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The Use of High Performance Cement Composite in Renovation and Restoration of Architectural Elements of Buildings Facades

Genadijs Šahmenko[a,*], Sandis Aispurs[b], Andrejs Krasnikovs[a]

[a]*Riga Technical University, Kalku st. 1, Riga, Latvia, LV1658*
[b]*Sculptor, Riga, Latvia, Latvia, LV1046*

Abstract

The problem of restoration of architectural monuments and facade of historical buildings is very timely over the world. Accelerated degradation of facades is caused by climatic factors and environmental pollution. The paper discusses the possibilities for use of high performance concrete for restoration and sculptures creating in historical buildings. Elaborated mix composition provides high workability of the mix, self-compacting effect and ability of perfect reproducing small elements during moulding. Laboratory testing of samples proved high mechanical strength, low water absorption and enhanced frost resistance. Created and installed sculptural elements perform perfect surface and shape and promise to be more durable comparing to production technology using traditional cement and lime mortar.

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1. Introduction

Renovation and restoration of architectural monuments and historical buildings is topical problem over the world. Historical masonry buildings are usually plastered with lime (or cement-lime) mortar and decorated with architectural elements made out of natural or artificial stone based on cement and lime based compositions. Current situation shows that a lot of facades are in bed condition, restoration process require a lot of resources. Reasons of

* Corresponding author. Tel.: +371 29160832; fax: +371 67089248
E-mail address: genadijs.sahmenko@rtu.lv

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accelerated degradation of plaster and decorative elements are influence of both climatic factors and contaminated environment [1]. In the countries of median and northern zone deterioration processes of cement and lime based compositions are accelerated by increased moisture and freezing-thawing cycles. In maritime climate degradation processes are accelerated by salt chemical attack. At the same time, in the south regions (especially in desire regions) erosion weathering and abrasive effect of sand are taking place.

Exploitation experience of historical buildings has shown that the degradation processes of front element can take place not only in old buildings, but also in new projects within a few years after restoration. Therefore, it is necessary to use modern materials and technologies that can guarantee durability and good exterior condition of architectural elements. Durability of exposed architectural elements also can be improved by special protective covering [2].

New architectural elements creating technology consists of creating and adjusting initial shape of restored element from appropriate plastic materials such as clay or special plastic mass. The next stage is mould producing, which copy original shape [3]. Gypsum is the most popular mould material, but gypsum moulds are single used. Multi used moulds may be produced from glass fiber composites which contains polymer resin and glass fiber mesh. Complicated elements may be cast in polyurethane or silicon rubber moulds, which are flexible and multiply used. Final stage is filling the mould by mortar, which copy initial shape after hardening. Traditionally gypsum and cement-lime based mortar compositions may be used. Gypsum sculptures are not waterproof and they must to be protected by special coverings. Cement-lime mortar sculptures are characterized by increased strength and climatic resistance, comparing to gypsum [4].

Restoration process is labour-consuming and requires big financial resources. Therefore, preferable are technologies and materials, which are able to provide prolonged time of future exploitation. Promising way here is to use latest achievements in concrete technologies, such as to use High Performance Concrete (HPC) and Fiber Reinforced Concrete (FRC) [5]. These materials are elaborated and practically applied in the world during last 3 decades. HPC is characterized by enhanced properties such as high strength, higher durability as well as good other technological properties. In the case of architectural application the combination of self-compacting and high performance properties [6] makes possible to achieve perfect surface of elements. Modern HPC is multi-component material, containing multi-sized aggregate, micro-filler [7], [8], low water/cement ratio and forming dense microstructural packing which provides high strength and impermeability [9]. Commonly, concrete is brittle material, especially high strength concrete. Fibers are added with purpose to increase ductility and bending strength of material [10]. In the case of architectural application, steel fibers can cause rust points on the surface, therefore plastic fibers may be used. Plastic fibers are not so effective as steel, but bending behavior and dimensional stability of material can be improved [11]. Multi-component and fine-graded high performance concrete, containing specific fibers can be defined as high performance cement composite (HPCC). The aim of research is to demonstrate the possibility to apply high performance cement composite for renovation of architectural sculptures in real historic heritage buildings.

2. Raw materials and sample testing methods

2.1. Raw materials and mix composition

HPCC mix compositionsModern high performance concrete is multi component mix, characterizing by wide range of particle sizes: from millimeters up to nanometers.

The main task of mix proportioning is to provide dense structural packing of cement matrix. In our case local quartz based sand was used as a basic aggregate (particle maximum size was 1 mm).

White high strength cement CEM I 52.5 R (alite based) was used as a binding agent.

Silica fume was used as efficient pozzolanic admixture and micro filler, it is characterized by very fine particles (in the range of 1 □m up to 15 nm).

PVA (Poly-vinyl-alcohol) fibers were added in order to improve material ductility, to increase bending behavior and shock resistance of final product.

Proportion of basic mix is summarized in Table 1.