POSSIBILITIES OF STAGED RENOVATION OF REINFORCED CONCRETE FACADES OF MULTI-FAMILY BUILDINGS IN THE CENTRAL ZONE OF NEW BELGRADE

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ABSTRACT

The central zone of New Belgrade represents an architectural and urban complex which construction began in the early sixties of the twentieth century. In the period from the early sixties to the end of the seventies, multi-family buildings were constructed in blocks: 21, 22, 23, 28, 29 and 30, and today they are classified as the most representative examples of domestic architecture. Based on its architectural and urban characteristics, the central zone has the status of a spatial cultural-historical entity from 2021. Although this zone represents a cultural asset, the multi-family buildings in the blocks are examples of buildings that in the past few decades have not undergone any planned renovations of facade envelopes. The goal of the work is to present the possibilities of restoring facade envelopes through the process of staged renovations while considering ways of treating the envelopes that potentially preserve the original appearance - given that the selected buildings are treated as architectural heritage. Different reinforced concrete facade assemblies and existing damages also require different approaches in staged renovations, as a legitimate solution to this problem. Unplanned and unorganised works aimed at the restoration of facade envelopes led to significant damage and general degradation of both their non-transparent and transparent zones. Despite such problems, the owners of the apartments in the buildings were forced, due to the lack of organised renovations, to individually solve the encountered problems of facade assemblies. This primarily refers to the replacement of dilapidated windows and doors in facade envelopes, while the treatment of non-transparent zones was not carried out according to plan. This led to unfavourable situations in which the degradation of facades is not prevented. By applying staged methods of renovation and activating tenants, these problems can potentially be overcome, which is the main goal of this paper.

KEYWORDS _ *New Belgrade, reinforced concrete facades, façade renovation, multi-family housing*

INTRODUCTION

The principles of staged renovation represent one of the variants of the way of renovation and energy improvement of buildings that can be applied today (EC Directive of 25 October 2012, 2012). On the territory of European countries, staged renovation has a significant application, and it is stated that it is important to carry out various types of renovation within buildings at certain intervals (Fritz et al., 2019). For the purposes of this paper, the principles of staged renovation, which is the renovation and improvement of the entire building, will not be considered, but the concept of renovation should be applied only in the areas of the facade envelopes of residential buildings. Also, the paper will not consider the processes that precede the formation of staged reconstruction, and refer to different research processes, as well as the process of forming the approach itself in the reconstruction. The goal is to show the basic steps in staged renovation that are the steps of renovation of reinforced concrete facades that can be applied and to show possible renovation scenarios.

The Central Zone of New Belgrade is an area that, from 2021, enjoys the status of a cultural asset as a spatial cultural-historical entity (Sl. Glasnik RS, 2021). Based on such a status, in today's circumstances, every intervention must be monitored by the Cultural Monument Protection Institute of the City of Belgrade, in order to obtain appropriate documents from the domain of technical protection measures. Also in today's time, there is a significant carelessness of tenants, a lack of initiative to implement activities aimed at the renovation of buildings, as well as the inability of tenants to cover the costs of renovation. Due to such complex situations, the stage renovation of facade envelopes is one of the possible renovation strategies. By properly analysis and establishing appropriate solutions based on the found condition in the buildings, it is possible to plan a certain number of stages on the basis of which the renovation would be carried out. The stages would represent a series of steps in the restoration, and the steps themselves would be designed in such a way that the most critical damages should be repaired first. Since the common and private parts of the building are defined by domestic regulations (Sl. Glasnik RS, 2016, 2020), the most common problems arise related to the maintenance of the common parts, which includes the facade envelopes. Such problems point to one of the solutions, which is reflected in the application of stage renovation, by which the acquisition of money could be carried out in stages with the aim of realizing certain repairs, which would perhaps represent a more acceptable solution for today's circumstances.

Figure 1: Examples of residential buildings in Central Zone of New Belgrade

POSSIBLE SCENARIOS OF STAGED RENOVATION OF CONCRETE FACADES

For the purposes of this paper, three possible scenarios for the renovation of reinforced concrete facades of multi-family buildings are formed (Table 1). The scenarios were derived on the basis of field research, which included analysis of blocks in the Central Zone of New Belgrade. Previous

research has established that various problems are present in non-transparent and transparent zones of facade envelopes. This situation aims to consider appropriate ways of restoring facades while respecting various factors. This primarily refers to the consideration of methods of restoration and protection of the original appearance, given that the objects belong to a zone that has the status of a cultural property (Sl. Glasnik RS, 2021). On the other hand, different types of damages are evident that need to be repaired so that the buildings can continue to have their primary functions.

Table 1: Presentation of scenario goals of staged renovation

	Renovation – damage repair	**Preservation of original appearance**	**Energy improvement measures**
Scenario I	- treatment of joints of facade elements (**outside**)	- preservation of original appearance	- replacement of windows and doors
Scenario II	- treatment of the entire surface of facade elements (outside)	- preservation of original appearance	- replacement of windows and doors
Scenario III	- treatment of the entire surface of facade elements (outside and inside)	- preservation of original appearance	- replacement of windows and doors, - replacing or adding new layers of thermal insulation (**inside**)

The defined scenarios of staged renovation are based on three general goals of the renovation of buildings and their facade envelopes. The goals relate to rehabilitation, preservation of the original appearance and energy improvement of reinforced concrete facades (Macut, 2022). By inspecting the existing state of reinforced concrete facades in the Central Zone of New Belgrade, various damages were identified, which are represented in different extents on the facade surfaces. Problems stemming from decades of non-maintenance and unplanned renovations have led to a situation where the renovation of facade assemblies is indispensable. Different types of damage such as small cracks, cracks, to serious damage in the form of broken parts of the facade, the presence of corrosion and deterioration of the final layers, as well as the constructive layers of the facade elements require different approaches in their restoration and return to functional conditions. On the other hand, due to significant damage, the buildings must be treated as cultural assets during the restoration process, considering the existing status. Because of such a situation, facades must have a special treatment with the application of appropriate technical protection measures issued by the Cultural Monument Protection Institute of the City of Belgrade. The treatment of facades implies the renovation of both non-transparent and transparent zones, and in this connection, the renovation of transparent zones today represents a significant factor that can be treated as a measure of energy improvement of facade envelopes. In addition to the renovation of transparent zones by replacing existing windows and doors, it is possible to treat non-transparent zones by replacing or adding new thermal insulation layers. Based on the stated objectives, three scenarios were defined, which will be explained in more detail below.

When it comes to the replacement of windows and doors in the case of the selected buildings, it must be emphasized that a significant percentage of those transparent surfaces have already been restored by installing new ones, but the initiators of these activities were only owners of flats. In the given buildings, planned window and door replacements were not done at the level of the entire building, but were only individual activities of the owners. Today, it can be observed that the percentage of replaced windows and doors reaches 70% of the total area of transparent zones. Related to that, the question arises whether during one of the steps of the stagged renovation, only the worn-out original windows and doors are changed, or whether all the windows are changed as planned. Such a question requires a separate analysis, which is not the subject of this paper, given that it is about buildings in protected zones. Certainly, the replacement of worn-out windows and doors is indispensable, in order to achieve energy improvement to a certain extent. On the other

hand, the performance of the energy upgrade is questionable, because the tenants replaced the windows and doors unevenly, where they usually differ according to their energy performance. Although such problems are evident, the goal is to show possible scenarios for the restoration of both non-transparent and transparent zones of facade envelopes.

SCENARIO I OF STAGED RENOVATION

The first defined scenario is based on one of the basic problems that is present in the case of the selected buildings. This refers directly to the problem of damaged joints between facade elements. Decades of exploitation and, in many cases, unprofessional interventions have led to the problem of water and moisture penetration, as well as blowing in the joint zones (Giebeler et al., 2009). Such problems adversely affect people's stay in their apartments or other types of space. In this regard, the first renovation scenario aims at the treatment of joints, and then a certain type of energy improvement, which is reflected in the replacement of windows and doors (Figure 2). In the case of the selected buildings, access to maintenance and activation of tenants in order to form building renovation strategies is a significant problem. Such a problem manifests itself through poor communication between tenants in buildings, lack of interest of tenants and the inability to make an agreement on how to pay for renovation costs. Due to the aforementioned existing problems, staged renovation of this type can give certain results. The first step in the renovation would be the extensive restoration and repair of the joint zones between the facade elements, where the horizontal and vertical joints would be repaired in parallel. Such an approach would prevent further unwanted damage to facade elements, as well as damage to the interior spaces of buildings. This type of building maintenance would lead to a situation where in one time interval only treatment is carried out in the zones of facade element joints, and in the second step the replacement of worn windows and doors is considered.

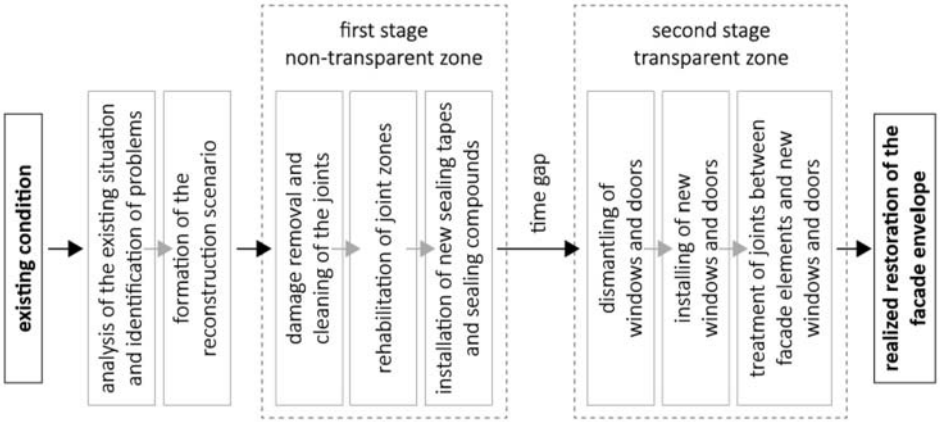

Figure 2: Diagram of the activities of the Scenario I

SCENARIO II OF STAGED RENOVATION

In the case of the Scenario II, non-transparent zones have a complete treatment in order to repair all the present damages. How different types of damage are represented on the selected facades, such as: small cracks, mesh cracks, cracks, areas with broken parts of facade elements and structural layers, occurrences of corrosion, damaged protective layers of concrete, damages in joint areas, etc. (Broomfield, 2003), it is necessary to treat such surfaces in order to repair them (Figure 3). The first phase in the formation of Scenario II represents the treatment of non-transparent zones with the aim of their renovation. Such renovation does not have the character of energy improvement, because with

this process, damaged surfaces are only returned to their original functional and designed state, and their energy improvements are not made by installing additional thermal insulation layers. The goal of this type of rehabilitation is to carry out the entire treatment of non-transparent zones, primarily from the outside of the facade surfaces, in order to prevent the penetration of various unfavourable atmospheric influences and to ensure a certain level of comfort in the interior spaces of buildings. In order to form and later realize such a complex renovation process, it is necessary to carry out preliminary research and identify the existing damages.

Figure 3: Diverse types of façade damages

The second stage of renovation according to the defined Scenario II refers to the treatment of transparent surfaces. As in the case of Scenario I, the same process of replacing worn out windows and doors can be in operation. The main goal is to carry out certain energy improvement of transparent zones, by installing new windows and doors, which will correspond to the possible requirements in the field of technical protection measures issued by Cultural Monument Protection Institute of the City of Belgrade. With this scenario, it is possible to fully restore the non-transparent and transparent zones with the possible preservation of the original appearance of the non-transparent zones, while the renovation of the transparent zones is carried out in such a way that the original appearance of the facades is not changed to a certain extent (Figure 4).

When it comes to the technological procedure for the implementation of Scenario II, it is certain that the renovation of the external surfaces can be carried out in several ways. Their implementation directly depends on the surface of the facade that contains damage. Based on that, with the necessary analysis process, it can be determined whether it is necessary to apply scaffolding in the reconstruction process or whether it is possible to realize the reconstruction by construction workers who will only use mountaineering equipment for work. The use of mountaineering equipment in the case of Scenario I is expected considering the treatment of only joint zones, while the use of scaffolding is more certain in Scenario II.

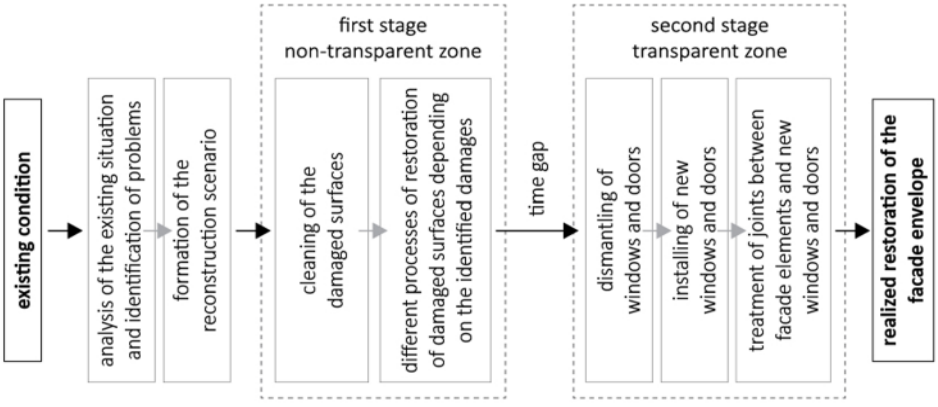

Figure 4: Diagram of the activities of the Scenario II

SCENARIO III OF STAGED RENOVATION

The defined activities in the renovation process in Scenario III are similar to the activities in Scenario II. This refers to the complete treatment of all external surfaces of non-transparent zones in order to restore them. The restoration of non-transparent zones is also in this case the subject of previous extensive research that must be done in order to form an appropriate strategy for their renovation. The principle of renovation and energy improvement of transparent zones is based on the same activities that were presented in the previous staged renovation scenarios. The difference compared to Scenario I and Scenario II is that in Scenario III, another large-scale activity is introduced, which is the treatment of non-transparent zones in the interior of buildings (Figure 5).

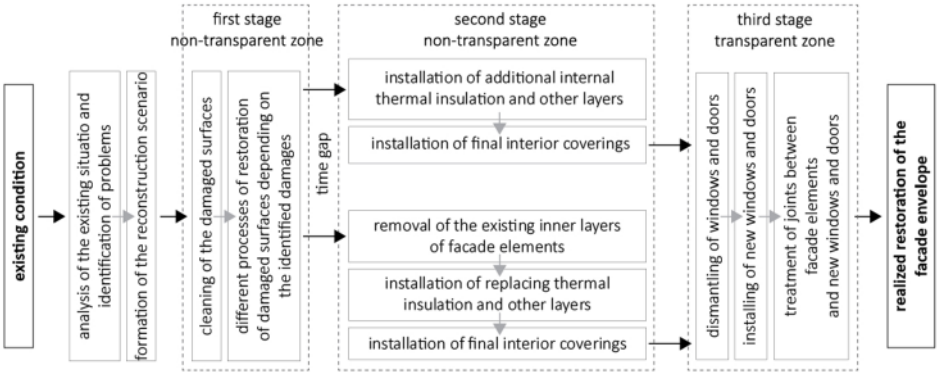

Figure 5: Diagram of the activities of the Scenario III

The treatment of internal surfaces of non-transparent zones can include various activities that primarily depend on the existing condition of facade elements, their structure and applied materials. Based on this, the processes that can include the removal of the existing inner layers and the installation of new replacement layers or the installation of new additional layers depend on it. The goal of such processes is to carry out the energy improvement of non-transparent zones. Considering the possible goal of renovation, this approach represents the most complex process of renovation because the works are carried out in the interiors of apartments and other spaces in buildings, which can directly impair the possibility of staying in flats during such interventions. Due to such methods of renovation, an extensive analysis of the functioning of the building during the execution of works is necessary. Such renovations can be applied to protected buildings, such as buildings in the Central Zone. The execution of works according to this scenario includes activities that are realized in the outer zones of the facades, and then they are realized in the inner zones, which primarily refers to the replacement of windows and doors and interventions on non-transparent surfaces.

DISCUSSION

In order to facilitate the discussion, an evaluation was conducted on the advantages and disadvantages of the three reconstruction scenarios that were previously defined. Given that the focus of this study is on architectural objects that are proclaimed a cultural asset as a spatial cultural-historical entity, the preservation of the original facade appearance takes precedence. As a result, the extent of facade renovation in the given scenarios has been adjusted to various possibilities based on the existing conditions of the facade (Table 2).

Table 2: Presentation of scenario goals of staged renovation

	Advantages	Disadvantages
Scenario I	- renovation of facade element joints - energy efficient improvement of the transparent zones of the facade - the whole process can be finished using mountaineering equipment, with no need for scaffolding	- not the entire surface of non-transparent zones of the facade is improved - there is no energy efficient improvement of non-transparent areas of the facade
Scenario II	- energy efficient improvement of the transparent zones of the facade - repairs are made to the non-transparent parts of the facade	- there is no energy efficient improvement of non-transparent areas of the facade
Scenario III	- renovation of external facade surfaces is underway - energy efficient improvement of transparent and non-transparent zones of the facade	- the impossibility of using the interior space during the execution of the works because they are carried out from the inside - adding layers in the interior reduces the useful area of the apartment - the impossibility of repairing thermal bridges on the façade completely - the possibility of condensation

CONCLUSIONS

Depending on the existing condition of the facade envelope and the possibility of financing the energy efficient refurbishment, the selection of the fitting renovation scenario, which is set out in the paper, is made.

In the first scenario, the focus of the renovation is on enhancing the sealing of joints in the facade to minimize water and moisture penetration and prevent further deterioration. Window and door replacements are also planned to improve energy efficiency. All of these renovations can be conducted using only mountaineering equipment without the need for scaffolding. However, this scenario does not address the overall thermal issues of non-transparent facade areas.

The second scenario improves upon the first by additionally rehabilitating damaged non-transparent parts of the facade. However, thermal characteristics of these areas are still not addressed.

The third scenario requires more extensive research, time, and financial investment. It involves comprehensive interior and exterior renovations. Non-transparent facade areas are fully rehabilitated with the addition of thermal insulation and other protective layers from the interior. Transparent facade elements are also upgraded through window and door replacements. This scenario achieves the highest level of progress in terms of energy efficiency. However, it has drawbacks such as the long duration of the works, disruption of normal usage of the apartments during renovations, occupation of interior space by additional layers, and the potential of forming thermal bridges after insulation installation, which can be challenging to repair while preserving the facade's original appearance.

Based on the provided information, it is crucial to conduct a detailed assessment of the building's condition prior to commencing renovations. This assessment will inform the selection of the most appropriate scenario based on available time and financial resources, ensuring that facade renovations achieve improved energy performance while preserving the building's original state and mitigating further deterioration. To ensure the effectiveness of these works, it is essential to carry out simultaneous renovations on the entire facade envelope of a single building. This approach will lead to improved energy performance and the preservation of the building's original condition, thereby slowing down further deterioration.

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