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ASSESSMENT OF PROTECTIVE STRUCTURES FOR ARCHITECTURAL HERITAGE: CASE STUDY OF POMPEII, LEPENSKI VIR AND GOBEKLI TEPE

Nastasija Kocić[1]
Sonja Krasić[2]
Jovana Tomić[3]
Isidora Mitrović[4]

Abstract

The protection of archaeological sites is crucial for preserving their authenticity and historical significance. This study evaluates the effectiveness of protective structures implemented at three different sites: Villa dei Misteri in Pompeii, Lepenski Vir in Serbia, and GT1 Göbekli Tepe in Turkey. Our focus extends to iconic landmarks where different types of protective structures and different types of protection were used. Each structure is assessed based on criteria such as preservation of authenticity, physical protection, accessibility and presentation, sustainability, and aesthetic impact.

The protective structures at all three sites demonstrate varying degrees of success in the selected criteria. Each structure has its advantages and disadvantages, highlighting the importance of careful design and maintenance to ensure the long-term sustainability of archaeological sites.

This study seeks to improve our understanding of the key role played by geometric design, material selection and technological application in the preservation and presentation of cultural heritage on a global scale. By providing insight into successful strategies and potential challenges, the primary goal of this research is to extract valuable knowledge from global practice, for later use on concrete examples.

Key words: *Protective Structures, Cultural Heritage, Preservation of Authenticity, Lepenski Vir, Pompeii,* Göbekli Tepe

[1] Master in Architecture, PhD student, Faculty of Civil Engineering and Architecture, University of Niš, nastasija.kocic@gmail.com; ORCID 0000-0003-4234-5616
[2] PhD, Full Professor, Faculty of Civil Engineering and Architecture, University of Niš, krasic.sonja@gmail.com; ORCID 0000-0002-3003-1022
[3] Master in Architecture, Teaching Assistant, Faculty of Civil Engineering and Architecture, University of Niš, jovanastomic@hotmail.com; ORCID 0000-0003-2594-4764
[4] Master in Architecture, PhD student, Faculty of Civil Engineering and Architecture, University of Niš, isidoramitrovic00@gmail.com; ORCID N/A

1. INTRODUCTION

Preserving architectural heritage is a key challenge in the contemporary context, where we face dynamic cultural, ecological, and technical changes [1]. There are three main approaches to protecting the remains of historic buildings. The first refers to remains that have been buried underground for centuries and involves re-covering them with earth. Another way is to undertake conservation efforts in the form of conservation and reconstruction. The third approach is the installation of a protective structure over the site [2].

Although covering is not a mandatory requirement for the protection of architectural heritage, if a decision is made to envisage a protective structure, there are numerous challenges and requirements that need to be met [3]. Protective structures can be completely closed or partially closed in the form of canopies [4].

This paper provides an analysis of various examples of protection used in the preservation of cultural heritage, focusing on three specific cases: Pompeii in Italy, Lepenski Vir in Serbia, and Göbekli Tepe in Turkey. Through a study of these cases, we explore the impact of modern approaches to designing protective structures on the preservation, presentation, and authenticity of architectural masterpieces. Emphasis is placed first on different types of protection, and then on different types of protective structures.

This research aims to enhance our understanding of the key role of geometric design, material selection, and technological applications in the preservation and presentation of cultural heritage worldwide. Through case study analysis, we uncover the complexities, challenges, and achievements arising from various types of protective interventions.

The selected examples, Lepenski Vir, Pompeii, and Göbekli Tepe, share some similarities but also differ in key aspects. All these sites have significant historical value and require protection from atmospheric conditions, human activities, and other potentially harmful factors to preserve the authenticity and integrity of archaeological remains [5]. The public nature of each selected site provides visitors with an opportunity to experience cultural heritage and gain education.

Pompeii, as a Roman-era site with diverse locations [6], Lepenski Vir, a prehistoric settlement with stone sculptures [7], and Göbekli Tepe, an early Neolithic settlement [8], represent different periods and civilizations. Artifacts and cultural influences associated with these sites reflect the diversity of cultural heritage.

While all these sites share a common purpose of preserving cultural heritage, their specificities require tailored approaches to protection and presentation. Each locality is a case in itself, determined by its geographical location and local influences. Therefore, an important contribution to the topic of protection is made by the analysis and assessment of different examples around the world [4]. Through a comprehensive analysis, this research aims to provide a basis for practical and sustainable solutions for the protection of architectural heritage around the world.

2. CRITERIA FOR THE ASSESSMENT OF PROTECTIVE STRUCTURES

Analysis of protective interventions in the context of cultural heritage preservation involves establishing clear criteria for evaluating their success [9]. When assessing the effectiveness of protective structures, several key criteria need consideration [4]. With the aim of providing a holistic overview of their functionality and contribution to the preservation of architectural masterpieces, this study will evaluate selected examples based on the following criteria: preservation of authenticity, physical protection, accessibility and presentation, sustainability, and aesthetic impact.

The fundamental criterion for evaluating the success of protective structures is their ability to preserve the authenticity of cultural monuments. Questions arising from this criterion include the extent to which a structure retains original architectural features and how observers perceive the authenticity of the site through the protective structure [10].

The efficiency of a structure in providing physical protection against weather conditions and potential hazards is of paramount importance. It is necessary to analyze the extent to which a protective structure prevents damage caused by precipitation, solar radiation, wind, and human activities that could impact the preservation of archaeological or historical elements [11].

Aspects related to access and visual presentation of cultural monuments are crucial for the overall visitor experience. A protective structure can either facilitate or restrict public access and influence the visual perception of an archaeological site.

The long-term sustainability of a structure is essential for ecological balance and the enduring protection of monuments. A protective structure also contributes aesthetically to the overall environment and cultural landscape, enhancing the overall visual experience. Integration with the surroundings is key to preserving harmony and the authentic spirit of the place.

The analysis of these criteria, set from the aspect of architecture, lays the foundation for subsequent sections of the research where these criteria will be applied in the context of specific examples: Pompeii, Lepenski Vir, and Göbekli Tepe.

3. CASE STUDIES

After archaeological excavations, the remains of historical buildings that have been buried for centuries must be physically protected, given their high sensitivity to various environmental influences. There are different approaches to preservation. One of them is to cover them again with soil. Another option is to leave them uncovered, preserve them, and regularly repeat this process with continuous monitoring, while the third strategy involves conservation and covering the location with a protective structure. The decision to build a protective structure must be carefully made, taking into account many factors. In this process, the analysis of the location and the perception of the value of the historical structure play a crucial role [2].

If the choice is to build a protective structure, even designing a small canopy poses a challenge in achieving protection, especially for fragile ruins. Causes of damage include: rain; wind; solar radiation; ultraviolet rays; rapid cycles of evaporation/condensation; and their combination [3].

3.1. Pompeii, Italy

The archaeological site of Pompeii, located near Naples, is significant as an ancient Roman city that was largely destroyed and buried during the eruption of Mount Vesuvius in 79 CE. Following archaeological excavations that began in the second half of the 18th century, Pompeii is now a UNESCO World Heritage Site and one of the most visited archaeological sites in the world [12].

Preserving archaeological sites, especially in locations like Pompeii, where the ruins cover vast areas, poses a challenge due to weather impacts. In Pompeii, during earlier excavations, several homes were restored, including roof renovations, serving a dual purpose: protection from weather conditions and restoration to their ancient appearance.

Villa dei Misteri, one of the most famous villas in Pompeii, stands out for its frescoes depicting mysterious rites. Its history dates back to the 2nd century BCE, with significant construction phases documented over different periods. Discovered in 1909, the villa now draws visitors eager to experience the unique atmosphere of ancient Roman times (Fig. 1) [13].

Figure 1. A suburban villa located next to the main archaeological area of Pompeii - Villa dei Misteri, source https://www.nomenclatorbooks.com/villapage.html (18.03.2024.)

During the 1960s and 1970s, most of the roof structures in the villa were replaced with heavy reinforced concrete frames or flat roofs with mixed reinforced concrete beams and hollow brick floors. Later, due to concerns about the load on the ancient masonry, these types of constructions were abandoned in favor of wooden structures (Fig. 2) [12].

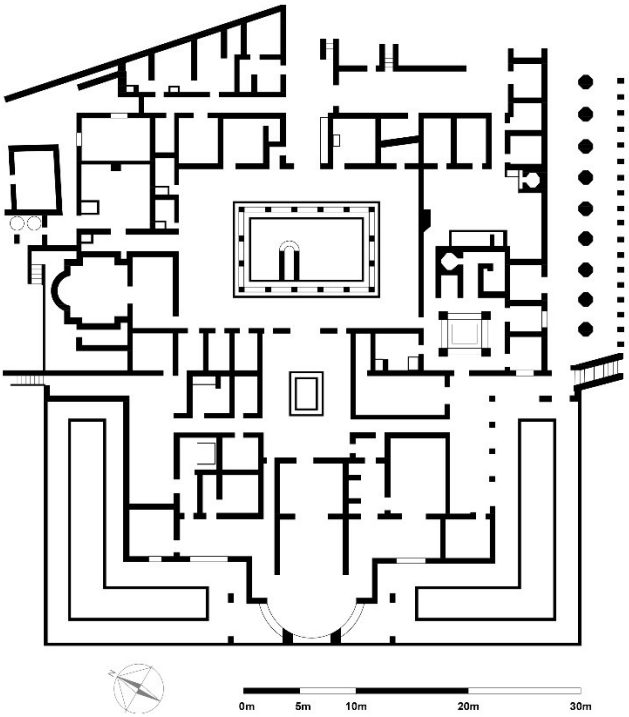

Figure 2. Technical presentation of the base of Villa dei Misteri, author N. Kocic according to [12]

Although such a construction revives the former appearance of the object, the use of heavy structural elements can lead to overloading of the existing walls, endangering the cultural heritage itself, as well as visitors. This is evidenced by the collapse of the wooden beam of the Peristylium in 2012, which was subsequently closed to the public.

Due to concerns about the safety of the monument, the Archaeological Park of Pompeii and ENEA implemented a conservation project that involved a multidisciplinary approach, including historical and archaeological analysis, geometric and structural research, damage assessment, drone surveys and vibration analysis for seismic safety [12].

3.2. Lepenski Vir, Serbia

The prehistoric settlement of Lepenski Vir enjoys the status of a cultural monument of exceptional importance (Službeni glasnik SRS 1979/14). This settlement holds particular significance as the oldest known sedentary prehistoric site in Europe. Numerous remains of sacral and residential architecture, totaling 136 structures, were unearthed through research conducted between 1965 and 1970. Residential structures included simple constructions, such as one-room pit-houses and huts, often shaped in basis like truncated circular segments obtained by cutting circles at angles of 30 or 60 degrees [14].

To preserve it from submersion due to the construction of the "Đerdap" Hydroelectric Power Plant, the site was relocated to a higher elevation before the power plant became operational. Subsequently, in 2011, a new protective structure was built, providing a permanent solution to shield the site from external influences

and making Lepenski Vir more accessible to visitors. This structure facilitates the preservation and study of the rich heritage of this significant archaeological site. 4

The protective structure is in the form of a cascading greenhouse, with a steel structural frame and semi-transparent panels (Fig. 3) [14].

Figure 3. Section of the steel-grid construction over the archaeological remains, author N. Kocic according to [13]

The construction of the protective structure has also improved the accessibility of the site. Considering that within the structure, in addition to the covered site, there are also accompanying auxiliary rooms, controlled access is provided to visitors, with the possibility of guided tours and interactive engagement.

It also plays a significant role in its visual presentation. The installation of transparent glass panels to allow for increased insolation draws a parallel with the organization of houses in the fishing settlement, as the former housing units were oriented towards the south with their wider side (Fig. 4).

Figure 4. View from the inside of the building, source https://www.politika.rs/sr/clanak/456203/Ugrozeno-arheolosko-nalaziste-Lepenski-vir (26.02.2024.)

3.3. Göbekli Tepe, Turkey

Structure GT1 covers a part of the archaeological site of Göbekli Tepe, which was first discovered in 1963, but archaeological excavations did not begin until 1995 [8].

The main idea of the protective structure project is to provide adequate protection to archaeological remains while allowing researchers and visitors to explore and experience this archaeological treasure. The protective structure is open, elliptical in shape at the base, with a roof membrane in the form of a hyperbolic paraboloid (Fig. 5). The choice of such a construction is a response to the criteria set by the location itself. The shape of the structure is resistant to local strong winds, with a minimal number of supports and overcoming a large span, leaving the interior space column-free [15].

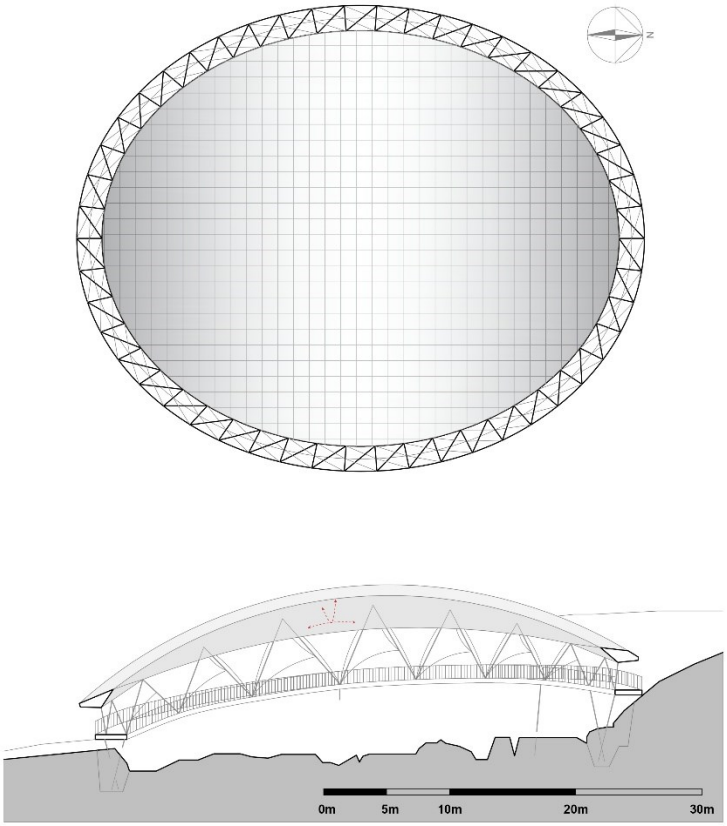

Figure 5. Technical presentation of the base and section of GT1 structure, author N. Kocic according to [15]

The steel skeleton of the roof structure forms the shape of a hyperbolic paraboloid, with all vertical structural elements located on the outside. The membrane is semi-transparent, allowing daylight to pass through, enhancing the visual comfort of visitors (Fig. 6) [16].

Figure 6. View of the protective structure from the east side, source http://www.transtinsaat.com/proje-detay/29/sanliurfa-gobeklitepe.html (27.02.2024.)

A wooden pathway is placed around the perimeter of the structure with four platforms, offering visitors a view of the archaeological remains, as well as enabling the work of archaeologists and conservators (Fig. 7) [17].

Figure 7. View from the inside showing the wooden pedestrian pathway, source https://eisat.de/en/projekte/schutzdach-1-fuer-die-ausgrabungen-am-goebekli-tepe-tuerkei (27.02.2024.)

4. RESULTS AND DISCUSSION

Selected examples differ in design approach, used materials, construction systems, location characteristics. In examining each case, a table mentioning their general characteristics is presented.

Table 1. Technical specifications of selected structures

Technical characteristics	Villa dei Misteri, Pompeii, Italy	Lepenski Vir, Serbia	GT1 Göbekli Tepe, Turkey
Material	concrete frames, roof tiles, wooden beams	steel-grid construction, transparent glass panels	steel construction, PTFE Mesh membrane roofing, timber
Shape	pitched roofs covering the existing structure	structure with rounded edges following the slope	hyperbolic paraboloid
Dimensions	up to 30m	cca 33m	37x45m
Visual effect	closed space	transparency	open design
Access	controlled	controlled	free

Villa dei Misteri, Pompeii, Italy

Advantages. Placing a protective structure directly on the existing construction of the Villa dei Misteri in Pompeii aims to restore its original appearance, which contributes to the preservation of its historical value and authenticity. The installation of roofs provides permanent protection from external influences, at the same time enabling visitors to visit the site regardless of weather conditions.

Disadvantages. Adding loads to an existing object must include both static and dynamic analysis. In addition, it is very important to implement adequate maintenance in order to avoid damage of protective layers, appearance of vegetation on the roof covering, occurrence of rust - which happened at the Villa in Pompeii.

Lepenski Vir, Serbia

Advantages. A permanent protective structure, such as an enclosed building, primarily provides long-term protection from weather conditions, such as rainfall, sunlight, wind and temperature – offering continuous and consistent protection, protecting archaeological remains from the direct effects of humans and wildlife. It also allows for constant surveillance and monitoring of the archaeological site with controlled access.

Disadvantages. The biggest problem of a closed structure with glass panels is the appearance of the greenhouse effect. Given the large volume of internal air, the existing HVAC system struggles to regulate its temperature, which results in overheating during the summer.

GT1 Göbekli Tepe, Turkey

Advantages. By using a structure that is not enclosed on all sides, the creation of artificial indoor climate is avoided. It facilitates natural ventilation under the shelter, providing thermal comfort.

Disadvantages. An open structure does not provide complete protection against external influences, necessitating regular maintenance and increased control. This type of construction is exposed to direct weather impacts, which over time can

cause gradual wear and degradation of archaeological remains. Maintenance is, therefore, crucial to ensure long-term functionality and preservation of the visual appearance. Additionally, an open structure may be susceptible to unwanted human activities, including vandalism or careless behavior by visitors, emphasizing the need for careful management and supervision.

4.1. Assessment of protective structures

Villa dei Misteri, Pompeii, Italy

Preservation of authenticity. The construction successfully preserves the authenticity of the archaeological site, allowing visitors to experience and understand the historical context.

Physical protection. Provides solid physical protection against weathering and potential damage, but there are some maintenance challenges.

Accessibility and presentation. The construction allows easy access for visitors, providing an educational experience.

Sustainability. The construction is functional, but there is room for improvement in terms of environmental sustainability.

Aesthetic impact. Contributes to the aesthetic experience of the visitors, it fits into the environment, but some elements could be improved for better aesthetics.

Lepenski Vir, Serbia

Preservation of authenticity. The construction aims to preserve the authenticity of the archaeological site, but the potential for improving the solution is recognized.

Physical protection. Ensures complete long-term protection of archaeological remains.

Accessibility and presentation. Access is controlled, but opportunities for interactive presentation and education are limited.

Sustainability. Improvement is needed to reduce the impact on the environment.

Aesthetic impact. Tries to fit into the natural landscape.

GT1 Göbekli Tepe, Turkey

Preservation of authenticity. The construction is designed to preserve the authenticity of the archaeological site as much as possible, giving visitors the opportunity to experience and understand the historical significance of this place.

Physical protection. Regular maintenance is necessary to ensure long-term protection.

Accessibility and presentation. Easy access to visitors, in addition to the presentation of archaeological remains, provides an educational experience with an insight into the work of conservators and archaeologists on site.

Sustainability. Designed using materials and technology that support environmental sustainability.

Aesthetic impact. It harmoniously fits into the natural environment and at the same time highlighting the cultural heritage.

The analysis of the mentioned criteria was translated into numerical grades (1 - poor, 5 - good) and shown in Table 2 and represents the view of the author, from the aspect of architecture.

Table 2. Assessment of protective structures shown with points from 1 to 5

Assessment criteria	Villa dei Misteri, Pompeii, Italy	Lepenski Vir, Serbia	GT1 Göbekli Tepe, Turkey
Preservation of authenticity	5	4	5
Physical protection	4	5	4
Accessibility and presentation	5	3	5
Sustainability	3	4	4
Aesthetic impact	4	4	5
Overall score	4.2	4.0	4.6

4. CONCLUSION

The protection of architectural heritage is essential for the preservation of cultural heritage, historical significance and community identity. It also contributes to tourist attractiveness, education, artistic and aesthetic richness, and supports long-term sustainability. Without adequate protection, architectural works can be exposed to various threats, which emphasizes the importance of taking measures to preserve and prevent loss, whether it is the reconstruction of the building or the construction of new protective structures.

This study has evaluated the effectiveness of protective structures implemented at three diverse archaeological sites: Villa dei Misteri in Pompeii, Lepenski Vir in Serbia, and GT1 Göbekli Tepe in Turkey. Through the assessment of various criteria such as preservation of authenticity, physical protection, accessibility and presentation, sustainability, and aesthetic impact, we have gained insight into the strengths and weaknesses of each protective structure.

The analysis emphasize the importance of careful design and maintenance to ensure the long-term sustainability of archaeological sites. While some structures excel in certain criteria, others may face challenges that need to be addressed for optimal preservation and presentation of cultural heritage.

This research contributes to our understanding of the significance of geometric design, material selection, and technological application in the protection and presentation of cultural heritage on a global scale. By examining different types of protective structures, we aim to draw valuable positive and negative experiences in order to lay the foundation for practical and sustainable solutions for protective constructions of architectural heritage.

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