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Evaluation of clinker microstructure changes resulting from different subsoil contacts after long-term exposition to Polish climate conditions

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Abstract

A face wall is defined as an element applied inside or outside which should have an attractive look. The achievement of expected results is very difficult. Usually, during the first years of exploitation efflorescence appears, covering mostly clinker surface. This is primary efflorescence which should disappear within the first year of exploitation. Long-term observations led by the author on real objects indicate that this period is definitely longer, and efflorescence change depending on seasons of the year. The essential influence has the wall and subsoil contact area. This is an area especially endangered with rain and soluble compounds contained in water. The cyclic character of these changes influences the clinker microstructure. This paper deals with clinker microstructure changes resulting from ten years of exposition to external climate. There are three cases of wall and ground contact: a tight concrete band, humus layer, and gravel filter layer. The tests were performed on a field station located at the University of Science and Technology in Bydgoszcz. Three types of clinker walls with different mortars were analyzed. Six samples of bricks designed for wall erecting were taken as initial material for microstructure evaluation. The tests were led on 5 mm thick face layer of bricks. Based on observation there were indicated areas of the biggest efflorescence intensity. Microstructure evaluation was done using mercury porosimetry method. The results obtained were used for comparative analysis of meso- and macropore share changes in clinker after ten years of functioning in external environment. These tests let us indicate the best solution taking into account the wall and ground contact.

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Keywords: face wall; mercury intrusion porosimetry; subsoil contact

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1. Introduction

One of the problems with contemporary face walls is their esthetics lowering due to salt crystallization. No matter which wall-mortar material set is used, on most of new buildings during the initial years of exploitation efflorescence appear with various intensity and chemical content.

Considering a complex character of interactions, there are two basic groups of destructive factors [1]. The first one are environment and external factors, including direct disposition of chemical pollutants.

The second group are internal factors including properties of built-in materials and their interactions. These factors result in transport, crystallization, and transformation of soluble mineral salts. Because of these processes crystal efflorescence can appear as well as pilling off ceramic surface and clinker microstructure damage [2].

The above actions were described with exposition classes. They define factors directly affecting construction, which in turn define the selection of appropriate wall elements, thus setting the structural wall protection. In face walls, the area most endangered by environment impact is the direct contact with substructure. In this zone there is extended intensity of rainfall, splash water, subsoil moisture, and persisting snow cover.

During last years it was noticed increased interest in numerical research of mineral salts transport in porosity materials [3]. Mathematical model created and their results gained from experimental research significantly contributed to development of computer programs modeling influence of salt crystallization process on building material strength and consequently, on face walls durability [4,5].

Simulation researches [6] indicate that in case of a brick wall, subsurface tensions can reach close to brick ultimate tensile strength equal to about $1N/mm^2$. It can lead to wall surface scars and damages.

From 2006 at the site of the University of Science and Technology in Bydgoszcz (Poland) there has been functioning a field research station in order to evaluate esthetics and durability of face walls. The walls were shaped in such way that they cover most of typical influences of external environment. For observation of wall-ground contact influence there were three options modeled: gravel filter layer, tight concrete band, and humus with a lawn.

Based on multi-year research it was stated that cyclic crystallization is present with particular intensity in spring (April for the discussed location). Analyses performed for appearing efflorescence showed that intensity and size of area covered depends not only on mortar used but also on solution of wall surrounding area. Additionally, the biggest salt concentration is present in a 5 mm layer close to ground surface, independent of wall-ground contact solution
used [7].

2. Research methods

2.1. Field research station

Field research station was located at premises of the University of Science and Technology in Bydgoszcz (Poland). The research station includes eight test one-brick thick walls sized 1.61 x 1.42 m.

Table 1. Composition of tested mortars

Mortar	Proportion of components	Contents of 1 m^3 Cement [kg]	Lime [kg]	Sand [m^3]	Plasticizer [kg]	Water [m^3]
CEM 1	(c:s)=1:3.5	378 CEM I 42.5N	-	1050	-	0.253
CEM + plasticizer	(c:s)=1:3.5	378 CEM I 42.5N	-	1050	0.4	0.233
C-L	(c:l:s) = 1:1.25:6.75	165CEMI 42.5N	97	950	-	0.304

The walls are situated with utmost sides facing wind direction distinguished on this area according to weather reports of Voievodship Inspectorate of Environment Protection in Bydgoszcz (Poland). Clinker brick was used to build the walls in sets with eight different mortars of which six had a known material content while two others were ready-made system mortars intended to use for face walls in order to eliminate efflorescence (Fig. 1). For purposes