Compressive Strength of Concrete Containing Merapi Cold Lava Sand

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Abstract

Reports from the literature state that Merapi sand is a good material as a filler in concrete to replace some of the fine aggregate because it has a high content of silica (SiO_2) and the sharp edges of the silica form angular particles. The potential function of Merapi sand as a filler and its use as a waste material prompted this study to be carried out. The objective of this study is to determine the potential of Merapi Sand in terms of concrete compressive strength as an effective replacement for local sand in the Cikarang area. In this study, Merapi cold lava was crushed to the size of fine aggregate by passing a 2.26 mm sieve. The percentages of Merapi sand used as a partial substitute for local sand are 10%, 20%, and 30%. The results of this study show that Merapi sand concrete (MSC) 30% at age of 7 days and 28 days provides the highest increase in compressive strength of 17.4% and 15.8% respectively compared to normal concrete (NC). The addition of a percentage of Merapi sand as a partial replacement for local sand tends to increase the compressive strength of the concrete. Based on this study, Merapi sand has the potential to be used as a partial replacement for local sand in increasing the compressive strength of concrete and reducing cold lava waste.

Keywords: Merapi sand, cold lava, concrete, compressive strength, mechanical properties

1. Introduction

The use of materials containing silica as concrete binders and fillers in concrete as well as uses for waste materials has been widely reported in the literature [1]. As a concrete binder, fly ash is known to be used as a substitute for all cement as a binder, thereby producing environmentally friendly Geopolymer concrete [2-3]. As a partial replacement for cement, refined waste cementitious materials such as glass powder have also been used [4-7]. Meanwhile, replacing some portions of the fine aggregate or as concrete filler is carried out using materials such as rice husk ash [8], volcanic ash [9] or cold lava [10] and waste glass powder [11-12].

This study will focus on the use of sand from cold lava which contains high silica as a partial replacement filler for fine aggregate. This study was motivated by the potential function of Merapi cold lava sand or Merapi sand as a filler reported in the literature and its use as a waste material [13-14]. Apart from that, the sharper form of the particle pattern of Merapi sand is what improves the interaction between Merapi sand and cement paste in concrete [15]. The mineral parts of the Mount Merapi eruption material is dominated by silica more than 60%, alumina of 17%, and other elements such as iron, calcium, and magnesium in very modest concentrations [16]. In terms of manufacturing concrete, numerous supporting chemical ingredients, such as silica and alumina, have the potential to improve the quality and durability of the concrete. As a result, Merapi sand is ideal for use in the production of concrete in order to increase the quality and durability of the concrete. Cold lava sand from other places such as from Mount Sinabung is also reported as a filler for concrete to replace some of the fine aggregate. The results of this study show that the use of cold lava sand as a partial replacement of fine aggregate up to 70%

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tends to increase the compressive strength of concrete [17].

In this study, the use of Merapi cold lava sand as filler was refined to the size of fine aggregate by passing a 2.26 mm sieve. Merapi sand replaces some of the local Cikarang sand by 10%, 20%, and 30%. The coarse material used was passing 9.5 mm and retained at 4.75 mm sieve. The objective of this study is to investigate the compressive strength of Merapi Sand concrete compared to normal concrete. Furthermore, this study is expected to contribute to environmental concerns through using Merapi waste material cold lava sand as partial substitution of fine aggregate in concrete.

2. Material and Method

In this study, the mechanical property of concrete is investigated as the compressive strength of the Merapi sand concrete and normal concrete at age of 7 days and 28 days. The percentage of use of Merapi sand as a partial replacement for fine aggregate is varied by 10%, 20%, and 30%. The purpose of investigation is to check the performance of the compressive strength of Merapi sand concrete compared to the normal concrete. All specimens are treated with immersion curing before tested in compressive strength [18]. The methodology of this study is shown in Fig. 1.

A brief explanation of the main concrete materials used in this study is as follows [19-21]. The main materials for normal concrete (NC) are cement, coarse aggregates, fine aggregates, and water. The cement used as a binder for the concrete mixture is Portland Composite Cement (PCC) Type I, the coarse aggregate uses crushed stone with gradation of passing 9.5 mm and retained at 4.75 mm sieve and its fineness modulus (FM) = 6.02% (Fig. 2), and the fine aggregate uses Cikarang local sand that passes a 2.36 mm sieve where its fineness modulus, FM = 2.51% (Fig. 3). Meanwhile, for Merapi sand concrete (MSC), there is additional Merapi sand as a partial replacement for the fine aggregate. The Merapi sand used passes a 2.36 mm sieve ranging between 0.075 mm and 0.150 mm (Fig. 4). The coarse and the fine aggregate are tested for specific gravity and absorption, mud levels, aggregate gradation, and aggregate moisture. The mix design of normal concrete and Merapi sand concrete can be seen in Table 1. The concrete specimens used in this study are cylinders with a diameter of $Ø$ = 150 mm and height of h = 300 mm (Fig. 5) and the curing type used the immersion curing (Fig. 6). The compressive strength test setup is showed in Fig. 7.

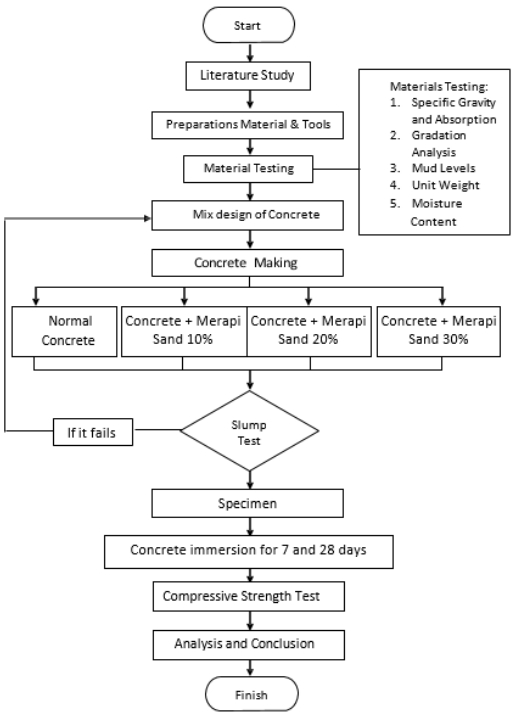

Fig. 1 Study methodology

Table 1 Mix design

Concrete type	Volume (1 specimen) (m^3)	Material compositions				
		Cement (kg)	Fine aggregate		Coarse aggregate (kg)	Water (kg)
			Sand (kg)	Merapi sand (kg)		
NC - 7 Day	0.00556	7.442	8.064	0.000	20.731	3.423
NC - 28Day	0.00556	7.442	8.064	0.000	20.731	3.423
MSC 10% -7 Day	0.00556	7.442	7.258	0.806	20.731	3.423
MSC 10% - 28 Day	0.00556	7.442	7.258	0.806	20.731	3.423
MSC 20% -7 Day	0.00556	7.442	6.452	1.613	20.731	3.423
MSC 20% - 28 Day	0.00556	7.442	6.452	1.613	20.731	3.423
MSC 30% -7 Day	0.00556	7.442	5.645	2.419	20.731	3.423
MSC 30% - 28 Day	0.00556	7.442	5.645	2.419	20.731	3.423
Total		59.537	54.838	9.677	165.848	27.384

Fig. 2 Coarse aggregate

Fig. 3 Fine aggregate

Fig. 4 Merapi sand

Fig. 5 Concrete specimens

Fig. 6 Concrete curing

Fig. 7 Compressive strength test

3. Results and Discussion

The slump tests indicated the results that all slump values in Merapi sand concrete and normal concrete in this study have an average value of 6.8 cm – 9.6 cm and this is in accordance with the design slump target of 6 cm – 18 cm (Fig. 8). The compressive strength (f_c') test results on the Merapi sand concrete and normal concrete specimens are shown in Table 2. Based on the compressive strength test results shown in Table 2 and Fig. 9, it shows that the compressive strength of Merapi sand concrete increases with increasing the content of Merapi sand.

The compressive strength of concrete with 30% of Merapi sand content (MSC 30%) showed the highest increase of 17.4% with the value of 24.80 MPa compared to the normal concrete (NC) compressive strength of 21.13 MPa at age of 7 days. An increase of compressive strength was also shown in the concrete at age of 28 days. The concrete with Merapi sand content of 30% showed the highest increase of 15.8% with the value of 31.88 MPa compared to normal concrete (NC) compressive strength of 27.54 MPa at age of 28 days. The results showed that the use of Merapi sand as a partial replacement for fine aggregate of Cikarang local sand in this study was reasonably good to improve the concrete compressive strength.

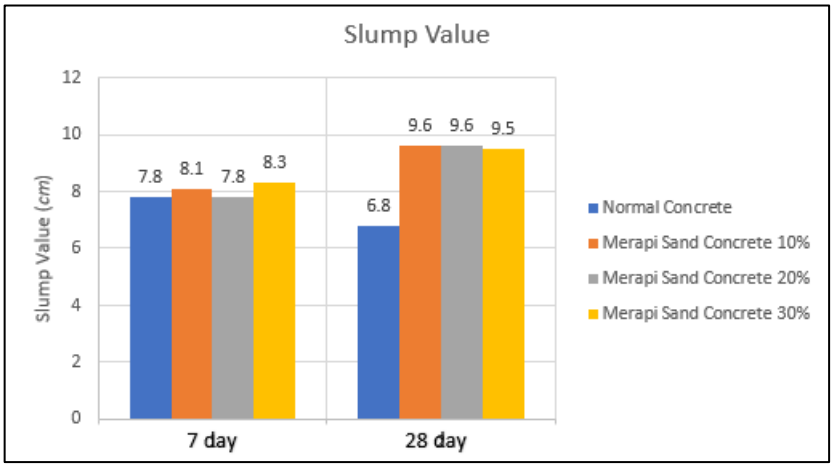

Fig. 8 Slump value of Merapi sand concrete and normal concrete

Table 2 Compressive strength tests result

Concrete type	Specimen	f'_c (MPa)	Average f'_c (MPa)
Normal Concrete (NC)-7 Day	1	21.50	21.13
	2	20.09	
	3	21.79	
Normal Concrete (NC)-28 Day	1	27.45	27.54
	2	27.16	
	3	28.01	
Merapi Sand Concrete (MSC) 10% -7 Day	1	20.37	21.22
	2	21.22	
	3	22.07	
Merapi Sand Concrete (MSC) 10% -28 Day	1	28.58	28.77
	2	29.99	
	3	27.73	
Merapi Sand Concrete (MSC) 20% -7 Day	1	24.33	23.30
	2	22.64	
	3	22.92	
Merapi Sand Concrete (MSC) 20% -28 Day	1	31.41	30.46
	2	28.86	
	3	31.12	
Merapi Sand Concrete (MSC) 30% -7 Day	1	25.46	24.80
	2	23.77	
	3	25.18	
Merapi Sand Concrete (MSC) 30% -28 Day	1	32.82	31.88
	2	31.69	
	3	31.12	

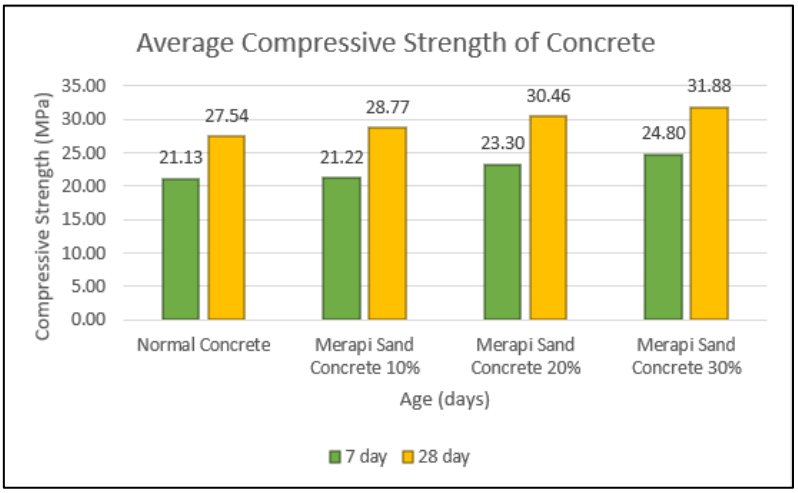

Fig. 9 Compressive strength test result

4. Conclusions

The mechanical property of concrete namely the compressive strength of concrete with Merapi cold lava sand as a partial substitution of fine aggregates with a percentage of 10%, 20%, and 30% at a concrete age of 7 day and 28 days has been investigated in this study. Based on the compressive strength test results, it indicated that the compressive strength of Merapi sand concrete increase with increasing the content of Merapi sand. The compressive strength of concrete with 30% of Merapi sand content (MSC 30%) showed the highest increase of 17.4% compared to the normal concrete (NC) compressive strength

at age of 7 days. An increase was also shown in the concrete compressive strength at age of 28 days. The concrete with Merapi sand content of 30% (MSC 30%) showed the highest increase of 15.8% compared to normal concrete (NC) compressive strength at age of 28 days. The results indicated that the use of Merapi sand as a partial replacement for fine aggregate of Cikarang local sand in Merapi sand concrete in this study was quite good to improve its mechanical property in terms of concrete compressive strength and utilization of waste materials.

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