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Structural and Physical Aspects of Construction Engineering

Influence of Partial Replacement of Hydraulic Binder by Ground Brick on the Characteristics of Composites

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Abstract

The influence of replacing cement by ground brick was investigated in this paper. The materials used in this study were two cements of different composition (higher and lower content of C_3A), and two ground fired-clay bricks of different composition ("acid" and "lime" bodies). The replacement levels of cement with ground bricks chosen for the tests were 10, 20, 30 and 40% wt. The main aim of this research was to investigate changes in physical and chemical properties and pore structural characteristics in modified composites. Experimental results showed that changes in the properties of the cement-brick composite depend not only on the replacement level, but also on the kind of brick.

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Keywords: hydraulic binder; ground bricks; pozzolan; pore structural characteristics

1. Introduction

Fine impurities generally function in concrete such that they complement granulometry poly-fraction mixture of concrete and, thus, contribute to the maximum volume filling of the concrete solid phase. Furthermore, they react with the components of hydrated concrete to form more stable interactions, usually possessing hydraulic characteristics, i.e. their pozzolanic activity applies here.

There are currently a number of compelling reasons to extend the practice of partial replacement of cement in concretes or mortars, with waste materials [1-5]. These reasons include overall reduction in energy consumption and CO_2 emissions, reduction of environmental damage, improvements in long-term durability of concretes and mortars, and, also, reduction in construction costs.

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The phase composition of the fired brick is variable depending on the initial raw material mix and firing conditions. Some of the phases present in the ceramic body may contribute to its pozzolanic activity, i.e. the ability to react with certain components of hydrated cement, e.g. with $Ca(OH)_2$ to give the novel compounds usually calcium silicate hydrate [6]. Pozzolanic properties can include, for example, a glassy phase in the body. In some cases, feldspar may be present, which, according to some sources, may also exhibit pozzolanic activity [7-9].

The objective of the current study is to determine the manner in which the replacement of Portland cement (PC) in mortars with powdered fired bricks influences the strengths and pore structure of mortar specimens.

2. Materials and experimental details

Two Portland cements (denoted as C1 and C2) with different chemical composition, especially with different tricalciumsilicate C_3A, were used for the preparation of the mortars. Two kinds of finely ground brick of different composition ("acid" and "lime" bodies), which were denoted as "A" and "L", were used as additives.

Table 1 shows, that brick A contains a high content of SiO_2 and low CaO content – so called "acid body". Brick L shows a lower content of SiO_2 and relatively high content of CaO showing in this way the "lime" body character.

Table 1. Chemical and physical properties of used cements and ground bricks.

Parameters		Cements		Bricks	
		C1	C2	A	L
SiO_2		20.53	20.28	73.64	60.06
Al_2O_3		5.68	4.59	13.58	16.21
Fe_2O_3		2.21	3.37	5.61	6.20
CaO		63.36	64.47	1.29	6.92
MgO		0.96	1.24	1.11	3.97
Na_2O	% wt	0.08	0.16	0.98	0.96
K_2O		1.16	0.95	2.51	3.08
SO_3		3.02	2.75	0.03	1.20
Insoluble residue		0.57	0.09	95.15	69.30
Loss on ignition		2.44	1.66	0.32	0.50
C_3A		11.32	6.47		
Specific surface Blaine	cm^2/g	3 046	3 163	4 292	4942

Mortars were prepared by mass of ingredients: a binder (cement, including additives) and standardized sand in ratio 1:3. All mixtures were prepared with water/cement ratio 0.5.

For these mixtures Portland cement, which had had ground brick substituted in the quantity of 0, 10, 20, 30 and 40% by weight of cement, was used. Mortars were mixed in a mixer according to ČSN EN 196-1. Specimens (20 x 20 x 120 mm in dimension) were removed from molds after 24 hours and then were cured up to 28 days, or 84 days respectively in water at a temperature of 20 ± 1 °C.

3. Results and discussion

3.1. Flexural strength

Specimen strength in flex was determined by loading specimens to failure. The loading test was used as four point bending test (seen in Fig. 1). Results of the flexural strength tests are graphically expressed in the Figs. 2 and 3, while each value represents the average of three measurements.

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