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Use of Contaminated Sand Blasting Grit for Production of Cement Mortars

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Abstract. The influence of the industrial waste on the surrounding environment has been under surveillance of researchers for many years. Various industrial wastes that need to be stored and disposed of can contaminate water and soil. One of the industrial wastes that has to be disposed is the sand blasting grit or sand blasting residue. Sand blasting is a process of removing outer layers, paint or rust from steel elements such as bridge lattice or warehouse frames. Safe disposal of waste products is costly and time consuming. The study analyses the suitability of contaminated sand blasting grit for production of cement mortars. The waste material was acquired from a local company and it was used as a non-reactive aggregate. The study focuses on the influence of the amount of the waste material on the rheological and strength properties of produced mortars. The sand blasting grit was added as a partial or full replacement of natural sand. Results of performed tests show a potential possibility of using the contaminated sand blasting grit for production of mortars. However, an increase in the overall amount of waste product in the mortars was followed a by decrease of the strength. The addition of the grit also decreased the flowability of the mortar. Use of contaminated sand blasting grit for production of mortars allows reduction of the high costs of waste disposal and storage.

1. Introduction

The problem of climate change and issues associated with global warming, water, air and soil pollution or vast amounts of waste materials generated by humans are some of the key topics for many current studies. The emission of CO_2 to the atmosphere is one of the greatest problems faced by the cement industry. Studies have shown that the cement industry can produce up to 10% of global CO_2 amounts [1].

The evaluation of the effect that the industry has on the environment is therefore an important issue. Various institutions have studied and researched the problem to propose unanimous solution. Therefore, the term Sustainable Development was introduced, incorporating the solutions to resource depletion, pollution and lifestyle of the civilization [2].

Sustainable development includes various ideas of preventing hazardous actions and increasing the eco-friendly approach in different branches of the industry. One of the solutions is to use the industrial wastes [3]. The idea has a double effect. On one hand, reactive wastes such as fly ash or silica fume can be used to replace the Portland cement, therefore contribute to the reduction of the overall carbon dioxide emissions. On the other, non-reactive wastes can be used to replace the aggregate, improving the properties of mortars or concretes.

One of the most problematic waste is the contaminated blasting grit. Blasting (or in general abrasive blasting) is a process of removing the layers of dirt, rust or paint from various surfaces. Sandblasting is a popular method of cleaning in various branches of industry including shipbuilding, civil engineering, maintenance or army. There are various types of abrasive blasting media used in the industry.

Out of the multitude of available material, sand is one of the most common due to its low cost. However, the blasting grit after use is considered as a waste product and has to be disposed of. Other mineral sands without free silica or various steel, coal or copper slags can also be utilized [4].

Other types of ABM, including steel shots or glass beads can be reused after proper sieving and separation of contaminants. The plastic beads have a special use in abrasive blasting as they are less damaging and are recommended to more sensitive surfaces.

The first major issue with sandblasting is the choice of proper abrasive blasting material (ABM). The clean grit should not impose negative effects on the environment and contain any hazardous materials. The exposure to silica dust, extreme noise exposure, and mechanical and electrical hazards are the major concerns for the safety of workers. Especially the first one can be at times problematic, particularly due to a high content of silica in the natural sand [5].

A lesser issue concerns the disposal of the used ABM. The global policies for reduction of waste products impose a necessity of proper disposal or safe recycling of contaminated grits.

The issue with contaminated sandblasting grit lies in the material from the cleaned surface. The layers can contain various hazardous compounds. Especially sandblasting of painted metal surfaces can be dangerous to the environment. Some paints, particularly on older structures, that were covered before development of strict environmental laws, can contain heavy metals. Those metals were once used as anti-corrosion agents. Removal of the layers of paint causes the metal petals and specks to incorporate themselves between the grains of the ABM. The contaminated grit must be tested to prove it is harmless [6].

This study tries to determine if the contaminated sandblasting grit obtained from a local company can be successfully used in the production of the cement mortars.

2. Materials and Methods

The study was performed at the West Pomeranian University of Technology in Szczecin as part of a cooperation between the researchers and local entrepreneurs. A local company that deals with production of steel elements, industrial maintenance and abrasive blasting services faced a long-time problem with disposal of sandblasting grit. The disposal of high quantities of waste material is costly and problematic.

The study started with determination of the properties of the ABM.

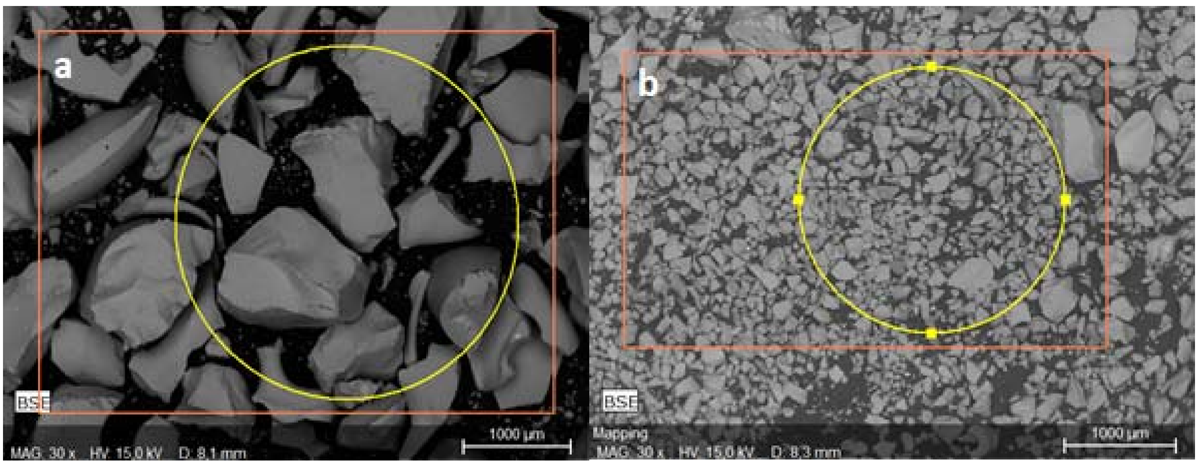

Figure 1. The microscopic view of the grit a) before sandblasting b) after sandblasting

The composition of the sandblasting grit and contaminated sandblasting grit was determined using Energy-Dispersive X-ray Spectroscopy (EDS). The view of the abrasive materials is visible in Figure 1.

It is clearly visible that the medium after the process of abrasive blasting consists of numerous smaller particles that were created in the process of breaking of the bigger particles.

The EDS method allowed to determine the elements within the grit. Sample results of the EDS for contaminated sandblasting grit is presented in Figure 2. The analysis was performed twice for each abrasive material. The mean values of component content are presented below.

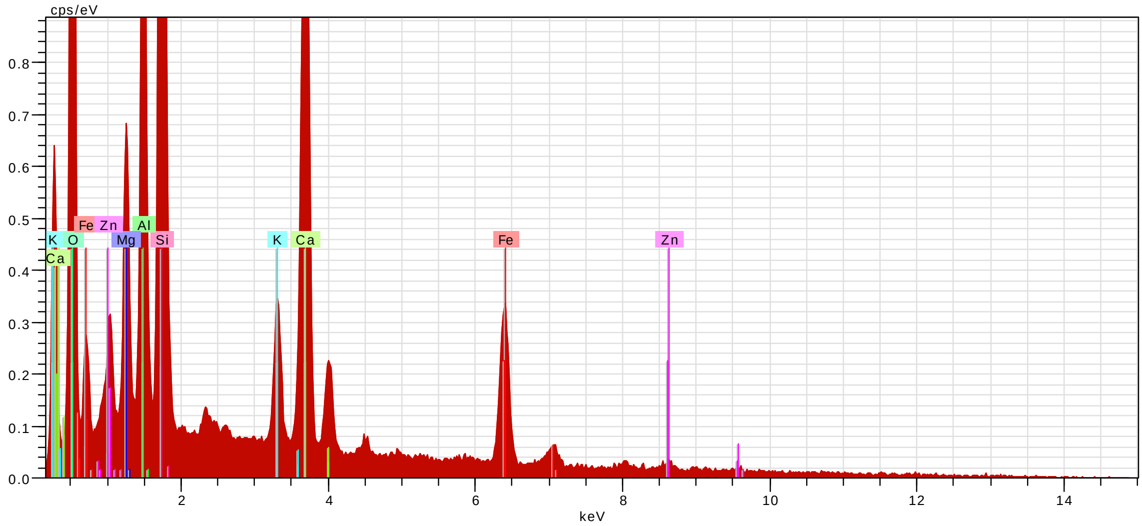

Figure 2. The results of the EDS determination of occurring elements

The analysis allowed to evaluate the oxide amount inside the blasting media. The comparison of element composition is visible in table 1.

Table 1. Chemical compositions (%) of abrasive material before and after blasting

Component	Before AB	After AB	Change
SiO_2	30.04	28.82	-4.08
CaO	25.91	27.57	+6.39
Fe_2O_3	16.61	18.20	+9.58
Al_2O_3	10.96	11.69	+6.65
MgO	7.00	6.56	-6.30
K_2O	4.58	4.56	-0.38
Na_2O	3.09	0.00	-100.00
C[a]	1.80	0.00	-100.00
ZnO	0.00	2.60	+100.00

[a] Due to characteristics of the abrasive material and requirements of the EDS method, the blasting media was glued on the carbon film. The occurrence of carbon in the results is probably inaccurate.

The analysis showed an increase in the overall amount of iron, zinc and aluminium, which is particularly predictable. The analysis showed that the grit does not contain any particularly hazardous contaminants such as Pb or Cd. This allows to assume that the grit can be used as a replacement for aggregate in cementitious materials.

The second stage of the study was to produce several mortars in which the aggregate was partially or completely replaced by the sandblasting grit. The mortars were produced using two types of cement, Ordinary Portland Cement CEM I 42.5 R and Slag Cement CEM III A 42.5. The mortars are named as

OCM (with Ordinary Portland Cement) and SCM (with Slag Cement) with percent of aggregate replaced.

The study involved determination of the mortar flow in accordance with PN-EN 1015-3 and tensile and compressive strength in accordance with PN-EN 197.

3. Results and Discussion

Results of the consistency and strength tests of mortars with Ordinary Portland Cement (OPC) CEM I are visible in table 2.

Table 2. Test results of mortars with Ordinary Portland Cement

Characteristic	OCM0	OCM50%	OCM75%	OC100%
Flow (cm)	14.8	13.8	12.0	11.3
Tensile strength (MPa)				
7 days	6.1	5.0	4.6	4.1
28 days	6.5	6.6	6.7	6.6
Compressive strength (MPa)				
7 days	36.5	33.4	26.3	23.3
28 days	44.2	41.2	39.8	35.6

Table 3. Test results of mortars with Slag Cement

Characteristic	SCM0	SCM50%	SCM75%	SCM100%
Flow (cm)	13.7	13.5	11.5	10.7
Tensile strength (MPa)				
7 days	4.7	4.1	3.1	1.0
28 days	8.8	5.9	5.6	5.0
Compressive strength (MPa)				
7 days	26.2	19.2	17.2	4.3
28 days	38.1	37.6	36.0	33.2

As visible in the tables above, the addition of the contaminated grit decreases the flow of the mortars. This occurred for mortars with both types of cement. The decrease of the flowability is caused by the higher amounts of powder fractions, obtained during blasting. The grit itself erodes due to force imposed during high pressure blasting as visible in Figure 1a and 1b.

The higher the percentage of the aggregate replacement with the contaminated sand blasting grit the higher the decrease of tensile strength of the mortars with OPC at 7 days. After the 28-day period, the tensile strength of the mortars was almost the same, regardless of the amount of replaced sand. This shows that the contaminated sandblasting grit slows down the hydration process. As a non-reactive aggregate, the grit probably incorporates a vast amount of hydration water due to the smaller particle size.

Increasing the amount of the replaced sand influenced the compressive strength of mortars. The higher the percentage, the lower the strength. The early strength (7 days) of mortar with 100% of contaminated grit was by 50% lower than for reference mortar with a natural sand. The difference in the 28-days strength was however not so significant.

As in the mortars with OPC, the mortars with Slag Cement with increased amounts of sandblasted grit had lower flow than the reference mortar. Similarly to the mortars with OPC, the contaminated grit decreased the tensile and compressive strength. However, the value differed greatly. Complete replacement of the sand with the contaminated sandblasting grit decreased the early (7 days) strength of concrete significantly more than in the case of OPC. Even taking into account that the OPC was a rapid cement, the strength value decreased almost by 80%.

a) b)

Figure 3. a) the mix after the flow test, b) contaminated sandblasting grit

Utilization of the waste products for concrete production has been particularly popular in recent years. Various studies have tried to find the application and test the properties of different waste products such as: waste glass [7,8], fly ashes [9,10] and other waste products that need to be disposed [11].

Use of waste material can not only enhance the properties of mortars, but also reduce the overall costs of production and servicing [12].

Sandblasting waste can contain many hazardous elements depending on the cleaned materials. The disposal of the contaminated grit has been a subject of different studies in the past [4,6,13].

4. Conclusions

The study has shown that there is a possibility of applying the sandblasting grit for production of cement mortars. Although replacement of the sand aggregate with the contaminated grit reduced the properties of cement mortars, obtained results could be still assumed as reasonable for civil engineering purposes. This preliminary study showed that there are certain issues concerning the use of the contaminated grit that need to be addressed in future research. Particularly the early age strength should be studied in details.

The other problem of the utilization of the contaminated sandblasting grit is tearing of the mortar and general flowability of the fresh mix. The mortars need to be heavily consolidated in the moulds. The mortars with high amounts of the sandblasting grit exhibit low thixotropy, meaning that they require more energy to be fully condensed. It might be necessary to utilize additional mineral additives or admixes to fully allow the sandblasting grit to be applicable.

Despite some issues, studies on the applicability of abrasive grit should be continued, as the possible benefits outdo the disadvantages.

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