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ScienceDirect

Procedia Engineering 151 (2016) 127 – 132

Procedia Engineering

www.elsevier.com/locate/procedia

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

Hygric properties of lime-cement plasters with the addition of a pozzolana

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Abstract

There are more than seven billion people currently living on the Earth and the demands of population are rising. Lime and cement are parts of most building materials, so their global consumption grows. Therefore, it is necessary to think both economically and ecologically, and search for a suitable alternatives and replacements. This study is aimed at an investigation of the influence of pozzolana as the third binder component on basic physical characteristics and hygric properties of lime-cement plasters. Results show that with the increasing amount of pozzolana in the mixture the open porosity goes down. This is accompanied by a liquid water absorption decrease. Also diffusion parameters are somehow worsened, as the water vapour diffusion resistance factor increases.

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

Keywords: Lime; cement; pozzolana; plaster; hydric properties; basic physical properties

1. Indtroduction

In these days, there is a wide variety of plasters, which are used either for external or internal walls. The binder material can be clay, gypsum, gypsum-lime, magnesium, quicklime, hydraulic lime, lime-pozzolana, lime-cement or cement [1]. Cement, which started to be utilized in plasters in 1920s, gives the material higher hardness and

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Peer-review under responsibility of the organizing committee of ICEBMP 2016
doi:10.1016/j.proeng.2016.07.403

strength, on the other hand the diffusion properties are somehow worsened, which is next to its less original appearance the reason why they are not recommended for use on historical buildings [2]. Lime plasters are commonly the most popular form of surface finishing. They have good diffusion properties [3], but they are less resistant to weathering and other external harmful influences.

Pozzolanic materials have been used as a part of binder since ancient times. Their presence in a mixture is beneficial in many ways, which was known already in the era of Roman Empire. The Romans used natural pozzolanas such as volcanic ash, tuff, spongolite or burnt clays. Nowadays, many natural pozzolanic materials and even pozzolanas of technogenic origin are frequently utilized. Investigation attempts are mainly focused on ternary systems; which means binder consists of three different components. The problematic issue is an appropriate ratio to reach the desired properties of a certain plaster, which request a well elaborated design.

This study is aimed at an investigation of water transport properties in connection with its open porosity and other basic physical properties of lime-cement plasters with the gradual substitution of the binder by a pozzolana – namely by ceramic powder.

2. Materials

The composition of studied plasters is given in Table 1. The main binary binder system is composed of lime and cement, where cement represents 10 % of their weight. The used lime hydrate comes from Vápenka Čertovy schody a. s. and cement CEM I 42.5 R [4] was supplied by Lafarge cement, a.s., Čížkovice. Except of the reference mixture the binary binder was substituted by a pozzolana, in amount of 10, 30 and 50 % of weight. The used pozzolana was fine ceramic powder, which originates during the manufacture of precise ceramic blocks, supplied by Heluz, v.o.s. [5]. The siliceous fine aggregate was dosed in three fractions, each of them in the same amount. Water to solid ratio was determined for each mixture separately in order to gain the flow of the fresh plaster of 160 mm [6].

Table 1. Studied plasters.

Mixture	Pozzolana (*kg*)	Lime hydrate (*kg*)	Cement (*kg*)	Aggregate (*kg*)			water/solid ratio
				0.3–0.8	0.6–1.2	1.0–4.0	
LCPP_R	0	5.63	0.63	6.25	6.25	6.25	0.220
LCPP_10	0.625	5.06	0.56	6.25	6.25	6.25	0.248
LCPP_30	1.875	3.94	0.44	6.25	6.25	6.25	0.224
LCPP_50	3.125	2.81	0.31	6.25	6.25	6.25	0.200

3. Experimental methods

The tested basic physical properties were the bulk density ρ ($kg{\cdot}m^{-3}$), matrix density ρ_{mat} ($kg{\cdot}m^{-3}$) and open porosity ψ_0 (-). These properties were measured using the water vacuum saturation method [7] and helium pycnometry [8]. Samples were dried at 80 °C and weighed. Afterwards samples were vacuum saturated by water. They were given to the vacuum desiccator for not less than 24 hours, and weighed again in the saturated state and in the Archimedes weight under water. The matrix density was determined also by helium pycnometry. This experiment was carried out by the device “Pascal 140 + 440”. This device has analogous principle as classic porosimetry.

Water absorption coefficient ($kg{\cdot}m^{-2}{\cdot}s^{-1/2}$) and apparent moisture diffusivity ($m^2{\cdot}s^{-1}$) were determined to characterize the liquid water transport. The absorption experiment was performed on samples insulated on lateral sides to ensure the one-directional absorption of water through the material. Samples were immersed in water 1 – 2 mm deep and continuously weighed by an automatic balance. From the dependence of weight increases on the square root of time, the water absorption coefficient was determined as the constant of proportionality and knowing the capillary moisture content the apparent moisture diffusivity was then calculated [9,10].

The diffusion of water vapour through the material was determined by both wet-cup and dry-cup methods according to ČSN 72 7030 [11]. Both methods are based on the diffusion of water vapour caused by different partial