AN INVESTIGATION ON THE POSSOIBLE USE OF BORON WASTES IN THE BRICK CONSTRUCTION

Bor Atıklarının Tuğla Üretiminde Kullanım Olanaklarının Araştırılması

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ABSTRACT

This work has studied the influence of colemanite waste (CW), tincal waste (TW) and Borax penta-hydrate waste (BW) on the physical properties of brick. Waste were replaced by clay in amounts 5, 10, and 20 wt % of sample. Physical and mechanical properties of the brick were investigated through a number of tests. It has been established that TW and BW replacement considerably increases compressive strength of the brick. However CW replacement has negative effects on the compressive strength. The results obtained were compared with the Turkish Standards , and in general, were found to be within the limit. As a result, TW and BW samples may be used in the production of brick.

ÖZET

Bu çalışmada colemanit atığı, tincal atığı ve borakspentahidrat atıklarının tuğlanın fiziksel özelliklerine etkisi çalışılmıştır. Atıklar 5%, %10 ve %20 oranında kil ile yer değiştirilerek tuğlanın fiziksel ve mekanik özellikleri bir takım testlerle araştırılmıştır. Tincal ve borakspentahidrat atıklarının tuğlanın basınç dayanımını artırdığı ve colemanit atığının basınç dayanımı üzerine negatif etki yaptığı bulunmuştur. Elde edilen sonuçlar Türk standartları Enstitüsünde belirtilen değerlerle karşılaştırılmış ve genelde standartlarla uyum gösterdiği bulunmuştur. Sonuç olarak tincal ve borakspentahidrat atıkları tuğla üretiminde kullanılabilir.

Key Words: Compressive Strength, Shrinkage, Tincal Ore Waste, Water Absorption, Brick

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1.INTRODUCTION

The development of the economy consumes a large amounts of resources and energy causing environmental pollution that results in destruction of the ecological balance. Recently, there is a continuing interests in establishing suitable process in which hazardous wastes can be valuably reused. Turkey with the 90002000 tons of known boron reserve is the second boron minerals and boron compound producer in the world (Erdoğan et al, 1994). In the course of processing of boron minerals significant amount of wastes are disposed. These wastes are used as land fill, which is an unsatisfactory solution both from an ecological and an economical point of view (Nebiler et al., 1999).

A number of efforts have been made to use boron waste as a partial replacement of the coarse and fine aggregate in the production of cement. Erdoğan and co-workers studied the utilization of borogypsum (Erdoğan et al, 1992), boric acid sludge (Demirbaş and Karslıoğlu, 1995), partly refined chemical by products gypsum (Erdoğan et al, 1994) and combination of these wastes with fly ash, and bottom ash as cement replacement material (Kula et al., 2001). Boron waste can also be used as additive material for promoting formation of glassy phase and reducing the melting point in the production of borosilicate glass and frit for ceramic glaze (Olgun, 1999; Yaman, 1998).

In this study, the possible use of boron waste in the production of brick was investigated. In recent years, the production of brick from waste material has been topic of many investigations. These studies indicated that unground rice husks (Carter et al., 1982), rice husks ash (Rahman, 1988), wood sawdust (Okungwu, 1988), coal fly ash (Rakina et al., 1976), lignite combustion residue ash (Köhler, 1988) and perlite can be used as brick additive materials. Perlite was preferred to promote prosity and sintering process at high temperature (Kolkmeier, 1989). In this work, since potential use of boron compounds in ceramic industry the waste containing significant amount of B_2O_3 was thought to be a suitable raw material for the brick production.

2.MATERIAL and METHOD

Clay was obtained from Turgutlu Brick Plant (Manisa, Turkey), Colemanite waste and Tincal waste were supplied from the concentrator at Etibor Foundation, Kutahya-Emet, Eskisehir-Kırka, Turkey, respectively. Borax penta-hydrate waste obtained from the filters in the production of Borax penta-hydrate (Eskisehir-Kırka, Turkey). The chemical compositions of CW, TW, BW and clay were done using x-ray fluorescence spectrometer. B_2O_3 in the wastes was determined according to MTA titration method (MTA). The chemical analysis of the used materials are given in table 1.

Wastes were dried at room temperature and crushed to 2.8mm- 0.2 mm. These waste were added to clay with different proportion. The weight of the material used for each mixture are given in table 2. Four series of mixtures were prepared according to Turkish standard (TS), and designated as A, B, D, G, than size fraction analysis and plasticity water were determined. Test slabs were prepared using a laboratory pneumatic extruder. They were than dried at 55 ^{o}C for 4 hours and at 110 ^{o}C for 24 hours. The specimens were fired at 800, 900, 1000 and 1100 ^{o}C for 14 hours. After firing the following properties were studied according to TS 4790 (TS):

- Linear dry shrinkage

- Linear firing shrinkage
- water absorption

Compression strength measurements were done according to TS 705 (TS). The strength value was the average of three specimens.

Table 1. Chemical Composition of the Investigated Materials

Chemical Analysis, (wt%)					
Oxide	Clay	Tincal Waste (-25mm)	Colemanite waste (-25mm)	Borax penta-hydrate waste (+3mm) Sample I	Borax penta-hydrate waste (+3mm) Sample I
SiO_2	59.20	16.00	33.21	14.83	11.28
Al_2O_3	17.15	1.80	9.65	1.88	1.26
Fe_2O_3	4.40	0.36	3.74	0.41	0.25
CaO	0.65	12.20	6.88	9.17	7.76
MgO	2.15	7.95	4.07	6.88	5.36
SO_3	0.14	0.20	0.08	0.26	0.23
Na_2O	0.73	0.73	0.06	1.01	1.26
K_2O	1.34	0.92	3.41	0.91	0.72
B_2O_3	-	17.92	21.28	13.30	16.23
L.O. I	-	41.91	17.68	46.06	46.65

3.DISCUSSION and RESULT

The results of the effects of waste material replacement on the properties of horizontal cored hollow brick are presented in table 2 and 3. The degree to which clayey raw materials can be shaped determined more precisely by standard plasticity tests. In a certain way this reflects the extent of linear dry shrinkage. Table 3 shows the linear dry shrinkage with 5, 10, 20 mass-% of waste material replacement by clay. The CW replacement reduces the linear dry shrinkage of specimens. For all the other specimens investigated, waste materials effect on the linear dry shrinkage was discernible at a 5 mass-% of replacement. When it is used to replace clay by CW the linear dry shrinkage of the sample was higher than those obtained from the other waste materials. On the other hand increasing replacement of waste material reduces the linear dry shrinkage of samples prepared from CW while increasing shrinkage for TW and BW samples.

Table 2. Physical Characteristics of Mixes

Sample	Mixes	Fineness (wt%) + 2.8 mm	Fineness (wt%) + 200 μm	Plasticity water (wt%)
A_1	5%CW+95%C	11.20	36.40	28.18
A_2	10%CW+%90C	11.22	43.80	30.31
A_3	20%CW+80%C	11.24	57.53	31.67
B_1	5%TW+95C	11.18	47.71	13.67
B_2	10%TW+%90C	11.21	51.36	13.71
B_3	20%TW+%80C	11.26	74.18	25.83
G_1	5%BW1+%95C	10.86	49.30	14.31
G_2	10%BW1+%90C	11.14	58.65	14.52
G_3	20%BW1+%80C	11.23	78.28	15.05
D_1	5%BW2+%95C	11.28	40.82	14.48
D_2	10%BW2+%90C	11.30	54.03	14.65
D_3	20%BW2+%80C	11.33	70.31	15.65

Table 3 shows that linear firing shrinkage (brick with 5 mass-% CW) initially amounts 6.05 (for 5 mass-% CW) which appears a negative shrinkage after the replacement of CW (10 or 20 mass-) between – 0.19% and –1 %. On the contrary, an increase of the linear firing shrinkage of the sample was also noted as a result of BW and TW replacement.

Table 3. Influence of Waste Materials Additives on the Products Properties

Sample	Linear dry shrinkage (%)	Linear firing shrinkage (%)	Water Absorption (%)
TSE 4790	2-3	6	13-16
A_1	6.04	6.04	12.30
A_2	5.45	5.45	14.60
A_3	5.04	5.04	18.63
B_1	2.00	5.50	12.24
B_2	2.50	5.80	12.97
B_3	3.00	6.00	14.05
G_1	2.00	5.23	12.08
G_2	2.50	5.64	13.24
G_3	2.70	6.30	14.58
D_1	2.13	5.22	12.26
D_2	2.64	5.74	13.18
D_3	3.29	6.21	14.43

Figure 1 shows the compressive strength of sample with different waste materials contents. CW replacement yielded the lowest compressive strength as compared to TW and BW samples. As seen from the table 2 water demand of the sample containing BW is bigger than those other mixtures. The volume of the waste decreases during the firing process due to evaporable water. This promotes prosity of the sample which result to a lower compressive strength. For mixes containing TW and BW compressive strength values are comparable with the TS. With the addition of TW and BW compressive strength was significantly increased compared to sample containing CW. This may be attributed to the melting behavior of the boron. Boron was preferred to promote glassy phase in the production of glass and frit for ceramic glaze (Kula et al., 2001; Yaman, 1998) Melted glassy phase may fill the pores that enhance the compressive strength of the sample.

4.CONCLUSIONS

Based on the above results and discussion, the following conclusions can be drawn:

1.Water absorption of the bricks produced increases with the increasing replacement of waste.
2.The results indicate that the incremental change in compressive strength as a function of waste content was significantly lower in the case of CW than in the case of TW and BW replacement. However, the values obtained for TW and BW were within Turkish Standards (TS 705).
3.CW replacement result to a higher dry shrinkage of sample. The values obtained were out of Turkish Standards (TS 705).

Industrial waste management is one of the major environmental problem in Turkey. Therefore, recycling and reuse of industrial wastes play vital role both in solving the industrial waste problem and getting benefit from it. As a result, it is suggested that tincal waste and Borax penta-hydrate waste can be used in the production of horizontal cored hollow brick up 20 % by weight of the sample.

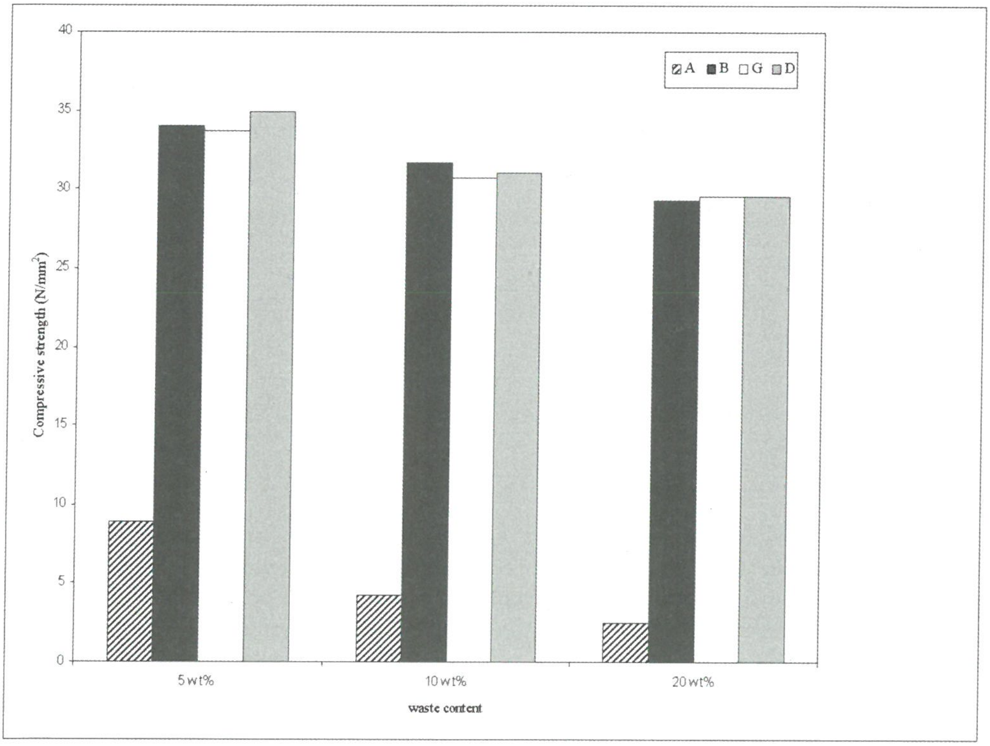

Figure 1. Compressive Strength of the Sample Containing Different Amount of Waste material.

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