ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Influence of Cement Dust on Ceramic Properties of Basalt Bricks

Randa M Osman, H Abu-El-Naga, EA El-Alfi

National Research Center, Dokki, Cairo, Egypt

ABSTRACT

The gradual substitution of altered basalt by by-pass cement dust up to 10% on ceramic properties of basalt bricks was studied. The samples were prepared and dried at 105˚C as well as fired at different temperatures such as 800, 900, 1000, and 1100˚C for 1-hour soaking time. The physico-mechanical and ceramic properties of the samples were evaluated. Some selected fired samples were investigated by XRD technique. The results show that the mechanical properties enhance with increasing firing temperature for all samples.. The study reveals that good quality of bricks can be produced with 5% by-pass cement dust at all firing temperatures.
Keywords: altered basalt, by-pass cement dust, bricks

**Corresponding author*

INTRODUCTION

Red bricks are made from the Nile silt is considered as one of the very old Egyptian building materials. As a result of the construction of High dam at Aswan, the amount of silt precipitated in the course of the Nile is decreased to less than 10% of the previous annual deposits. Altered basalt materials which can replace Nile silt for brick making would be the answer to this problem [1]. Basalt is currently being extracted at a number of quarries at Abu-Zaabal near Cairo, Egypt. At some of these quarries, altered basalt is produced as a by-product in large amounts. This waste has actually no significant value and the cost of its removal, in addition to the space problem led to consideration of utilizing of this material.

The possibility of using weathered basalt in the manufacture bricks was studied [2]. Samples made from ground altered basalt were formed into a compact mass in a 1-inch cylindrical moulds and fired at 800, 900,1000, and 1050 and 1100˚C for 2 hours soaking time. The results illustrated that a good ceramic properties were produced at a firing temperatures of 1050˚C.

The effect of substitution of clay by sand as well as by-pass cement dust on the ceramic properties of clay bricks has been studied [3]. Briquettes were made, and fired for 2 hours at 800˚C, and the ceramic properties were studied. The data show that the substitution of 20% clay by sand improves the crushing strength, bulk density and apparent porosity as well as the prevention of bloating of the fired clay bricks. A sand addition over 20% decreases the mechanical properties. The addition of 5% by-pass cement dust to mix containing 80% clay and 20% sand improves the ceramic properties of the fired samples.

Building bricks made from Abu-Zaabal altered basalt and de-aluminated kaolin wastes were Investigation [4]. Mix batches were made from mixture containing 90-70% basalt and 10-30% de-aluminated kaolin, respectively. Samples were prepared and dried at 105˚C as well as fired at different temperatures ranging from 900 up to 1100˚C for two hours soaking time. The ceramic properties of the fired samples were tested. The study reveals that a good of bricks can be produced from 90-70% basalt and 10-30% de-aluminated kaolin.

In this study, we are trying to determine the feasibility and utilization of the cement kiln dust as a part, in place of the raw materials used for basalt bricks production and its effect on reducing the firing temperature and phase composition of prepared bricks.

Experimental work

The materials used in this investigation were altered basalt (from Abu-Zaabal quarries) and by-pass cement dust as a by-product of National cement company, Egypt. Using a roller mill, the pre-crushed lumpy basalt was ground to a size of 0-6 mm. The output was further ground on a fine roller mill (gap setting 0.5). This crushed basalt was then ground by means of a steel ball mill to a fine powder of about 100 µm. The cement dust was sieved through (150 µm) sieve. The ground basalt and cement dust were investigated for their chemical composition using wet silicate analysis. The characterization of the altered basalt by means of DTA, TG, and XRD were done in the previous work [2]. The chemical analysis of starting materials was shown in Table (1). Five mixes from ground basalt and cement dust with different ratio such as A (100/0), B (97.5/2.5), C (95/5), D (92.5/7.5), and E (90/10) were prepared, respectively.

Table (1) the chemical oxide analysis of starting materials.

material	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	SO_3	Alkalis	Cl	L.O.I	total
basalt	48.98	14.35	11.84	3.37	10.52	6.09	0.00	3.11	0.00	1.02	99.28
Cement dust	13.35	3.25	1.89	n.d*	45.75	1.80	4.10	4.25	2.77	22.31	99.47

n.d*: not determine

These mixes were molded in a compact mass of one-inch cylindrical mould with 7% water under pressure of 80 kg/cm^2. The Samples were dried at a rate of 10˚C/min from room temperature up to 105˚C. The dried samples were followed by firing at 800˚, 900˚, 1000˚, and 1100˚C for 1 hour soaking time. The firing rate used was 100˚C/min till the desired firing temperatures was reached. The ceramic properties of the fired samples such as firing shrinkage, apparent porosity, bulk density, and crushing strength were studied. Some selected fired samples were investigated by XRD technique to identify their phase composition.

RESULTS AND DISCUSSION

The results of chemical analysis of altered basalt and by-pass cement dust show that the cement dust is mainly composed of CaO, $CaCO_3$, SiO_2, Al_2O_3, SO_3, and alkalis. Also, basalt has CaO, MgO, total iron oxide as Fe_2O_3, Al_2O_3, and SiO_2 with predominance of SiO_2. These are the main oxides forming the plagioclase and pyroxene minerals.

These results reveal the general trend of oxide contents of the prepared batches. As the by-pass cement dust content increases from 0 up to 10%, the batches become lower in iron, titanium, magnesia, and silica and the sum of the fluxing oxides consequently decrease and the presence of CaO content enhances. On the other side, the presence of CaO tends to higher the binary eutectic temperatures of alumina-silica mixture, the major components of the fired samples [5-6].

The results of firing shrinkage of the fired samples having 0-10% of cement dust are shown in Figure (1). Results indicate that by increasing the firing temperature from 800 up to 1100˚C, the shrinkage of all tested sample slightly increased gradually. This was followed by more rapid increase of linear shrinkage at 1100˚C. It is clear that the linear shrinkage of the control sample (without addition) gradually increases up to 1000˚C, and sharply enhances at 1100˚C. This may be attributed to higher alkalis and alkaline earth oxide contents in the altered basalt, which leads to good sintering properties and more linear shrinkage. During firing of the basalt batches up to maturing temperature, some of its minerals continued to dehydrate up to 700˚C, giving rise to a mixture of active amorphous SiO_2, Al_2O_3 [7]. Between 700 and 850˚C, notably at temperatures exceeding 800˚C, impurity oxide of iron, titanium, alkalis and alkaline

ISSN: 0975-8585

earth oxide act as fluxing agents for the SiO_2 and Al_2O_3 in the fired batches. The presence of these fluxing oxides tends to lower the maturing temperature, reducing the melting point of the liquid phase. On the other hand, as the cement dust content in the specimens increases the linear shrinkage decreases at all firing temperatures. The cement dust has a higher amount of free calcium oxide which is an important ingredient in all ceramic bodies. Its behavior in firing is more complex, so, it cannot be classified simply as a filler sample or a flux. On firing, it reacts with other constituents to form new ceramics phases rather than enter into the glassy phase.

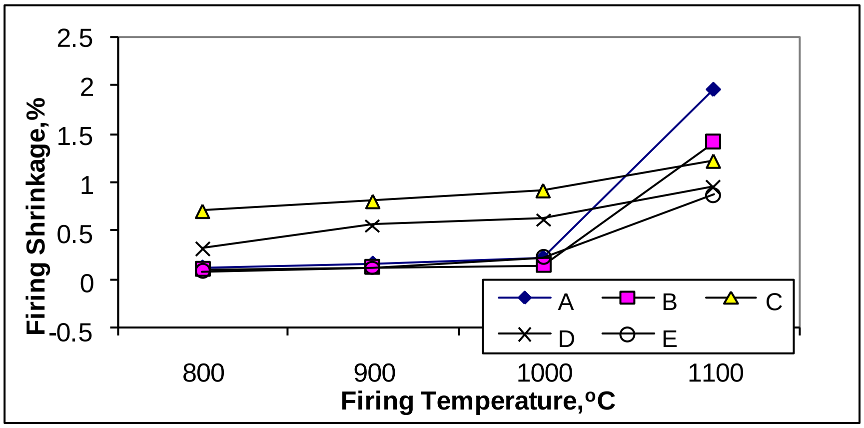

Figure (1) Effect of firing temperature from 800˚C up to 1100˚C on the shrinkage of tested samples having 0-10% of cement dust

Figure (2) shows the bulk density of the fired samples as a function of firing temperatures. The data show that with the increasing the firing temperature, the densification process develop for each fired specimens. This attributed to that altered basalt contains a higher amount of fluxing agents which leads to give a good sintering properties as well as increasing the bulk density at all firing temperatures. Also with enhancing the by-pass cement dust content from 0 up to 10%, the bulk density decreased. This indicates the presence of open pores with the increasing of the cement dust content which causing lower bulk density.

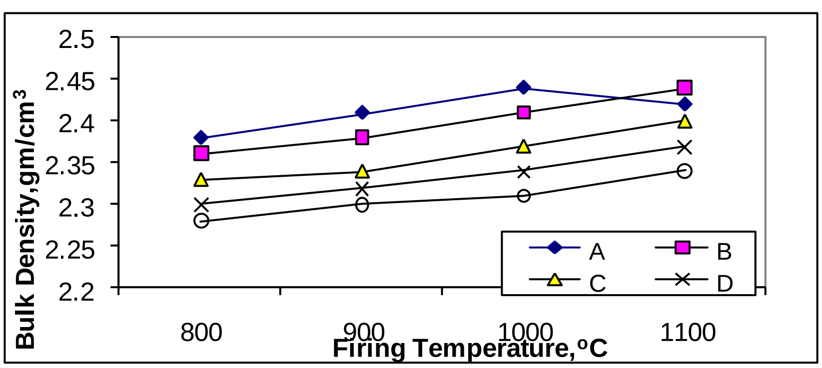

Figure (2) Effect of firing temperature from 800˚C up to 1100˚C on the bulk density of tested samples having 0-10% of cement dust

Figure (3) shows the apparent porosity of fired samples as a function of the heating temperatures. Generally, the apparent porosity of the fired samples decreases with increasing the heating temperatures. Also, the data show that as the firing temperature enhances up to 1000˚C, the apparent porosity slightly decreases. While between 1000˚C and 1100˚C, it is sharply decreases, coinciding with the beginning of densification [8]. On the other side, with increasing the cement dust content, the apparent porosity enhances. Also, the sample which contains 90% basalt and 10% cement dust has a higher percentage of porosity than other those samples at all firing temperatures. When the altered basalt content increases the mixes are rich in iron, titania, magnesia, and the fluxing oxides namely NaO_2, K_2O, Fe_2O_3, and MgO. The presence of these oxides tends to lower the maturing temperature with reducing the melting point of the liquid phase which leads to give a good sintering properties as well as reducing the apparent porosity [9]

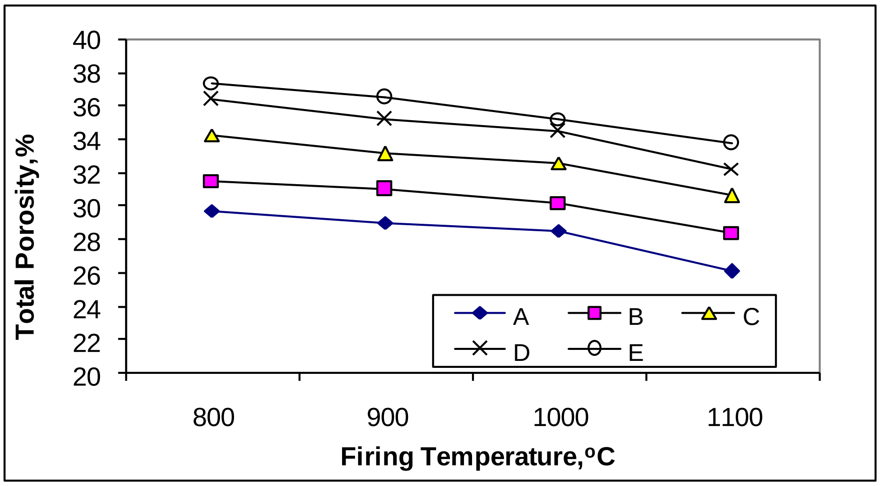

Figure (3) Effect of firing temperature from 800 ˚C up to 1100˚C on the Total Porosity of tested samples having 0-10% of cement dust

The crushing strength of the fired samples is graphically represented as function of firing temperature is shown in Figure (4). The crushing strength increases with firing temperature for all fired batches. This is attributed to the increasing amount of the liquid phase leading to an increase in the ceramic properties of the fired samples. In addition, as the cement kiln dust increases up to 5%, the crushing strength of the samples sharply enhances especially at 1100˚C. The increase of cement dust content over 5% increases the permeability and accompanied by a decrease of crushing strength. This is congruent with the bulk density and apparent porosity results. It can be concluded that the mixes containing 2.5 and 5.0% cement dust give suitable ceramic properties.

Figure (5) illustrates the XRD patterns of the fired samples containing 0, 5, and 10% cement dust fired at 1100˚C. The results show that substitution of altered basalt by cement dust has noticeable effect on the phase composition of all batches. It clear that the intensity of the albite peaks is reduced with increasing of the cement kiln dust. Also, as the cement dust contents enhances, the intensity of diopside peaks increases. The cement dust is mainly composed of CaO, SiO_2, SO_3, and alkalis. Also, basalt has CaO, MgO, total iron oxide as Fe_2O_3, Al_2O_3, and SiO_2 with predominance of SiO_2.

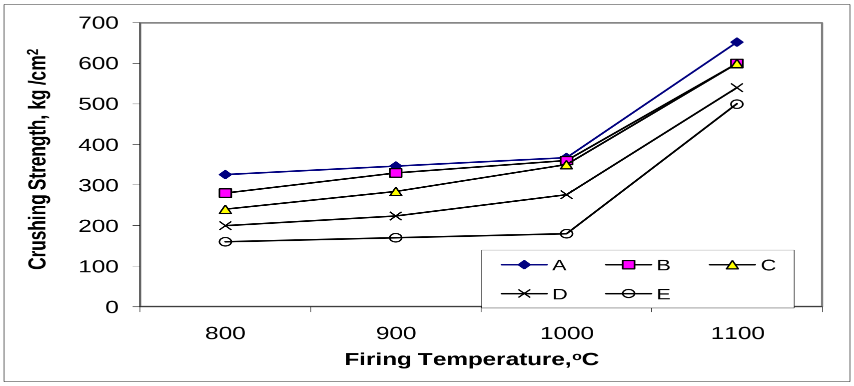

Figure (4) Effect of firing temperature from 800 ˚C up to 1100˚C on the Crushing Strength of tested samples having 0-10% of cement dust

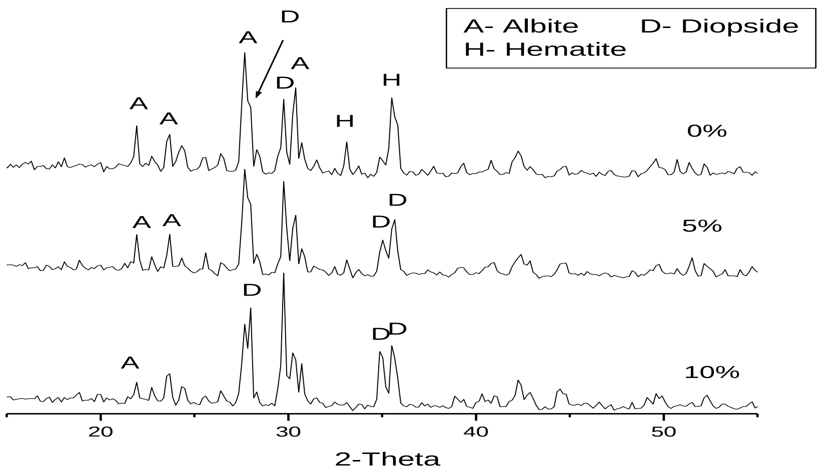

Figure (5): XRD patterns of the fired samples containing 0, 5, and10% cement dust fired at 1100° C.

Figure (6) illustrates the XRD patterns of the samples containing 5% cement dust and fired at 800°, 1000°, and 1100° C. The data show that the relative amounts of plagioclase and pyroxene (augite) phases are reduces with heating temperature. This is due to the higher contents of SiO_2 and Al_2O_3 as well as Fe_2O_3 and TiO_2 as fluxing oxides which lead to the dissolution of relatively higher amounts of basalt components and cement dust during heating. On the other side, the intensity of the diopside contents is gradually increased with firing temperature, so, the crushing strength enhances. Also, the results indicate that the diopside phase increases and the albite phase decreases with increasing of the firing temperature.

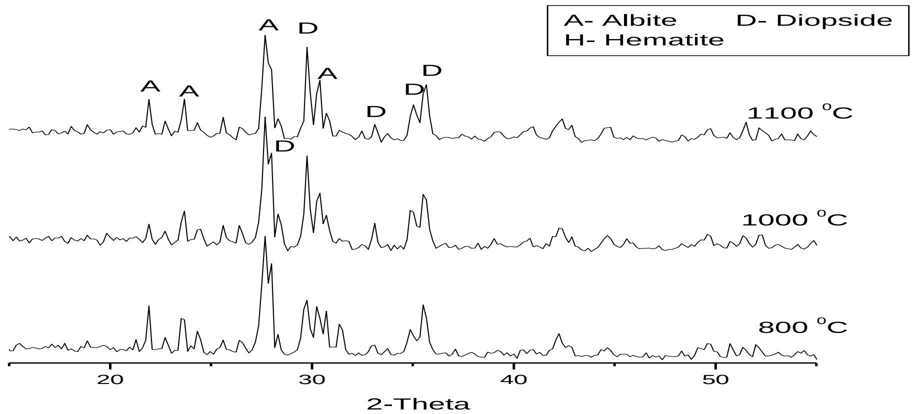

Figure (6): XRD patterns of the sample containing 5% cement dust fired at different temperatures.

CONCLUSION

To reduce the plasticity of the basalt bricks, by-pass cement dust can be used as non-plastic materials in the manufacture of basalt bricks. The mix containing (0-5%) cement dust gives suitable ceramics properties of the fired bricks at all firing temperatures.

REFERENCES

[1] EA El-Alfi, AG Othman, MM Elwan. Ind Ceram 1999;19(9):145-150.
[2] EA El-Alfi, AM Radwan, MH Aly. Interceram 2004;53(3):178-181.
[3] MM Elwan, EA El-Alfi, H El-Didamony. Ind Ceram 2001;21(2): 87.
[4] AM Radwan, RM Othman, H Abu-El-Naga. Interceram 2011;60(2):130-133
[5] NL Bowen, JW Greig. Amer Ceram Soc 1924;7:238.
[6] S Aramaki, R Roy. Amer Ceram Soc 1962; 45 :229.
[7] EA El-Alfi. I J Eng Mat Sci 2002;9:147-152.
[8] G Cultrone. J European Cer Soc 2004;24:547-564.
[9] H El- Didamony, BA Sabrah and N Burham. Sprechsaal 1982;115(3): 219-222.