

The utilization of sandblasting sand waste for mortar and normal concrete

Q Qomariah*, S Sugiharti and S Riyanto

Civil Engineering Department of Politeknik Negeri Malang, East Java, Indonesia

*qomariah@polinema.ac.id

Abstract. Nowadays, large amounts of sandblasting sand waste are being produced and pollute environment. Sandblasting utilize to remove accumulated organic matter and other debris on concrete, steel, and wood components. The objective of experimental Laboratory for an analyse utilization of sandblasting waste in term of mortar strength, concrete strength, absorption and work ability of the mix. An experiment was conducted at civil laboratory POLINEMA using mortar cube 10 x 10 cm, and cylindrical concrete mould ϕ 15 x 30 cm, the curing time 3 and 7 day for mortar, 7 and 28 days for concrete. The testing refere to ASTM C-150 for mortar and Normal concrete with SNI-03-2834-2000. Fraction of waste sand are 0%,10%,20% and 30% of natural sand. The result, mortar compressive strength 3 days, 120 kg/cm²(0%), 125kg/cm²(10%), 129kg/cm² (20%), and 131kg/cm² (30%). For 7 Days, 190 kg/cm²(0%),200 kg/cm²(10%), 203 kg/cm² (20%), and 213kg/cm² (30%). For concrete strength 7 days, 150 kg/cm² (0%), 161 kg/cm² (10%), 168kg/cm² (20%),174 kg/cm² (30%), For 28 days, average concrete strength 225 kg/cm² (0%),259 kg/cm² (10%), 269 kg/cm² (20%),272kg/cm² (30%). An absorption decrease 8%(0%), 5%(10%), 4.5%(20%), and 3.9%(30%), work ability of the mix increase 3.5cm (0%), 3.57 cm (10%), 4.5cm (20%), and 4.9 cm (30%), that is indicated by slump value.

1. Introduction

Abrasive blasting, more commonly known as sandblasting, is the operation of forcibly propelling a stream of abrasive material against a surface under high pressure to smooth a rough surface, roughen a smooth surface, shape a surface or remove surface contaminants. The first abrasive blasting process was patented by Benjamin Chew Tilghman on 18 October 1870. Mineral Silica sand can be used as a type of mineral abrasive. It tends to break up quickly, creating large quantities of dust, exposing the operator to the potential development of silicosis, a debilitating lung disease. To counter this hazard, silica sand for blasting is often coated with resins to control the dust. Sandblasting is used for cleaning industrial as well as commercial structures, but is rarely used for non-metallic work pieces. One of the original pioneers of the wet abrasive (vapor matting) process was Norman Ashworth who found the advantages of using a wet process a strong alternative to blasting with silica sand, which is banned in many countries. the ability to use extremely fine or coarse media with densities ranging from plastic to steel, the ability to use hot water and soap to allow simultaneous degreasing and blasting, elimination of dust so silica materials can be used without worry, hazardous material or waste can be removed without danger e.g., removal of asbestos, radioactive, or other poisonous products from components and structures leading to effective decontamination. Waste sandblasting sand is for free from PT Boma Bisma Indra in Pasuruan, East Java, Indonesia. According Government Rule no. 85 in the year of 1999, waste sandblasting sand as a harmful product. Utilization on concrete mix as an innovation of waste



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sand use for concrete, also another solution of problem waste. Sandblasting equipment typically consists of a chamber in which sand and air are mixed. The mixture travels through a hand-held nozzle to direct the particles toward the surface or work piece. Nozzles come in a variety of shapes, sizes, and materials. Boron carbide is a popular material for nozzles because it resists abrasive wear well.



Figure 1. Sandblasting process.



Figure 2. Waste sandblasting sand scattered on the ground which is produced by sandblasting process.



Figure 3. Sample of waste sandblasting sand (left).



Figure 4. Worker sandblasting wearing full coverage protective gear (right)

2. Literature review

Heath use sandblasting waste sand for asphalt concrete mix as an economic and effective way [1]. Setyarini and Sulisty, sandblasting utilized to remove accumulated organic matter and debris from concrete, steel and wood [2]. Kasiati, et al., used waste sandblasting sand as an alternative for concrete [3]. Antonius et al., used waste sandblasting sand for concrete by volume composition 1:2:3 filled the standard strength of concrete [4]. NASA, used sandblasting waste about 42% [5]. Wildani and Sukandar, utilize of waste sandblasting sand for protection of the environment and saving the natural energy [6]. According to Government Regulation number 85 in the year of 1999, waste sandblasting as a harmful product.

3. Experimental program

3.1. Mortar composition

In this paper, waste sandblasting sand substitute natural sand by variation of 0%,10%,20% and 30% in the mortar mix and concrete mix. At the Civil laboratory for mortar and concrete research, 4 MC and 4 CC (concrete composition) were investigated. Before used in concrete, In the first, 4 MC (mortar composition) trial by using four type mix as in the table 1 below.

Table 1. Number of spicement of mortar mix.

Sandblasting (%)	Age (days)		Number of spicement
	3	7	
0	6	6	12
10	6	6	12
20	6	6	12
30	6	6	12

Table 2. Material composition Of mortar mix with sandblasting sand according to ASTM C – 109.

Sandblasting sand (%)	Composition of material (gram)				
	Cement	Natural sand	Waste sand	water	W/C
0	500	1375	0	185	0.37
10	500	1237.5	137.5	185	0.37
20	500	1100	275	185	0.37
30	500	962.5	412.5	185	0.37

3.2. Mix design of concrete

For calculating the needs of each material concrete according to SNI -03-2834-2000 Mix Design of Normal Concrete with the quality of materials that fulfilled quality standard for the normal concrete mix, and the number of sample need is in the table 3 and table 4 below.

Table 3. Number of concrete sample of mix and the curing time.

Sandblasting sand (%)	Age (days)		Number of sample
	7	28	
0	12	12	24
10	12	12	24
20	12	12	24
30	12	12	24

The need of each material in mix design of concrete after correction process because of water content and absorption value in physical characteristic fine and course aggregates is in table 4 below.

Table 4. Material composition of concrete mix with cylinder mould 15 x 30 cm (24 cylinders).

Sandblasting sand (%)	Composition of material (kg)					
	Cement	Coarse Aggregates	Natural sand	Waste sand	Water	W/C
0	41.34	119.6	119.6	0	24.804	0.6
10	41.34	119.6	107.6	11.96	24.804	0.6
20	41.34	119.6	95.68	23.92	24/804	0.6
30	41.34	119.6	83.72	35.88	24.804	0.6

Table 5. Chemical compound content of silica sand

Chemical Compound	Content (%)
SiO ₂	55,30 – 99,87
Fe ₂ O ₃	0,01 – 9,14
Al ₂ O ₃	0,01 – 18,00
TiO ₂	0,01 – 0,49
CaO	0,01 – 3,24
Mg O	0,01 – 0,26
K ₂ O	0,01 – 17,00

Silicon is, next to oxygen, the most abundant element in the earth's crust. It occurs in combination with oxygen with silica, SiO₂, and in combination with oxygen and metallic element in a wide range of

silicates. Silica and silicates are the basis of many ceramic materials. The silicon atom is tetravalent and forms links with four oxygen atoms in a tetrahedral structure. The SiO_4 unit has a deficiency of electrons and forms ionic or covalent bonds between the corner oxygen atoms and other tetrahedra or metal ions. Some silicates have chain structures with the tetrahedra adding in one plane only. An extension of the chain type of structure could give a plate, or layer type of lattice. This type of structure is found in clays, talc and mica. In layer lattices there is a strong covalent and ionic bonding within layers, but comparatively weak Van der Waals' forces of attraction between layers. This allows for easy cleavage of the crystal into thin sheets, as is the case with mica. In table 5 An explanation of the chemical composition of Silica sand, before using for sandblasting process. Before applying the sand in mortar and concrete mix by substituting waste sand to the natural sand, the XRF test is taken to make sure and for knowing the content of silica compounds are not changed or contaminated by debris.

3.3. Material testing

Table 6. Some compounds in sandblasting waste sand with XRF test.

No	E 378			E 378 HELIUM		
	Compound		Compound	Compound		Compound
1	Si	94 %	SiO_2	Si	79.9 %	SiO_2
2	K	0.3 %	K_2O	K	0.32%	K_2O
3	Ca	0.21%	CaO	Ca	1.46%	CaO
4	Ti	0.8 %	TiO_2	Ti	0.19 %	TiO_2
5	Cr	0.072 %	Cr_2O_3	Mn	1.1 %	MnO
6	Fe	2.28 %	Fe_2O_3	Ba	1.2 %	BaO
7	Cu	0.032 %	CuO	Pr	4.3 %	Pr_2O_3
8	Zn	0.703 %	ZnO	Nd	9.6 %	Nd_2O_3
9	Ba	0.1 %	Ba			

Before using the sandblasting waste sand, the XRF test is taken for knowing the compounds on the waste, as to assure that the quality of the compound is not decreased. Figure 5 and Figure 6, are two methods for knowing the amount and type of compounds existing.

3.3.1. The XRF test

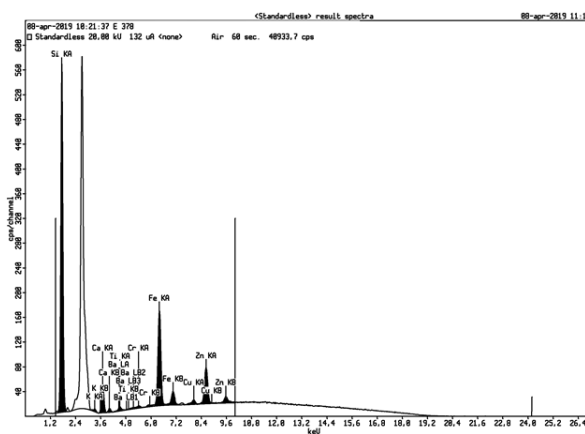


Figure 5. E 378 helium spectra

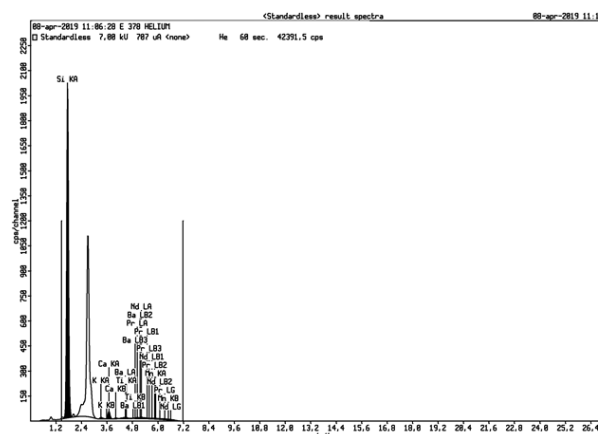


Figure 6. E 378 spectra.

According the compound of silica sand before using for sandblasting process (see table 5), most of compound is not contaminated by sandblasting process, also the content of silica is still high for using in concrete. The content of silica compound, which is in the table 6 about 90 %. (E 378). The content of silica compound is almost the same with silica compound without sandblasting process. For this result, the quality of waste sand can be used for mortar mix and concrete mix.

3.3.2. Physical testing of fine aggregates. Beside XRF test, Physical testing of the waste sand is taken for applying in the mortar and concrete mix. As a result, the quality of waste sand and natural sand are very closely alike and this material can be used both for mortar and concrete mix, as it describes the table 7 below, the quality of waste sand and natural sand generally for concrete and mortar fulfilled the quality fine aggregate for mortar and concrete in the table 7 below.

Table 7. Quality waste sand (WS) and natural sand (NS) for mortar and concrete mix.

Type of testing	Natural sand			Sandblasting sand		
	Result	unit	Quality standard	Result	Reference	
Specific gravity	2.62	Kg/cm ³	2.2-2.6	2.51	ASTM C-128-01	Ok
Water content	5.2	%	0 - 10	0.7	ASTM C-556-67	Ok
Absorption	4.46	%	0 - 10	1.89	ASTM C-128-01	Ok
Organic Content	0.46	%	3	2.4	ASTM C-49-99	Ok
Fine Modulus	3.2	-	2-4	1.8	ASTM C-136-01	Ok

For the gradation of both sand, there has to be fulfilled the quality gradation for mortar and concrete mix, according to SNI T-15-1990-03 (Indonesian Standard), the gradation of both natural sand and sandblasting sand fulfilled the quality sand, but natural sand, the size of mineral is scattered above ϕ 0.60 mm, which is the mineral of the waste sand between fineP sand course sand is the same. While sandblasting sand, most of the mineral size is under ϕ 1.18 mm, The size of mineral content needs more cement in the mix for bonding course and fine aggregate. It can be seen in the next figure 7 below.

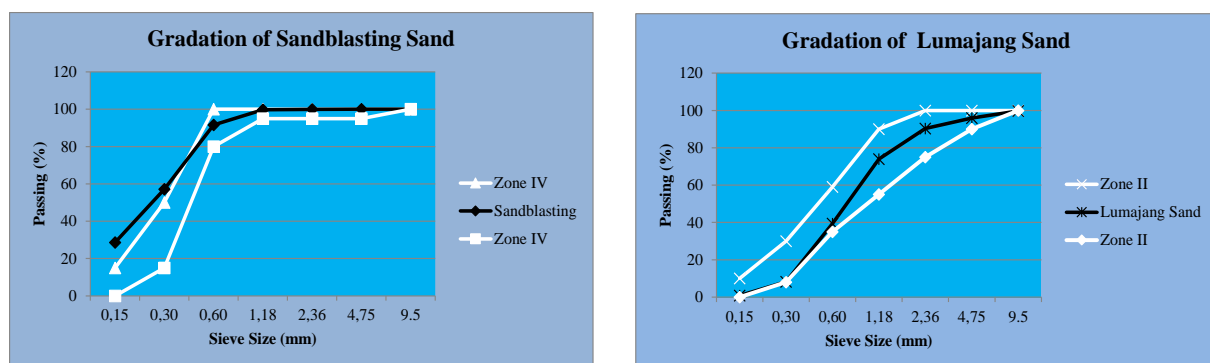


Figure 7. Sandblasting sand fit to the zone IV (left), natural sand fit for zone II (right).

Gradation of sand, the size of mineral sandblasting fulfilled zone IV, which is most of mineral content is very fine, but the mineral still can be used both for mortar and concrete mix. For sandblasting sand need more cement for applying in the mix, while the natural sand the need as a mix design calculation of concrete.

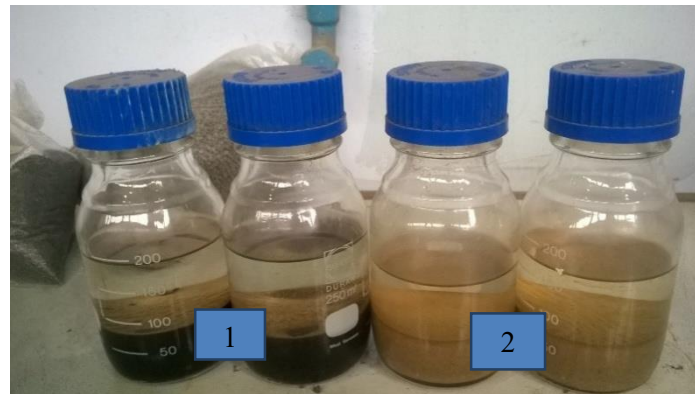


Figure 8. Sample of organic content for natural sand (1), and waste sand (2).

The result, in the bottle 1 and 2 quality of waste sand almost the same with natural sand for an organic content, the quality of both sand is clear, no debris or dust content. The quality of sand fulfilled for mortar and concrete mix. The process of testing the organic content by mixing each sample with a solution of Natrium hydroxide and water, then shake the bottle in 10 minutes, then let the solution and sand settle in 24 hours, the next day observe the colour of water, the height of deposit above sand.

4. Results

4.1. Compressive strength of mortar

Mortar mix with sandblasting waste show the compressive strength increase, as a result of interface zone between mortar and cement paste filled with finest sand grains, so no porous in the interface zone, make the mortar weight increase and also the strength, in addition, curing help the bonding of compound silica and cement paste stronger, then the compressive strength of mortar increase by increase of the waste sand. As we can see in figure 9 below.

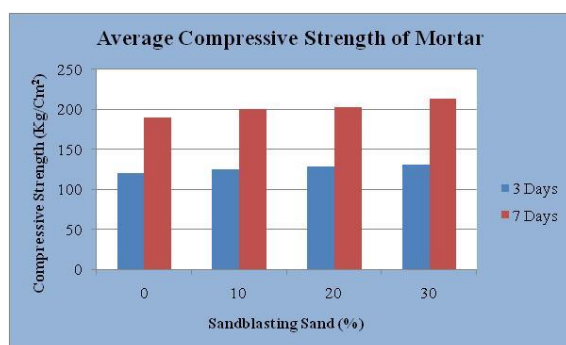


Figure 9. Average compressive strength of mortar

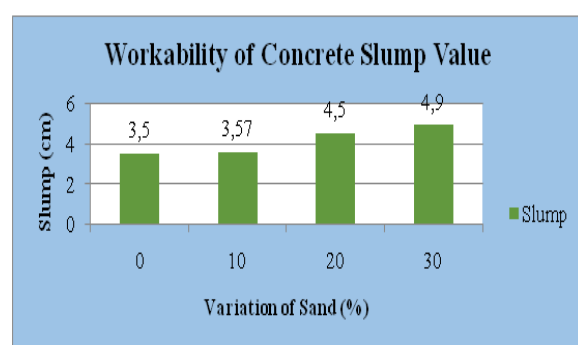


Figure 10. Slum Value of concrete.

Increase in waste sand content, make the concrete mix becomes workable as a function of the amount use of finest sand, the more finest sand increase in slump value, less water is in the mix, easy to form and flow in the mould, but the quality of the mix is not more than the design mix. Also an absorption become smaller and the concrete strength increase as an addition of amount waste sand.

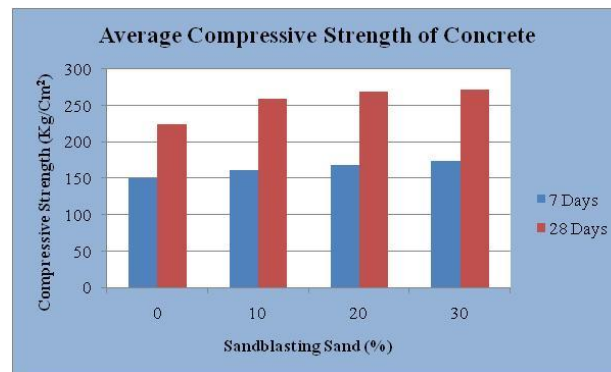


Figure 11. Average compressive strength of concrete.

Effect of utilize the waste sand, increase the compressive strength, also the maturity as function of curing time. The silica content together with silica in mineral cement are having strong bonding with in layers of cement paste and between transition zone mortar, the strength growth as a bonding layer of cement paste to the whole course aggregate.

5. Conclusion

From the evaluation of utilize waste sand, strength of mortar increase as an increase in the fraction of waste sand:

- Substitute natural sand with waste sand develop the strength of mortar, small pore and increase the weight of mortar
- For Concrete mix, the mix become workable to pour in the mould by increasing the slump value
- For the strength of concrete increase as a function of substitute natural sand to waste sand, although the level of fresh concrete increase.

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