The Bezdin church, technologies used in restoration

Olariu Gigi Dumitru[1]
Affiliation Faculty of Architecture and Urbanism, Polytechnic University of Timișoara, Romania[1]
proiectare@casa-sibiana.eu[1]

ABSTRACT
The creative spirit of mankind emerged at the dawn of its birth and has evolved over time. The effect of this synergy is a high degree of cultural-artistic representation specific to each civilization. Therefore, this collective inheritance can be seen as a living and dynamic part of human settlements, contributing to their local identity and cultural wealth, being concurrently a factor of historical and spatial continuity in the narrative of time.
The concept of heritage and the operation of enhancing its qualities are closely related from a chronological point of view. Shortly after defining the first one, the action of its validity came as an economic opportunity, setting in motion a general awareness towards the preservation of historical, aesthetic values of cultural relevance.
However, this heritage has experienced constant deformation throughout history due to deteriorations and disasters caused by natural and anthropic factors. In this sense, it is often under threat from environmental conditions, physical instability, under-funding, or increased tourism and development.
Such a condition asks for systematic management of response to the constant changes, creating a need for the acquisition of geospatial information based on numeric data. Due to the complexity of the nature surrounding a historical monument, a more precise perspective on the process of preservation can only be acquired through an increased level of exact detailed information.
Therefore, the use of three-dimensional (3D) scanning technology comes as a response to this problem, being a modern and reliable method in the digitalization of information. Nowadays, surveying methods like 3D laser scanning compiles accurate, complex and realistic 3D models, as well as their settings that depict their historical periods. This method creates a 3D model from recorded data, that is a mathematical representation similar to the physical reference with a millimetric precision. This is why the use of three-dimensional coordinate data for a variety of analysis has recently assisted in the conservation and management of cultural heritage sites and monuments. Three-dimensional scanning is a representative documentation technology, allowing specialists to monitor the behavior of the object in question over time.
The objective of this essay is to reveal the benefits of 3D laser scanning in relation to the preservation of heritage, with the specific application of its use on the church in the Bezdin monastery. This monument is a testimony of the local Serbian community in the west of Transylvania, serving as an eloquent example of architecture specific to this region.

Keywords: heritage, monument, restoration, technology, 3D scanning.

I. INTRODUCTION

I.1. Definition and Importance of Heritage

The concept of "monument" does not refer only to individual architectural objects, but also groups of buildings and sites. In this regard, the Venice Charter (1964), referring to the preservation and restoration of historical monuments, gave a broader meaning to the notion of monument by introducing new terms, in its "Definitions" chapter as well as in the "Convention concerning the Protection of the World Cultural and Natural Heritage". An exact meaning of cultural heritage can be found along with its importance in relation to societies:

"Article 1. The concept of a historic monument embraces not only the single architectural work but also the urban or rural setting in which is found the evidence of a particular civilization, a significant development or a historic event. This applies not only to great works of art but also to more modest works of the past which have acquired cultural significance with the passing of time."[1].

Cultural Heritage can be defined as monuments, buildings, or landscapes of "outstanding universal value from the point of view of history, art or science." [2].

I.2. The Bezdin Monastery – Geographical and Historical Context

The monastery consists of the following monuments: "The Assumption of the Virgin Mary" church (LMI code AR-II-m-A-00632.01) and the hermitage enclosure for the monks (LMI code AR-II-m-A-00632.02) [3].

This site is located in the west of Romania, in the county of Arad, on the southern bank of river Mureș, near the town of Pecica. Bezdin monastery is 36km west of Arad, 67km from Timisoara and 150km from Oradea.

The landscape in which the Bezdin monastery was built is now part of the protected area of the "Lunca Mureșului" Natural Park, which stretches over an area of 17,455 hectares along the Mureș River at the border with Hungary. It is classified as a natural park of national importance [4].

From a historical perspective, the Bezdin monastery was initially built as a fortress, and it was first recorded in the year 1233 [5] (Fig. 1). The most intense periods of development occurred during the eighteenth century, featuring the building of the "pronaos" and bell tower, along with the eastern extension of the monastery. It also included carpentry works, and in the nineteenth century the replacement of the roof and tower coverings. The corridors of the hermitage from the south were paved with marble slabs, and in the last half of the twentieth century there was a series of restoration works [6].

Fig. 1. First painting of Bezdin monastery

II. MONASTIC FUNCTIONAL ORGANIZATION

In its current state, the monastery can be illustrated by a three-sided building. The church is slightly shifted towards the south-west of the center of the courtyard (Fig. 2). By the end of the eighteenth century, the southern wing which was built on two levels had a symmetrical composition, consisting of a central entrance supported by two lateral risers. The interior areas are larger than those usually found in hermitages. The eastern side of the main wing was the abbot's living area, built with large interconnecting rooms. The northern wing of the monastery was also part of the living area and is built on a single level. There were cloisters opening towards the courtyard. There were also different types of barns and workshops, a smoking-house with a pyramid-shaped ceiling, and other zones that were needed to satisfy the monastery's needs.

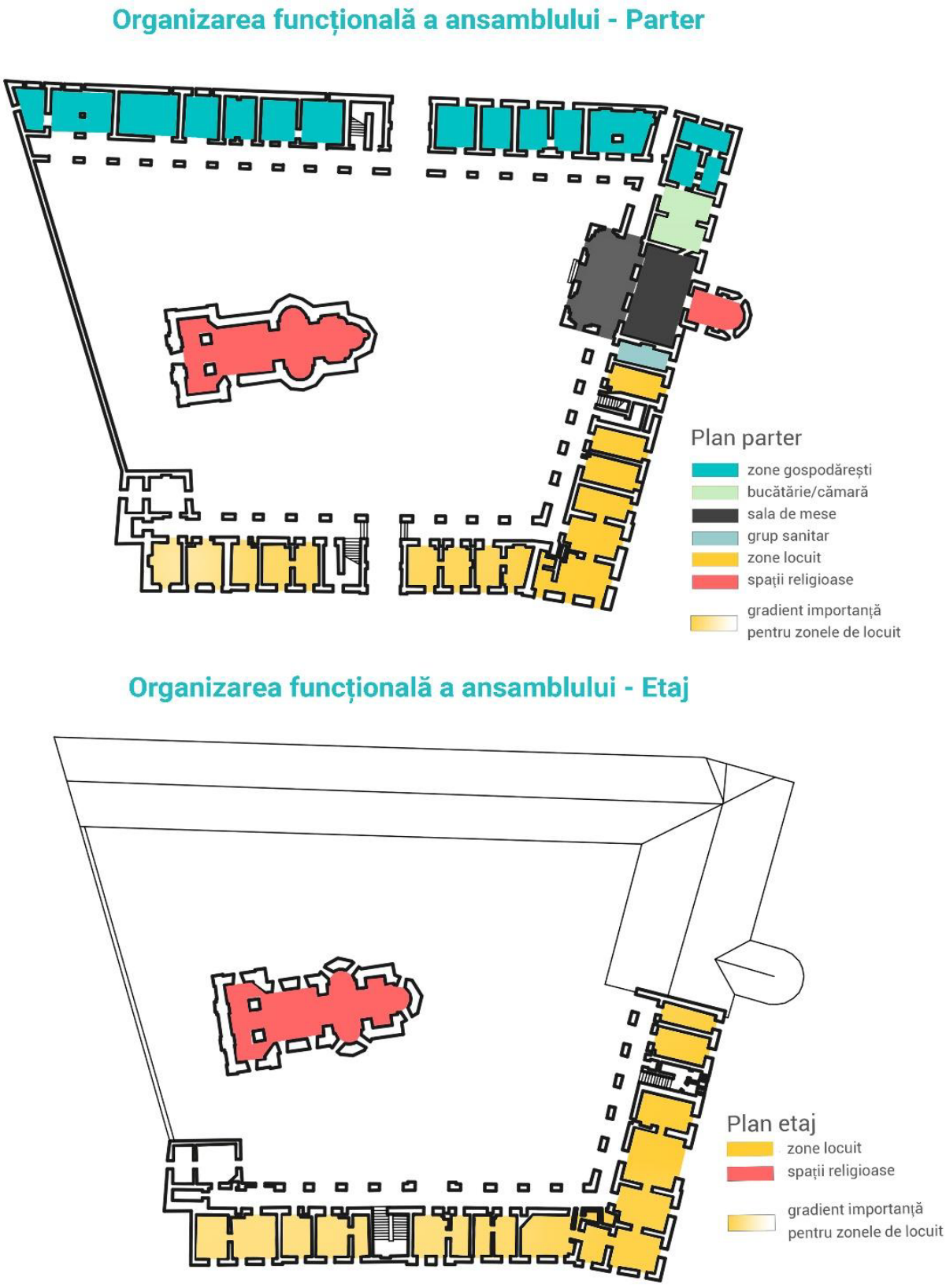

Fig. 2. Functional organization of the monastery

III. RESEARCH METHODOLOGY

The research began by understanding the historical and cultural importance of the church building, complementary to its role in relation to the whole monastery. The next phase was the analysis of the construction materials and techniques used, followed by the documentation of the developments and extensions throughout time.

This implied a visual investigation, through a survey of the undertaken construction, its degradation and its surrounding topography. A 3D scanning (laser scanning) was made, along with archive and publication research and several discussions with the custodian and beneficiaries. An exhaustive, visual and mechanical analysis of the surfaces of the entire monument was made, resulting in the identification of all the pieces that should undergo restoration. An essential element in this process has definitely been the 3D scanning technology, which allowed for the digital archiving of the monument, without making an impact on the object's physical integrity. This method plays a key role in the process of further maintenance and monitoring.

IV. USE OF 3D SCANNING TECHNOLOGY

Nowadays, several methods are being used for the surveying, documentation and quantification of cultural and architectural heritage sites. The documentation in the surveying studies of either a particular structure or a site, using digital imaging or three-dimensional laser scanning devices is an emerging technique in this field. The data acquired from these scanning devices results in a very complex vector image which consists of millions of points, forming a point cloud. In this image, all the curves and surfaces transform into visible lines making them possible to be observed. The beam sent from the laser scanning device reflects on objects or surfaces and returns as millions of data points to the computer where it can be seen as an object formed by the point cloud [7]. As each point in the image has its own coordinate value, the lines formed by these points can be manipulated to produce digital illustrations. This representation can register the actual size of the analyzed object, which is processed in a short period of time. This point cloud system has 3D-referenced coordinates (x, y, z values), allowing the direct visualization in different types of software. Virtual copies of the studied object can be rapidly produced with a high accuracy rate and millimetric precision [8]. The scale of the detail to be drawn is directly related to the density ratio of the laser beams being reflected on the structure [7].

This facilitates the scanning of particular details of historical buildings, such as column caps on the facade, relief, decorations, and carvings.

V. IMPACT OF 3D SCANNING TECHNOLOGY

V.1. Usage of Data

The result of using the 3D laser scanning technology is a digital copy of the Bezdin church (Fig. 3, 4). This process revealed a variety of benefits, the most important being the significant time and cost savings when compared to traditional survey methods. The gathered data can be recorded for further processing in the office, with varying degrees of detail for future planning in digital programs. It can be applied both in recording and monitoring damage, creating a timeline of the building's evolution.

Fig. 3. 3D laser scanning of Bezdin church – façades

The 3D scanning of Bezdin church was made on cross-sections, as well as at the façade level, revealing the current state of the building: from the structural system to the iconostasis. This allowed for precise identification of the degradation process, contributing to finding solutions in a shorter period of time.

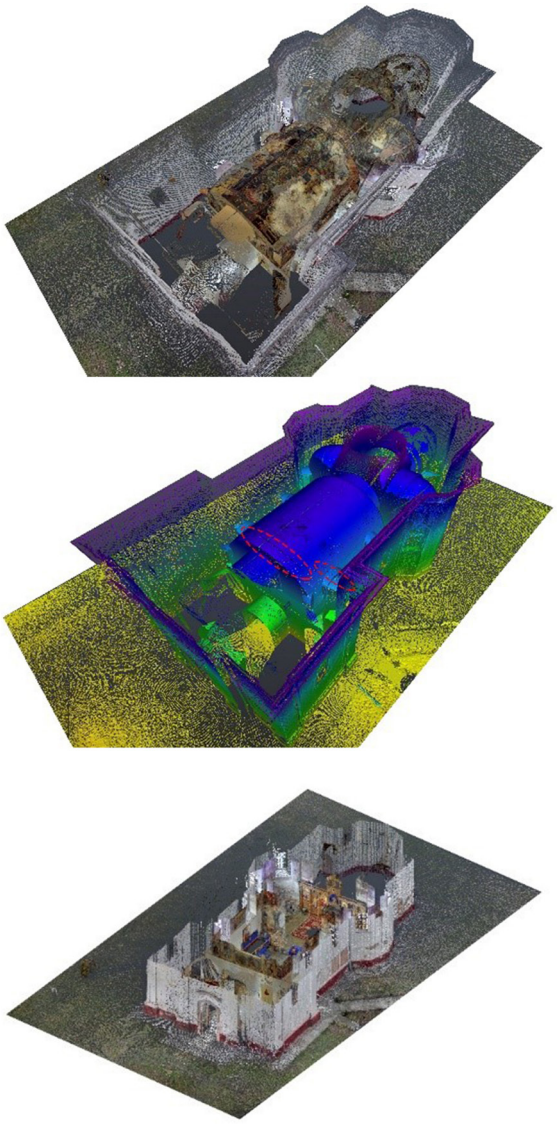

Fig. 4. 3D laser scanning of Bezdin church – cross-section

V.2. Structural Consolidation Solutions

From a structural point of view, both the porch and the "naos" tower will be consolidated. The porch tower has a major dislocation on the side facing the central nave. This problem will be solved through a system of flexible suspension cables, trapped in dynamometric pre-tensioning rollers anchored at the top of the central nave. On the west side of the tower, the suspension cables will be (chemically) grounded in the masonry. This will be performed through drillings made in the masonry and cemented on an inclined plane, leaving a ring for the grounding of the elastic suspension cables. Similarly, the cylindrical vault of the central nave will be consolidated with the same system of flexible suspension cables, trapped in dynamometric pre-tensioning rollers (Fig. 5). In order to restore the initial volume of the roof covering, the image of the two towers will be adapted according to existing photo documentation.

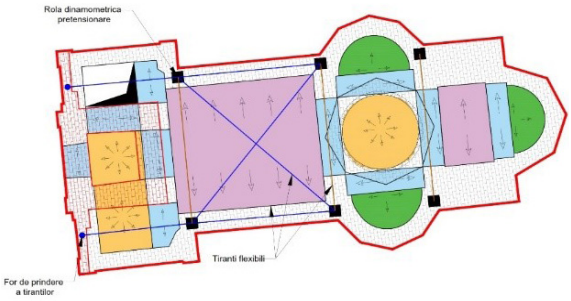

Fig. 5. System of flexible suspension cables

VI. POTENTIAL OF 3D SCANNING TECHNOLOGY

This method greatly improves the quality of the planning and execution stages, while also giving the possibility to monitor the project by performing successive scanning, as it can be found in similar case studies [9,10].

The digital image of the monument contributes to the conservation and protection of national heritage, having the potential of stimulating tourism in the area with exciting presentations, such as virtual reality or holograms.

Ultimately, a virtual 3D museum can be obtained by the centralization of such digital technology.

VII. CONCLUSIONS

The article describes the application of 3D laser scanning in the survey of the Bezdin church, a church recognized as national heritage. The building and the survey method are presented and analyzed, highlighting the benefits of this technology. The results of the research are important in raising awareness of the potential of

this emerging technology. Therefore, 3D laser scanning helps specialists restore and monitor historical monuments with very good accuracy and in a shorter time compared to previous methods of survey.

REFERENCES

[1] International Charter for the Conservation and Restoration of Monuments and Sites, "The Venice Charter," 2nd International Congress of Architects and Technicians of Historic Monuments, Venice, 1964.
[2] United Nations Educational Scientific And Cultural Organisation, "Convention Concerning the Protection of the World Cultural and Natural Heritage," In The General Conference of the United Nations Educational, Scientific and Cultural Organization meeting, Paris, France, 1972.
[3] Ministerul Culturii, "Heritage buildings 2015 (in Romanian)," 2015. [Online]. Available: https://patrimoniu.ro/images/lmi-2015/LMI-AR.pdf [Accessed: May. 04, 2020].
[4] "Parcul Natural Lunca Mureşului – Ghidul touristic," Ed. Excelsior, 2013.
[5] Primăria Secusigiu, "Monografia comunei Secusigiu,", 2017. [Online]. Available: http://www.primariasecusigiuar.ro/wp-content/uploads/2017/02/Monografia-comunei-Secusigiu.pdf [Accessed: May. 04, 2020].
[6] O. Velescu and A. Corvătesacu, "Un monument din vestul țării – Mănăstirea Bezdin", Revista Monumentelor Istorice, Institutul Național al Patrimoniului, 1972. [Online]. Available: http://www.revistamonumenteloristorice.ro/?articol=57052-un-monument-din-vestul-tarii-manastirea-bezdin [Accessed: May. 04, 2020].
[7] B. Gulhan and G. O. Derya, "Use of laser scanning for cultural heritage documentation," International Journal Of Electronics Mechanical And Mechatronics Engineering, vol. 3, no. 1, pp. 447-454, 2013.
[8] H. J. Young and S. H. Hong, "Three-Dimensional Digital Documentation of Cultural Heritage Site Based on the Convergence of Terrestrial Laser Scanning and Unmanned Aerial Vehicle Photogrammetry", International Journal of Geo-Information, vol. 8, no. 2, pp. 53-67, 2019.
[9] A. Oliveira, J. F. Oliveira, J. M. Pereira, B. R. de Araújo, and J. Boavida, "3D modelling of laser scanned and photogrammetric data for digital documentation: the Mosteiro da Batalha case study," Journal of Real-Time Image Processing, vol 9, no. 4, pp. 673–688, 2012.
[10] A. Gil, "From the city scale to the building scale: Virtual reconstruction of monastic Lisbon," In Proc. EAUH 2016: Reinterpreting Cities, 2016