3RD INTERNATIONAL ACADEMIC CONFERENCE ON PLACES AND TECHNOLOGIES

EDITORS
EVA VANIŠTA LAZAREVIĆ
MILENA VUKMIROVIĆ
ALEKSANDRA KRSTIĆ-FURUNDŽIĆ
AND ALEKSANDRA ĐUKIĆ

CONFERENCE PROCEEDINGS

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PLACES AND TECHNOLOGIES 2016

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PROBLEM OF PROTECTION OF ORIGINAL APPEARANCE OF PREFABRICATED CONCRETE FACADES AND ENERGY IMPROVEMENT MEASURES – EXAMPLE OF NEW BELGRADE

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ABSTRACT

As a result of renewal of the Serbian capital after the World War II, a newly built residential settlement named New Belgrade was erected on the left bank of the river Sava. The most intensive time of its construction includes the period from 1950 to 1980, when prefabricated construction systems were omnipresent. As a manner and reflection of that time, diverse design solutions were applied on residential buildings from New Belgrade in which concrete was the main façade material. The most widespread finishes were: exposed concrete panels with different textures and reliefs; coated, i.e. painted concrete panels; concrete panels with ceramic tiles finishing; combined façades of exposed concrete and brick.

Today, in many cases of New Belgrade residential blocks, there are serious damages of concrete façades that require extensive repair. At the same time, some of the blocks enjoy the status of previous protection as cultural monuments. On the other hand, referring to existing buildings, the question of energy efficiency as one of the imperatives of nowadays building practice implies the need for additional thermal insulation along the building's thermal envelope. This type of intervention is, in most of the cases, applied externally, representing in this way a measure that might significantly change the original building appearance. In both cases, preservation of appearance of concrete façades is questionable, which raises the problem of protection of original appearance of analysed buildings.

This paper strives to present the overview of the applied concrete façades and their present condition in selected residential blocks from New Belgrade in the light of energy performance of their facade envelopes in the present state. This review should point out potentials and limitations for their further improvement having in mind the need for preservation of authenticity of the analysed buildings.

Keywords: prefabricated concrete facades, energy renovation, authenticity, residential blocks, New Belgrade

[1] Corresponding author

INTRODUCTION

The problem of protection of original appearance of prefabricated concrete facades which is the topic of this paper is analysed on the area that is well known as *the central area of New Belgrade*. This group of blocks: 21, 22, 23, 28, 29, 30, together with blocks 1 and 2 represents the area of the first erected residential buildings since the 1958. During the era of late modernism, architects brought to us different design solutions as the manner of the time, so every block has its own concept of urban composition, followed with the use of specific type of facades where, in the most cases, concrete dominated. Due to their specific conceptual characteristics and applied principles of modern urbanism, today this huge area has a defined status as area with previous protection. Analysed construction period from 1958 to the 1980s is well known for the use of prefabricated construction systems, where the reinforced and prestressed concrete were the main materials. Consequently, different types of prefabricated concrete facades dominated during that time. Apart from concrete, other materials, such as brick, ceramic tiles and different renders, where also in use in design and construction of facade structures.

In this paper four different main types of prefabricated concrete facades are presented. This number of different types was defined by the most widespread types of facades which are omnipresent in analysed area of New Belgrade. Although there are many different types of facades by their shapes, applied materials and dimensions of prefabricated elements, those four can present and become the real represents of them. Four types of facades are classified in groups by their finishing so there are: exposed concrete facades, coated concrete facades, concrete facades with coulier finishing and concrete facades covered with ceramic tiles. Every of classified types have their own characteristics by their structure of prefabricated elements and their existing condition. It is necessary to mention that those selected types of facades were in use in certain blocks of this area and are the most widespread. Those prefabricated elements are analysed by three basic steps. First step is defined as the view and presentation of existing condition of facades after the period of construction and throughout their exploitation. Second step has a purpose of presenting the real thermal characteristics of prefabricated facade elements, with the view of materials which were in use during the construction and their production. Third step of analysis aims to present possibilities of reconstruction of facade elements and improvement of their thermal characteristics in case of protection their original appearance.

EXISTING CONDITION OF FACADE ENVELOPES

During the construction period of residential buildings in the central area of New Belgrade few construction systems were in use such as: IMS, Cross wall panel system and *Jugomont* system. Every system has its own types of facades which were in use. A small number of applied construction systems did not affect the diversity of façade elements, so many different types of façade elements were in use with structures and finishing of different kind. The existing condition of them is different, from those that experienced serious damages by the time, to those that are almost intact. Those damages have different causers which can be classified in four basic groups. First group is related to the architects and civil engineers and their improper design solutions. Various types of applied production and construction technologies, which in some cases induced poorly produced elements, are classified in the second group. Third group is related to the period of exploitation of buildings and the aging of those applied materials, for the buildings of the central area of New Belgrade have not been reconstructed since the period of erection. Fourth group of causers is defined as a set of human factors, which badly influence the building condition, as well as the condition of facade envelopes. Existing condition of facades is classified by four different types of represented finishing of prefabricated concrete façade elements This classification was preceded by a field work which included analysis and mapping of all types of facade finishing in selected residential blocks. According to that work, the map of applied types of facade finishing is presented in Figure 1.

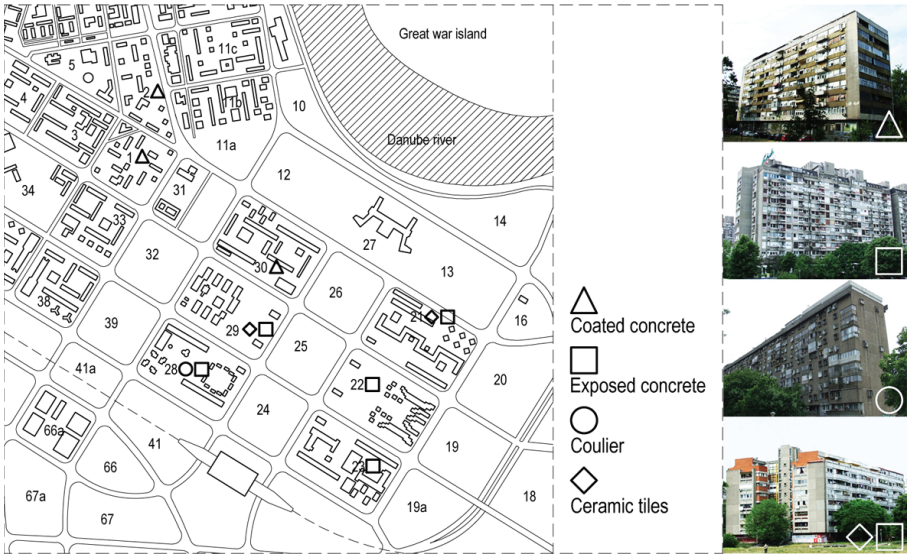
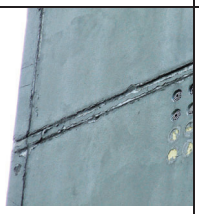


Figure 1: Presence of different types of facade finishing on buildings in analysed blocks (source: Macut, N., 2015)

Exposed concrete facades are present in the central area of New Belgrade in blocks 21, 22, 23, 28, 29 in Figure 1. This type of finishing is present on different types of facade elements such as: parapets, one storey panels, linear elements and elements with different shapes. Texture of façade panels was also one of the specifics of the use of exposed concrete, because it was possible to produce flat elements with rough or smooth surfaces, cannelured or grooved shapes, or shapes with specific geometries according to the design. That diversity of shapes and design solutions brought to us manners of the design period and diffused the use of exposed concrete. Coated pefabricated elements are present in blocks 1, 2, 29, 30 (Figure 1). With those coatings architects were stressing facade elements such as: parapets, linear elements, one storey panels, between windows elements with different geometries of surfaces in case of forming visual effects in specific tonal scales. Concrete facades of this type are present in block 28 in Figure 1. Coulier was in use also during the 1960s until the 1980s. This technique of materialisation gave specific appearance to façade elements. The most important factor of design is related to the types of aggregate. In block 28 two types were in use as pebble and as crushed stone. Every type has its own tonal scales in regard to the type of fraction which is in correlation with roughness of facade surfaces. Coulier was only in use for production of one storey panels. Concrete facades covered with ceramic tiles are present in blocks: 1, 2, 21, 29 (Figure 1). During the construction period only three types of tiles regarding their dimensions were in use. However, their use in different colours and tonal scales formed variety of ornaments on the surfaces of facade elements. Ceramic tiles were integrated elements of panels as they were fixed to the surfaces during the production processes in construction facilities. After approximately 50 years from the construction period, every facade has its own specific condition regarding different factors they were exposed, so it is possible to perceive the existing condition of each facade by field work and analysis (Table 1).

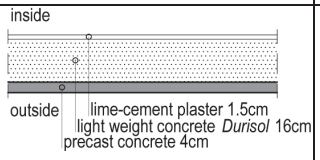
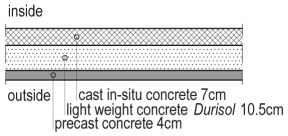
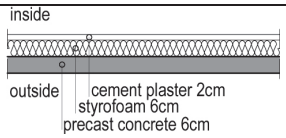
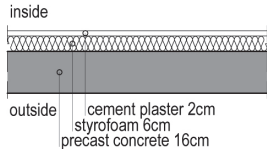
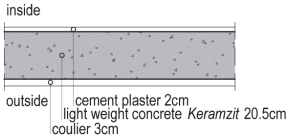
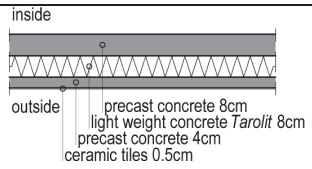
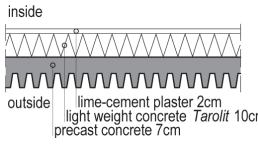
Table 1: Existing condition of facade elements with different finishing (source: Macut, N., 2015)

		Type of finishing			
		Exposed concrete	Coated concrete	Coulier finishings	Ceramic tiles
Geometry of façade elemnt	Parapets			/	
	One storey panels				/
	Linear elements			/	
	Between windows elements	/		/	
	Decorative elements		/	/	/

EXISTING THERMAL CHARACTERISTICS OF FACADE ENVELOPES

Although the problem of reconstruction of damages on facade surfaces is one of the basic problems which has to be determined, there is another great problem that affects concrete facades of existing buildings. Problem is related to their energy performance which is far below the nowadays requirements and which contributes to the high rate of energy consumption. To solve this problem and define some future strategies and measures of energy improvement it was necessary to analyse the existing thermal properties, in the first place to calculate the U - value [W/m²K] of selected prefabricated elements (Table 2). Facades were selected for analysis according to the previously created classification of facades by their finishing. Parapet elements and one storey panels with different finishings were selected for analysis. In the group of selected panels three-layer panels are the most widespread (Type 1a, Type 2b, Type 2a, Type 2b, Type 3b, Type 4b). Only one of the selected panels has four layers in its structure (Type 4a). Such structure is result of the fact that during the analyzed construction period facade panels were designed of a bearing layer, thermal insulation layer and a finishing layer. Although those panels resemble some contemporary facade structures, their thermal performances are inadequate. Diverse types of panels were analyzed and U - values of their present condition were calculated. Calculation showed that none of the analyzed prefabricated elements do not fulfill nowadays requirements regarding the maximum heat transfer coefficient set for external wall. Relevant Serbian regulation has set the value of U_{max}=0.40W/m²K as recommended value for existing buildings which are subject of reconstruction or energy improvement.

Table 2: Existing condition of thermal characteristics of selected facade types

		Structure of parapet	U - value		Structure of one storey panel	U - value
Block 1	Type 1a		0.632 W/m²K	Type 1b		0.894 W/m²K
Block 23	Type 2a		0.598 W/m²K	Type 2b		0.543 W/m²K
Block 28	Type 3a	This type does not xist	/	Type 3b		1.577 W/m²K
Block 29	Type 4a		0.913 W/m²K	Type 4b		0.769 W/m²K

ENERGY IMPROVEMENT MEASURES OF EXISTING CONCRETE FACADE PANELS

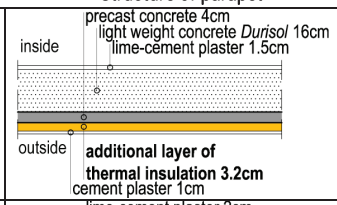
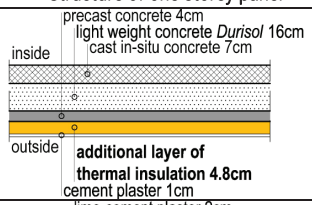
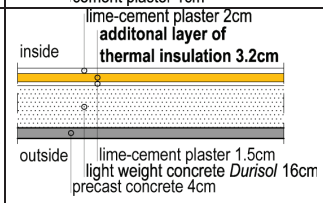
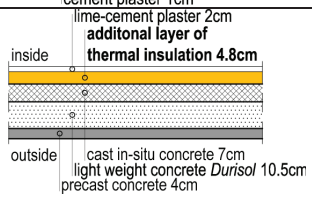
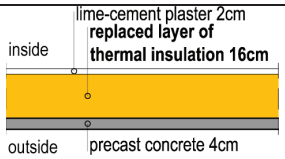
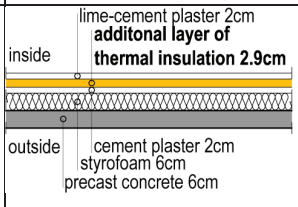
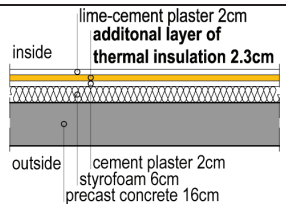
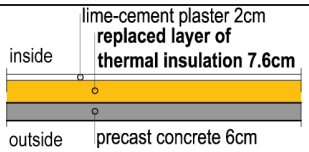
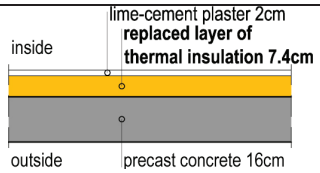
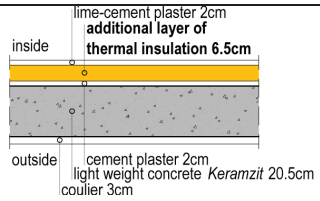
In case of energy improvement of existing concrete façade panels, different principles where analysed and calculated. Calculation of the present state shows insufficient thermal properties of existing façade panels. Their complex structure and visual characteristics that provide a specific appearance of the building require careful consideration when choosing the measures for their energy improvement. One problem refers to the question of the thickness of additional thermo-insulating layer. With the already calculated real U-values of panels it is possible to calculate the thickness of additional layer or layers which can improve the thermal properties of a panel aiming to reach the new value of U=0.40W/m²K. Having in mind that values of conventional thermo-insulating materials such as stone wool, glass wool, extruded polystyren (XPS) and expanded polystyren (EPS) are almost the same or similar, accepted value of thermal conductivity of additional thermal insulation for the conducted calculation is λ=0.035 W/m²K. With respect to this, necessary thickness of additional thermal insulation is calculated. The following step in defining the energy improvement measures refers to the placement, i.e. to the possible position of defined insulation layer. Generally speaking, two types of improvement strategies might be applied and are defined as: a) keeping existing layers and adding new ones, and b) replacing of old layers of thermal insulations with new layers with better thermal characteristics (Table 3). Theoretically, these actions could be performed either on the external, or on the internal side of the façade panel.

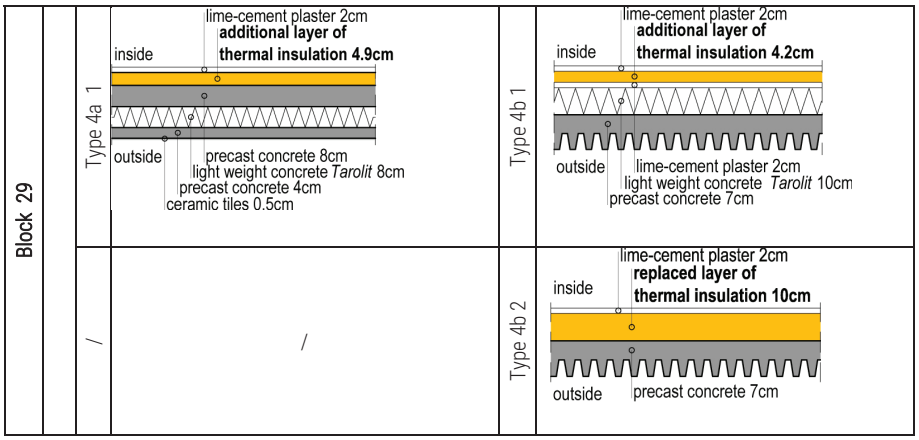
First way of improvement considers placing of additional thermal insulation layers and fixing them to the existing panel. Additional layers could be fixed on the outside or inside surfaces of panel. Although this principle is possible, specific problem which is related to the original appearance of facade and its finishing after the process of reconstruction is raised. In this case facades with exposed concretes (Type 2a, Type 2b), ceramic tiles (Type 4a) and coulier finishing (Type 3b) could not be improved by adding new additional layer on the outside surface of wall since such measure would completely change the original appearance of a building. In case of facades, either with specific coatings, and/or with flat surfaces (Type 1a, Type 1b) it is possible to place additional insulation on the outside surface of panel and to coat it with specific facade plaster that is similar to the original one. This principle is only possible if this system of reconstruction do not disturb the original appearance of facade panels.

Other principle of replacing insulation with a new one also has some specific requirements which are directly related to the structure of layers inside the panel. Analysing the selected panels, only four panels (Type 1a 3, Type 2a 2, Type 2b 2, Type 4b 2) (Table 3) could be reconstructed by using this principle. Displacement of the old insulation requires removing the layer of internal plaster before the removal of old insulation. Depending on the thermal properties of the new thermal insulation, the thickness of the material might be either thicker (Type 2a 2 and Type 2b 2) or as thick as the original material. (Type 1a 2 and Type 4b 2). Replaced insulation could be coated with lime, cement or lime-cement plasters, or cladded with gypsum board on the internal surface.

Internal application of thermal insulation (either additional layers of new-replacing layers) might bring the problem of reduction of the net area of flats, due to which such measures often do not find the approval of users.

Table 3: Possible improvement measures and dispositions of new thermal insulation layers

		Structure of parapet	Structure of one storey panel
Block 1	Possible dipositions of new layers of thermal insulation in facade panels	Type 1 a1 	Type 1 b1 
		Type 1a 2 	Type 1b 2 
		Type 1a 3 	/
Block 23		Type 2a 1 	Type 2b 1 
		Type 2a 2 	Type 2b 2 
Block 28	/	/	Type 3b 1 



CONCLUSIONS

Throughout the process of analysing different types of facade panels it is possible to make an overview of applied materials from the construction period. This information is very important for the further analysis of possible processes of facade reconstructions. By analyzing façade panels through detailed observation, mapping and calculation of thermal characteristics it is possible to realize the real condition of concrete panels and relevant characteristics of applied materials. In this way it is much easier to reconstruct certain facade element and to propose an appropriate energy improvement measure which will fulfil the nowadays criteria. It was shown that since energy improvement became an integral part of nowadays reconstruction of existing buildings, specific building heritage of New Belgrade requires a complex methodology of energy improvement measures that takes into consideration the problem of protection of original appearance of original facades, since these buildings represent the spirit of an era of extensive work on construction of residential buildings and housing block areas.

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