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Research Article

Utilization of Marble and Boron Waste in Brick Products

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Abstract:

In this study, usability of marble and boron wastes as alternative raw materials in the production of bricks was investigated. They were used in different ratios to prepare samples. Marble waste in concentrations of 5, 10, 15 and 20 wt% were added to the boron waste. Afyon brick clay was used as a binder in 10 wt%. Specimens were shaped by hydraulic press and fired at temperatures from 850 to 1050 °C for 4 hours. The crystalline structure and morphologies of the samples are characterized by X-ray powder diffractometer (XRD) and scanning electron microscopy (SEM), respectively. Flexural strengths of samples were measured. Acceptable mechanical properties have been obtained from the brick sample containing 5 wt% marble waste, 85 wt% boron waste and 10 wt% clay sintered at 1050 °C for 4 hours.

1. Introduction

Marble and boron wastes are one of the major environmental problems in Turkey. Only in Afyon province, disposed waste marble material is about 12 million tones/year and amount of boron waste resulting from the boron plants in Turkey is more than one million tone in a year[1-2]. There is an urgent demand to manage it in order to reduce the environmental impact. Large areas have to be allocated for disposal of them. Thus, waste storage causes environmental pollution and economical loss [3-5]. There are many studies on the use of marble and boron wastes as additive or filling materials in various applications such as ceramic [6-8], concrete [9-10], brick [11], and building materials [12].

In this study boron and marble wastes were evaluated in brick product. They were mixed in different proportions and shaped by hydraulic press. Then they were characterized by mechanic test, X-ray diffraction (XRD), scanning electron microscopy (SEM).

2. Materials and Method

Marble waste was supplied from Reis Marble Factory in Afyon. Boron waste was kindly supplied from Eti Maden Emet Boric Acid Factory in Emet, Kütahya. Marble and boron wastes were dried in oven at 100 °C, then ground in jet mill under the size of 250 µm. In order to prepare brick samples powdered marble waste, powdered boron waste and Afyon brick clay as a binder were mixed in the compositions as given in Table 1. They were shaped by hydraulic press under 100 bar and fired at temperatures from 850 to 1050 °C for 4 hours. The crystalline structure and morphologies of the brick samples were characterized by X-ray powder diffractometer (XRD) and scanning electron microscopy (SEM).

Table 1. *Materials ratios in brick mixtures*

Samples	Boron waste, wt %	Marble waste, wt%	Clay, wt %
BM1	90	-	10
BM2	85	5	10
BM3	80	10	10
BM4	75	15	10
BM5	70	20	10

Table 2. *Chemical analysis of boron and marble wastes.*

Boron waste	Component	CaO	SiO_2	MgO	Al_2O_3	Fe_2O_3	K_2O	SO_3	Cr_2O_3	SrO	B_2O_3	LOI
	Wt (%)	36.7	9.96	2.33	1.66	2.64	0.92	20.5	1.24	2.27	1.21	19.5
Marble waste	Component	CaO	SiO_2	MgO	Al_2O_3	Fe_2O_3	K_2O	-	-	-	-	LOI
	Wt (%)	54.30	0.75	0.22	1.15	0.20	0.23	-	-	-	-	43.20

3. Results and Discussion

The best sintered samples at each temperature and mechanical strengths of fired samples in each composition were given in Fig. 1 and Fig. 2, respectively. As clearly seen from Fig. 2, the flexural strength of brick decreases linearly with increase of marble waste addition. The maximum strength was obtained with BM1 sample. However, the bricks having BM2 composition gave the reasonable strength values. Considering the reusing of the marble waste in addition to the boron waste, the BM2 brick mixing was preferred as suitable composition. The figures also show that the best temperature for sintering is 1050 ºC for the bricks. SEM images (Fig. 3) and XRD analysis (Fig.4) support this case. At 850 ºC, sintering is very poor and a heterogeneous structure with high porosity is seen. However, at 1050 ºC, some hydrated calcium sulphates in boron waste reacts with clay minerals and also CaO resulting from the thermal decomposition of marble waste in order to form akermanite mineral a kind of spinel phase. So that, the microstructure of the brick became more compact and homogeneous by means of solid-state sintering mechanism (Fig. 3).

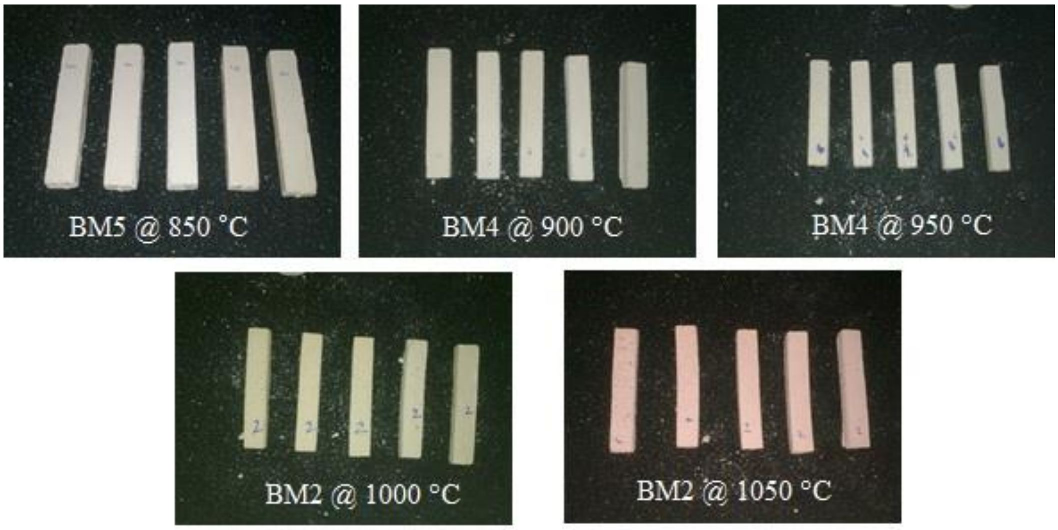

Figure 1. *The best fired samples at different temperatures.*

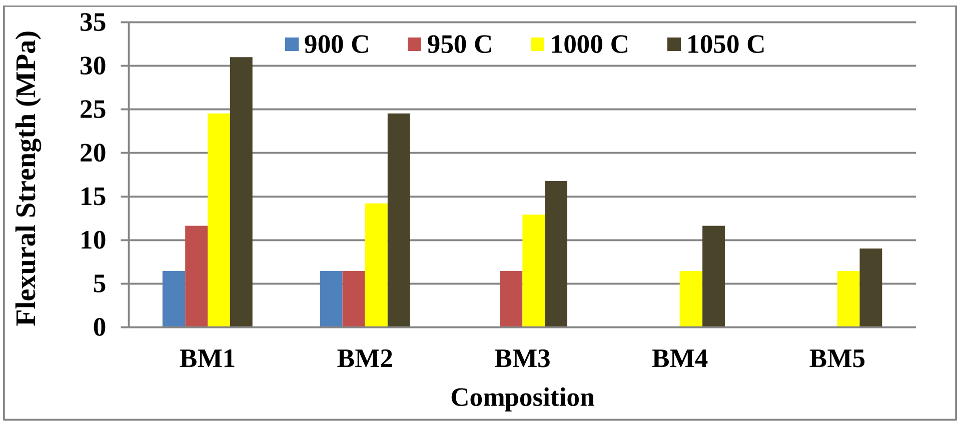

Figure 2. *Flexural strengths of samples fired at different temperatures.*

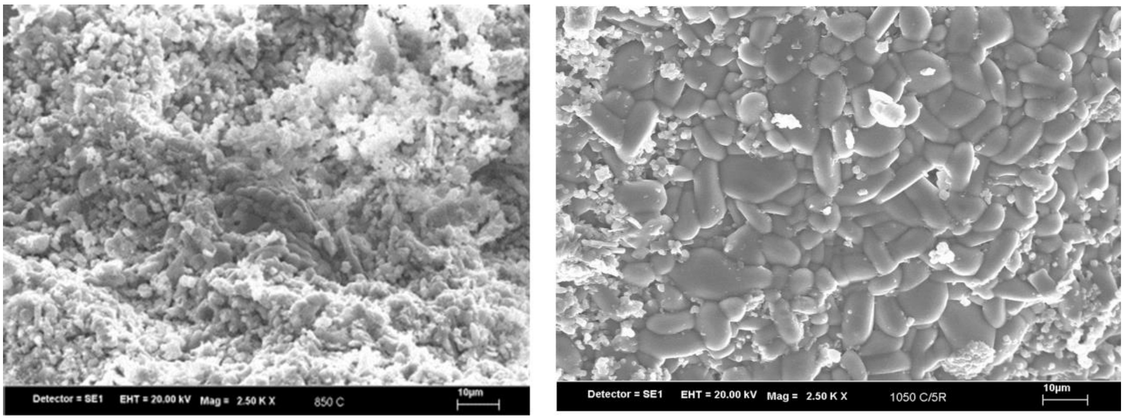

Figure 3. *SEM images taken from the fracture surface of sintered BM2 samples at 850 (left) and 1050 oC (right).*

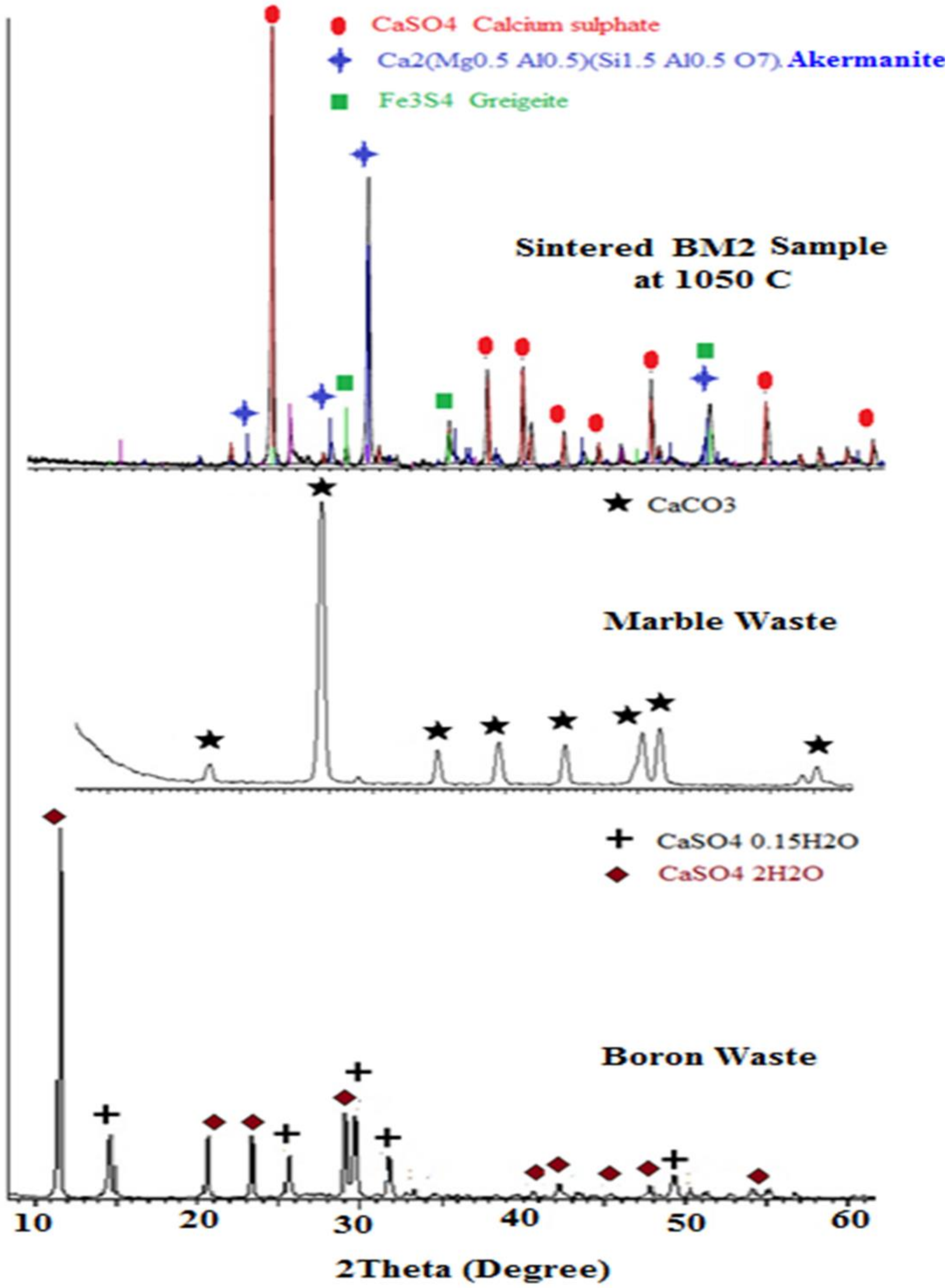

Figure 4. *XRD pattern of raw materials and sintered BM2 sample.*

4. Conclusion

Considering utilization of both of the boron and marble wastes the best flexural strength (~25 Mpa) value has been obtained from the brick sample containing 5 wt% marble waste, 85 wt% boron waste and 10 wt% clay sintered at 1050 °C for 4 hours. More than 5wt% marble waste addition into brick composition decreases the flexural strength of the brick significantly.

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