ENGINEERED STONE MADE OF MODIFIED BOF SLAG

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Introduction

Utilising and reusing resources effectively is vital for the development of circular economy in the society. For environmental protection and reducing exploitation of natural resources, making good uses of resources that produced from industrials has become more and more important. Here, we present an engineered stone made by modified BOF slag, which is treated by oxygen and silica injection during its molten state.[1] An engineered stone with area up to 100×100 cm^2 made of modified BOF slag is present. By choosing an appropriate ester as a binder and optimising the size distribution of modified BOF slag particles, an engineered stone consisted of 95.2% modified BOF slag (particle size < 1.7 mm) was successfully fabricated. The high filling percentage of modified BOF slag with good volumetric stability and superior physical properties makes the engineered stone a compact structure with excellent physical properties. Indeed, the water absorption (< 0.3%), compressive strength (121.7 MPa) as well as flexural strength (41.6 MPa) of the engineered stone made of modified BOF slag are similar or even superior to commercial ones made of natural aggregates. Consequently, it is believed that the modified BOF slag is a potential material for the production of high value-added products such as engineered stones.

Results and Discussion

Hot Stage BOF Slag Modification

By injecting silica and oxygen into the molten slag (Figure 1a), the f-CaO would thus react with silica, forming calcium silicates so as to removal of f-CaO. This technique, called hot stage BOF slag modification (HBM) technique, was developed in CSC (Figure 1b) in 2012.[1] The volumetric expansion of the BOF slag decreases largely (<0.4%) after aging at 90°C for 30 min), indicating the removal of f-CaO is done efficiently by HBM treatment. At present, the successful rate of BOF slag modification is above 96%, which is the best-ever achieved among the other steel factories in the world. By establishing and developing our own HBM technique, the volumetric expansion problem of BOF slag is solved, which sheds lights on BOF slag recycling and reuse.

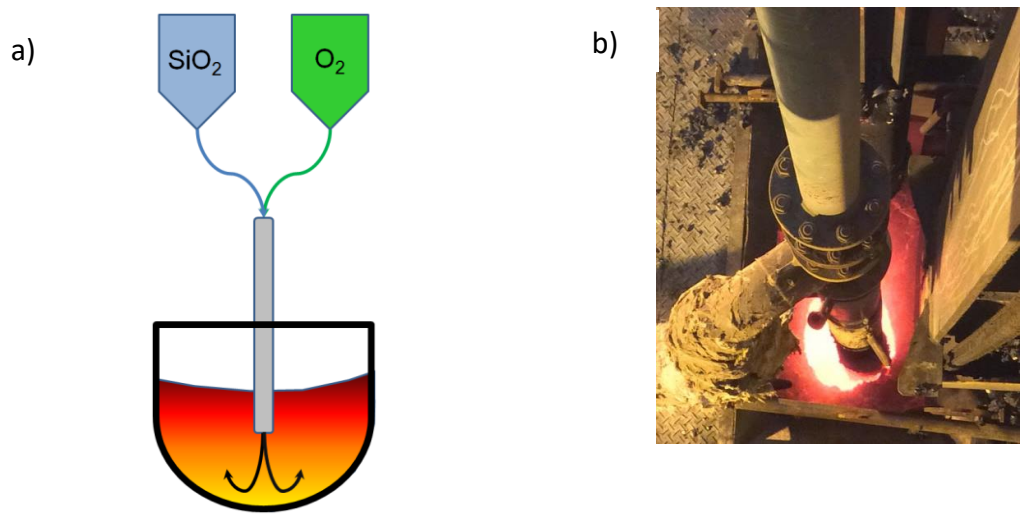

Figure 1: (a) the BOF slag modification was carried out by injecting silica and oxygen into the molten BOF slag (b) the process BOF slag modification in CSC

Fabrication of the Engineered Stone

As there are more defects seen in larger particles, the modified BOF slag with the grain size ≤ 1.7 mm (Figure 2a) was used as a main inorganic phase of the engineered stone, while the modified BOF slag powder (≤ 0.15 mm, Figure 2b) was utilised as a material for filling up defects.

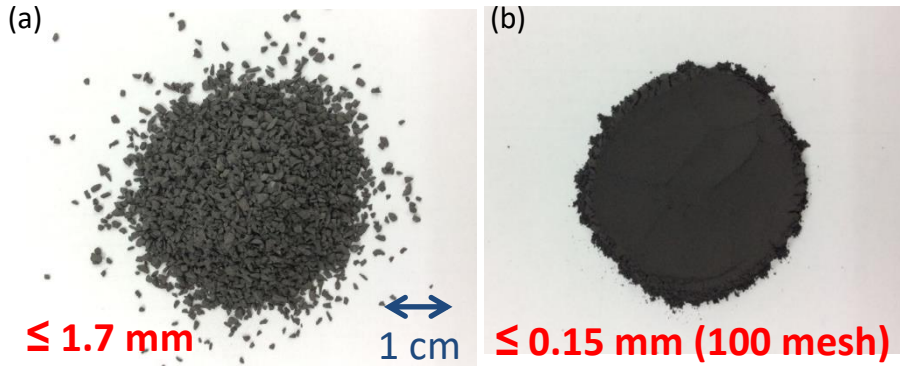

Figure 2: (a)the modified BOF slag grain (≤ 1.7 mm) and (b) the modified BOF slag powder (≤ 0.15 mm) utilised as a main inorganic phase and a material for filling up defects in the engineered stone, respectively

For the production of the engineered stone, normally, 84% of the modified BOF slag (≤ 1.7 mm) was physically mixed with 16% of the modified BOF slag powder (≤ 0.15 mm) first. Then around 10 ~ 15% resin (type: 2738A, Eternal Materials Co., Ltd.) was added into the container filled with the modified BOF slag aggregates (Figure 3a). Later, the container was spun and lasted for 5 mins until the harden reagent of resin was added. Another spinning of the container was applied for 5 mins after the harden reagent of resin was added (Figure 3b). After the procedure of mixing the modified

BOF slag grains/ powder, resin and harden reagent was done, the mixture was immediately discharged from the container into the 100×100×20 cm^3 steel mould (Figure 3c). The mould was sealed by the cover connected to the vacuum. At this stage, vibration and vacuum was applied alternatively for removing bubbles embedded in the engineered stone (Figure 3d). Finally, the cover was removed to allow the product being aged for 1 day before it was removed from the mould (Figure 3e).

Figure 3: (a) the modified BOF slag grains/ powder, resin and harden reagent were added into the container (b) the container spun to mix the mixture (c) the mixture ischarged from the container into the mould (d) vibration and vacuum were applied to the mixture (e) the engineered stone made of modified BOF slag and resin was aged for 1 day before it was removed from the mould.

Properties of the Engineered Stone

As Figure 4 shows, a smooth and shiny surface of the engineered stone made of the modified BOF slag is demonstrated, which indicates the defects of the modified BOF slag were successfully filled up with the slag powder (≤ 0.15 mm). Due to the superior physical properties of the modified BOF slag, the engineered stone presents a similar or even better quality (flexural strength ~ 41.6 MPa) than commercial products made of natural aggregates as Table 1 shows. It is known that engineered stones made by natural aggregates are commonly with the shortages of defect[2] or weathering[3] appearance. With better properties in abrasion/soundness resistance, the compact engineered stone made of the modified BOF slag shows promise for turning BOF slag into higher value-added products.

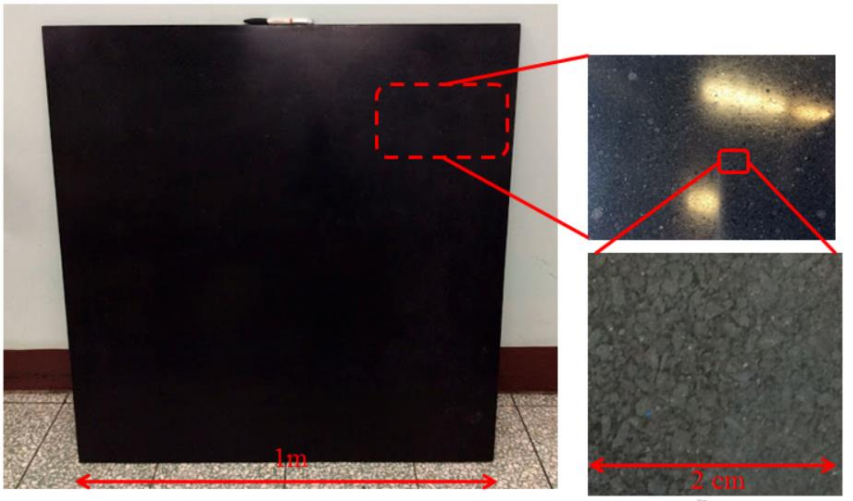

Figure 4: The engineered stone (100×100 cm^2) made of the modified BOF slag shows smooth and shiny surface

Table 1: The comparison of physical properties between the engineered stone made of the modified BOF slag and natural aggregates, respectively.

Properties	Values	Commercial Product
water absorption (%)	0.3%	0.2%
flexural strength (MPa)	41.6	14.4
compressive strength (MPa)	121.7 ± 14.8	130

Summary

The engineered stone made of modified BOF slag with area up to 100×100 cm^2 is demonstrated. The engineered stone consisted of 95.2% modified BOF slag presents (particle size < 1.7 mm) a compact structure with excellent physical properties. The water absorption (< 0.3%), compressive strength (121.7 MPa) as well as flexural strength (41.6 MPa) of the engineered stone are similar or even superior to commercial ones made of natural aggregates, which indicates modified BOF slag is a potential material for the production of high value-added products such as engineered stones.

References

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