RECONSTRUCTION OF THE HERITAGE BUILDING OF THE ŽIČA MONASTERY FOR THE PURPOSE OF SUSTAINABILITY

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ABSTRACT

The Žiča Monastery was built at the beginning of the 13th century, in Serbia, near the present-day town of Kraljevo, in the village of Žiča, and was declared as a cultural monument of exceptional importance in 1979. Even today, 800 years after its construction, the Žiča Monastery has high significance and represents an uninterrupted spiritual mission of the holy place for all Orthodox Serbs. The subject of the research in this paper is the Dining Room within the Žiča Monastery property which was built in 1935. The aim of the paper is to present a methodology which deals with sustainability and reconstruction in case of adaptive re-use of historic buildings in accordance with modern needs. Restoration of historic buildings that includes energy refurbishment measures will ensure successful reuse of them. An appropriate systematic approach of the reconstruction of heritage buildings is crucial in its preservation. All interventions on historic buildings, aimed at restoring and improving energy efficiency, are a reversible process and can be done in accordance with the conservation requirements.

The results of the research are recommendations for the restoration and adaptive re-use of historic buildings, while meeting modern requirements for comfort and environmental protection. The greatest contribution of this paper is the practical verification of energy refurbishment of the restored historic building, the Dining Room, by applying the principles and measures of energy efficiency, maintaining its authentic appearance. The possibility of practical verification of the achieved results by applying the principles and measures of energy efficiency in the restoration of the listed historic building is of great significance.

KEYWORDS _ *heritage conservation; energy refurbishment of historic buildings; methodology of reconstruction; conservation requirements*

INTRODUCTION AND PREMISES

Preservation and conservation of historic buildings, which are part of a society's monumental heritage, are essential to prevent further deterioration. These buildings should be restored and adapted to meet modern requirements while respecting the original appearance and materials. By incorporating energy refurbishment measures, the restored buildings can successfully serve contemporary needs. This study focuses on the restoration of the Dining Room in the Žiča Monastery property, located near Kraljevo, Serbia. The research examines the energy efficiency aspects and modern conservation requirements involved in this restoration project.

Heritage buildings hold significant architectural and historical value, and their preservation plays a vital role in transmitting cultural identity to future generations [1]. The uniqueness of the Dining Room lies in its unchanged role and function within the monastic life over the past ninety years.

The aim of the research is to:

- improve knowledge of the importance of preservation, restoration and revitalization of historic buildings, their remains and the potential of these monuments (resources),
- undertake active research of the site which will contribute to the protection and preservation of the monument as well as the management of the site,
- determine construction measures in order to improve energy efficiency of historic buildings,
- systematize the acquired knowledge in the field of improving the energy efficiency of historic buildings, form recommendations for their preservation, restoration and revitalization in terms of energy refurbishment and make the results of this research available to the academic community.

Prior to initiating the restoration process and implementing energy refurbishment measures, it is crucial to evaluate the energy efficiency of the existing historic building. Improving energy efficiency in such buildings not only results in energy savings but also safeguards their material historical value and unique characteristics [2]. The key to a successful energy refurbishment project for historic buildings lies in identifying and comprehending the existing energy-efficient aspects of the original construction. By preserving and retaining these aspects, along with implementing new measures aimed at enhancing energy efficiency, a more efficient and sustainable outcome can be achieved.

The subject of the research is the restoration and improvement of comfort conditions for users of this facility during their stay in this area, in order to improve energy efficiency, preserve the environment and maintain the authentic visual appearance of the facility and its materialization.

Authenticity is a central concern and an essential criterion of most conservation principles, and preserving authenticity is the highest goal of conservation. The understanding of authenticity (The Nara Document on Authenticity) [3] is of fundamental importance in the research of cultural heritage, in the planning of conservation interventions, as well as in the inscription on the World Cultural Heritage List. Authenticity was defined by the 1994 Nara Document on Authenticity [3]. By preserving the building as an authentic cultural monument, its original function or by introducing a new one, by improving the comfort conditions in the building that is the subject of restoration and reducing energy consumption, we strive to establish a model of sustainability. Restoration of historic buildings and sustainability are inextricably linked.

The hypotheses of this paper are:

- in accordance with conservation requirements and application of appropriate construction measures and authentic construction materials, it is possible to restore the existing devastated building, keep the existing function and improve comfort conditions, while maintaining the authentic appearance and unity with the protected ambient whole, such as the Žiča Monastery,
- restoration of the existing devastated parts of the building and use of energy refurbishment measures ensure energy saving and energy efficiency of the building in accordance with the preservation of the environment.

The goals of this paper are:

- use of site conditions for the protection and preservation of the historic building without negatively affecting the environment,
- improving the knowledge about the importance of preserving cultural heritage and historic buildings, their potentials, methods of restoration and use of authentic building materials, in accordance with the conservation requirements,
- use of construction measures in order to improve energy efficiency in the restoration of historic buildings and contribute to the preservation of the environment of this site,
- on the basis of the obtained results on the application of certain types of materials in the restoration and energy refurbishment of the historic building, to determine the most important factors required for their preservation, restoration and adaptive reuse, and make the findings of the research available to the academic community.

THE RESEARCH AND THE RESULTS FOR THE DINING ROOM WITHIN THE ŽIČA MONASTERY

Specific characteristics of the Žiča Monastery Property

The Žiča Monastery, situated in the village of Žiča near Kraljevo, Serbia, was constructed in the early 13th century. It derives its name from the village where it is located. Even after 800 years since its establishment, the Žiča Monastery continues to hold great significance and serves as a continuous spiritual sanctuary for all Orthodox Serbs. The central structure within the monastery is the Church of the Holy Dormition, built between 1206 and 1221 by Serbian King Stefan Nemanjić, known as Stefan Prvovenčani, who was also crowned within the monastery [4]. In 1979, the Žiča Monastery was designated as a cultural monument of exceptional importance. The monastery complex encompasses various buildings, including the Church of the Holy Dormition, the Church of St. Sava, the Church of the Nativity of St. John the Baptist, the Church of the Holy Apostles Peter and Paul, the Episcopal Palace, the Dining Room, the nuns' residence, and other facilities [4]. Throughout its history, the Žiča Monastery has endured destruction, fires, and devastation. Today, it serves as a nunnery where nuns lead a monastic life.

The Dining Room is a ground floor building, located in the southwestern part in relation to the outer narthex of the Church of Holy Dormition. In the extension of the Dining Room, on the east side, there is a closed vestibule (porch), to which the Church of St. Sava continues (Figure 1). The Dining Room was built in 1935. This facility was meant to be a guest house, i.e. a dining room where guests and believers who visit the monastery can relax and have some juice, coffee, tea or liqueur made by the nuns themselves. This facility is used during the morning and afternoon from 9 am to 5 pm, and is heated when it is necessary by underfloor heating via heat pumps. This large building, the Dining Room, consists of a reception area, a kitchenette, intended only for making tea, coffee, serving and washing dishes. It is not meant for preparing, cooking or serving food. There is also one office and a toilet area.

Figure 1: The Dining Room of the Žiča Monastery property: left - appearance of the church of St. Sava and the Dining Room from monastery yard, right - the interior of the Dining Room (provided photos taken by the author)

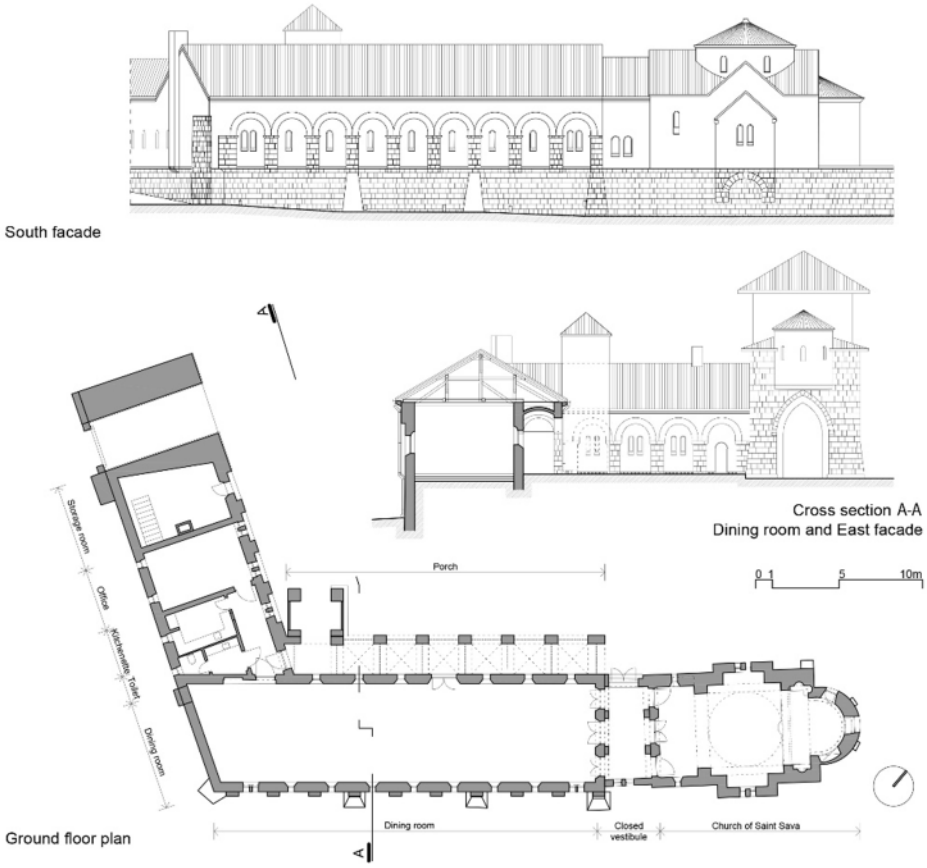

Figure 2: The Dining Room within the Žiča Monastery property

The Research Findings

This paper deals with the analysis of the ground floor building of the Dining Room, built in 1935, within the Žiča Monastery property, in terms of their energy efficiency, through the comparison of relevant parameters of three models:

- the first model – the existing condition of the Dining Room (restored in 2008 and 2009) - M01 (Figure 1.),
- the second model – the proposal for the 2019 restoration of the Dining Room - M02,
- the third model – the proposal for improving the planned restoration of the 2019 Dining Room - M03.

The proposals for the restoration and improvement of the Dining Room were given through the application of individual construction measures and in accordance with the conservation requirements [5]. Energy performance simulation for the three models of the Dining Room was done in the OpenStudio, the energy simulation software based on EnergyPlus, energy simulation software [6].

Restoration of the Dining Room within the Žiča Monastery

The on-sight analysis shows the condition of the mentioned Church of St. Sava and the Dining Room. The current condition of the Dining Room is the first model in the research - M01. All these perimeter walls of the Church and the Dining Room are plastered and frescoed on the inside (M01) (Figure 1.b). The façade longitudinal wall of the Dining Room was made of façade brick and was erected, like the wall of the church, on the perimeter, supporting, stone wall of the monastery property.

In 2008 and 2009, the Dining Room and the Church of St. Sava underwent a restoration process. This included replacing the deteriorated roof covering and installing underfloor heating in both buildings. The existing windows in the Dining Room are made of wood and consist of single-glazed glass panels that are 4mm thick. Similarly, the doors of the Dining Room and the ones between the Dining Room and the church are also constructed from wood.

Despite the restoration efforts in 2008 and 2009, moisture issues persisted within the Church of St. Sava and the Dining Room. To address this ongoing concern and prevent further harm to these buildings, a new restoration and structural rehabilitation project was developed in 2019. This paper presents the details of this project as a second model, referred to as M02. The aim of this project is to rectify the moisture-related problems and ensure the long-term preservation of the Church of St. Sava and the Dining Room.

The perimeter walls of the Dining Room and the Church of St. Sava are constructed using brick. The Dining Room's façade walls are plastered and adorned with frescoes on the interior (M02), while the exterior façade is made of unplastered brick, except for the wall beneath the porch. As part of the restoration, the entire wooden roof of the Dining Room will be dismantled and replaced with a new roof structure, including shingles as the roof covering. A new roof framework will be constructed directly above the Dining Room, combining a double roof hanger for the Dining Room area itself and roof trusses above the wall that separates the Dining Room space from the porch. The ceiling will be covered with wooden panelling, similar to the existing one. A steam dam and thermal insulation layer will be placed between the beams on the upper side of the ceiling boards, creating a floor within the attic space (M02). The existing windows will be replaced with new wooden ones featuring a 9 cm frame and double thermal insulation glass (4+12+4mm) filled with krypton gas. The new restoration project maintains the original purpose of all the rooms.

The proposed enhancement for the 2019 restoration of the Dining Room is presented as the third model for simulation, referred to as M03. This research paper suggests improvements to the 2019 restoration project, maximizing the potential of the restoration while minimizing construction interventions. The exterior facade walls of the Dining Room, which are made of brick, will be fully preserved. The interior walls will be plastered and adorned with frescoes to maintain their authenticity. The facade wall, which is plastered and frescoed on the inside and plastered and painted on the outside facing the porch, will be enhanced by adding external thermal insulation and facade plaster (M03). In the attic space, additional thermal insulation will be installed above the planned floor layers to create a new insulated floor in the attic (M03). The proposed improvements also involve replacing the windows with new wooden frames measuring 11 cm, fitted with triple-layer thermal insulation glass (4+8+4+8+4mm) filled with xenon gas. These enhancements aim to improve energy efficiency and enhance the overall comfort and quality of living in the Dining Room space.

Energy performance analysis

According to the research conducted, the proposed energy efficiency measures in model M02 would result in a 25.67% reduction in specific annual heating demands compared to the current condition of the restored facility (model M01) [5]. However, by further enhancing the energy efficiency of the Dining Room in model M03, the specific annual heating demands would be reduced by 51.94% compared

to the current state of the restored building (model M01) [5]. If we compare the potential improved model M03 to the originally proposed model M02 from the 2019 restoration, there would be a 35.34% reduction in specific annual heating demands [5]. These findings indicate the significant impact of the additional energy efficiency interventions proposed in model M03, leading to a substantial reduction in heating demands compared to both the current state and the initially proposed restoration model.

Considering that the rate of use of the equipment, lights and occupancy are the same, the most indicative aspect is the heating energy demand. The efficiency of the refurbishment measure proposed in the three models are presented in Table 1. From the results of the energy performance simulating presented in Table 1 it can be concluded that the Model M03 significantly outperforms the Model M02 and it is an improvement of the baseline Model M01.

Table 1: Energy performance of the three models of the Dining room [5]

(kWh/m2.year)	**Model M01**	**Model M02**	**Model M03**
Heating energy demand	46.72	32.7	18.35
Lighting	5.20	5.20	5.20
Appliances	2.70	2.70	2.70
Total energy demand	54.62	40.6	26.25

DISCUSSION

The analysis of the Dining Room within the Žiča Monastery, conducted through the simulation of three models and proposed structural rehabilitation and energy refurbishment measures, has led to the conclusion that it is indeed possible to achieve significant energy savings while preserving the building's visual character and adhering to conservation requirements. By implementing maximum thermal protection measures on the building envelope, satisfactory energy efficiency can be achieved.

The research involved field observation, the assessment of the Žiča Monastery property, and energy efficiency testing of all three models (M01-M03) using Building Performance Simulation (BPS). The results confirmed the hypothesis that by implementing appropriate rehabilitation and construction measures during the restoration of historic buildings, comfort conditions can be improved, energy efficiency can be enhanced, and energy savings can be achieved. These measures are designed to maintain the original function of the Dining Room within the Žiča Monastery, a cultural monument of exceptional importance.

This research validates the principles and measures of energy efficiency in the context of building refurbishment for structures within the Žiča Monastery property, which is recognized as a cultural monument of exceptional importance. The study holds significance both from a scientific perspective and in terms of practical applications, with potential for implementation in other locations with similar historic buildings of comparable construction and materialization. The practical application and verification of this research at the Žiča Monastery site further strengthens its value and contribution.

Recommendation for increasing energy efficiency and re-usability potential of historic buildings in preservation and building restoration project

Energy efficiency measures for heritage buildings should include the following procedures, in accordance with the conservation requirements:

- optimal thermal insulation of building envelope,
- heat loss reduction,
- heating installation.

Taking into account historic and architectural character and integrity of heritage buildings, as prescribed by the conservation requirements, it is not allowed to apply standard measures of thermal insulation by installing thermal insulation on the outside of the facade walls. The proposed energy efficiency measures that were applied in order to achieve energy refurbishment of the historic building of the Dining Room within the Žiča Monastery property:

- thermal insulation of the perimeter walls where it is possible and only from the inside, which was the case with only one wall in the unheated storage room, while all the walls in the main space of the Dining Room are facade walls and fresco painted on the inside and it is not possible to thermally insulate them on the inside,
- thermal insulation of floors on the ground,
- thermal insulation of the mezzanine structure (floor structure) towards the unheated attic,
- replacement of facade joinery (windows and front doors),
- new heating system,
- energy management.

CONCLUSIONS

The need to preserve the existing historical building and prevent its further decay, while preserving the fresco paintings on the inside of all perimeter walls and authentic brick facade and maintaining the continuity of the original purpose of this building, influenced the restoration of the Dining Room within the Žiča Monastery property. The application of selected construction measures in accordance with conservation requirements, in order to improve the energy efficiency and comfort conditions of the building, enables uninterrupted connection between cultural heritage and modern needs while maintaining the original purpose and authentic visual appearance of the building. In conclusion, the restoration of historic and listed buildings, coupled with the implementation of suitable energy efficiency measures, necessitates an individualized approach for each cultural monument. Installing thermal insulation on the building envelope, in line with conservation requirements, emerges as the most effective means of significantly enhancing the energy efficiency of historic structures and reducing heat losses. Throughout the research conducted on the Dining Room building within the Žiča Monastery property, various restoration models were tested and analysed using building performance simulations (BPS). The paramount contribution of this study lies in the opportunity for practical validation of the achieved energy refurbishment results through the application of energy efficiency principles and measures in the restoration of listed historic buildings. By respecting conservation requirements and upholding the authentic appearance of the Dining Room, this research offers valuable insights into optimizing energy performance while preserving cultural heritage.

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