

ANALYSIS OF THE CONDITION OF HISTORICAL BUILDINGS IN SERBIA – LITERATURE REVIEW

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ABSTRACT

Historical buildings represent an essential part of cultural identity and architectural heritage, particularly in countries with rich historical and urban traditions such as Serbia. However, these structures are increasingly exposed to environmental, structural, and seismic risks while simultaneously facing demands for improved energy performance and sustainable use. This paper presents an overview of the current state of research related to risk management, energy efficiency, and seismic vulnerability of historical buildings in Serbia, based on recent literature and case studies. The paper analyzes traditional construction systems, seismic assessment methodologies, energy retrofitting strategies, and sustainable regeneration approaches applied to protected historical buildings. Historical buildings in Serbia possess significant cultural and environmental value, but there are often problems with poor thermal performance, old and aging materials and structural vulnerabilities. Through literature review is shown that integrated and context-sensitive interventions can significantly improve both the seismic resilience and energy efficiency of historical buildings while preserving their architectural authenticity and cultural significance.

Key words: historical buildings, risk management, energy efficiency, seismic vulnerability

INTRODUCTION

The preservation and sustainable modernization of historical buildings have become major challenges in contemporary architectural and engineering practice. Across Europe, increasing attention is being directed toward reducing energy consumption, improving resilience to natural hazards, and preserving cultural heritage. This literature overview focuses on analysis of the condition of historical buildings in Serbia. The aim is to understand existing building typologies, assess their vulnerabilities, and evaluate possibilities for energy and seismic retrofitting while respecting their cultural and architectural identity.

In Serbia, historical buildings include a wide range of traditional rural houses, urban masonry structures, religious complexes, and public buildings. Many of these structures were constructed using traditional materials and techniques that reflect local climatic conditions and cultural practices. However, due to aging materials, insufficient maintenance, and changing environmental conditions, many buildings face deterioration and increased vulnerability to earthquakes and climate-related risks.

Recent scientific studies emphasize the need for integrated risk management strategies that combine seismic assessment, energy retrofitting, sustainable regeneration, and urban planning. This paper presents the key findings from the reviewed literature and discusses approaches to sustainable heritage preservation.

HISTORICAL BUILDINGS AND TRADITIONAL CONSTRUCTION IN SERBIA

Traditional architecture in Serbia was defined by the natural environment. The influence of natural factors can be found in the all the segments of the house: usage of natural materials found in the surrounding environment, dimensional adjustment and adjustment to the terrain done to fit available natural materials and climatic conditions which led to forming a functional space (Radivojević et al., 2017). These buildings often demonstrated efficient passive climate control through thick walls and natural ventilation.

The principles of sustainable architecture and the reduction of the negative environmental impacts in all phases of the building lifecycle are recognized in many ways (biodegradability, recycling, and reuse potentials of materials and structures) (Radivojević et al., 2017).

Radivojević et al., (2017) wrote that inevitable changes that happened over time first influenced urban architecture. Modernization has contributed to the improvement of certain aspects of living comfort, and increased the longevity of buildings. During the nineteenth and early twentieth centuries, Serbia experienced rapid urbanization and modernization, resulting in significant transformations in construction techniques and development of building regulations. That results in the use of new building materials which were more durable, but which carried a larger environmental burden in comparison to natural ones. Radivojević et al. (2016) describe the transition from timber-framed and mixed structural systems, that for that period had good resistance to seismic activity as well as good maintainability, toward massive masonry structures and the introduction of reinforced concrete.

Historical urban centers such as Belgrade and Novi Pazar (Muminovic et al., 2020.) contain numerous examples of protected buildings that require preservation and functional revitalization. These structures often possess significant cultural and historical value but face technical challenges related to structural stability, thermal performance, and adaptive reuse.

SEISMIC VULNERABILITY AND RISK MANAGEMENT

The formulation of seismic vulnerability in Serbia is not only of interest for predicting the economic impact of future earthquakes, but can also be of importance for risk mitigation (Radovanović and Petronijević, 2009). Seismic vulnerability represents one of the most significant risks affecting historical buildings in Serbia and the Balkan region. Earthquakes such as the 2010 Kraljevo earthquake and the 2020 Petrinja earthquake demonstrated the fragility of unreinforced masonry buildings and highlighted the necessity for improved seismic risk assessment (Blagojević et al., 2021).

Blagojević et al. (2021) focused on simplified seismic assessment methodologies for unreinforced masonry residential buildings in Serbia. Their study introduced the Wall Index concept which is based on the minimum requirements for the total wall area relative to the floor plan area derived from Eurocode 8. Main purpose of Eurocode 8 is to use Wall Index for design and build new buildings but for Blagojević et al (2021) research authors use it for seismic assessment of existing masonry buildings in pre- and post-earthquake situations.

Additional advances in seismic assessment were achieved through the Adriseismic methodology developed within the Interreg ADRION program. Predari et al. (2023) proposed an expeditious seismic assessment method that was developed to mitigate seismic risk associated with urban heritage buildings that was build with unreinforced masonry commonly found in the Adriatic and Balkan regions. These countries are characterised by the high seismic exposure and significant stock of vulnerable unreinforced masonry (URM) buildings, which were designed to withstand only gravity

loads and were unable to sustain the effects of moderate to strong earthquakes without substantial damage. The methodology evaluates masonry quality, structural response, and potential collapse mechanisms.

Furthermore, the classification of Serbia's residential building stock developed by Blagojević et al. (2023) established a foundation for regional seismic risk assessment studies consists of three components: hazard, vulnerability, and exposure modelling. Effective risk management in historical buildings therefore requires a combination of preventive conservation, structural monitoring, seismic strengthening, and strategic planning. These interventions must minimize damage while preserving the authenticity and cultural significance of heritage structures.

ENERGY EFFICIENCY AND SUSTAINABLE RETROFITTING

Improving the energy efficiency of historical buildings represents another major challenge in heritage conservation. Many historical buildings in Serbia exhibit poor thermal performance due to inadequate insulation, inefficient heating systems, and deteriorated building envelopes. However, aggressive energy retrofitting measures may compromise historical appearance and material authenticity.

Stanojević et al. (2021) proposed a multi-criteria decision-making model based on the fuzzy Analytic Hierarchy Process (AHP) for selecting optimal energy retrofitting strategies for heritage buildings with maximal preservation of building itself. Their research demonstrated that interventions should depend on the level of heritage protection and should prioritize minimally invasive solutions such as technical system upgrades and internal insulation. The National Typology of Residential Buildings in Serbia (Krstić-Furundžić et al. 2013) also demonstrated significant energy-saving potential across different building categories. Standard and advanced renovation scenarios showed that heating demand could be reduced by more than 70% through improvements in insulation, heating systems, and energy management.

A practical example of sustainable energy refurbishment was presented through the restoration of historical structures in the Hilandar Monastery complex. Šekularac et al. (2018) applied Building Performance Simulation methods to evaluate energy refurbishment end energy efficiency while respecting conservation requirements. Their study confirmed that renewable energy integration and energy-efficient retrofitting can be successfully implemented without compromising visual authenticity of historic structures.

Sustainable regeneration approaches are also visible in rural heritage preservation. Research on the traditional houses of Sirinička Župa demonstrated that traditional construction techniques possess valuable environmental characteristics and climate resilience. Functional reactivation and adaptive reuse of rural heritage can therefore contribute to sustainable regional development while preserving cultural identity. (Kosanović et al., 2019)

CONCLUSION

The analysis of scientific literature and case studies related to historical buildings in Serbia reveals that the country's architectural heritage possesses significant cultural, structural, and environmental value, but also faces notable challenges. Historical buildings, whether vernacular rural houses, early modern urban masonry structures, or protected heritage complexes, often suffer from energy inefficiency, material degradation, and varying levels of seismic vulnerability. At the same time, their preservation requires strict adherence to conservation principles, which limits the range of permissible interventions.

Research studies in this paper emphasize several important themes. First, sustainable materials and traditional construction methods used in Serbian architecture demonstrate inherent environmental advantages and provide a foundation for culturally appropriate retrofitting strategies. Second, the shift from timber framing to unreinforced masonry and early reinforced concrete necessitates varied seismic

assessment approaches, while new tools such as the Adriseismic method contribute to more efficient vulnerability screening and strengthen regional seismic risk mitigation efforts. Energy efficiency represents another critical dimension. Studies on retrofitting scenarios and building performance simulations confirm that substantial reductions in energy demand are possible, even within strict conservation limits, particularly when focusing on internal insulation, system upgrades, and renewable energy integration that preserve the building's visual identity.

At the same time, strategic planning and sustainable regeneration models can transform historical buildings into resilient and functional components of modern urban and rural environments. By integrating seismic strengthening, energy efficiency improvements, and conservation ethics, future interventions can ensure both the preservation of cultural heritage and the achievement of broader sustainability goals.

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REFERENCES

- Blagojević, N., Brzev, S., Petrović, M., Borožan, J., Bulajić, B., Marinković, M., Hadzima-Nyarko, M. Koković, V., Stojadinović, B. (2023). Residential building stock in Serbia: Classification and vulnerability for seismic risk studies. *Bulletin of Earthquake Engineering*, 21, 4315-4383
- Blagojević, P., Brzev, S., Cvetković, R. (2021). Simplified seismic assessment of unreinforced masonry residential buildings in the Balkans: The case of Serbia. *Buildings*, 11, 392. <https://doi.org/10.3390/buildings11090392>
- Kosanović, S., Folić, B., Kovacević, S., Nikolić, I., Folić, Lj. (2019). A study on the sustainability of the traditional Sirinić houses in the Šar Mountain region, the South-Western Balkans. *Sustainability*, 11, 4711. <https://doi.org/10.3390/su11174711>
- Krstić-Furundžić, A., Kosorić, V., Gajić, R., Ignjatović, D. (2013). National typology of residential buildings in Serbia. Faculty of Architecture, University of Belgrade
- Muminović, E., Radosavljević, U., & Beganović, D. (2020). Strategic planning and management model for the regeneration of historic urban landscapes: The case of historic center of Novi Pazar in Serbia. *Sustainability*, 12, 1323. <https://doi.org/10.3390/su12041323>
- Predari, G., Stefanini, L., Marinković, M., Stepinac, M., Brzev, S. (2023). Adri-seismic methodology for expeditious seismic assessment of unreinforced masonry buildings. *Buildings*, 13, 344. <https://doi.org/10.3390/buildings13020344>
- Radivojević, A., Roter-Blagojević, M., Đukanović, Lj. (2017). Sustainability and the material aspect of traditional residential buildings in Serbia. In *Materials for a Healthy, Ecological and Sustainable Built Environment: Principles for Evaluation* (pp. 1–10). <https://doi.org/10.1016/B978-0-08-100707-5.00010-1>
- Radivojević, Lj., Đukanović, M., Roter-Blagojević, M. (2016). From tradition to modernization – Building techniques in Serbia during 19th and early 20th century. In K. Van Balen & E. Verstrynghe (Eds.), *Structural analysis of historical constructions – Anamnesis, diagnosis, therapy, controls* (pp. 922-929). Taylor & Francis. ISBN 978-1-138-02951-4
- Radovanović, S., & Petronijević, M. (2009). Building types and vulnerability to ground shaking in Serbia. Paper presented at the International Conference on Earthquake Engineering, Banja Luka, Bosnia and Herzegovina, October 26–28. 2009 (pp. 181-192)
- Stanojević, A. D., Milošević, M. R., Milošević, D. M., Turnšek, B. A. J., Jevremović, L. Lj. (2021). Developing multi-criteria model for the protection of built heritage from the aspect of energy retrofitting. *Energy and Buildings*, 250, 111285. <https://doi.org/10.1016/j.enbuild.2021.111285>
- Šekularac, N., Šumarac, D., Čikić-Tovaročić, J., Čokić, M., Ivanović-Šekularac, J. (2018). Re-use of historic buildings and energy refurbishment analysis via building performance simulation (BPS): A case study. *Thermal Science*, 22(Suppl. 5), 89–89. <https://doi.org/10.2298/TSCI171124089S>