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Influence of Sand Casting Waste as Subsitute of Quarzt Sand in Mortar

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ABSTRACT

Sand casting waste has the potential to replace quartz sand in mortar manufacture because it contains high silica. This study uses sand casting waste from the steel industry in Gresik, Indonesia to observe how it affects the quality of the mortar. Initial characterization were carried out to determine the properties of the material, including; magnetic test which results are not attracted by magnets, moisture content test with a value of 0.328%, XRD test to determine the crystallinity content which results contain 99.52% Silica Quartz, and XRF test to determine the content of the compound in which results are 81.25% Silica dominant. Then observations were made by making mortar with the replacement of quartz sand by sand casting with variations of 0% wt, 25% wt, 50% wt, and 100% wt and then tested its compressive strength at 3 days, 7 days, and 28 days. Based on the research that has been done, the optimum result using sand casting is at 25% wt with a compressive strength of 251.15 kgf/cm2 at 28 days of age which is higher than the standard.

Key words *: sand casting, quartz, silica, mortar*

INTRODUCTION

Development of Concrete and Mortar research converge on cutting edge product such as geopolymer (U Anggarini et al., 2017) and utilization of indutrial waste to meet environmental issue. Several industries such as ; steel, oleochemistry, power plant, paper and pulp produced various kind of wastes, one of which contain cementitious materilas such as SiO_2, Al_2O_3, and $CaCO_3$ as a main compunds of concrete and mortar (FA Prasetya et al., 2017).

Studies on the use of steel industry waste for concrete materials have been widely discussed. But generally it is still limited to the use of copper slag (MAG Dos Sanjos et al., I, 2017; Abbishek et al., 2020), nickel (Ashis Kumer et al., 2020; Qiseng Wu, et al, 2018; Qi Wang., et al, 2019), and steel (Qia dong, 2020; SB Duraman, 2020; Lei Lang, 2019). Meanwhile, there are another several wastes from steel industry which has potential for concrete; sand casting and sand blasting (A Gholampour, 2020; Nat Makul, 2018; AR Patil, 2020).

Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material (A Ktari, 2020). The term "sand casting" can also refer to an object produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 60% of all metal castings are produced via sand casting process. In the concrete industry, the manufacture of mortar requires quartz sand to supply silica content. Meanwhile, sand casting itself contains a lot of silica (FD Benedetto, 2016). However, sand casting waste is still rarely used. This research will observe the effect of replacing quartz sand with sand casting waste and then doing a compressive strength test to determine the performance.

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METHODS

In this study, experimental research has conducted to determine the influence of sand casting waste as a subsitutor of Quartz in Mortar. Raw materials of this study is sand casting waste obtained from PT. X, East Java, Indonesia (Steel manufacturer). Several characterizations conducted to determine its influence on compressive strength of mortar compare with SNI Compressive strength.
In the early stages, a magnetic test is carried out which aims to identify the nature of the waste, whether it is easily attracted by a magnet or not, so that the results can be used as initial data on the material content in the waste. Moisture Content testing aims to determine the water content of sand casting waste, namely the ratio between the weight of water contained in the sand casting waste and the dry grain weight of the sand casting waste which is expressed in percent. This test is performed using a moisture balance tool owned by PT. Semen Indonesia and readings are in the form of graphs and digital data.

Samples that have been identified based on physical and chemical properties will then be classified in several ways including: XRD & XRF test (to find out what type of material is contained in the sample), PSA test (to determine the size of the sample diameter). Raw mix design of mortar dough in this research is by varying the composition of fine aggregate with the types of sand casting waste as follows: 0% wt, 25% wt, 50% wt, and 100% wt of quartz sand. Testing for sand casting waste as the use of cement products in this study is by making a test object in the form of a 5x5x5 cm3 mortar with a variation in the composition of silica sand and sand casting waste. The next test is the compressive strength test with variations in curing time of 3 days, 14 days and 28 days. The sample of the compressive strength test cube amounted to 2 pieces for 1 variable with average results.

RESULTS AND DISCUSSION

Initial characterization was carried out by identifying the waste by physical observation. After the physical identification is done, the results are obtained, namely the type of waste sand casting in the form of sand powder, dry, black and homogeneous or uniform in shape. From the physical identification results, it can be said that sand casting type waste can be continued for the next characterization test because the waste is in the form of powder which can be continued in XRD and XRF testing without the need for special treatment so that XRD and XRF testing can be carried out.

Figure 1. Sand Casting Waste

Magnetization Test

After carrying out physical identification, then conducting a magnetic test which aims to determine the magnetic properties of the waste. The magnetic test is carried out by bringing the waste magnet closer and then making observations. In Figure 2, it can be seen that the results obtained for sand casting type waste have weak magnetic properties.

Figure 2. Magnetization Test of Sand Casting Waste

Moisture Content

The first step is to prepare a sample of sand casting waste and then take a five gram waste sample and put it in a moisture balance tool. Then run the test on the moisture balance tool and record every change in weight and percent of moisture balance on the tool and do the experiment 10 times. In Figure 3 it is known that for the results of testing Moisture Content, sand

casting waste is the smallest 0.26% and the highest is 0.54% with an average of 0.328%.

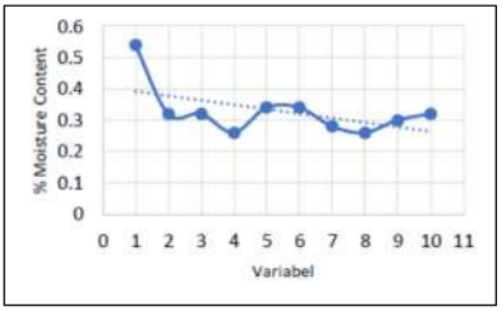


Figure 3. Moisture Content of Sand Casting

Particle Size Analyzer (PSA)

The size of the sand casting waste has a particle size distribution of ≤ 500 µm as much as 100% of the total sample of sand casting waste that is included in the PSA test instrument (readable particle size). The standard of raw materials that enter the cement raw mill is from a size of 5-7 cm and then out of the raw mill with a size of 0-9 microns (Alsop, 2005). It can be concluded that the sand casting waste meets the size requirements in the raw mill.

X-Ray Diffraction (XRD) Data

From the XRD test data of sand casting waste in Figure 4, it shows that the most dominant crystal form is Quartz with 99.52% content, 0.04% Dolomite, and 0.43% Calcite, Dolomite and Calcite only as impurities. The function of quartz silica sand in cement is to meet the demand for cement raw materials which are around 9%.

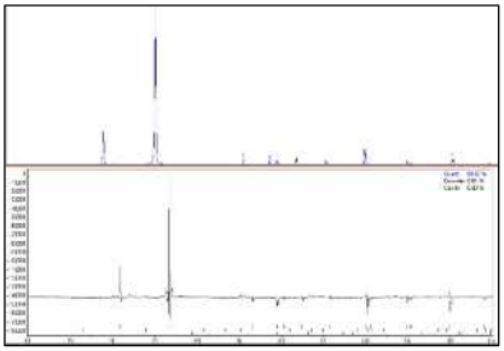


Figure 4. XRD Data of Sand Casting

In general, silica sand is present along with other metal oxides, the purer the SiO_2 content the whiter the silica sand, the less SiO_2 levels the more red or brown, besides, the easier it is to clump because of the high water content. Silica sand is good for cement making with SiO_2 content of approximately 90%. From the XRD test results data on sand casting waste has a similarity to quartz sand whose crystal form is predominantly Quartz and if the sand casting waste is used as an alternative raw material, the raw material for cement is as a substitute for silica sand (SiO_2).

X-Ray Flourescence (XRF) Data

From the XRF test data on sand casting waste, there are several substances where the SiO2 content has the highest content (81.25%), this shows that from the XRD and XRF data above sand casting waste can be used as an alternative raw material in cement as substitute for silica sand. Silica sand is a type of sand that contains silica material. Silica is the largest part of sand and sandstone. Silica sand can be used for various human purposes, such as: cement mixture, slab glass making material, sodium silicate material, cast steel reference sand, and others.

Table 1. XRF Data of Sand Casting

No	Compounds	Percentage (%)
1	SiO_2	81.25
2	Al_2O_3	4.21
3	Fe_2O_3	1.41
4	Cr_2O_3	0.48
5	CaO	0.33
6	Na_2O	0.2

Compressive Strength Data

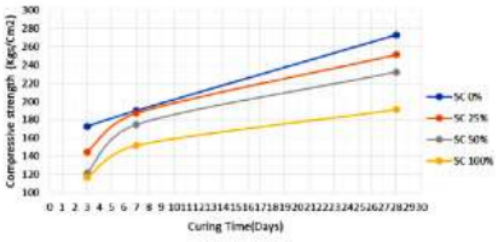
From Table 2 it can be seen that the variables 3, 7, and 28 days for each addition of sand casting (0% wt, 25% wt, 50% wt, and 100% wt) experienced a decrease. The more the addition of sand casting waste (Casting Sand), the compressive strength produced will also decrease. However, if it is compared with the SNI compressive strength for mertar, it can be seen that the variable sand casting 0% wt, 25% wt, 50%, wt meets the compressive strength test standards according to the standards set in SNI 7064: 2004.

Mortar with 100% sand casting waste variable does not meet the standards set in SNI 7064: 2004, so the use of sand casting waste as a cement mortar product can still be used on condition that it does not use 100% sand casting waste as a substitute for standard silica sand (main aggregate). From Figure 5. it can be seen that the variable addition of sand casting 0%, 25%, 50%, and 100% for each immersion time (3, 7, and 28

days) has increased. The longer the soaking time in the sand casting waste cement mortar, the higher the compressive strength it will produce. The results of the compressive strength test concluded that sand casting waste has the potential to be used as a subtitutor of fine aggregate (sand) up to 50% in the concrete industry.

Table 2. Compressive Strength Data

Days	Compressive Strength Score (kgf/cm²)			
	Sand Casting 0%	Sand Casting 25%	Sand Casting 50%	Sand Casting 100%
3	175.75	144.65	121.95	117.15
7	190.05	187.15	174.75	151.85
28	272.95	251.15	232.35	191.15



CONCLUSIONS

Based on the data, optimum sand casting waste who produced by Steel Manufacturer in Gresik, Indonesia, as a waste from sand blasting process, contain dominant compound of Silica with Quartz Crystallization. It has potential to substitute quartz sand in mortar industry. It is proven by strength characterization that result 251.15 kgf/cm2 at 28 days of mortar age by 25%wt of Sand Casting substitution. It is higher than standard mortar.

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