5th INTERNATIONAL ACADEMIC CONFERENCE ON PLACES AND TECHNOLOGIES

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PLACES AND TECHNOLOGIES 2018

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POSSIBILITIES OF ENERGY EFFICIENT REFURBISHMENT OF A FAMILY VILLA IN BELGRADE: A CASE STUDY

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ABSTRACT

A systematic approach to the restoration of an architectural structure is considered to be of crucial importance for its preservation. The objective of the research is to identify adequate methodologies for structural restoration in terms of energy efficiency, in accordance with modern requirements. The main method of this study is the observation of an architectural structure during its restoration and exploitation, and analysis and evaluation criteria for the findings regarding energy efficiency increase and energy saving. The subject of the research is a 1930s family villa in Belgrade, the analysis of the results achieved during the restoration of the villa in terms of energy efficiency and meeting modern living and comfort requirements. The study findings are recommendations for increasing energy efficiency during the restoration of a family villa in accordance with all modern living requirements. The key strategies to energy efficient refurbishment of the existing building are understanding and defining the already existing energy efficiency aspects of previous construction styles, in order to keep applying them efficiently, along with the latest construction methods. The study findings present the recommendations for increasing energy efficiency during restoration of the existing structures, while at the same time preserving the authenticity of those structures. The main contribution of the study is a practical evaluation of energy refurbishment of the restored structure, which is realized through various principles and measures of energy efficiency along with the use of renewable energy sources, in accordance with the conservation requirements and protection and preservance of authentic appearance of the building itself.

Keywords: restoration of architectural structures, increased energy efficiency, renewable energy sources, energy saving

Introduction

Energy efficient restoration of historical buildings is one of the main conditions to provide and maintain comfort standards, as well as ensure indoor environmental quality and new life for restored buildings. This study deals with the restoration of a 1930 family villa, designed in the spirit of classicism, at Dedinje, in Belgrade. The objective is to increase energy efficiency, apply renewable energy sources, ensure environmental protection, preserve authentic appearance and materialisation of the villa and enable its reuse.

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Hypotheses of this study are:

- adequate construction methods, in accordance with conservation standards, can help achieve significant energy saving, increase energy efficiency in restored buildings, preserve authentic appearance and harmony with their architectural surroundings,
- application of renewable energy sources for heating, air conditioning and sanitary hot water contributes to environmental protection.

The aim of the research is to:

- perform an active on-site analysis in order to protect and preserve the building and its surroundings,
- increase awareness of protecting such significant architectural structures - since they are model buildings reflecting various epochs of architectural history, as well as of their resources and reuse potentials,
- determine construction methods in order to increase energy efficiency and environmental protection during the restoration of an architecturally valuable building, along with the use of renewable energy sources,
- organize the findings of the research in relation to energy refurbishment during the restoration of this type of buildings, provide recommendations on how to preserve, restore and reuse these properties; make research findings available to academic community.

The architectural structures, which were built in the early part of the last century but were not listed as special architectural or cultural values, are not different from the buildings with similar structural and architectural elements when it comes to energy refurbishment concept. The methods of this type of refurbishment depend on the characteristics of the building itself and on reuse potentials. Only after the current condition and energy efficiency potentials of the building have been assessed, should the restoration and energy refurbishment measures start. Not only will these energy efficiency measures achieve energy savings, they will also protect material and historical values. The key to adequate energy refurbishment of the architectural structures built in the past is to determine and understand the existing energy efficiency aspects of previous construction styles in order to keep them, preserve and continue applying them along with the latest construction methods aimed at increasing energy efficiency.

Restoration of architectural structures aimed at increasing their energy efficiency

Restoration and rehabilitation of buildings should include the following procedures in order to create a high-quality, energy efficient building [1]:

- analyses of location, orientation and form of buildings,
- high-level thermal insulation on outer coating of buildings; thermal bridges are to be avoided,
- use the benefits of solar power; ensure protection from excessive sunlight exposure,
- further exploitation is to include the implementation of energy efficient heating systems as well as cooling and ventilation systems along with renewable energy resources.

Restoration of architectural structures with visible facing bricks, such as the building presented in this research, can include the following energy efficiency measures:

- thermal insulation of external wall - internally insulated only,
- roof thermal insulation,
- ceiling thermal insulation – covering the area toward unheated basement space,
- selecting adequate windows and external doors.

Comparative review of the restoration of an architectural structure built in the spirit of classicism, for the purpose of increasing its energy efficiency – Case Study

This study deals with the analysis of energy efficiency of an architectural structure, a family villa in Belgrade. The building is located in a residential part of Belgrade known as Dedinje. This 1930 villa consists of a basement, ground floor and attic. The basement is partially buried below the ground floor. It is a free-standing building on a very large lot and has a rectangular base (Fig. 1.).

The analysis of energy efficiency is provided through a comparative review of relevant parameters in three cases:

- the first case – the building prior to restoration (1930 - 2008),
- the second case – current condition (the building restored in 2008),
- the third case – recommendations for potential restoration for the purpose of increasing energy efficiency.

The first case – the building prior to restoration (up to 2008)

This residential building used to be a city villa, occupied by one family using the ground floor and a part of the attic. The basement was partially buried below a smaller part of the building. The building was designed as a massive construction with facade basement walls made stone and bricks, and ground floor walls made of 25 cm and 38 cm thick bricks. The attic walls were made of 25 cm thick bricks. All the facade walls were plastered from the inside only, which means that facing bricks were visible on the external walls.The structure above the unheated basement is Prussian vault, and the ceiling above the ground floor, toward the unheated attic area is made of wooden beams left exposed across the ceiling and covered by mud plastered reeds. The roof is traditional, made of plain tiles. Classic hardwood flooring was installed over the floor joists. Plastering on the ceiling was performed over the reeds and wooden laths.The wooden, single-glazed windows had large external casement. The entire ground floor used to be heated.

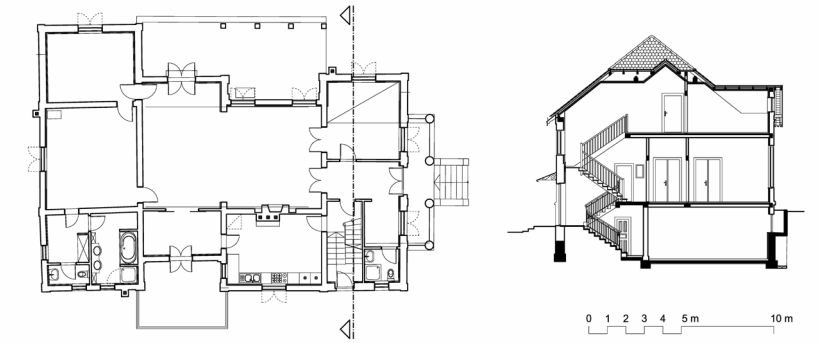

Figure 1: The residential building built in 1930; ground floor plan and cross section

From the day it was built until 1948, the villa was occupied by the same tenants – the family who had built it. After the Second World War, upon the political decision made by the communist regime of that time, the villa was taken and given to new tenants after the real owners had been

forcibly evicted without an adequate compensation. Sixty years later, due to the Restitution Act, the villa was returned to its pre-war owners.

Several decades of exploitation left the villa in great need of renovation due to rather deteriorating condition, which was the consequence of decades long lack of maintenance. Another significant reason is the decision made by the current owners of the villa – they wanted to improve thermal comfort without endangering the authentic appearance of the villa. They also wanted to renovate and remodel all worn-out elements in order to add aesthetic value to this remarkable architectural structure (balcony pergola, fan over the entrance, damaged fence, etc.). The owner insisted on keeping and returning the authentic appearance of the villa. The renovation of the villa began in 2008, in accordance with all conservation requirements (Fig. 2)[2].

Figure 2: The residential building, Belgrade, the original appearance: North-west façade (left), South-west facade (right) (photos taken by the author)

The second case – current condition (the building restored in 2008)

After the basement renovation, a fully buried basement was built below the entire building. The Prussian vault remained at the same place where the previous basement used to be - as a visible mezzanine floor structure on the lower side. A new thermal insulation layer and extended cement screed were installed over the existing basement ceiling (the Prusssian vault). A mezzanine floor was built as a lightweight semi-prefabricated composite floor between the new basement and the ground floor. Under the new mezzanine floor, a thermal insulation and layers of suspended plasterboard ceiling.

The brick style is visible on all external walls – this major features of the facades remained the same during the restoration. Thermal insulation as exterior cladding is to be avoided since the loss of authentic facade made of bricks would be an incomparably worse loss than energy efficinecy gains. Therefore, in order to keep the authentic appearance of the building and visible facade bricks, the only way to improve thermal comfort was to install thermal insulation on the inside of perimeter facade walls. Thermal insulation and gypsum plasterboards as a final brick cladding system were installed on the inside of all, 25 cm and 38 cm thick perimeter walls, over the coat of mortar. From the structural point of view, the facade is a non-ventilated type.

The entire timber mezzanine floor above the ground floor was replaced with a new lightweight semi-prefabricated floor. The entire attic area below the complex sloped roof was remodelled and converted into a usable, residential attic. In the attic area, between the rafters, thermal insulation was installed along the full height of the rafter and gypsum board on the lower side, as the ceiling.

The old, external casement windows were not replaced. However, the external single-glazed

2 Static stability assessment and structural design was realized by Prof.N.Sekularac, PhD

window pane was kept, and a new, insulated glass package with a double-glazed, low emissivity glass was installed in the new fillister of the inside pane. All the necessary rubber window strips were installed on the window panes in order to create a window with a low heat transfer coefficient. The front door is made of wood and glazed with the same type of glazing with thermal insulation glass and additional rubber strips. In the attic, new roof windows (skylights) were installed – wooden, double-glazed, low emissivity windows.

The third case – recommendations for further restoration in order to improve energy efficiency of the building

The research of this study implied the recommendations for another restoration of this villa in accordance with maximum benefits from restoration, based on the latest Building Regulations and Energy Performance of Buildings [2], in order to increase energy efficiency and improve overall comfort conditions and living quality in this villa.

The suggested new restoration would not include the improvement of thermal insulation on the inner side of the facade walls, since it would significantly reduce the size of the ground floor rooms. Also, the current thermal insulation meets all the requirements for allowed values of heat transfer, in accordance with the Regulations on Energy Performance of Buildings [2]. There is a possibility to install a wooden subconstruction over the lower side of the existing rafters, in the attic space, as well as a new, additional thermal insulation and gypsum plasterboards over the lower side.

The appearance of the building would remain the same – brick facade and plain roofing tiles as a roof cladding. Window openings, windows and front door would also be the same as before. The existing window panes and external single-glass are planned to remain, while internal package is to be replaced with a new, improved thermal insulation system with a low-emissivity glass.

Further research and comparative review of all three analyzed cases will show to what extent the suggested renovation of the villa contributes to decreasing total heat loss as well as annual energy consumption. The research will test and analyze energy efficiency through simulation and analysis of two different restoration models, using Building Performance Simulation (BPS) method and and energy efficiency optimization. Parameter values and plans for carrying out calculations and performance of cooling and heating systems, building occupancy, lighting, home appliances and sanitary hot water supply were defined to meet actual requirements of the villa's users.

Further research will deal with analyzing cost-effectiveness of installing PV panels. In this way, photovoltaic panels (PV modules) boost solar energy gains, thus providing a part of required energy from renewable sources. The installation of photovoltaic panels is planned to be carried out in the yard, given the large surface of the land and most favorable conditions for a great variety of placing PV modules. The position of PV panels in the yard will not have a negative impact on visual and aesthetic quality of the villa and its surroundings.

Conclusion

The restoration of the villa – installing additional thermal insulation, replacing the existing glazing with new thermal insulated glass packages with low-emissivity glass and improved thermal performance, significantly contributes to energy saving and environmental protection.

In-depth analysis of the presented cases: the original 1930 building, the building renovated in 2008, and the recommended new restoration, leads to the conclusion that the implementation of maximum thermal protection measures on all the elements of the building envelope can help achieve an energy saving home.

During the restoration of architectural structures for the purpose of increasing energy efficiency,

it is necessary to:

- define the type of rehabilitation and restoration based on current condition of a building,
- select adequate construction methods for carrying out energy refurbishment and reuse, in accordance with conservation requirements,
- select adequate methods of producing total annual energy from renewable sources in order to achieve energy saving and energy efficiency as well as environmental protection, as a part of establishing energy management.

The restoration of buildings having architectural, historical and aesthetic values as well as representative values for a certain epoch or architectural styles, requires a specific individual approach, along with using adequate energy efficiency measures. In order to achieve energy saving in accordance with the conservation requirements, it is necessary to plan the following construction methods: installation of thermal insulation on the building envelope from the inside, taking special care of the authentic appearance of the building itself, and replacement and installation of adequate windows and doors.

The above presented measures as well as renewable energy sources aimed to meet total annual energy needs, can significantly improve energy efficiency of these buildings. The main contribution of this study is a practical evaluation of the achieved results in relation to energy refurbishment, carried out by applying energy efficiency principles and measures for the restored villa built in the spirit of classicism, in accordance with the conservation requirements and authentic appearance protection.

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