



# THE CHARACTERISTIC OF SAND FROM THE ERUPTION OF MOUNT KELUD AND ITS EFFECT TO CONCRETE COMPRESSIVE STRENGTH

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## ABSTRACT

People living around the volcano utilize material from the eruption of mount Kelud to rehabilitate buildings that have been damaged by the eruption of the volcano. They believe that such material is good as aggregate substitute for fine aggregate, without knowing the effect of the use of these materials. The study aimed to examine the physical characteristics of the sand from the eruption of Mount Kelud in early 2014 and its effects in normal concrete compressive strength. The sand of Mount Kelud were obtained from Ngantang, Kediri, Indonesia. The experimental study of physical properties of sand from mount Kelud's eruption include: density, absorption, moisture content and gradation of sand, using a standard test ASTM C 128 and ASTM C 117. Concrete mix design and the method of testing the compressive strength of the sample were using ACI method. Test results of the characteristics of the sand from the eruption of mount Kelud obtained SSD density of sand: 2.68 gr/ cm<sup>3</sup> (as most of the natural sand). Absorption, moisture content and modulus fineness Kelud sands are in the range that was ideal specified in ASTM C33, which was 2.17 % ; 2.167 % and 1.52. A combination of 20 % sand of Kelud with 80 % sand of Karawang can increase the compressive strength of concrete by 15 % at the age of 3 days, compared to concrete without sand of Kelud, but in general the use of sand of Kelud caused a decline in the compressive strength of concrete.

**Keywords:** sand of kelud, characteristics, compressive strength of concrete.

## 1. INTRODUCTION

Mountain Kelud eruption in early 2014 spread around 150 million cubic meters solid material that spread to areas around the mountain. These materials are now widely used by the locals to rehabilitate damages caused by the eruption. They believe that these materials are good aggregate substitutes to local aggregate and cement. This condition conducted by people in Kediri and Ngantang, which are two areas located fairly close to Mountain Kelud.

A preliminary study conducted by UMY team [2], they resulted the compressive strength of concrete of 150 kg/cm<sup>2</sup> for the replacement of cement usage up to 10% by fly ash from mount Kelud. Another assessment conducted by another team from UMY also showed the acidity of 5,5 (pH) in mountain Kelud's volcanic ash from one of the affected location. This number was inconvenient for the use of concrete production.

Study conducted by Hossain, KMA. [3] recommends that the use of cement replacement up to 20% of fly ash gives the results of concrete compressive strength up to 60 MPa.

Of the three studies above illustrate that the research material volcanic eruptions are still limited to the volcanic ash. Whereas at a distance closer to the center of the eruption of Mount Kelud like Kediri and regions Ngantang (Malang) was dominated by materials such as sand eruption classified as fine aggregate which could be used widely in the construction world.

The effect of the use of this sand on the characteristics of normal concrete is a challenging thing to be studied.

## 2. LITERATURE REVIEW

### Normal concrete

Concrete was a material structure of the process of mixing cement, sand, gravel, water and the added material (admixture or additive if necessary) with a specific composition.

Actually, concrete was a complex material. But, nevertheless still made by people who do not have sufficient knowledge of concrete technology, so that the resulting poor quality of the concrete, at the same price with concrete produced by individuals or entities that have knowledge of concrete technology.

Nawy, EG [8] defines: Concrete was a set of mechanical and chemical interactions of the constituent material. It means that there are two kinds of processes that occur in these concrete admixtures, the process of physical and chemical processes. Results of the physical processes in the concrete will be good, or produce concrete with good performance, if the material used, also had a good performance as well as the exact composition of the material as well. In terms of the characteristics of each material making up the concrete mix determines the performance of concrete produced.

Concrete performance can be obtained from:

- Workability, include consistency, segregation, bleeding, etc.
- Strength: tensile strength or compressive strength.
- Durability.

Consistency is considered a close indication of workability. Increased consistency could be made by adding water to the concrete mixtures. However, the method was inversely proportional to the strength of the



concrete. But by adding admixtures were easily obtained today, increasing consistency could be done without the addition of water so it did not reduce the strength of concrete.

In terms of durability, according to [5] a reduction in the water content will bring about a corresponding reduction in the cement content at a given value of strength, which in turn, will reduce thermal contraction, autogenously shrinkage, and drying shrinkage of concrete. In addition, the concrete-forming material which were water, aggregate and cement and admixture must meet the maximum content of chloride ions as efforts to protect the reinforcement from corrosion.

In general, the compressive strength was a key performance observed in the manufacture of concrete, but in practice, the determination was considered depending on the intended use of the concrete at the time. Normal concrete was concrete with compressive strength between 20-40 Mpa [8]. Normal concrete was commonly found daily on the construction of the building.

### Materials for concrete

Portland cements are hydraulic cements composed primarily of hydraulic calcium silicates. Hydraulic cements set and harden by reacting chemically with water. During this reaction, called hydration, cement combines with water to form a stonelike mass, called paste. When the paste (cement and water) is added to aggregates (sand and gravel, crushed stone, or other granular material) it acts as an adhesive and binds the aggregates together to form concrete, the world's most versatile and most widely used construction material. A type 1 Ordinary Portland Cement was used as the binder through out this experimental programme.

Aggregates occupy the highest number in the process of making concrete mixture. Aggregates generally occupy 60%-75% of the concrete volume [4], or 70% to 85% by mass.

Aggregates concrete forming consists of two kinds, namely:

- Coarse aggregates consist of one or a combination of gravels or crushed stone with particles predominantly larger than 5 mm. These aggregates were quite determining the characteristics of the concrete produced, because there are quite a lot, which was about 31% up to 51% of the total weight of the concrete mix.
- The fine aggregates (sand), which serves as a filler empty cavity.

Because the aggregates are the ones most widely used as concrete forming, then in order to obtain concrete with high performance and cheaply as possible should be used materials with good characteristic too. Clean Crush stone was used in this experimental study.

ASTM, Britwash Standard, ACI and SNI 2847-2013 was a reference that could be used to test and investigate the characteristics requirement of aggregates. In addition, these standards also limit the value of the

characteristics that qualify in order to obtain a desired concrete performance. Subsequently, based on the values that have been obtained aggregates characteristics, can be designed concrete mix proportions for the desired performance by ACI or standards applicable.

Because coarse aggregate occupies the highest number in the concrete mix, the strong and unbreakable coarse aggregate would result in a strong concrete. The strength of the aggregate could be tested by Los Angeles equipment.

For optimum engineering use, aggregates must conform to certain standards: they must be clean, hard, strong, durable particles free of absorbed chemicals, coatings of clay, and other fine materials in amounts that could affect hydration and bond of the cement paste.

Although the fine aggregate (sand) more function as filler cavities, but from the results of a survey conducted by ASTM to 27 respondents, stated that the fine aggregate rank to 2 that much of an effect on the performance of concrete after the cement, so that the characteristics of fine aggregate needed concern. Natural fine aggregate from Karawang was used in this experiment. Some fine aggregate following characteristics, need to be tested and must meet ASTM standards in order to obtain the desired performance of concrete, there are :

- Gradation of aggregate and fineness modulus.
- Relative density (Specific gravity) and bulk density (unit weight)..
- Water absorption and surface moisture.
- The mud content.

### Material of Kelud eruption

Mountain Kelud spewed material in the form of ash, volcanic sand and gravel as shown in Figure-1 below.



**Figure-1.** Sand volcanic area 3 km from the summit of mount Kelud (Source: [7])

According to Bernard and Border, 1997 in [5], the chemical composition of the material from the eruption Kelud is presented in Figure-2 below.



	1	2	3	4	5
SiO <sub>2</sub>	55.19	56.15	56.06	55.24	55.05
TiO <sub>2</sub>	0.58	0.57	0.58	0.62	0.62
Al <sub>2</sub> O <sub>3</sub>	18.2	18.28	18.48	18.7	18.5
Fe <sub>2</sub> O <sub>3</sub>	7.51	6.46	8.23	8.71	8.84
MnO	0.17	0.16	0.2	0.2	0.21
MgO	3.85	3.43	3.94	3.5	3.74
CaO	8.86	8.48	9.15	9.09	9.2
Na <sub>2</sub> O	2.42	2.39	3.3	3.11	3.05
K <sub>2</sub> O	0.57	0.59	0.53	0.83	0.79
P <sub>2</sub> O <sub>5</sub>	0.08	0.07	0.08	-	-
L. I.	1.73	2.7	0.16	0.08	0.26

1 and 2: pre-1990 eruptions, 3 and 4: 1990 pumice and 5: 1990 scoria.  
1-3 from Bernard (unpublished), 4-5 from Bourdier et al. (1997).

**Figure-2.** Chemical composition of Mount Kelud eruption product.

From Figure-2 above, it appears that from some of the research data material from the eruption Kelud in 1990 pertained pozzolan material, where the highest substance contained by the material was silica (SiO<sub>2</sub>), an average of 55.54%, then alumina (Al<sub>2</sub>O<sub>3</sub>) by an average of 18.43%. Both of these substances are classified as active [9], whereby if the silica reacts with free lime (Ca (OH) 2) were left out of the hydration reaction of cement and water produces calcium silica hydrate that was hard.

### 3. MATERIAL AND METHODS

#### Experimental program

The implementation of the study consisted of 3 groups:

- I. Material properties test.
- II. Concrete mixtures and specimen preparation.
- III. Specimen test.

For fine aggregate, it was planned characteristic tests as follows:

- Gradation of aggregate and fineness modulus.
- Relative density (Specific gravity) and bulk density (unit weight).
- Water absorption and surface moisture.
- The mud content

Based on the results of testing the material characteristics of concrete in stage I above, mix design made by using the method of ACI (American Concrete Institute) for normal concrete targets with strength 30 Mpa.

Mix Design was intended to get the mix proportions of each ingredient constituent of concrete (coarse aggregate, fine aggregate, cement and water) which was optimal in order to obtain concrete strength maximum cost of the least expensive, considering the cement was the most expensive ingredient of all components of the concrete.

The ACI Standard 211.1 was used to design the proportion of concrete mixture, because, this method has been commonly used in the construction world and closer to reach the targeted of optimum strength result.

Subsequently, four groups concrete mixes and specimen were, namely:

- Group O, a mixture of concrete without sand Kelud (0%)
- Group A, the concrete mix with sand Kelud percentage of 10% of the total weight of fine aggregate needs.
- Group B, the concrete mix with sand Kelud percentage of 20% of the total weight of fine aggregate needs.
- Group C, the concrete mix with sand Kelud percentage of 40% of the total weight of fine aggregate needs.

For each of these mixed groups, there were made 9 cuboid specimens with a size of 15 cm x 15 cm x 15 cm, which consists of 3 specimen for testing the concrete 3 days, 3 specimen for testing the concrete 7 days and 3 specimen for testing concrete age of 28 days, bringing the total number of specimens to be created was 36 pieces.

The proportion of the concrete mix should produce normal concrete qualified in terms of:

- Consistency, the concrete should be workable.
- The strength requires for construction. SNI 03-2847-2002 requires for  $f'_c$  to be at least 17.5 MPa for normal concrete. This study use  $f'_c$  30 Mpa as a target strength.
- Durability.

Considering the limited funds available, the research is not yet assess the durability of concrete using sand Kelud.

The next step is to test the specimen:

1. Unit weight of concrete.
2. The compressive strength of concrete.

For more details, flowchart in Figure-3. below illustrates the workflow research below,

#### Aggregates

In this study, the use of coarse aggregate such as crushed stone (split) obtained from stores material in Joglo Jl Raya, West Jakarta. Results of testing physical properties of coarse aggregate in general can meet the necessary requirements. SSD coarse aggregate specific gravity of 2.63 g/cm<sup>3</sup>. coarse aggregate water absorption of 1.22%, unit weight of 1.457 g/cm<sup>3</sup>, meet the minimum requirements specified weight of ASTM C.33 ie 1.2 gr/cm<sup>3</sup>.

There were two kinds of fine aggregates (sand) used in this study,

1. Sand Karawang (as the main fine aggregate)
2. Sand from the eruption of Mount Kelud.

Sand Karawang was the sand that came from Karawang, and obtained from a hardware store on Jl. Joglo Raya, West Jakarta. While the sand of mount Kelud was the sand that came from the result of Mount Kelud eruption in early 2014 and taken from the area of Ngantang, Malang district, with uniform gradation as shown in Figure-4 As follows.

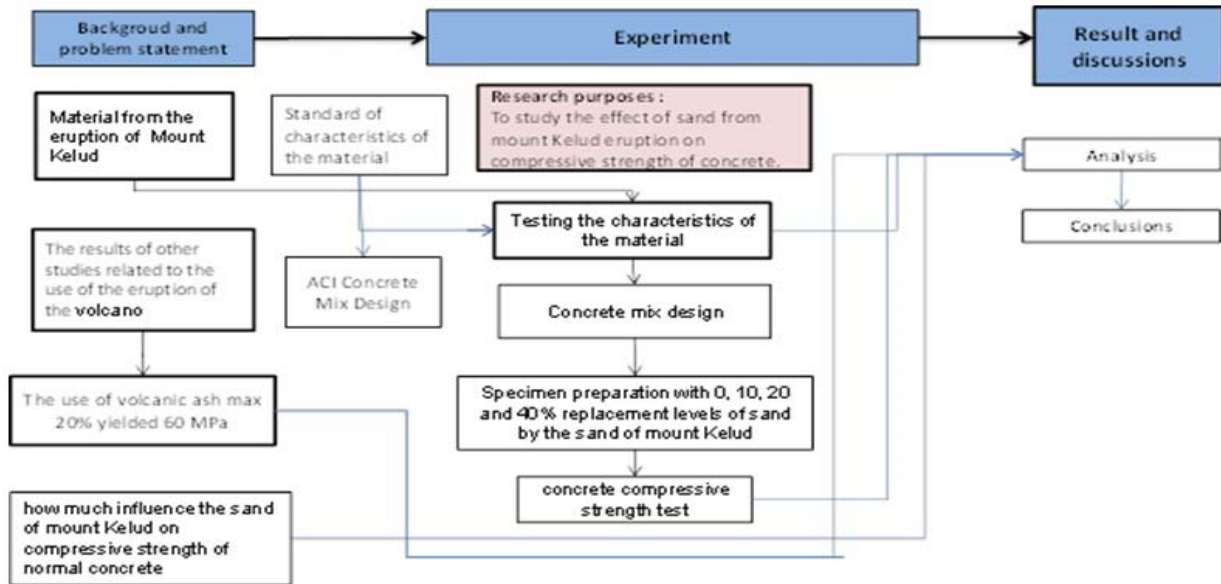


Figure-3. Research flow chart.



Figure-4. Sand of Mount Kelud and sand Karawang.

Testing the characteristics of fine aggregate in the material laboratory of Mercu Buana University obtained the results as shown in Table-1, 2, 3, 4 as follows,

Table-1. Test results of fine aggregate (sand) Karawang.

No	Characteristic test	Test designation	Result	Requirement
1	Density & Absorption	ASTM C128		Max 4
	➤ Unit weight (Bulk) – (gr/cm <sup>3</sup> )		2.49	
	➤ Specific gravity (SSD) – (gr/cm <sup>3</sup> )		2.56	
	➤ Absorption (%)		2.9	
	➤ Surface moisture (%)		2.9	
2	Sieve analysis : ➤ Fineness Modulus (FM) (%)	ASTM C128	2.86	2.3-3.2
3	Agregate constituents: The amount of material finer then No. 200 sieve.	ASTM C117	10.13%	ASTM C.33 : max 5%

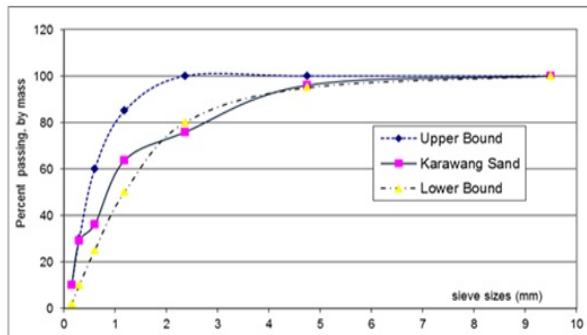
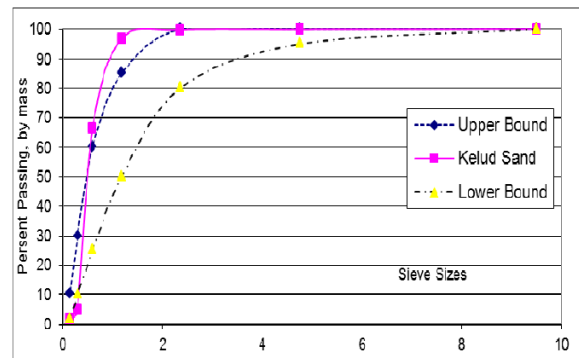
**Table-2.** Test results of fine aggregate (sand) of Mount Kelud.

No	Characteristic test	Test designation	Result	Requirement
1	Density & Absorption	ASTM C128		Max 4
	Unit weight (Bulk) – (gr/cm <sup>3</sup> )		2.62	
	Specific gravity (SSD) – (gr/cm <sup>3</sup> )		2.68	
	Absorption (%)		2.17	
	Surface moisture (%)		2.167	
2	Sieve analysis : Fineness Modulus (FM) (%)	ASTM C128	1.52	2.3-3.2
3	Agregate constituents: The amount of material finer then No. 200 sieve.	ASTM C117	17.77%	ASTM C.33 : max 5%

Table-1 above, shows that the results of material through the sieve no. 200, exceeding the limit according to ASTM C.33 ideal, but the sand was still used to consider Karawang's mud assay results: 4.78%, still below the maximum requirements, namely 5% and no other data of the test results meet the requirements.

Table-2 shows that Fineness Modulus (FM) of Kelud's sand was below the ideal limit and by inspection of materials through sieve no. 200, has exceeded the limit according to ASTM C.33 ideal. But considering Kelud's sand was not used completely, and was mixed with other sand (in this study was mixed with Karawang's sand), it was still could be used, as long as the mixture of sand characteristic figures still meet the ideal limit.

If the plot was made in the form of a graph, the sieve analysis curve of Karawang's sand and mount Kelud's sand compared to the provisions of fine aggregate gradation limits according to ASTM C33 shown in Figure-5 and 6.

**Figure-5.** Gradation curves of Karawang's sand.**Figure-6.** Gradation curves of Mount Kelud's sand.

The combination of Karawang Sand and Kelud Sand gradation with the percentage of Kelud sand by 10%, 20%, and 40% compared with the provisions of the boundary gradation of fine aggregates according to ASTM C33 shown in Table-3, 4, 5 and 6 below,



**Table-3.** Gradation of combination of 90% Karawang sand with 10% sand of Mount Kelud.

Sieve Sizes (mm)	90% Karawang Sand, gr	10% Kelud Sand, gr	Combine sands	% restrained	cumulative restrained, %	% passing	Lower Bound	Upper Bound
9.5	10	0	10	0.97	0.97	99.03	100	100
4.75	35	0	35	3.52	4.49	95.51	95	100
2.36	180	0	180	18.02	22.51	77.49	80	100
1.18	109	3	112	11.15	33.66	66.34	50	85
0.6	245	30	275	27.53	61.19	38.81	25	60
0.3	62	61	123	12.34	73.53	26.47	10	30
0.15	170	3	173	17.26	90.79	9.21	2	10
	90	2	92	9.21				
Total	900	100	1000	100	287.14			
Fineness modulus				2.87				

**Table-4.** Gradation of combination of 80% Karawang sand with 20% sand of Mount Kelud.

Sieve Sizes (mm)	90% Karawang Sand, gr	10% Kelud Sand, gr	Combine sands	% restrained	cumulative restrained, %	% passing	Lower Bound	Upper Bound
9.5	10	0	10	0.97	0.97	99.03	100	100
4.75	35	0	35	3.52	4.49	95.51	95	100
2.36	180	0	180	18.02	22.51	77.49	80	100
1.18	109	3	112	11.15	33.66	66.34	50	85
0.6	245	30	275	27.53	61.19	38.81	25	60
0.3	62	61	123	12.34	73.53	26.47	10	30
0.15	170	3	173	17.26	90.79	9.21	2	10
	90	2	92	9.21				
Total	900	100	1000	100	287.14			
Fineness modulus				2.87				

**Table-5.** Gradation of combination of 60% Karawang sand with 40% sand of Mount Kelud.

Sieve Sizes (mm)	60% Karawang Sand, gr	40% Kelud Sand, gr	Combine sands	% restrained	cumulative restrained, %	% passing	Lower Bound	Upper Bound
9.5	6	0	6	0.65	0.65	99.35	100	100
4.75	23	0	24	2.39	3.03	96.97	95	100
2.36	120	1	121	12.07	15.10	84.90	80	100
1.18	72	12	84	8.40	23.50	76.50	50	85
0.6	163	122	285	28.51	52.01	47.99	25	60
0.3	41	245	287	28.68	80.69	19.31	10	30
0.15	113	12	125	12.51	93.20	6.80	2	10
Pan	60	8	68	6.80				
Total	600	400	1000	100	268.20			
Fineness modulus				2.68				



From Table-3 shows that the gradation of Combination of 90% Karawang Sand with 10% Sand of Mount Kelud did not meet the conditions set ASTM C.33 for normal concrete, but for a combination of sand with sand Kelud percentage of 20%, 30% and 40% produced a gradation of sand that has met the conditions set ASTM C.33 for normal concrete.

#### Mix design

In this study, a concrete mixture designed for the compressive strength target  $f_c' = 30$  MPa, using ACI method as described above. Given the number of samples in the average for 3 pieces (small, <1 000 m<sup>3</sup>) for each composition and mixing is done in the laboratory, so that relatively good job at all. However, since the implementation of concrete test research is not often done, it's currently considered the level of employment is still lacking. Based on SNI. 03-2834-2000, standard deviation for this condition is 7 MPa. Target slump value between 5-7.5 cm.

Mix design was calculated based on the results of testing of each material had been obtained above.

## 4. RESULT AND DISCUSSION

#### Specimen test results

This research focuses to determine the effect of the use of sand from the eruption of Mount Kelud to the concrete mix on the concrete compressive strength. To achieve these objectives, the specimen of concrete mix with sand of Mount Kelud was made with percentage of 10%, 20%, 30% and 40% by weight of the total fine

aggregate needed, and the rest of the required fine aggregate filled by sand Karawang. The pressure test results of samples using sand of mount Kelud with particular level, then compared to a sample with the same mix design (but without using sand of mount Kelud) or just use sand Karawang as a fine aggregate (Standard Concrete). The whole work of these experiments were done in the material laboratory, Civil Engineering, Mercu Buana University, West Jakarta, Indonesia.

Considering the limited funds available in this study, the compressive strength of concrete was done only at 3 days, 7 days and 28 days. Increased strength of concrete obtained were compared with prescribed standards SK SNI T-15-1990-03 as follows:

**Table-6.** Coefficient of increased compressive strength of normal concrete.

Concrete Ages (hr)	Coefficient
3	0.4
7	0.65
14	0.88
21	0.95
28	1
90	1.2
365	1.35

#### Concrete specimen testing from concrete mixture without sand of mount kelud (standard concrete)

The compressive strength of standard concrete from concrete mixture without using sand Kelud was obtained from specimen test, and the result as shown in Table-7 below

**Table-7.** Testing result of standard concrete without sand of Mount Kelud.

Specimen	Weight (gram)	Unit Weight (gr/cm <sup>3</sup> )	P (kN)	Age (days)	$f_c$ Mpa	$f_{cr}$ (Mpa)
Kbs 1 - 0 % Kld	8273	2.451	595	3	21.42	20.88
Kbs 2 - 0 % Kld	8288	2.456	565	3	20.34	
Kbs 3 - 0 % Kld	8155	2.416	750	7	27	26.91
Kbs 4 - 0 % Kld	8172	2.421	745	7	26.82	
Sldr 1 - 0 % Kld	12280	2.316	295	7	16.694	invalid
Kbs 5 - 0 % Kld	8137	2.411	920	28	33.12	33.04
Kbs 6 - 0 % Kld	8215	2.434	910	28	32.76	
Kbs 7 - 0 % Kld	8170	2.421	923	28	33.228	

The average of Unit Weight 2.416

Where:  $f_c$  = Specimen compressive strength at the ages.

$f_{cr}$  = The average of specimen compressive strength at the ages.

From Table-7 above, obtained compressive strength of the average concrete which was well above the target of  $f_c' = 33.228$  MPa, while the target compressive strength of this research was  $f_c' = 30$  MPa, and the average unit weight of the concrete = 2.416 gr / cm<sup>3</sup>. This shows

the research has been sufficiently thorough, while preliminary estimates the quality of the work was still not good, and the quality of the material was also good, better still fresh cement from PT Readymix and sand Karawang with sufficiently high density and the amount of sludge that qualify.



### Effect of the use of sand kelud with levels 10% fine aggregate on concrete mixture to compressive strength

The use of sand of Mount Kelud 10% of the needs of fine aggregate produced concrete compressive strength as shown in the following Table-8.

**Table-8.** The specimen test result from concrete mixture with 10% replacement levels of sand by sand Mount Kelud.

Specimen	Weight (gram)	Unit Weight (gr/cm <sup>3</sup> )	P (kN)	Age (Days)	fc Mpa	fc <sub>r</sub> (Mpa)
Kbs 1 - 10 % Kld	8172	2.421	460	3	16.56	16.90
Kbs 2 - 10 % Kld	8090	2.397	485	3	17.46	
Sldr 1-10 % Kld	12280	2.316	295	3	16.694	
Kbs 3 - 10 % Kld	8063	2.389	475	8	17.1	19.98
Kbs 4 - 10 % Kld	8015	2.375	450	8	16.2	
Kbs 5 - 10 % Kld	7837	2.322	740	28	26.64	28.21
Kbs 6 - 10 % Kld	7835	2.321	780	28	28.08	
Kbs 7 - 10 % Kld	7982	2.365	700	28	25.2	
Sil 2 - 10 % Kld	11528	2.175	550	28	31.124	
Sil 3 - 10 % Kld	11963	2.257	530	28	29.992	

The average of Unit Weight 2.334

Preliminary results of the test in Table-8 shows that the compressive strength of concrete at age of 3 days dropped 19%, from 20.88 MPa (see Table-7) to 16.90, at the age of 7 days fell 16%, from 26.91 MPa to 19.98 MPa, at age of 28 days fell by 15%, from 33.04 MPa to 28.21 MPa, MPa when using sand Kelud 10% of the needs of fine aggregate needed.

These results allegedly due to the percentage of sand Kelud 10%, the gradation combination sand obtained did not make a concrete mixture can be solidified very well, as seen from the average unit weight of concrete dropped to 2,334 g/cm<sup>3</sup> of the original 2.416 gr / cm<sup>3</sup> when using 10% Kelud sand.

### Effect of the use of sand Kelud with levels 20% fine aggregate on concrete mixture to compressive strength

The use of sand of Mount Kelud 20% of the needs of fine aggregate produced concrete compressive strength as shown in the following Table-9.

From Table-9 was seen that the use of sand of mount Kelud by 20% of the needs from fine concrete has increased compressive strength on average by 15%, from 20.88 MPa (concrete without sand of mount Kelud) to 23.94 MPa at the age of concrete 3 day, whereas at 7 days age of concrete, compressive strength of concrete fell by 18%, from 26.91 MPa to 22.05 MPa. On the concrete age of 28 days, decreased by 11%, from 33.04 MPa to 29.24 MPa. In line with the increased compressive strength of concrete at the age of 3 days, the weight of an average type of concrete also increased from the original 2.414 gr/cm<sup>3</sup> become 2.431 g/cm<sup>3</sup> when using sand of mount Kelud by 20% of the needs of fine aggregate.

**Table-9.** The specimen test result from concrete mixture with 20% replacement levels of sand by sand Mount Kelud.

Specimen	Weight (gram)	SG of Concrete (gr/cm <sup>3</sup> )	P (kN)	Age (days)	fc Mpa	fc <sub>r</sub> (Mpa)
Kbs 1 - 20 % Kld	8160	2.418	670	3	24.12	23.94
Kbs 2 - 20 % Kld	8260	2.447	660	3	23.76	
Kbs 3 - 20 % Kld	8265	2.449	605	5	21.78	22.05
Kbs 4 - 20 % Kld	8255	2.446	620	5	22.32	
Kbs 5 - 20 % Kld	8200	2.430	780	7	28.08	28.05
Sldr 1 - 20 % Kld	12535	2.364	495	7	28.011	
Kbs 6 - 20 % Kld	8225	2.437	850	28	30.6	29.24
Kbs 7 - 20 % Kld	8239	2.441	835	28	30.06	
Sldr 2 - 20 % Kld	12410	2.341	495	28	28.011	
Sldr 3 - 20 % Kld	13427	2.533	500	28	28.294	

The average of Unit Weight 2.431

### Effect of the use of sand Kelud with levels 40% fine aggregate on concrete mixture to compressive strength

The use of sand Kelud 40% of the needs of fine aggregate to produce concrete compressive strength and density of concrete as shown in the following Table-10.



**Table-10.** The specimen test result from concrete mixture with 40% replacement levels of sand by sand Mount Kelud.

Specimen	Weight (gram)	SG of Concrete (gr/cm <sup>3</sup> )	P (kN)	Age (days)	fc Mpa	fc <sub>r</sub> (Mpa)
Kbs 1 - 40 % Kld	8296	2.458	530	3	19.08	17.37
Kbs 2 - 40 % Kld	8300	2.459	435	3	15.66	
Kbs 3 - 40 % Kld	8250	2.444	715	7	25.74	
Kbs 4 - 40 % Kld	8242	2.442	735	7	26.46	26.10
Slidr 1- 40 % Kld	12290	2.318	385	7	21.79	
Kbs 5 - 40 % Kld	8130	2.409	820	28	29.52	29.60
Kbs 6 - 40 % Kld	8128	2.408	810	28	29.16	
Kbs 7 - 40 % Kld	8215	2.434	830	28	29.88	
Slidr 2 - 40 % Kld	12900	2.433	530	28	29.99	
Slidr 3 - 40 % Kld	15978	3.014	520	28	29.43	

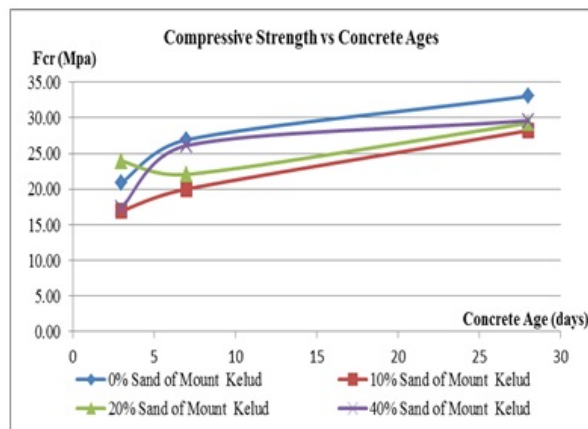
The average of Unit Weight

2.482

From Table-10 above, the use of sand Kelud as much as 40% of the needs of fine aggregate resulted in concrete compressive strength lower, both on the concrete age of 3 days, and at the age of concrete 7 days. At the concrete age of 3 days, compressive strength of concrete fell from 20.88 MPa (Table-7) to 17.37 MPa or decrease of 16.8% from the standard concrete without sand of mount Kelud, whereas at the concrete age 7 days, compressive strength concrete fell from 26.91 MPa (Table-7) to 26.10 MPa, or decrease of 3%, the concrete age of 28 days, the compressive strength of concrete fell by 10%, from 33.04 MPa to 29.6%, while the density of the concrete rose to 2.482 g / cm<sup>3</sup>, or increased up to 0.5%.

## RESULT AND DISCUSSION

From the test results of specimens of concrete age of 3 days, 7 days and 28 days, it appeared that the use of sand Kelud 20% of the needs of fine aggregates can increase the compressive strength of concrete, especially at the age of concrete 3 days. In general, the use of sand Kelud caused a decline in the strength of concrete, as shown in Figure-7 below.

**Figure-7.** Influence of sand Kelud against normal concrete compressive strength at age 3, 7 and 28 days.

## CONCLUSIONS AND RECOMMENDATION

### Conclusions

Based on the results of data analysis and discussion above, drawn conclusions as follows:

- Sand Karawang used for the manufacture of concrete normally good enough, it appeared that the compressive strength of concrete obtained in conditions without combined with sand of Kelud produced compressive strength exceeded the desired target, although this sand gradation did not meet the ideal standard.
- The use of sand Kelud 20% of the needs of fine aggregate concrete could improve the strength of concrete by 15% at the age of 3 days.

1. In general, the use of sand Kelud caused decrease in compressive strength of concrete.
2. The use of sand Kelud with appropriate levels could increase the early strength of concrete.

### RECOMMENDATION

In order to repair and provide input to the relevant parties, there are suggestions or recommendations as follows:

1. There should be further study in order to obtain the optimum percentage of sand Kelud
2. There should be further study regarding the most dominant variable in influencing the compressive strength of concrete.

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