Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 172 (2017) 319 – 324

Procedia Engineering

www.elsevier.com/locate/procedia

Modern Building Materials, Structures and Techniques, MBMST 2016

Fired hydraulic binder based on fluidized combustion fly ash

Dominik Gazdič[a]*, Karel Kulísek[a], Marcela Fridrichová[a], Karel Dvořák[a]

[a]Brno University of Technology, Faculty of Civil Engineering, 602 00 Brno, Czech Republic

Abstract

This study is focused on possibilities of utilization of fluidized combustion fly ash for manufacturing of fired hydraulic binders as one of the principal raw materials for production of binders close to traditional cements. As a basic raw material high-calcium limestone was used, which was subsequently mixed with fluidized combustion filter fly ash (FCFFA) and fluidized combustion bed fly ash (FCBFA). The selected value of the hydraulic module was 1.7. Total two two-component raw material mixture were prepared which were burnt in a laboratory furnace under conditions at temperature of 1200 °C and 1250 °C. The evaluation was done on the basis of mineralogical composition using X-Ray diffraction (XRD) analysis, determination of the chemical composition of clinker and achieved basic physical properties. The aim was to produce a binder which could be very similar to strongly hydraulic lime or to cements of lower strength classes.

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

Keywords: fluidized combustion fly ash, hydraulic binder, lime, limestone, cement, clinker.

1. Introducing

In general, inorganic binders can be distinguish as air binders and hydraulic binders. After setting in the air, the hydraulic binders form rigid framework even under damp conditions and in water and are stable in these environments. Among these substances count hydraulic lime, roman cement, Portland clinker cement and special binders.

Hydraulic lime is produced from a mixture containing calcareous constituents, respectively calcium magnesium carbonates with specific amount of hydraulic oxides such as SiO_2, Fe_2O_3, Al_2O_3 by firing under sintering point. Other procedure involves intergrinding of air lime with hydraulic admixtures.

* Corresponding author. Tel.: +420 54114 7511; fax: +420 54114 7502.
E-mail address: gazdic.d@fce.vutbr.cz

1877-7058
Peer-review under responsibility of the organizing committee of MBMST 2016
doi:10.1016/j.proeng.2017.02.019

Due to its properties and composition, stands this binder on the border between air lime and Portland cement. It differs with Portland cement in amount of free lime CaO. In addition, in hydraulic lime is tricalcium silicate $3CaO.SiO_2$, which is formed at temperature above the sintering point of 1350 °C, absent, but Portland cement contains it. Hydraulic lime is characterised by hydraulic module, i.e. ratio of amount of CaO to amount of hydraulic oxides according to (1). According to the value of hydraulic module, nomenclature of hydraulic lime is as follows: M_H = 1.7 – 3 strongly hydraulic lime; M_H = 3 – 6 moderately hydraulic lime; M_H = 6 – 9 feebly hydraulic lime [1,2,3]

$$M_H = \frac{CaO}{SiO_2 + Fe_2O_3 + Al_2O_3} \tag{1}$$

There is an increasing emphasis on utilization of secondary raw materials in all of industry sectors recent years. Some investigators have studied the processing and utilization of various secondary raw materials [4,5,6,7,8,9]. Fluidized combustion fly ash (FCFA) also belongs among these substances. FCFA is from the mineralogical point of view comprised of quartz, amorphous aluminum-silica phase, unsoluble anhydrite and free lime. Exactly the anhydrite, the real product of desulphurization process, limits the range of possible mortars only to those with the burning temperature below the point of reverse decomposition of this product. Considering all conditions, manufacturing procedure of mortar hydraulic lime-alike was designed. The mortar brings benefit due to requirement of lower burning temperature, thus its production is economically convenient. Further advantage can be seen in applications where binder both with sufficient plasticity and simultaneously with certain strength and volume stability is needed, in particular in the industry producing both mortar and plaster mixes. Concerning the true development, it was necessary to aim to two crucial issues: whether is possible to produce sufficiently reactive raw meal forming the hydraulic minerals and if is practicable to burn this raw meal at adequate temperature without risk of redecomposition forming calcium oxide and sulfur oxide.

2. Materials and methods

Two raw meals were prepared throughout this study. The raw meal contained two components, FCFA and high-calcium limestone. The composition was calculated in order to achieve both values of preferred hydraulic module of 1.7 (corresponding to strongly hydraulic lime) and alumina module of 1.5. FCFFA and FCBFA from the power plant Hodonín were examined, whose chemical composition is shown in Table 1.

Table 1. Chemical composition of fluidized fly ashes.

Oxide	FCBFA (%)	FCFFA (%)
SiO_2	42.71	36.63
Al_2O_3	19.21	18.67
Fe_2O_3	4.63	7.27
CaO	17.74	20.86
SO_3	9.22	8.58
Other oxides	6.49	7.99

Design was performed in two steps: dosage proportions of the two components were initially computed, the ratios were rounded onto technically acceptable values which were used for calculation of hydraulic and alumina modules reversely. Table 2 presents sample weight proportions and recalculated hydraulic and alumina modules.

Table 2. Weight proportions and recalculated modules.

Weight proportions and recalculated modules	Two-components mixture	
	FCFFA	FCBFA
Fly ash portion (%)	33.30	28.60