Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 151 (2016) 236 – 240

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Ecology and new Building materials and products, ICEBMP 2016

Carbon admixtures influence on the electrical properties of slag mortars focusing on alternating conductivity and permittivity

Miroslav Lunak*, Ivo Kusak, Zdenek Chobola

Institute of Physics, Faculty of Civil Engineering, Brno University of Technology, Veveří 95, 60200 Brno, Czech Republic

Abstract

New materials based on alkali-activated slag mortars may be an important contribution of applied research, which strives to offer the use of waste materials as a full replacement for the currently used binders and explores the impact of forms of carbon incorporation on the physical and mechanical properties. The influence of graphite powder addition on the electrical properties of alkali-activated slag mortars was investigated. 1–10 wt. % of graphite powder (with 1 % step) was incorporated into the mortar and the electric resistance spectra, permittivity and loss factor of the prepared prismatic samples were measured. The unique Vector analyzer R&S ZNC with a coaxial probe DAK-12 from Speag was used to determine permittivity and loss factor, electrical resistance was measured using two channel oscilloscope. Higher content of graphite powder increases the electrical conductivity, which makes the tested materials more sensitive and measurable via electromagnetic methods. The most striking change in the relative conductivity was observed at excitation frequency of the external electric field of 10 kHz. At high frequencies electrical excitation field 10 MHz to 3 GHz were determined by vector analyzer value of the real part of permittivity, which fell from the 20 to the 4. Dissipation Factor shows in his semi arc spectrum a peak at 1.2 GHz. These measurements are among the building materials still little used and open new possibilities of diagnostics.

Peer-review under responsibility of the organizing committee of ICEBMP 2016

Keywords: Electric measurement; alkali-activated slag; building materials; carbon admixtures; dissipation factor;

* Corresponding author. Tel.: +0-420-541-147-659.
E-mail address: lunak@dp.fce.vutbr.cz

Peer-review under responsibility of the organizing committee of ICEBMP 2016
doi:10.1016/j.proeng.2016.07.359

1. Introduction

Aluminosilicate production of non-clinker binders is one possible suitable utilization of waste substances. Alternative binders based on alkali activated slag were used in concrete production since the second half of the 20th century, especially in Eastern Europe, Scandinavia and China.

Various kinds of slag can be used, e.g. blast or steel furnace slag, slag from casting of non-ferrous metals and other slags with high content of amorphous phase. These slags have latent hydraulic properties, which can be activated with a suitable activator. As activators are used mostly silicates, hydroxides and carbonates of a sodium or of potassium.

There are good results in the chemical industry with mixing carbon powder into many materials. Carbon provides firming and greater durability of materials.

This paper presents the basic electrical properties of laboratory prepared alkali-activated composite materials based on slag with the addition of different amounts of micronized natural graphite. [4,5,6]

Impedance spectroscopy (IS) is a non-destructive testing (NDT) method ranking in the electrical engineering measuring method group. It outputs data providing information on material electric and dielectric properties. Microscopically inhomogeneous materials are frequently used in the building industry. Unfortunately, the impedance spectroscopy results and their characterization on the basis of this method are not unambiguous. [1]

Admixture of carbon powder should give different electric properties by using alternating electric field than obvious cement based paste.

2. Material used

Alkali-activated finely ground granulated blast furnace slag was chosen as a binder. Activation was carried out by water-glass solution, Susil MP 2,0. As filler were used both test norm-sand (0-4 mm) and carbon powder Cond 896. Triton X-100 was used to treat the graphite surface and defoaming agent Lukosan S was added to minimize the gas content. The compositions of each mixture are summarized in Table 1.

Table 1. Recipes of mixtures of specimens.

Components / COND	Ref	1%	2%	3%	4%
slag (*g*)	450	450	450	450	450
Susil (*g*)	90	90	90	90	90
sand (g)	1350	1350	1350	1350	1350
COND 8 96 (*g*)	0	4.5	9	13.5	18
0.5% Triton X-100 (*ml*)	0	30	30	30	30
1% Lukosan S (*ml*)	0	5	5	5	5
water (*ml*)	185	150	155	160	165

Components / COND	5%	6%	7%	8%	9%	10%
slag (*g*)	450	450	450	450	450	450
Susil (*g*)	90	90	90	90	90	90
sand (g)	1350	1350	1350	1350	1350	1350
COND 8 96 (*g*)	22.5	27	31.5	36	40.5	45
0.5% Triton X-100 (*ml*)	60	60	90	90	120	120
1% Lukosan S (*ml*)	10	10	15	15	20	20
water (*ml*)	135	140	110	115	85	90

Mixing method: Water-glass Susil and Triton treated graphite powder were put together with a part of water (about 100 ml) and stirred in a mixer for 1 min. Then the slag, sand, the rest of the water and Lukosan S was added and stirred