The effect of m-sand and waste marble for strength of concrete

by Ranti Hidayawanti

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R Hidayawanti[1*], **Yuhanah**[2], **D Mayasari**[3] **and B Wicaksono**[4]

[1,2,3,4] Department of Civil Engineering, Institut Teknologi PLN, Indonesia

*Corresponding author's e-mail: ranti@itpln.ac.id

Abstract. Concrete is a construction material composed of cement, water, and aggregate in the form of sand and gravel. Furthermore, Indonesia experiences a yearly increase in the need for building material, including concrete, due to the rise in development. Smooth and coarse aggregate materials are required to manufacture concrete with the inappropriate disposal of waste marble, adversely impacting environmental pollution. Therefore, tremendous efforts need to be carried out to reduce environmental problems associated with the disposal of waste marble to provide adequate economic value for construction and reduce the collection of rough aggregates in the river. A lot of industrial companies are needed to produce a coarse aggregate with various size variants, thereby, manufacturing waste, also known as M-Sand. The stone ash is one of the numerous coarse aggregate materials that are less desirable in concrete production. Therefore, this study was carried out to determine the compressive strength and water absorption content between fine and coarse concrete using a variety of coarse aggregate replacement materials from the waste marble with a 40% M-Sand substitute. The results showed waste marble variations of 0%, 25%, 50%, 75%, 100% substitution of coarse aggregate with 40% M Sand substitution of fine aggregate. The optimum compressive strength was found in variation 3 (40% M Sand + Waste Marble 50%) of 35.801 MPa at 28 days, with the optimum water absorption obtained at variation 1 (40% M-Sand + 0% Waste Marble) at 1.77%. By analysing the waste marble result of R close to 1, it is concluded that this variation can act as an alternative to the composition of a concrete mixture.

1. Introduction

1.1. Utilization of Concrete Waste

Indonesia experiences a yearly increase in the need for building material, including concrete, due to the rise in development. The use of concrete as a construction material is increasingly widely, as seen from the rise in its production, especially in the ready mix industry. Approximately 70% of building material compilers in the construction world use concrete [1] because it is a relatively inexpensive with a large compressive strength, easy to work with and can be formed according to the desired shape and corrosion resistant [2]. One of the material needs for making concrete is coarse aggregate, which is taken from rivers. The continuous extraction of this material from river causes damages to it, therefore, the use of other resources is expected to minimize and reserves this aggregate sources. One of such alternatives is the use waste of marble. Furthermore, many industrial stone companies are needed in the construction

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world to produce coarse aggregates of various sizes known as M-Sand or stone ash, which is used an alternative material [3]. M-Sand is a less desirable material used as a substitution of natural sand in concrete production. Therefore, this study examines the manufacture of M-Sand as an alternative to fine aggregate and waste marble as an alternative to coarse aggregate in concrete production [4]. This research was also carried out to determine the compressive strength and absorption rate of the remaining waste marble and M-Sand.

1.2. The Problem to be addressed
The increasing difficulty in obtaining raw materials for coarse aggregate (gravel) and fine aggregates (sand), to minimize the use of marble and M-Sand are some problems to be addressed in this study. The waste needs to be tested against its compressive strength to determine its ability to fulfil the SNI standard requirement for normal concrete. The study utilized the composition waste marble variations of 0%, 25%, 50%, 75% 100% for coarse aggregate and 40% M-Sand of fine aggregate to determine the value that produces optimum compressive strength. M-Sand and waste marble is an environmentally friendly concrete material[5], with more values as a substitute for sand and gravel[6]. Utilization of M-Sand and waste marble has a better compressive strength and absorption value than conventional concrete. In addition, to determine the proportion of the mixture of waste marble with M Sand 40% and to determine the comparison of the compressive strength and absorption of concrete using a mixture of M-Sand and the variation of waste marble with conventional concrete.

2. Methodology

2.1. Proportion of Mixed Concrete used for Mix Design of M-Sand and Waste Marble

Table 1. Material requirements needed for the variation of m-sand and waste marble test

No.	Sample	Material Composition					
		Water (Kg)	Cement (Kg)	Sand (Kg)	Gravel (Kg)	M-Sand (Kg)	Waste Marble (Kg)
1.	Normal Concrete	11.6107	24.7038	48.7398	73.7458	0	0
2.	Variation 1 (M-Sand 40% + Waste Marble 0 %)	11.611	24.704	29.244	73.746	19.49593288	0
3.	Variation 2 (M-Sand 40% + Waste Marble 25%)	11.611	24.704	29.244	55.309	19.496	18.436
4.	Variation 3 (M-Sand 40% + Waste Marble 50%)	11.611	24.704	29.244	36.873	19.496	36.873
5.	Variation 4 (M-Sand 40% + Waste Marble 75%)	11.611	24.704	29.244	22.124	19.496	51.622
6.	Variation 5 (M-Sand 40% + Waste Marble 100%)	11.611	24.704	29.244	0	19.496	73.746
	Total	69.664	148.223	194.959	261.797	97.48	180.677

2.2. Research process
This study determines the correlation value between the use of M-Sand and waste marble as a substitution of fine and coarse aggregate materials in manufacture of conventional concrete. Materials used are water, cement, fine aggregate (sand), coarse aggregate (gravel), M-Sand and waste marble.

Figure 1. Several materials for testing specimen of concrete

3. Result and Discussion

3.1. Laboratory testing result
The aggregate that will be used as concrete mixture material on the test specimens is checked for parameters including gradation, specific gravity, sludge content, organic, absorption.

3.1.1. M-sand gradation analysis test result

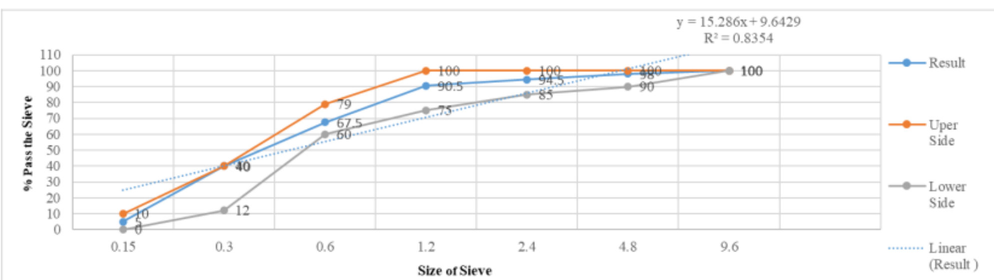

Figure 2. M-Sand gradation analysis test results (source of analysis 2020)

Figure 2 shows the category of M-Sand testing entered in the fine sand (zone III) with a fineness modulus of 3.045, which meets the refinement requirements stipulated in ASTM C-33[7]. The refinement modulus of 2.3 - 3.1, enables the utilization of this broken rock waste as a concrete mixture material.

3.1.2. Specific gravity of m-sand and water absorption

Table 2. Specific gravity data for m-sand and water absorption

No.	Description		Result
1.	Weight of Laboratory (S)		500 gr
2.	Weight of Laboratory after drying (A)		495 gr
3.	Water Weight + pycnometer (B)		872 gr
4.	Pycnometer weight + 500 gr Laboratory + Water (C)		1193 gr
5.	Dry Specific Gravity	$\left(\frac{A}{(B+S)-C}\right)$	2.76
6.	*Saturated Surface Dry* (SSD)	$\left(\frac{S}{(B+S)-C}\right)$	2.79
7.	% Absorption	$\left(\frac{S-A}{A} \times 100\%\right)$	1.01%

The results of testing the specific gravity of M-Sand and water absorption show that the dry specific gravity in the test was 2.76 and the specific gravity under SSD (Saturated Surface Dry) conditions obtained was 2.79. Meanwhile, the test results of water absorption of 1.01%.

3.1.3. Mud content in m-sand

Table 3. Result of mud content data in m-sand

No.	Description		Result
1.	Container Weight (W_1)		306 gr
2.	Weight of the test specimens + container (W_2)		806 gr
3.	Weight of the test specimens (W_3)		500 gr
4.	Dry weight of test specimens after oven + container (W_4)		796.50 gr
5.	Dry weight of test specimens after oven (W_5)		490.50 gr
6.	*Saturated Surface Dry* (SSD)	$\left(\frac{W_3-W_5}{W_3} \times 100\%\right)$	1.90 gr

3.1.4. M-sand water content

Table 4. M-sand water content data result

No.	Description	Result
1.	Container Weight (W_1)	306 gr
2.	Weight of the test specimens + container (W_2)	806 gr
3.	Weight of the test specimens (W_3) = W_2 - W_1	500 gr
4.	Weight of the test specimens after oven + container (W_4)	800 gr
5.	Weight of the test specimens after oven (W_5) = W_4 - W_1	494 gr
6.	% Sand Water Content = $\frac{W_3 - W_5}{W_5} \times 100\%$	1.21%

The examination results of the M-Sand water content showed a test percentage of 1.21%. Furthermore, the water content in the aggregate is strongly influenced by the amount contained in the aggregate. The

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greater the difference between the original aggregate weight before and after drying the oven, is determined.

3.1.5 Waste marble gradation analysis

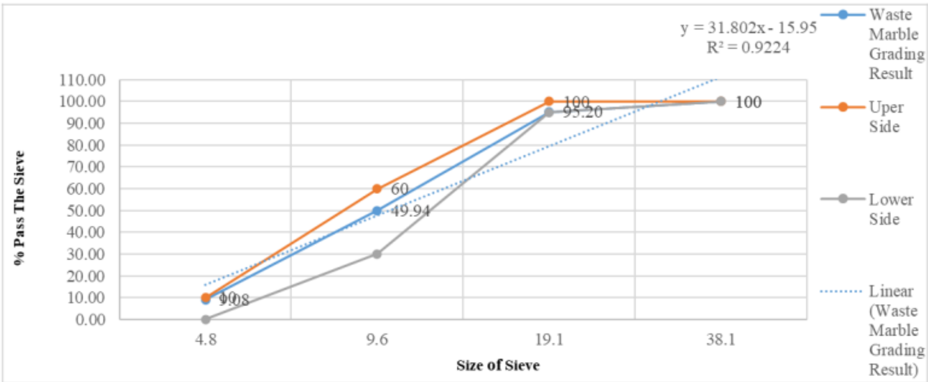

Figure 3. Graphing waste marble gradation analysis testing chart (source analysis 2020)

In the waste marble grading analysis, the experiment needs to be tested with a similar method as the coarse aggregate grading analysis experiment using a set of sieves with 38.1 mm, 25.4 mm, 19.1 mm, 15.9 mm, 9.92 mm, 9.42 mm, 4, 76 mm, 2.4 mm, 1.2 mm and pan. After testing, the results of the gravel left in the sieve are weighed. Therefore, based on the above test, the results showed that the gradation of marble waste used falls into the same category as gravel, at a nominal size of 38.10 mm. The results for the fineness modulus obtained was 6.64, and the modulus value of refinement as a gross aggregate substitution fulfilled the requirements according to SNI 03-2461-2014 [8], which is does not exceed 7%. Figure 3 shows that the Linear Regression method can be applied because R = 0.9224 is close to 1 [9]

3.2. Slump test result

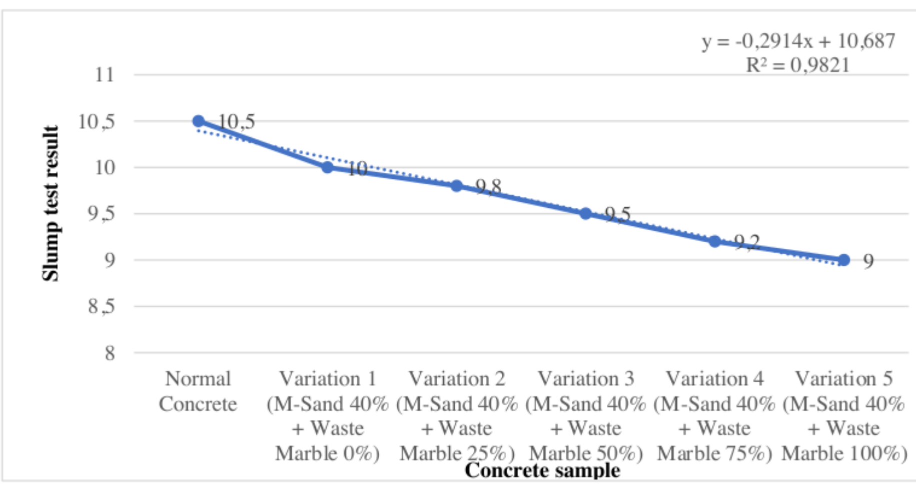

Figure 4. Slump test result for all variations (source analysis 2020)

Figure 4 shows that the slump test obtained is following the specified values ranging from 80 mm to 130 mm and in accordance with National Indonesia standards [10].

3.3. Compressive strength test result

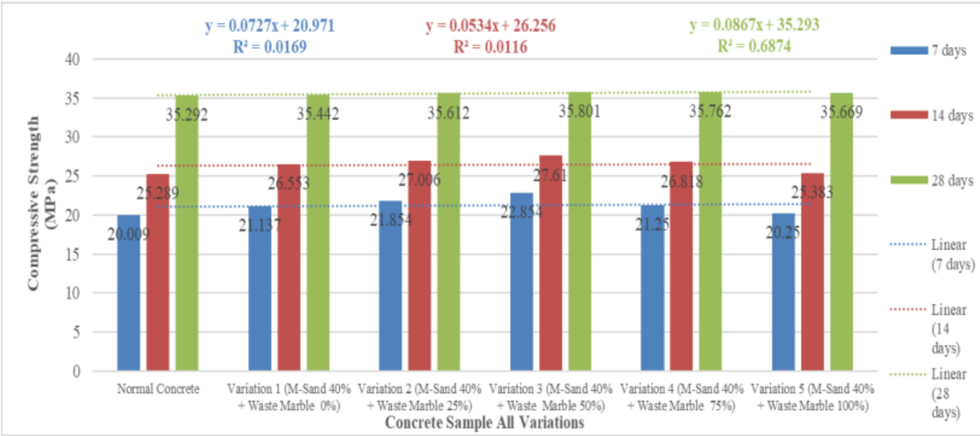

Figure 5. Compressive strength test result for all variations (source analysis 2020)

Figure 5 showed that the highest compressive strength for concrete samples with variation 3 is obtained, with a mixture of 40% M-Sand and 50% waste marble, thereby producing a compressive strength of 27.61 MPa in 28 days. The concrete variation 3 gained an increase with a difference of 2.321 Mpa when compared with the normal variation concrete with compressive strength of 25.289 MPa.

3.4. Concrete Absorption Test Result

Absorption testing is carried out when the concrete age is 28 days, as shown in figure 6.

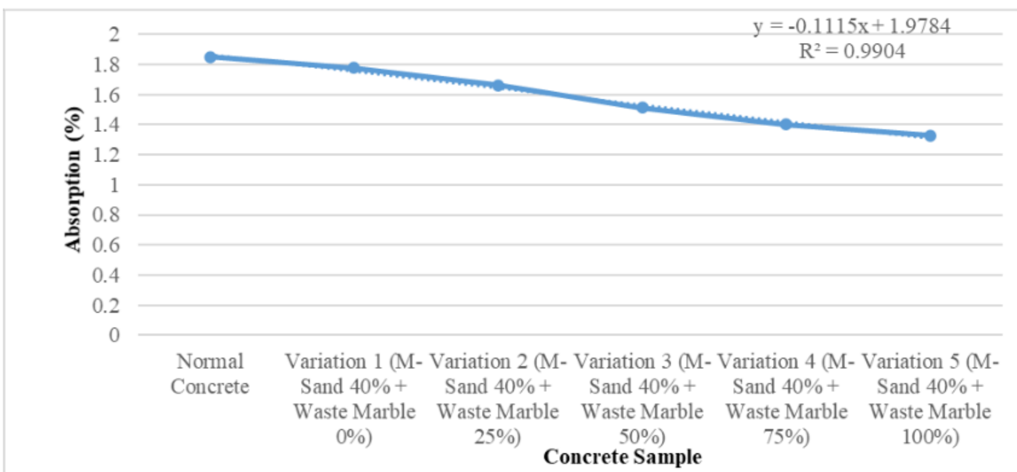

Figure 6. Test results for absorption of all variations (source analysis 2020)

Figure 6 shows that the highest value of the absorption test is normal concrete. The value of variation 1 (M-Sand 40% + Waste Marble 0 %) is closed to the optimum in the alternative use substitutes.

4. Conclusion

The research and analysis results showed that the effect of waste marble at variations of 0%, 25%, 50%, 75%, 100% substitution of coarse aggregate (gravel) and 40% M-Sand produced fine aggregate (sand) with the greatest compressive strength in Variation 3 (M Sand 40% + 50% Waste Marble) of 35.801 MPa in 28 days with a percentage value of 16.76%. This is because coarse aggregate composition is still dominant to help the compressive strength value, with a decrease in compressive strength due to the use of fewer coarse aggregate such as variations 4 and 5.

Furthermore, the optimum value of concrete water absorption was found in concrete variation 1 (M-Sand 40% + 0% Waste Marble) at 1.77% because the addition of material prolongs the water absorption rate. This happens for additional variables that significantly affect water. The more waste marble, the smaller the absorption and impact on workability. However, an R-value close to 1 shows that it can be used for concrete mixes.

Acknowledgments

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