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The role of mortar microstructure in providing the face wall structural integrity

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Abstract

The basic condition for proper function of a face wall in external environment is providing structural integrity within its entire period of usage. Structural integrity can be defined as construction ability to maintain bearing capacity, functionality and shape within acceptable ranges without arising state of emergency during exploitation. Wall structural integrity results first of all from construction mortar which, except for bearing function should also provide protection from entering water into the wall interior. The processes of water capillarity, drying, and freezing are dependent on microstructure and open porosity.

In the article there are introduced tests of three mortars (cement, cement with plasticizer, and cement-lime based) formed in wall joints. In order to prepare mortar samples from joints of wall elements for porosimetry tests, mortar was separated from bricks in such way that whole joint was left intact. By breaking, each layer of mortar was divided parallel to the joint surface into three parts – two parts adjacent to brick base (each 1/4 of layer thickness) and the middle part sized 1/2 of joint thickness. By Mercury Intrusion Porosimetry the basic microstructure parameters were measured, as well as pore volume distribution in the function of their diameters as integral and differential relation. The analysis of pore volume variation for integral distribution let us state the pore sizes which as additional, are formed in mortar in the area of joint adjacent to wall element surface. Independently of mortar type, in this area there are additional pores created, which are responsible for capillary flow. In cement mortars there are additionally macropores created which decides about water migration through a joint and about its gas permeability.

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Keywords: microstructure; mercury intrusion porosimetry; masonry mortar

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1. Introduction

The basic condition for proper functioning of walls is maintenance of structural integrity throughout the entire period of usage. This feature is largely discussed in the context of wall strength to static and dynamic loads as well as in ensuring proper work conditions of historical buildings [1,2]. Arandigoyen et al. [3] wrote that for maintenance of wall continuity the choice of mortar is essential. In this case a special role is fulfilled by lime, which affects mortar plasticity and ability to absorb strains resulting from wall movements. Researches led on lime-based mortars in historical buildings indicated that this binder causes proper lime placement in the joint and favorable shaping of microstructure [4]. Mechanical and rheological features of mortar are shaped by all components. Besides binders, aggregate has significant influence [5], but also eventual additions. Special role is played by plasticizers. They are additions which basic application is to modify features of concrete mixture and concrete. However, numerous researchers claim that they can be effectively used for cement mortars [6]. According to Kamouna et al. [7] a plasticizer can reduce water content, improve mortar workability and compressing strength. It allows also slower pace of cement mortar workability decrease [8]. But masonry mortar should be adjusted to both a wall element and joint [9]. Its main task is to provide homogeneity in contact area of a wall unit and mortar. The mortar used should protect against water entering into wall interior and enable to let it outside (e.g. after intensive long lasting rain). The choice of mortar should take into account its service function toward wall elements. Kubica et al. claim that mortar should be a link for a wall element, and elastic bed. Loss of wall integrity is caused first of all by inappropriate choice of mortar [10].

Traditional macroscopic tests do not allow exact prediction of clinker behaviour in contact with mortars and external environment. Processes of capillary rise, freezing and drying are tightly associated with microstructure and open porosity. Due to limited permeability and capillarity of present clinker elements the meaning of mortar microstructure formed in joint is increasing.

2. Research methods

The tests were performed on a group of three masonry mortars: cement, cement with plasticizer, and cement-lime with contents described in Table 1. The basic goal of research was a comparative evaluation of formed mortar microstructure changes in:

- Standard beams sized 40x40x160mm, cured for 28 days in standard conditions,
- In a joint of connected samples, made of two clinker bricks joined with masonry mortar 1cm thick, cured for 28 days in standard conditions.

Table 1. Composition of tested mortars

Mortar	Mortar contents (volume)			
	Cement CEM I 42.5N	Lime	Sand	Plasticizer [g/kg cement mass]
Cement mortar 1	1	-	3.5	-
Cement mortar 2	1	-	3.5	0.32
Cement-lime mortar	1	1.25	6.75	-

For the particular three types of mortar there were formed two kinds of samples, each including six standard beams and connected samples. After the curing period the beams were dried to solid mass for 72h in temperature of +105±5°C. Then samples were taken out from the drier, they were cooled in an exsiccator and weighed after the temperature was from 30 °C to 40 °C. Next they were measured and mortar volume density was defined (ρ_{ob}). Then mortars from central part of beams were taken, and they were combined into general sample which was again dried to solid mass. From the general sample there were three random elements taken which served for measuring density (ρ) by a pycnometer. The rest of the sample was put again into the drier 40°C to maintain drying effect.