Construction and Building Materials 182 (2018) 284–289

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Utilizing industrial waste-water as alkali activator in sand-cement kiln dust bricks

Sabry A. Ahmed, Mostafa-Elnabawy A. Metwally, Sahar E. Zakey *

Faculty of Engineering, Zagazig University, Zagazig, P.O. Box 44519, Egypt

HIGHLIGHTS

- An industrial waste recycling is a good solution for pollution problems.
- Using industrial alkali wastewater as mixing water.
- The effects of degree of concentration and curing temperature on compressive strength, unit weight and water absorption were studied.
- The industrial alkali wastewater can be used as alkali activator.

ARTICLE INFO

Article history:
Received 4 March 2018
Received in revised form 11 June 2018
Accepted 15 June 2018

Keywords:
Sand-cement kiln dust bricks
Industrial alkaline waste-water
Alkali activation
Curing temperature and time

ABSTRACT

Recycling of wastes as building materials appears to be viable solution; not only to overcome pollution problems but also for economical purposes. In this study the cement kiln dust (CKD) produced during the production of ordinary Portland cement was used to produce sand-CKD bricks at 25, 30 and 35% CKD of the dry weight. Also, two types of industrial alkaline waste-water of textile and aluminum pots factories with 850, 8000, 12,500 and 52,000 ppm were used as mixing water, beside the use of tap water in the reference mix. After complete drying, the samples were subjected to heat curing at different temperatures of 120, 150 and 200 °C for different times of 3, 6, 12 and 24 h. The sand-CKD bricks made with 30% CKD, 12,500–52,000 ppm alkaline waste-water and heat cured at 120 °C for 3 h had compressive strength of 12.5 MPa, unit weight of 1.66 ton/m^3 and water absorption of 10%. Increasing the heating temperature to 200 °C for 12 h raised the compressive strength and water absorption to 16.5 MPa and 13.7%, respectively, while decreased the unit weight to 1.46 ton/m^3.

1. Introduction

Nowadays, there is a large demand to building materials owing to the increase in population. Recycling of natural and industrial wastes as building materials appears to be viable solution; not only to overcome pollution problems but also for economical purposes. Many previous researches Ahmed and Omar [1] Kusiorowski et al. [2], Hegazy et al. [3] and Ghazaly et al. [4] showed valuable results to the use of industrial wastes in concrete and brick production. Also, research efforts have been directed towards the development of alkali activated cementitious materials Al-Bakri et al. [5] and Pacheco-Torgal et al. [6]. The alkali activation results from the reaction of an alkaline liquid with the silicon (Si), aluminum (Al) and calcium (Ca) in a source material and formation of the reaction product. The source material could be mineral or industrial byproduct that should be consisting primarily of Si, Al and Ca.

According to the source material used, there are two models of alkali-activation. The first model is the activation of materials having high content of Si and Ca such as blast-furnace slag (BFS) with mild alkaline solution, producing C-S-H as the main reaction product. The second model is the activation of materials having high content of Si and Al such as metakaolin with high concentration of alkaline solution, producing the geopolymer Al-S-H as the main reaction product Pacheco-Torgal et al. [7].

The exact reaction mechanism, which explains the setting and hardening of alkali-activated binder, is not yet quite understood; although it is thought to be dependent on the source material as well as on the alkaline activator. According to Pacheco-Torgal et al. the mechanism of alkali activation is composed of conjoined reactions of destruction condensation that include the destruction of the source material into low stable structural units, their interaction with coagulation structures and the creation of

* Corresponding author.
E-mail address: saharzakey@hotmail.com (S.E. Zakey).

https://doi.org/10.1016/j.conbuildmat.2018.06.129
0950-0618/

condensation structures. The first steps consist of breakdown of the covalent bonds Si-O-Si and Al-O-Si when the pH of alkaline solution rises. These groups transform into colloid phase then an accumulation of the destroyed products occurs, which interacts among them to form a coagulated structure leading in a third phase to the generation of a condensed structure. However, those phases occur almost simultaneously, preventing their analysis in an individual mode.

Ahmari and Zhang [8] have attempted to use CKD to enhance the physical and mechanical properties and durability of copper mine tailings-based geopolymer bricks. Their results showed significant improvement in the compressive strength and durability with a slight increase in the water absorption. El-Mahllawy [9] and Attia [10] showed similar trend of results when the CKD was used in acid resisting bricks consisted of clay, glauconite and Na_2CO_3, and also when used in building bricks consisted of fine sand, $Na(OH)$ and Na_2CO_3.

In this paper dune sand, CKD and untreated industrial alkaline waste-water were used to produce low cost and good quality building bricks. Three CKD ratios of 25, 30 and 35% of dry weight were mixed with four different concentrations of alkaline waste-water of 850, 8000, 12,500 and 52,000 ppm as mixing water. The specimens were heat cured at 120, 150 and 200 °C for 3, 6, 12 and 24 h then the compressive strength, unit weight and water absorption were measured.

2. Experimental work

The materials used in this study were sand, CKD and alkaline industrial wastewater. The sand was dune sand from Sinai desert. It had a yellow color and its particles were very fine; passing through sieve No. 30. Its specific gravity and fineness modulus were 2.8 and 2.5, respectively. CKD is the byproduct of OPC manufacturing process; collected from exhaust gases. It had a gray color and its particles were relatively uniform in size, with maximum size of 300 μm and specific surface area of 4600–14,000 cm^2/g; its chemical composition is shown in Table 1.

Two different types of industrial alkaline waste-water collected from textile and aluminum pots factories with alkalinity of 850, 12,500 ppm and pH of 11.67, 13.1, respectively, were used. To increase the alkalinity, samples of the two types of waste-water were subjected to evaporation for 48 h in open air; their alkalinity, as measured, was increased to be 8000 and 52,000 ppm, respectively. Therefore, the industrial waste-water became four different

Table 1
Chemical analysis of CKD.

Component	SiO_2	TiO_3	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	SO_3	Cl	L.O.i
%	31.04	2.23	7.87	2.20	1.05	1.80	43.64	1.23	3.71	2.11	2.37	6.21

Fig. 1. Steel mold.