5th INTERNATIONAL ACADEMIC CONFERENCE ON PLACES AND TECHNOLOGIES

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PLACES AND TECHNOLOGIES 2018

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PRESERVATION OF ORIGINAL APPEARANCE OF EXPOSED CONCRETE FACADES, CASE STUDY: RESIDENTIAL BLOCK 23, NEW BELGRADE

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ABSTRACT

Block 23, located in New Belgrade presents multifamily residential block constructed during 1970s. It was designed in the manner of the era of Brutalism. Consequently, exposed concrete was selected and applied as the main material for bearing structures and façade envelopes. This period was typical for the mass production of multifamily buildings and in the efforts to perform faster construction of buildings, prefabricated building systems were in use.

Technique of prefabricated production enabled the production of specific shapes of façade elements. Therefore, architects of the buildings in the Block 23 designed different types of facade elements resulting with specific architectural expression of this urban complex. In general, facade elements can be classified in specific groups by their shapes and dimensions. In the analysed block, five main groups of elements are present such as: parapets, one storey panels, linear elements, panels between windows and decorative elements.

After approximately 40 years of exploitation followed with different causes of damages and decay of exposed concrete, the condition of those elements deteriorated and they need to be reconstructed and renovated. Since these buildings do not fulfill the requirements of nowadays regulation regarding energy efficiency of buildings they also require energy rehabilitation. Having all this in mind, this paper strives to analyse potential solutions for reconstruction and energy renovation of these prefabricated concrete facades with respect to the need of preservation of their original appearence. This complex problem is supported by the fact that the block has the status of previous protection as the architectural and cultural heritage of one important period of Serbian architecture.

Keywords: Exposed concrete, Prefabricated facades, Residential block, Original appearance, Facades reconstruction

Introduction

The main topic of this paper is defined as the set of the problems which have to be solved in case of preserving the original appearance of concrete facades. Case studypresents residential Block 23 in New Belgrade designed by the Serbian architects Aleksandar Stjepanović, BožidarJanković and BranislavKaradžić in the manner of the era of Brutalism. There are several reasonsfor selecting this block for analysing in the paper. In the first place, the Block 23 has the status of previous protection as architectural heritage of the huge era of Modernism but the buildings which are approximately 45 years old are not in a good condition, so they need to be renovated. Another reason is related to the type of applied façades. In the whole block the same type of exposed concrete façades is omnipresent. The facades are also not in

1 Corresponding author

a good condition since they are damaged during the period of exploitations. Another problem is that they have never been reconstructed or renovated since the construction period.The problem of energy efficiency of selected buildings is also present since façade structures are not in accordance with regulation related to the problem of energy efficiency of buildings. With theexisting damages on façades, problems of reconstruction and energy renovation of Block 23 presents the great effort,having in mind the simultaneous need for preservation of the original appearance of façades and the need forenergy renovation.

Applied constructions and materials of buildings in residential Block 23, New Belgrade

Residential block 23 was designed in late 1960s, but buildings were constructed during the whole decade of 1970s. Block has specific urban composition which was created by combiningthree types of residential buildings(Figure 1). According to the design solution, three types of residential buildings are classified by their heights and shapes.

For this huge construction project architect and civil engineers defined the specific systems of construction. In the first place, it is necessary to explain the applied systems of bearing structures. Type 1 and Type 2 of buildings were built with combined bearing system. [Ćulafić, 1978] Those systems present combination of industrial pre-casted skeletal system IMS and system of bearing walls cast in-situ. Skeletal systems were for the use in the zones of flats. Systems of bearing walls were designed for zones of vertical and horizontal communications and in the planned zones of flats with the purposes of seismic walls. Floor constructions are produced as pre-casted hollow cored slabs, which rely on the columns and walls. Type 3 of buildings were designed with systems of bearing walls. They also have the purpose of receiving seismic impacts. Walls are casted in-situ and have variable dimension of profiles throughout the floors. Floor constructions were designed in systems of hollow cored pre-casted slabs which rely on the walls. Analysed buildings also have the specific number of pre-casted non-bearing façade elements and some of them are present in the façade structures of all three types as unitised elements with specific functions. Reinforced concrete presents the main material for bearing and non-bearing elements. Architects designed residential buildings with elements of exposed concrete, in the manner of Brutalism. Surfaces of façade planes were designed with the lot of number of different specific details. Elements were produced with smooth, cannelured or rough surfaces, according to the ideas of the architects and the applied building technology. Domination of exposed concrete diversity of façade elements represent a special value and recognition mark of this specific urban block.

Figure 1: Position of Block 23 and types of residential buildings: Type 1, Type 2, Type 3 (source Macut, N., 2016)

Typology of applied façade elements

Two main types of façade elementsare defined throughout the detailed analysis of residential buildings of Block 23. According to the applied systems of construction façade elements can be classified as elements cast in-situ or pre-casted elements. Every of defined types are produced from exposed reinforced concrete.

Cast in-situ reinforced concrete elements

Defined type presents in most of the casesdesign solution for bearing walls(Table 1). Those walls were cast in-situ and have heights of one floor. They were built in zones of vertical and horizontal communications between two wings of flats as seismic and bearing walls. In case of Type 2 walls were also positioned between the flats with the purpose of dividing and seismic walls casted in-situ. Exposed bearing walls were constructed with specific manner of finishing, so the surfaces are either cannelured or smooth, which was achieved by special type of formwork. Type 3 of analysed buildings has thicker walls which have height of one floor. They are also designed as seismic walls. All of them were built from exposed reinforced concrete with specific profilingand finishing according to the design.Review of applied types of façade wall are presented in Table 1.

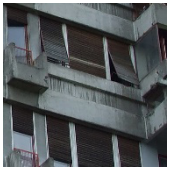
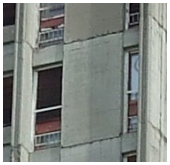
Table 1: Review of applied types of façade walls(source Macut, N., 2016)

	Type of building		
Type of element	Type 1	Type 2	Type 3
Bearing wall			

Prefabricated reinforced concrete elements

Types of elements are defined in groups according to the detailed analysis of façade structures. The design concept enabled the combination ofseveral prefabricated elements, resulting with variety of formal expressions of buildings. First group is represented by linear elements and in case of analysed buildings they are placed horizontally in the zones of floor constructions(Table 2).Parapets of exposed concrete present a type of unified prefabricated elements with the same geometry which was created of two prefabricated elements standing one on the other. Main element is fixed to the floor construction, while theother is set on the main one representing awindow sill. One floor height exposed concrete prefabricated panels were in use as façades elements. The panels are fixed in the zones of floor constructions and have different shapes and finishing with smooth, rough or cannelured planes.Panels were produced as independent elements of façade or as the finishing layers of cast in-situ bearing walls. The last ones present the group of others as the group of most different elements which are present on façades. They also have different functions and positions such as: decorative plastic elements designed for different positions on façades, railings of the terraces and flat roofs, flower pots.

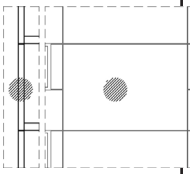
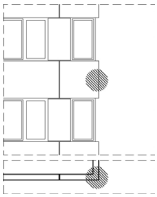
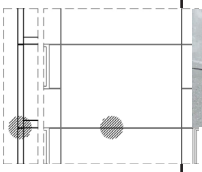
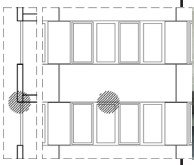
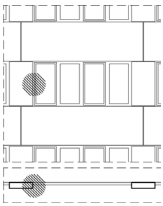
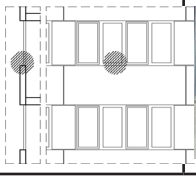
Table 2: Review of applied types of façade elements (source Macut, N., 2016)

Type of element	Type of building		
	Type 1	Type 2	Type 3
Linear			
Parapet			
One floor height	/		
Others			

Types of damages on façade elements

The present damages on reinforced concrete walls are classified by the specific criteria. First step of classification is related to the present types of façade elements.The damage diagnostic methodology considered the field work which included the mapping of their exact position on façades. Each of defined types of reinforced concrete elementsis possible to analyse, enabling every damage to be mapped and then classified[Macut, Radivojević, 2016]. (Table 3)

Table 3: Presence of different types of damages on analysed building types (source Macut, N., 2016)

	Type of element	Type 1, Type 2 or Type 3 of buildings
Free surface		
Free edge of element		
Horizontal joint		
Window lintel		
Window jumbs		
Window sills		

Detailed mapping of positions of possible damage show their presence in the following positions:

- free surface of element,
- free edge of element,
- horizontal joint,
- window lintel,
- window jambs,
- window sills.

Those positions are defined according to the geometry of analysed façades of residential buildings in Block 23. When the step of defining positions of damages present on the façades is done, then it is necessary to conduct a precise analysis of each damage. Their classification included the definition of their causes. Damages of reinforced concrete can be caused by several factors such as:

- applied technology,
- design process,
- time factors - ageing of elements and maintenance of building.

Reinforced concrete as building material is a result of specific production technologies and installation techniques. Theirinadequate application can provoke different types of damages on façade planes during the exploitation period. Several types of damages can be caused by:

- the segregation of concrete mixture,
- small covering layer of concrete for protection of steel bars of reinforcement which induces the corrosion of steel bars,
- abrasion and erosion of façade elements,
- different types of cracks,
- scrapped pieces of concrete from the façade element.

Possible measures of façade reconstruction

Existing condition of Block 23 requests large scale reconstruction of whole buildings. Since the Block 23 has a status of previous protection as an architectural and urban heritage, this paper explores the possible scope of reconstruction, emphasizing the need to preserve the original appearance, i.e. the exposed concrete.

In this process there are two problems that need to be considered. The first one refers to the decay of façade planes and methods of their repair, while the second oneinvestigates the possible measures and methods of energy renovation of façades.

Repair of damages

There are specific approaches in the treatment of damages on façade planes. Due to the recognition of the values of the analysed block, method of intervention includes the aspect of authenticity which should be respected. Therefore, damage repair includes the analysis of the achieved look of the façade element after the intervention which should be harmonized with the original appearance.

Similar investigations pointed out that selection of a particular methodof repair depends on the extent of the damage of the façade element[Heinemann, 2013]. Generally speaking, damages could be repaired based on one of the following scenarios:

- repair of small scale damage by using modern, compatible materials;
- repair of damage by placing new layers over the original material;

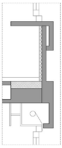
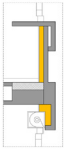
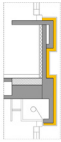
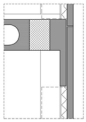
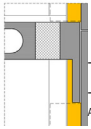
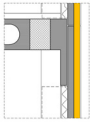
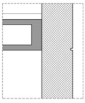
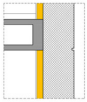
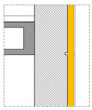
- replacing whole elements with a new, same or different structure from the original.

Possible measures of energy renovation of façades

Block 23 was built in the period prior to the time of adoption of regulationsregarding energy efficiency of buildings.Therefore, energyperformances of analysed buildings do not fulfil nowadays requirements for thermal comfort of buildings. Required energy improvement of façade elements can be based on two principle methods: from the interior side of the façade element, or from the exterior side.

According to the analysis of existing façade elements four groups of the most present façade elements were identified: linear ones, parapet elements, large elements (one floor height) [Krstić, 2003] either prefabricated or cast in-situ(Table 4).Each of selected elements has specific geometry and structure which affect the possibility for energy renovation.

Table 4: Possible measures of energy renovation (source Macut, N., 2018)

Type of element		Type 1, Type 2 or Type 3 of buildings		
		Existing condition	Internal placement of thermal insulation	External placement of thermal insulation
Linear		 -no thermal insulation -thermal bridge	 -thermal bridge -replaced window -the original appearance	 -no thermal bridge -replaced window -new appearance
Parapet		 -with thermal insulation -thermal bridge	 -thermal bridge -replaces window -the original appearance	 -no thermal bridge -new appearance
One floor height	Prefabricated	 -with thermal insulation -thermal bridge	 -thermal bridge -the original appearance	 -no thermal bridge -new appearance
	Cast in-situ	 -no thermal insulation -thermal bridge	 -thermal bridge -the original appearance	 -no thermal bridge -new appearance

Prefabricated elements present one important group which are designed and applied on all three types of buildings. From the perspective of energy performance of a building, the way they were used and combined with other façade elements, together with a lack of thermal insulation, induces the presence of linear heat losses on façades. Adequate solution for the problem of energy renovation [Pravilnik o EEZ, 2011] can be found in the placement of external layer of thermal insulation with specific façade finish. However, this method may be used without limitations for the buildings which are not recognized as architectural heritage. In other case, placement of external layer of insulation compromised the original appearance of the building. In this case, protection of original appearance can be achieved with the internal application of insulation layer.

Parapets built as exposed concrete panels are present on all three types of analysed buildings. Original structure of parapets is composed of three thin layers of: concrete, internal thermal insulation and plaster, but not in a sufficient thickness to fulfil the nowadays requirements. First possibility refers to the replacement of existing thermal insulation with the new one, which would inevitably lead to the application of much thicker insulation layer, influencing the reduction of the net area in the flats. On the other hand, this method does not exclude the presence of liner thermal bridges, which are present as result of applied construction details. Other renovation approaches are related to the installation of external insulation layer and new finishing layer, with or without the replacement of the existing thermal insulation. In these cases, the original appearance is endangered since the renovated façade gives completely new look of the building.

Applied façade elements designed with one floor height were constructed as prefabricated panels or cast in-situ. Originally, some of them were additionally insulated with an internal thermal insulation, but this was not a general rule. The analysis of technical documentation pointed out that many of the cast in-situ walls were designed without any layer of thermal insulation. The energy improvement methods are of the same nature as in the case of previously described façade elements.

Conclusion

The conducted analyses show that the emphasis on the need for preservation of original excludes the application of certain methods of energy renovation and points us to the solutions that bring partial solutions and different kind of problems and dilemmas. Such approach requires compromises regarding the achievement of necessary thermal performances of façade elements and favours the intervention on the internal side of façade elements.

Better results might be expected to be achieved by the combination of façade repair with the window replacement which is proved to be the energy improvement measure which influences the most energy balance of the building, or by investigation of application of new, innovative materials that enhance the thermal properties of building structures.

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