Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 153 (2016) 599 – 603

Procedia Engineering

www.elsevier.com/locate/procedia

XXV Polish – Russian – Slovak Seminar "Theoretical Foundation of Civil Engineering"

Some aspects of the development and application of silicate expanded aggregates in lightweight concrete structures

Sergey A. Mizuryaev[a]*, Aleksandr G. Chiknovorian[a], Galina S. Solopova[a], Roman V. Demidov[a]

[a] *Samara State University of Architecture and Civil Engineering, Molodogvardeyskaya St., 194, Samara, 443001, Russia*

Abstract

The objective of this paper is a short analysis of the most widely used expanded aggregates and of lightweight concretes containing them. It shows the main characteristics of highly-porous silicate-sodium aggregates and displays their advantages. The paper contains a procedure to produce silicate sodium aggregates as well as the main methods to select a composition of a lightweight concrete with a highly-porous silicate-sodium aggregate combining a minimum density with a maximum strength. The paper addresses the main properties of the lightweight concrete components and of the lightweight concrete containing them. The authors demonstrate a possibility to use these components for a lightweight concrete providing the density of 760-845 kg/m3 and compression strength of 3,8-5 MPa.

Peer-review under responsibility of the organizing committee of the XXV Polish – Russian – Slovak Seminar "Theoretical Foundation of Civil Engineering".

Keywords: lightweight concrete; expanded aggregate; selection of composition; density; strength.

1. Introduction

The component of lightweight concrete determining its properties is mainly the expanded aggregate. It influences insulating properties, predicted mean vote and others [1-4]. Almost all lightweight concretes used in modern construction are produced using expanded aggregates such as expanded clay aggregate, aggloporite, slag, haydite

* Corresponding author. Tel.: +7-937-997-9488.
E-mail address: mizuriaev@gmail.com

Peer-review under responsibility of the organizing committee of the XXV Polish – Russian – Slovak Seminar "Theoretical Foundation of Civil Engineering".
doi:10.1016/j.proeng.2016.08.199

gravel and broken stone. These are produced by high-temperature bloating [5-8]. Apart from the necessity of high temperatures for their production their another disadvantage is rather high packed density (600-900 t/m3 in most regions of RF). Their advantages include heat resistance, fire safety, routine practice of production of lightweight concretes including porous ones [11-15].

Newly developed methods of manufacturing products from lightweight concretes with foam polystyrene aggregates appear promising due to their low density. However, we believe that production of such concretes should be restricted or even stopped on the grounds of their low fire resistance, toxic gas emissions from foam plastic particles and their high decomposition rate in alkaline environment of the concrete [16, 17].

The above-mentioned reasons make it vital to develop production techniques for porous inorganic granulated aggregates with the density of 350-400 kg/m3 and for fire-safe lightweight concretes with such aggregates.

2. Research

A solution to this problem is a production technique for a highly-porous silicate-sodium aggregate produced using water-glass [18-22].

The production technique for a highly-porous silicate-sodium aggregate is based on the use of modified hydrated sodium silicate (according to the RF Patent 2211196 of 02.11.2000) with the admixture of a clay-containing component [23, 24].

The composition is used to form particles which are then heat-treated at 250-300 OC. This causes bloating resulting in forming a granulated inorganic material with the density of 350-450 kg/m3 making it highly efficient for lightweight concrete production [25-27]. It should be noted that any clay or clay-containing material including industrial waste can be used as a clay-containing component.

A pilot batch of expanded aggregate with particle diameter of 5-10 mm (Fig. 1) and average packed density of 360 kg/m3 was made by the authors in a laboratory model of a rotating furnace at 250 OC.

Fig. 1. Physical form and structure of the particles.

The main characteristics of the aggregate produced are given in Table 1.

The experiments showed the need to increase the aggregate’s water resistance. After the 250 OC bloating it was near zero which made it impossible to use conventional methods to produce concrete mixes with hydraulic binding materials.

The research and the tests proved that water resistance of the silicate-sodium aggregate used can be considerably increased (up to 0.9) either by an additional firing at 840-860 OC or by treating the aggregate with special organosilicon hydrophobic substances [25, 28].

Water resistance is evaluated by the softening factor. It is the relation of the aggregate’s strength after a 24-hour water storage to the strength of the dry aggregate. The firing temperature for the given composition proved to be 850 OC. It made the aggregate water resistant and provided a little after-bloating. A further increase in temperature led to the sintering of the material and to some shrink of the particles which increased the density.