The Rehabilitation Process of an Emblematic Historic Building of Iasi County

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Abstract. In the last decades, the modern society exhibited an increasing interest towards the necessity of preserving the national identity also through its built cultural heritage. The numerous historic buildings from Iasi County, most of them being badly affected by the environmental conditions and the improper maintenance, drawn the attention of the competent authorities upon their major responsibility to undertake wide restoration works.

One of the emblematic architecture monument of Iasi is a central palace which is a valuable historic landmark for the local cultural heritage of the city. The sumptuous palace is placed in the historic core of Iasi, in the Union Square, and during its lifetime, it served different purposes, such as hotel, bank and political party office. Unfortunately, the communism period dramatically changed its destiny. The upstairs rooms of the three-storey palace have been transformed into social apartments. Nowadays, only the ground floor hosts an art gallery.

At the moment, the palace is severely damaged, being classified into the first seismic risk category. The town hall, the actual owner of the palace, has initiated an important rehabilitation and consolidation process of it, partly with European funds. The paper focuses on the main rehabilitation and consolidation proposed solutions. It also presents the conclusions drawn by the team of experts and describes the necessary intervention measures for the structural performance improvement.

Keywords: Historic landmark · Historic masonry buildings · Structural damage · Rehabilitation works · Structural safety

1 Introduction

1.1 The Importance of Historic Buildings' Conservation

The historic buildings are part of a country's history and represent the cultural and architectural heritage for the present generations, but mostly for the future ones. Thereby, within the actual context of sustainable development, there is a growing awareness of

A. Rotaru (Ed.): CRIT-RE-BUILT 2019, SSGG, pp. 553–567, 2021.
https://doi.org/10.1007/978-3-030-61118-7_45

modern society to preserve the universal cultural and natural heritage for the future generations [1].

In the post-war period, the significant impact on the built environment, the mass destructions and substantial structural damages of the historic monuments from the entire Europe, prompted the necessity of developing common international theories, methodologies and techniques regarding the protection, conservation and restoration of the built cultural heritage. The International Council on Monuments and Sites (ICOMOS) is the first professional association founded in 1965 in Warsaw as a result of the "Venice Charter for the Conservation and Restoration of Monuments and Sites" from 1964 [2], which offers advice to UNESCO on World Heritage Sites [3].

The main goal of restoring the historic buildings is to maintain and perpetuate the historical landmark of a city. There are both cultural and practical reasons for a community to promote and sustain the preservation, restoration and rehabilitation of its historic buildings. They have the great potential of offering valuable benefits for the touristic development of a country and especially, of a city. Any historic building has the particularity of providing the visitors with impressive and attractive memories through its singularity in terms of architectural design and craftsmanship.

The rehabilitation process of the existing buildings also presents the advantage of a positive environmental impact through the natural resources conservation and the natural land saving. The historic buildings are usually made of durable construction materials which are resistant to premature deterioration. So, the preserved natural materials can be also valuable assets to the cultural heritage of a city, since they could have been supplied from sources that no longer exist [4]. Another great benefit is provided by the elimination of waste disposal necessity and of air pollution which can be caused by the demolition of damaged buildings in the historic center of a city.

Historic buildings restoration involves major responsibilities and great specific care. Sometimes, their structural integrity can be impaired by the lack of maintenance and repairing works. The rehabilitation process demands to maintain as much of the initial structural system as possible, beside the original architecture. There are cases when the structural integrity is so much affected that a new system of structural elements has to be designed and its integration to strengthen the existing one without altering the building's architectural features is the real challenge. For the safety, security and operational reasons, the rehabilitation process requires a rigorous conformity to the national building codes and regulations. Preservation experts' assistance and a thorough documentation of the building's historical background are also needed [5].

1.2 The Conservation Principles of Historic Buildings

The Romanian historic buildings had an unprosperous fate mainly during the communism period. Some of them have been improperly used, others have been transformed to serve various inappropriate purposes, and other ones have been abandoned to be simply destroyed by the time passing. The seismic events of high intensities, the difficult foundation soils, the diminished materials' properties, the structures massiveness and the lack of specific norms and regulation for addressing the adequate maintenance and repairing methods, also contributed to the actual damage state of the historic buildings. But still, Romania boasts a quite impressive architectural heritage. Iasi is one of the cities

hosting the most iconic historic buildings from Romania and it was officially declared Historical capital of Romania, in December 2018. Among the beautiful landmark sites of Iasi, the Palace of Culture, the Metropolitan Cathedral, the National Theater, Golia Monastery, the Palace of the University, the Military School, and the Great Synagogue are only a few of them deserving to be outlined (Fig. 1).

Fig. 1. A collage of the most beautiful landmark sites of Iasi (Bogdan Muraru/creative commons.org) [6].

Most of the historic buildings are made of masonry. They usually have a basement, a reduced number of storeys and an attic floor. The load bearing walls and the foundations are massive stone works and sometimes the footings are made of natural stones.

In our country, the earthquake hazard is high and the structural rehabilitation under these circumstances represents a great challenge for the civil engineers due to the various structural configurations, materials and technologies, more or less common, which have been used along the years for the construction of the historic buildings [7]. The historic masonry buildings could not have been designed in accordance to the currently used building codes and nowadays they do not have an adequate seismic capacity [8]. Consequently, an appropriate conservation process is needed to preserve the cultural, aesthetic and affective value of a historic building, without impairing its architecture, its character-defining features and finishes [4].

The modern intervention works applied in case of historic buildings include:

– *rehabilitation*: the process of reconstruction or upgrading of a damaged building with the aim of restoring its initial operational and safety level;
– *consolidation*: the process of increasing the strength and/or stiffness of the structural members or system with the aim of improving the structural performances for any potential exceptional event (e.g. occurrence of a significant seismic event);
– *restoration*: the process of accurate reconstruction of character-defining shapes, features and finishes of a damaged building, as it was initially constructed, paying great care to the historical background and by eliminating any previous interventions [9].

The time evolution of structural behaviour in accordance with the intervention measures is illustrated in the next figure (Fig. 2). It shows that the lifetime of a historic building and the safety level are highly correlated with the maintenance works which have the important role of early damage prevention [7].

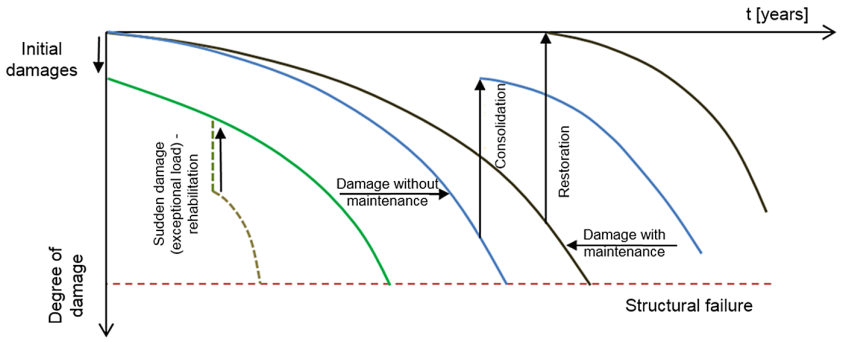

Fig. 2. The evolution of structural damage in accordance with the intervention measures [9].

1.3 Damage Assessment Methodologies of Historic Masonry Buildings

According to the current Romanian methodology which regulates the risk assessment and the intervention measures for historic buildings, MP 025-04-"Methodologies of risk evaluation and strengthening solutions for heritage buildings" [10], these intervention processes and works need to satisfy the following criteria:

– *efficiency*: the intervention works need to be efficient and this feature have to be demonstrated by qualitative and quantitative assessments;
– *compatibility*: the intervention works need to be compatible with the original structural system and the used materials must have chemical, mechanical and architectural characteristics identical to the initial ones;
– *durability*: the intervention works need to be performed using techniques and materials having an assessed durability similar to the other existing materials;
– *reversibility*: the intervention works have to be as much as possible reversible, so that an utilized solution to be easily removed when a future and maybe a better one will be adopted.

The implementation of all the previous mentioned aspects requires strong collaboration of experts with advanced knowledge in structural engineering, geotechnical engineering, architecture, history, archaeology and materials science [11]. The seismic safety assessment is even a more complex issue due to the fact that the historic monuments cannot comply with the damage assessment and the consolidation design rules of newly constructed buildings [12]. The intervention works may range from simple reparation works, when the cultural value of the existing building can be preserved, to individual or overall consolidation works, when the structural safety level is badly affected [13].

The structural performance assessment of a historic masonry building is based on: the identification of the construction details, the analysis of the historical background and an accurate survey of the actual damage state. Within this context, the needed information are: the structure's geometry; the masonry pattern and texture; the structural members' constructive details and cross sections; the physical, chemical and mechanical properties of the constituent materials; the masonry characterization as a composite material; the location of the structure under consideration and the characteristic seismic and climatic actions; the neighbouring buildings; the foundation soil properties [14].

2 Case Study

2.1 Historical Background

One of the emblematic architecture monument (class II – according to [15]) of Iasi is a central palace constructed between 1913 and 1914 by a Jewish family. The dome has been completed in 1915 and at its opening, an art exhibition took place inside it. The architect of the Art Nouveau style palace was Herman Clejan. This is a valuable historic landmark for the local cultural heritage of the city (class B – according to [15]), being listed by the Romanian Ministry of Culture and National Patrimony in the National Register of Historic Monuments [15]. The sumptuous palace is placed in the historic center of Iasi and during its lifetime it served different purposes, such as hotel, store, jewelry, bank and political party office. Unfortunately, during the communism period, the upstairs rooms of the three-story palace have been transformed into social apartments and have been progressively damaged due to the lack of maintenance and repairing works. Only the ground floor functioned as an art gallery for the Romanian Union of Plastic Artists – Iasi Branch, for many years, being somehow preserved [16].

Down the ages, the palace resisted three crucial events: the big flood from 1932, when numerous old buildings from Iasi have been partially or completely destroyed, the bombing of Iasi county during the World War II and the 2nd most powerful earthquake recorded in Romania in the 20th century, the 1977 Vrancea earthquake, when most of the buildings that survived the flood and the bombing events, finally collapsed [16].

The advanced damage state of the central palace determined the town hall, the actual owner of the palace, to evacuate the inhabitants and to start a wide rehabilitation, restoration and consolidation project of the building. The newly rehabilitated palace will mainly serve for cultural purposes and will host various art exhibitions [16] (Fig. 3).

Fig. 3. The central palace in 1930 [17] and 2009 (Argenna/commons.wikimedia.org) [18].

2.2 Building Geometry and Structural Configuration

The entire built-up area sums up 585.70 m^2 and the building has 3 stories, a ground floor and a basement, with different heights and compartmentalization. The maximum height of the building is of 16.51 m at the eave level, 21.77 m at the ridge level and 27.71 m at the dome level (see Fig. 4).

The foundation is made of natural stone bound with a lime-sand mortar and the superstructure is consists of structural masonry walls, made of different units of burnt clay bricks, solid and cored bricks, bound with a lime-cement mortar, and reinforced concrete (RC) slabs. The RC slabs transfer the loads directly to the masonry walls or indirectly by means of a system of RC beams. The strip footings beneath the walls have the thickness ranging from 0.75 m to 1.95 m, and the foundation depth is of 1.60 m from the basement slab level. The superstructure walls' thickness varies from 0.90 m to 1.80 m. The reduced thickness of the slabs, of 8 cm to 10 cm, cannot provide a satisfactory contribution to the lateral resistance of the structure [16].

The basement of 2.85 m height includes a technical room, a winery, a kitchen and bathrooms. The ground floor has a height of 5.56 m and large open spaces with big windows, and it lately hosted a bookstore and an art gallery. The upper floors have different heights, 4.3 m, 3.85 m, and 3.6 m respectively, with load bearing masonry walls and reinforced concrete slabs. The wooden roof structure and the dome were severely damaged and even reconstructed along the palace lifetime, mainly after the 1940 and 1977 Romanian earthquakes, and lately due to the partially destroyed metal roof covering [16].

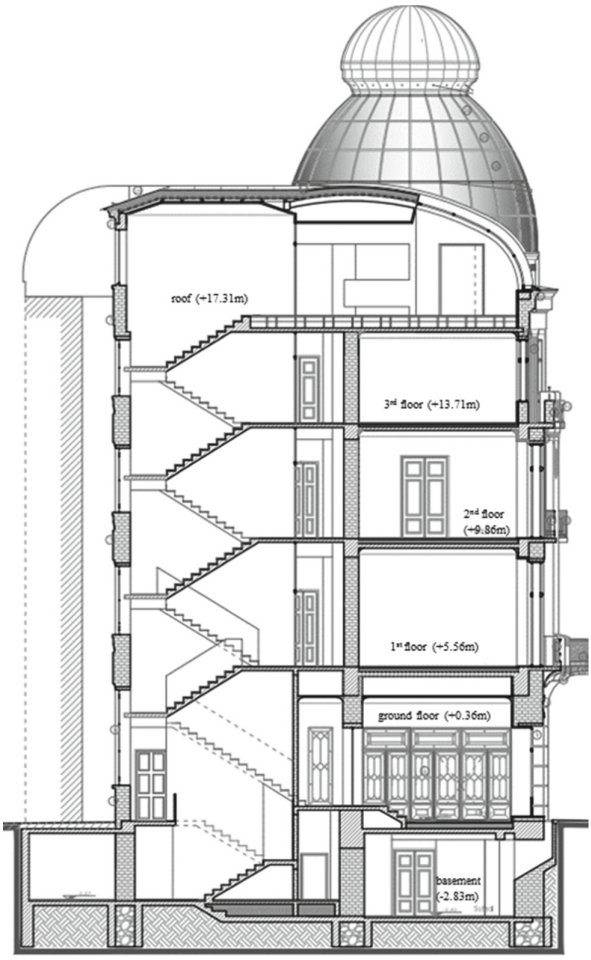

Fig. 4. Building transverse cross-section [16]

2.3 Building Damage Assessment

According to the Romanian design provisions for earthquake resistant structures [12], the building is placed in an area with moderate seismicity, with the design peak ground acceleration (PGA) of 0.25 g (2.452 m/s^2) and the corner period (T_C) of 0.7 s. It is ranked in the second importance class, being a cultural heritage building, and in the first class of seismic risk [16, 19], meaning that it is supposed to probably collapse or to be significantly damaged in case of a future earthquake larger than or similar to the 1977 Vrancea earthquake, and urgent structural interventions are essential [20].

The past intervention measures applied to the palace, especially after the two strong Romanian earthquakes from 1940 and 1977, and after the bombing during World War II, could not be performed in accordance with any standardized methodology of heritage buildings' restoration and strengthening [2, 10]. These interventions haven't been at

least preceded by an adequate damage evaluation process and haven't been executed conforming to a rehabilitation project. Unfortunately, these measures contributed to a progression of the damage state. They included: the exterior connection of the dome to the palace façade by means of some steel strips; the cracks repairing with inadequate filling mortar; local replacements of the masonry units with new types of bricks and mortar; plaster, coating and architectural finishes improper replacement; local concrete underpinning of the footings; improper repairing of the wooden roof structure and of the steel covering [16]. The next figure illustrates the palace after the World War II (Fig. 5).

Fig. 5. The central palace after the World War II [16]

A recent expert survey of the damages [16] revealed some important issues that will be hereinafter mentioned.

The foundation soil is a high compressible silty clay which actually has an increased moisture content. The level of the underground water is very close to the footings. The foundation soil suffered along the years differential settlements. The super-structure cracks have been initiated from the foundation structure (see Fig. 6).

The open ground floor with some vertical RC elements and the various compartmentalization of the interior masonry walls form the upper stories do not provide the vertical regularity and that increases the seismic vulnerability of the palace [21]. The RC slabs of reduced thickness cannot behave as diaphragms to properly withstand horizontal earthquake forces. The masonry walls are not homogeneous structures since different types of masonry units have been used or replaced along the years: solid bricks and cored bricks (see Fig. 7). The utilized lime-cement mortar has reduced mechanical properties and the overall strength and stiffness of the masonry walls has been also impaired by the construction of some chimneys inside their structure.

The plaster exfoliation caused by the environmental conditions determined the corrosion of the reinforcement, as Fig. 8 illustrates, and the severe damage of the masonry elements and of the exterior architectural finishes, as shown in Fig. 9.

Fig. 6. Cracks developed in the concrete cover and in the elements of the super-structure [16]

Fig. 7. Plaster exfoliation revealing the non-homogeneity of the masonry walls [16]

Fig. 8. Plaster efflorescence and exfoliation followed by steel reinforcement corrosion

The integrity of the wooden roof structure and of the dome are badly affected by the water leaks and by the lack of maintenance works, which are so necessary in case of wood structural elements and of metal coverings (see Fig. 11).

Fig. 9. The severe damage of the masonry elements and of the architectural finishes [16]

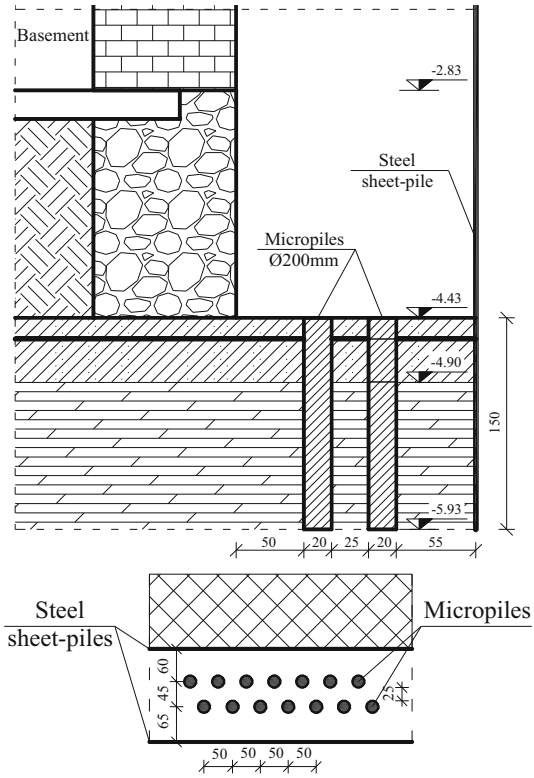

Fig. 10. a) The proposed soil stabilization solution; b) micropiles arrangement [16]

2.4 Structural Rehabilitation Solutions

The underlying soil stabilization aiming to improve its strength and to increase the resistance to softening by water, can be achieved by jet grouting process. It consists of creating some micropiles under the existing foundation level, which have to be embedded in the good foundation soil (Fig. 10a). They need to be executed on the exterior contour

Fig. 11. a) The dome metal covering badly affected by the environmental conditions [16]; b) current rehabilitation stage

of the building, on two rows at a specified distance, so that to form in plane equilateral triangles (Fig. 10b). This process has to be very carefully executed so that to avoid any additional settlement or any local failure of the existing footings. The previous strengthening of the stone footings by cement injection is highly recommended [22].

The infrastructure consolidation is needed to increase the strength, stability and stiffness of the affected footings due to the differential settlements. This can be performed by using a framing system which consists of encasing the existing natural stone footings in a new reinforced concrete system with inferior and superior lateral ring beams vertically connected like the Vierendeel trusses and transversally connected together, as showed in Fig. 12 [23, 24]. The compound effect between the new RC system and the old foundations can be ensured by using some steel rods and grout or a special adhesive. The use of this kind of framing system has the advantage of enhancing the moisture transfer from the masonry walls. The construction of some additional transverse reinforced concrete beams is indicated for an improved load transfer at the foundation level and to ensure a better behaviour to any possible differential settlement.

The water proofing of the foundation and of the basement walls is also required because of the high level of the underground water and of the increased moisture content of the foundation soil [16].

In case of super-structure masonry walls, serious decay of the mortar joints and of the bricks have been observed on the façade of the palace. The repointing of the eroded joints, the mortar or grout injection of the occurred cracks and local repairs or even partial replacement of the masonry units which are deteriorated beyond repair are necessary. It is of utmost importance to previously determine the physical, chemical and mechanical properties of the existing materials and to use new ones with similar size, colour, texture and durability, as much as possible. The cleaning process has to be carefully done and only in justified circumstances so that not to induce more harm to the masonry [25].

Due to the overall weakening of the structural system of the building, partial concreting or the construction of some new reinforced concrete elements may be needed, such as: tie-columns, ring beams, lintels, corner area bindings, vertical reinforced concrete strips. The spatial rigidity improvement can be achieved by using a cross-tying system

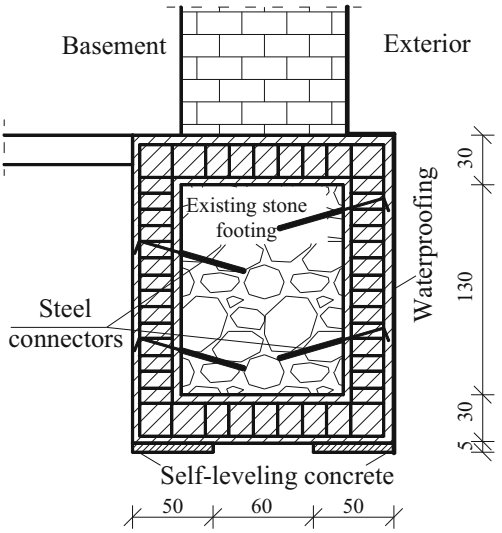

Fig. 12. Strengthening solution of the stone footings [16]

and by inserting some vertical RC elements (lamellar cross-section of 15–20 cm thickness) inside the structure of the load bearing masonry walls on the inner face, as shown in Fig. 13. At the same time, the chimneys embedded in the walls need to be removed and their structure to be reconstructed in order to improve their load bearing capacity. The use of a ring beam at the roof level is also needed to further enhance the structural stability. All these intervention measures have to be meticulously done so that not to impair much more the initial architectural features of the palace.

In order to gain a better behaviour to lateral loads, a reinforced topping concrete, with thickness in the range of 5–10 cm, can be placed on the RC slabs. Before pouring the topping concrete it is very important to obtain a perfect clean and smooth surface. This can require a previous grout injection of the existing cracks or the repairing of the concrete segregations, if they will be discovered.

The interior and exterior decorative plasterworks and architectural finishes require a thorough restoration and reconstruction process, paying careful attention to the selection of the used materials and techniques in order to preserve the original Art-Nouveau style of the palace.

Unfortunately, the severely damaged structure of the roof and of the dome cannot be saved. The entire wooden structure is intended to be replaced by a steel structure and the dome to be covered with a glass cladding system. The destination of the obtained space inside the dome is that of an art gallery, as the initial owner desired.

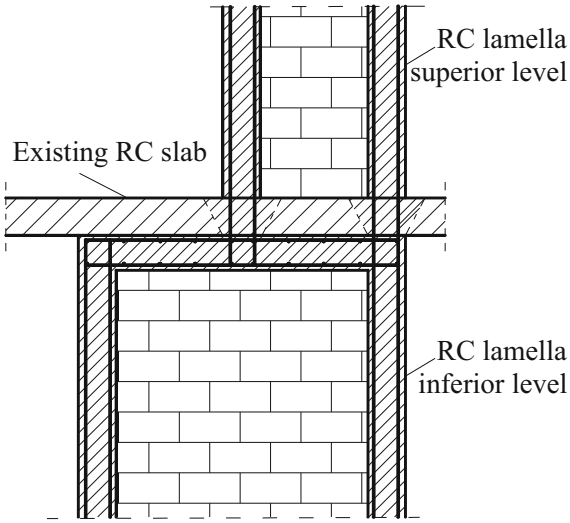

Fig. 13. Strengthening solution of the masonry walls with additional RC elements [16]

3 Conclusions

The intervention measures needed to restore the historic buildings or the architecture monuments are very complex and have to be carefully selected and performed. They can range from simple repairs or restoration processes to the consolidation or the rehabilitation of the affected structural members or of the entire structural system when the safety level of the considered building is significantly decreased due to the suffered damages.

The central palace from Iasi, located in the historic centre of the city, was exposed along the years to major events, such as floods, earthquakes, the city bombing during World War II, but also to various environmental conditions, and the lack of maintenance works or the wrongly applied intervention measures progressively contributed to its actual advanced damage state.

Wide consolidation and restoration works are now undertaken aiming to strengthen the entire structural system of the palace and to improve its stability in the event of a strong seismic action, but not only. Also the foundation soil necessitates stabilization for the improvement of its strength and to increase its resistance to softening by water, taking into consideration that the ground water level is very close to the footings. All these interventions are performed in accordance with the currently standardized norms and methodologies related to the conservation, restoration and strengthening of heritage buildings.

The aim of the local authorities is to restore the historic status of this beautiful architecture monument to become again a valuable landmark for the local cultural heritage of Iasi city. A media library, some art exhibition galleries and some cultural centres of the city will be hosted by the newly rehabilitated palace.

References

1. Avrami, E.: Making historic preservation sustainable. J. Am. Plan. Assoc. **82**(2), 104–112 (2016). https://doi.org/10.1080/01944363.2015.1126196
2. Venice-Charter: The Venice Charter for the Conservation and Restoration of Monuments and Sites. The second international congress of architects and specialists of historic buildings, Venice, Italy (1964)
3. ICOMOS Hrsg.: The international council on monuments and sites. Heritage at Risk. World Report 2014–2015 on Monuments and Sites in Danger, pp. 8–10 (2016)
4. LNCS Homepage. https://www.cammconstruction.com/blog/benefits-historic-building-restoration/. Accessed 12 Oct 2019
5. Subramaniam, S.R.: A review on repair and rehabilitation of heritage buildings. Int. Res. J. Eng. Technol. (IRJET) **3**(4), 1330–1336 (2016)
6. LNCS Homepage. https://commons.wikimedia.org/wiki/File:Ia%C5%9Fi_Colaj.jpg, Bogdan Muraru [CC BY-SA 4.0]. https://creativecommons.org/licenses/by-sa/4.0. Accessed 22 Oct 2019
7. Pleşu, R.: Contributions Regarding the Rehabilitation Methods of Mansonry Structures. Ph.D. Thesis, Iasi, Romania (2013). (in Romanian)
8. Vicente, R., et al.: Seismic vulnerability and risk assessment of historic masonry buildings. In: Costa, A., Guedes, J., Varum, H. (eds.) Structural Rehabilitation of Old Buildings. Building Pathology and Rehabilitation, vol. 2, pp. 307–348. Springer, Heidelberg (2014). https://doi.org/10.1007/978-3-642-39686-1_11
9. Soveja, L.: Structural Restoration of Orthodox Cultural Buildings. "Matei-Teiu Botez" Academic Society Publishing House, Iasi, Romania (2016) (in Romanian)
10. MP 025-04: Methodologies of Risk Evaluation and Strengthening Solutions for Heritage Buildings. Directive of the Ministry of Transportation, Construction and Tourism, No. 743, Bucharest, Romania (2004). (in Romanian)
11. De Felice, G., De Santis, S., Lourenco, P., Mendes, N.: Methods and challenges for the seismic assessment of historic masonry structures. Int. J. Archit. Herit. **11**(1), 143–160 (2017). https://doi.org/10.1080/15583058.2016.1238976
12. P100-1/2013: Code of Seismic Design. Part I – Rules for Seismic Design of Buildings. Directive of the Ministry of Regional Development and Constructions, No. 489. Bucharest, Romania (2013). (in Romanian)
13. Lupăşteanu, V., Soveja, L., Lupăşteanu, R., Chingălată, C.: Installation of a base isolation system made of friction pendulum sliding isolators in a historic masonry orthodox church. Eng. Struct. **188**, 369–381 (2019)
14. Barbu (Mogosanu), A.M., Calbureanu, M.X.: Contributions above the rehabilitation of heritage buildings in advanced degradation - precollapse due to the action of environmental factors and strong earthquakes occurred during their lifetime. In: International Multidisciplinary Scientific GeoConference: SGEM, Sofia, vol. 18, no. 1.1 (2018). https://doi.org/10.5593/sgem2018/1.1/s05.093
15. LNCS Homepage. http://www.cultura.ro/sites/default/files/inline-files/LMI-IS.pdf. Accessed 22 Oct 2019
16. Cusutura, S.: Structural Rehabilitation of Braunstain Palace. Dissertation Thesis, Iasi, Romania (2015). (in Romanian)
17. LNCS Homepage. https://www.facebook.com/plugins/post.php?href=https%3A%2F%2Fwww.facebook.com%2F229031573813414%2Fphotos%2Fa.248593048523933%2F1786371734746049%2F%3Ftype%3D3&width=500. Accessed 26 Oct 2019
18. LNCS Homepage. https://en.wikipedia.org/wiki/File%3ARO_IS_Iasi_%2C_Braunstein_Palace.jpg, Argenna [CC BY 3.0] https://commons.wikimedia.org/w/index.php?curid=8755848. Accessed 29 Oct 2019

19. P100-3/2019: Code of Seismic Design. Part III – Provisions for Seismic Assessment of Existing Buildings. Directive of the Ministry of Regional Development and Public Administration No. 2834. Bucharest, Romania (2019). (in Romanian)
20. Lungu, D., Arion, C.: Seismic risk and/or real estate risk for the bucharest heritage buildings. In: 15th World Conference of Earthquake Engineering Proceedings, Lisbon, Portugalia, 10 p. (2012)
21. Bhosale, A., Davis, R., Sarkar, P.: Vertical irregularity of buildings: regularity index versus seismic risk. ASCE-ASME J. Risk Uncertain. Eng. Syst. Part A Civ. Eng. **3**, 04017001 (2017)
22. Przewłócki, J., Zielinska, M.: Analysis of the behavior of foundations of historical buildings. Procedia Eng. **161**, 362–367 (2016)
23. Vicente, R., Lagomarsino, S., Ferreira, T.M., Cattari, S., Mendes da Silva, J.A.R.: Cultural heritage monuments and historical buildings: conservation works and structural retrofitting. In: Costa, A., Arêde, A., Varum, H. (eds.) Strengthening and Retrofitting of Existing Structures. BPR, vol. 9, pp. 25–57. Springer, Singapore (2018). https://doi.org/10.1007/978-981-10-5858-5_2
24. Lupăşteanu, R., Soveja, L., Lupăşteanu, V.: Structural rehabilitation of old masonry churches. a cost-oriented case study. Bull. Polytech. Inst. Jassy. Constr. Architect. Sect. **LXI/LXV**(2), 27–42 (2015)
25. Covatariu, D., Lungu, I., Ţăranu, N., Budescu, M., Toma, I.O.: The influence of joints rehabilitation on structural response of masonry with low-strength mortars. Roman. J. Mater. **43**(3), 251–262 (2013)