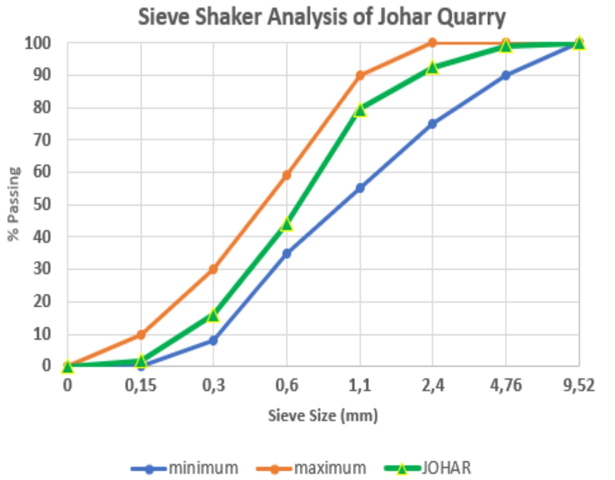

Figure 1. Graph Sieve Analysis of Johar Quarry

Fineness modulus of johar quarry is:

$$FM = \frac{\text{Total \% passing}}{100} = \frac{366{,}45}{100} = 3{,}67$$

The test results of the sieve analysis of sand from the Tanjung Karang quarry can be seen in table 3. The results of sieve analysis test show that the sand derived from Tanjung Karang quarry is a category of mild sand (zone 3). This can be seen in Figure 2.

Table 3. Sieve Analysis of Tanjung Karang Quarry

Sieve Size (mm)	Weight Retained (gr) sample 1	sample 2	mean	% Retained	% Total Retained	% Passing	Limits of Zone 3
9,52	0	0	0,00	0,00	0,00	100,00	100
4,76	2,64	2,4	2,52	0,25	0,25	99,75	90 - 100
2,4	31,35	31,63	31,49	3,15	3,40	96,60	85 - 100
1,1	64,7	62	63,35	6,34	9,74	90,26	75 - 100
0,6	277	269	273,00	27,30	37,04	62,96	60 - 79
0,3	330	337	333,50	33,35	70,39	29,61	12 - 40
0,15	238	234	236,00	23,60	93,99	6,01	0 - 10
pan	56,31	63,97	60,14	6,01	100,00	0,00	0
Total	**1000**	**1000**	**1000**		**314,80**		

Fineness modulus of tanjung karang quarry is:

$$FM = \frac{\text{Total \% Passing}}{100} = \frac{314{,}80}{100} = 3{,}15$$

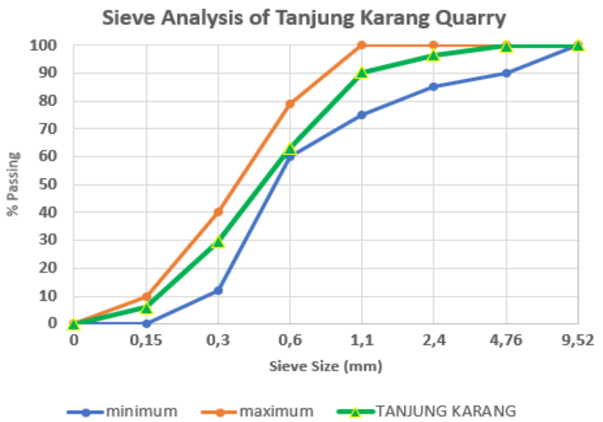

Figure 2. Graph Sieve Analysis of Tanjung Karang Quarry

The test results of the sieve analysis of sand from the Alur Bamban quarry can be seen in table 4. The results of sieve analysis test show that the sand derived from Alur Bamban quarry is a category of fine sand (zone 4). This can be seen in Figure 3.

Table 4. Sieve Analysis of Alur Bamban Quarry

Sieve Size (mm)	Weight Retained (gr) sample 1	sample 2	mean	% Retained	% Total Retained	% Passing	Limits of Zone 4
9,52	0	0	0,00	0,00	0,00	100,00	100
4,76	2,58	2,36	2,47	0,25	0,25	99,75	95 - 100
2,4	5,6	6,96	6,28	0,63	0,88	99,13	95 - 100
1,1	11,36	11	11,18	1,12	1,99	98,01	90 - 100
0,6	86	69	77,50	7,75	9,74	90,26	80 - 100
0,3	409	416	412,50	41,25	50,99	49,01	15 - 50
0,15	378	373	375,50	37,55	88,54	11,46	0 - 15
pan	107,46	121,68	114,57	11,46	100,00	0,00	0
Total	**1000**	**1000**	**1000**		**252,39**		

Fineness modulus of alur bamban quarry is:

$$FM = \frac{\text{Total \% Passing}}{100} = \frac{252{,}39}{100} = 2{,}52$$

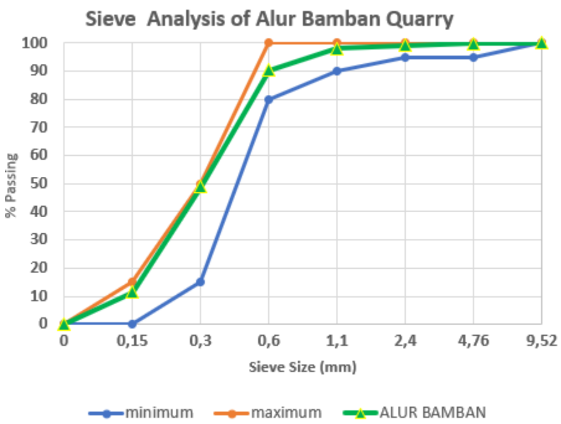

Figure 3. Graph Sieve Analysis of Alur Bamban Quarry

Test results of 3 types of sand it can be concluded that the largest Fineness Modulus (FM) value obtained in the sand from the johar quarry is 3.66. The comparison of each test result can be seen in figure 4.

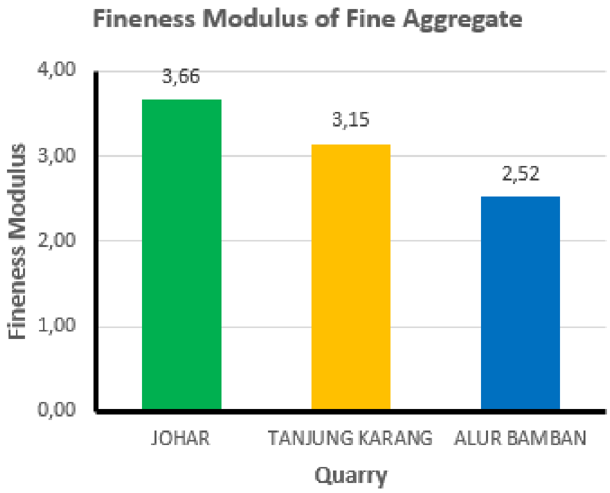

Figure 4. Graph Fineness Modulus of Fine Aggregate

The test results of the sieve analysis of coarse aggregate can be seen in table 5 and Figure 5.

Table 5. Sieve Analysis of Coarse Aggregate

Sieve Size	Weight Retained (gr) sample 1	sample 2	mean	% Retained	% Total Retained	% Passing	Limits
25,4	0	0	0,00	0,00	0,00	100,00	100
19,1	24	21	22,50	2,25	2,25	97,75	95 - 100
9,52	500	492	496,00	49,60	51,85	48,15	25 - 55
4,76	469	479	474,00	47,40	99,25	0,75	0 - 10
2,38	7	8	7,50	0,75	100,00	0,00	0 - 0
1,19	0	0	0,00	0,00	100,00	0,00	0 - 0
pan	0	0	0,00	0,00	100,00	0,00	0
Total	**1000**	**1000**	**1000**		**453,35**		

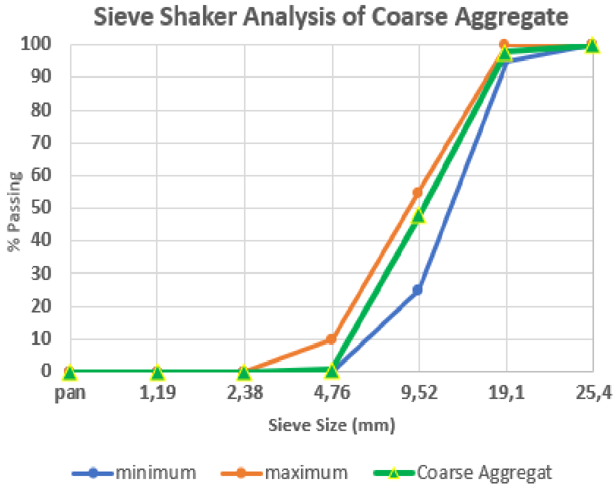

Figure 5. Graph Sieve Analysis of Coarse Aggregate

Concrete mixing method used in this research is American Concrete Institute Method (ACI). planned concrete strength of 21 MPa or K-250, with w/c factor of 0.5.

Preparation of the planned test object is the cube with the size of 15 cm x 15 cm x 15 cm as much as 36 pieces of concrete cube with four stages of testing, namely the concrete age 7, 14, 21, and 28 days. Total specimens of cubes can be seen in Table 6. Concrete mix design of each materials can be seen in Table 7.

Table 6. The specimens 150x150x150 mm cubes were used for the compression test

No	*Quarry*	Cube concrete specimens (days) 7	14	21	28	Total
1	Johar	3	3	3	3	12
2	Tanjung Karang	3	3	3	3	12
3	Alue Bamban	3	3	3	3	12
					Total	36

Table 7. Concrete Mix Design base on ACI

Quarry	Water (Liter)	PC (kg)	Sand (kg)	Stone Crash (kg)
Johar	195	374,8	721,35	1094
Tanjung Karang	195	374,8	702,12	1136
Alur Bamban	195	374,8	622,93	1136

The specimens 150x150x150 mm cubes were used for the compression test. Three specimens were tested for the required age and mean value was taken. The calculation of concrete conpressive strength can be seen in Table 8.

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Table 8. Calculation of Concrete Compressive Strength

Quarry	Days	Weight (kg)	Force (ton)	Compressive Strength kg/cm^2	Compressive Strength MPa	Mean (MPa)
Johar	7	8,13	38	168,9	14,0	14,9
	7	8,143	43	191,1	15,9	
	7	8,034	40	177,8	14,8	
	14	8,143	46	204,4	17,0	16,4
	14	8,13	43	191,1	15,9	
	14	8,1	44	195,6	16,2	
	21	8,164	51	226,7	18,8	18,4
	21	8,169	47	208,9	17,3	
	21	8,279	52	231,1	19,2	
	28	8,235	57	253,3	21,0	21,1
	28	8,36	59	262,2	21,8	
	28	8,06	56	248,9	20,7	
Tanjung Karang	7	8,345	39	173,3	14,4	15,9
	7	8,154	46	204,4	17,0	
	7	8,254	44	195,6	16,2	
	14	8,118	47	208,9	17,3	17,2
	14	8,136	49	217,8	18,1	
	14	8,077	44	195,6	16,2	
	21	8,133	51	226,7	18,8	18,8
	21	8,18	53	235,6	19,6	
	21	8,002	49	217,8	18,1	
	28	8,025	63	280,0	23,2	22,1
	28	8,089	57	253,3	21,0	
	28	8,268	60	266,7	22,1	
Alur Bamban	7	7,89	44	195,6	16,2	14,9
	7	7,02	37	164,4	13,6	
	7	7,01	40	177,8	14,8	
	14	8,02	47	208,9	17,3	16,8
	14	8,047	44	195,6	16,2	
	14	8,153	46	204,4	17,0	
	21	8,019	52	231,1	19,2	18,6
	21	8,163	48	213,3	17,7	
	21	8,073	51	226,7	18,8	
	28	8,035	64	284,4	23,6	21,5
	28	8,197	53	235,6	19,6	
	28	8,197	58	257,8	21,4	

Figure 6. Sample of concrete variation

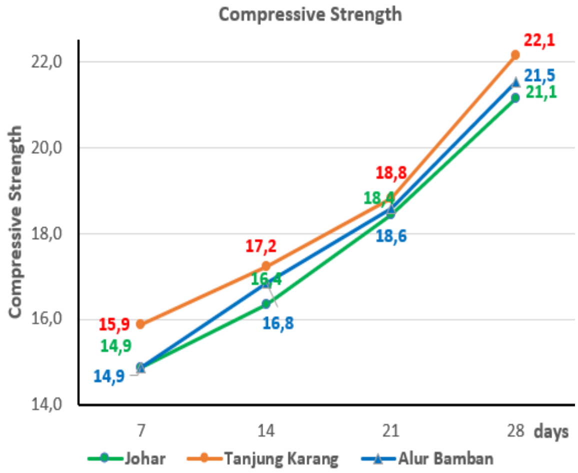

Figure 7. Graph Compressive Strength

III. CONCLUSSIONS

1) Sand fineness modulus (FM) of Johar quarry is 3.66 called medium sand. Sand fineness modulus of Tanjung Karang quarry is 3.15 called mild sand. And, Sand fineness modulus of Alur Bamban quarry is 2.52 called fine sand.

2) The concrete compressive strength test results on johar quarry specimen is 21.1 MPa, tanjung karang quarry specimen is 22.1 MPa, and Alur Bamban quarry specimen is 21.5 MPa. Sand fineness modulus does not affect the concrete compressive strenght. The best classification of fine aggregate to increse concrete compressive strenght is mild sand (Tanjung Karang quarry).

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