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Content

Use of archaeological structural survey and the analysis of standing structures on mediaeval castles

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Archaeological structural survey is a non-invasive procedure that determines the existence of architectural remains and records the archaeological contents of architectural remains, or their parts visible above the ground. The archaeology of standing structures is a method that involves arranging the observed stratigraphic units in a chronological sequence, applying the so-called Harris matrix (and linking the obtained results with other sources, primarily written, legal acts, graphic historical representations, and the results of archaeological research and archaeometric analysis (samples of stone and mortar). Both methods were used in the research of the remains of medieval castles. The paper will show the results of these analyses on two case studies: the Cesargrad Castle in Hrvatsko Zagorje and Grižane Castle in the Vinodol Valley. In the case of Cesargrad different construction, phases have been identified, showing a rich architectural history of the castle, ranging from the 13th to the 17th centuries. In the case of Grižane Castle, the data suggest that the visible traces date to only one phase of construction during the 15th century, contrary to the known historical data. With the application of the structural survey, the architectural remains of the castle have been documented for the first time.

The use of these methods allows new insights into the architectural development of the archaeological remains in question, gives answers to specific research questions, especially in the field of late medieval and post-medieval archaeology, and enriches the data of individual architectural remains. The data can be used in later monuments protection programs, as the foundation for a better understanding of the architectural remains and the proper method of their preservation.

Keywords: *archaeological structural survey, archaeological documentation, archaeology of standing structures, medieval castles*

Introduction

Archaeological survey is used by archaeologist to discover sites, assess archaeological remains or damage done to archaeological sites, and a survey can range from informal exploration to very detailed strategies (Banning 2002:1). The results of any archaeological survey depends on the objectives it was designed to achieve so strategies and methods can vary depending on the goals of archaeological survey (Banning 2002: 27-38). Ever since its early days, archaeological science came upon underground historical architectural remains. Above-ground architectural remains were studied by members of similar disciplines only, such as art historians. Although the interest of contemporary archaeology goes beyond the architectural remains themselves, since the 1980s, the attention given to more detailed research of architectural remains preserved in elevation has become an inevitable part of archaeological excavations in some countries.

Structural surveys

When collecting large amounts of spatial data, archaeology implements the method of systematic field survey which is used for discovering and cataloguing archaeological remains. The systematic field survey represents a typical walking technique most commonly applied at the sites where the surface of the ground is visible, primarily in the fields with scarce vegetation. It can also yield good results in surveying visible surface structures in grasslands, forests, etc. (Mercer 1985; Fasham 1986; Čučković 2012: 247-248). Systematic field surveys can encompass the sites with architectural remains as well. Lately, the system of documenting finds began including the architectural remains which are often preserved in elevation, above the ground. Researchers ascertained that the principles of archaeological field surveys and the documentation of archaeological finds can be applied to this type of sites as well. This survey can be defined as an archaeological structural survey. The archaeological structural survey is a non-invasive procedure used for establishing the existence of archaeological finds of architectural remains and recording their position, i.e., the position of their visible, above-ground parts. This method is supplemented by structure analysis with the goal of complementing the findings and documenting certain construction interventions, elements, and construction processes, as well as collecting samples of construction materials. If necessary, the archaeological structural survey can include clearing out the surface of the ground or structures, naturally, without changing their shape or reaching deeper into the site's stratigraphy. While the surface surveys can collect data on numerous sites, systematic field surveys have the potential to collect detailed data on single sites, on their size, character or/and temporal determination. In the case of the structural survey the same can be said, but with the main goal of collecting data of architectural remains preserved above ground. Archaeological structural survey has the goal of documenting position and state of preservation of architectural remains and should be supplemented with the stratigraphic analysis of standing structures.

Gathering a large amount of data was made easy by introducing new documentation techniques in archaeology. This can also include documenting architectural

Figure 1. On site recording of the Grižane Castle. (Photo by: A. Janeš).

remains. The use of total stations at archaeological excavations enabled researchers to collect large amounts of field data faster and easier compared to the classic way of documenting in the form of drawing the finds on graph paper by hand and situating them in the environment by using a grid (Fig 1.). The use of a camera combined with a total station or a global navigation satellite system (GNSS), which has lately become more common, introduced the technique of photogrammetry in archaeology. The analysis of gathered data in CAD programmes brought the archaeological remains preserved in elevation closer to archaeologists. The introduction of a 3D laser scanner in the process of documenting sites increased the amount of gathered data exponentially (Grgurić and Novak 2018). Despite the widespread use of 3D laser scanners, photographing the site to acquire data and recording it with a total station to create a 3D model is accepted as a more cost-effective technique, especially in archaeology. The recorded data is used to create 3D models through the so-called *image based modelling* technique (Fig. 2). The combination of the images of an unmanned aerial vehicle, recordings made

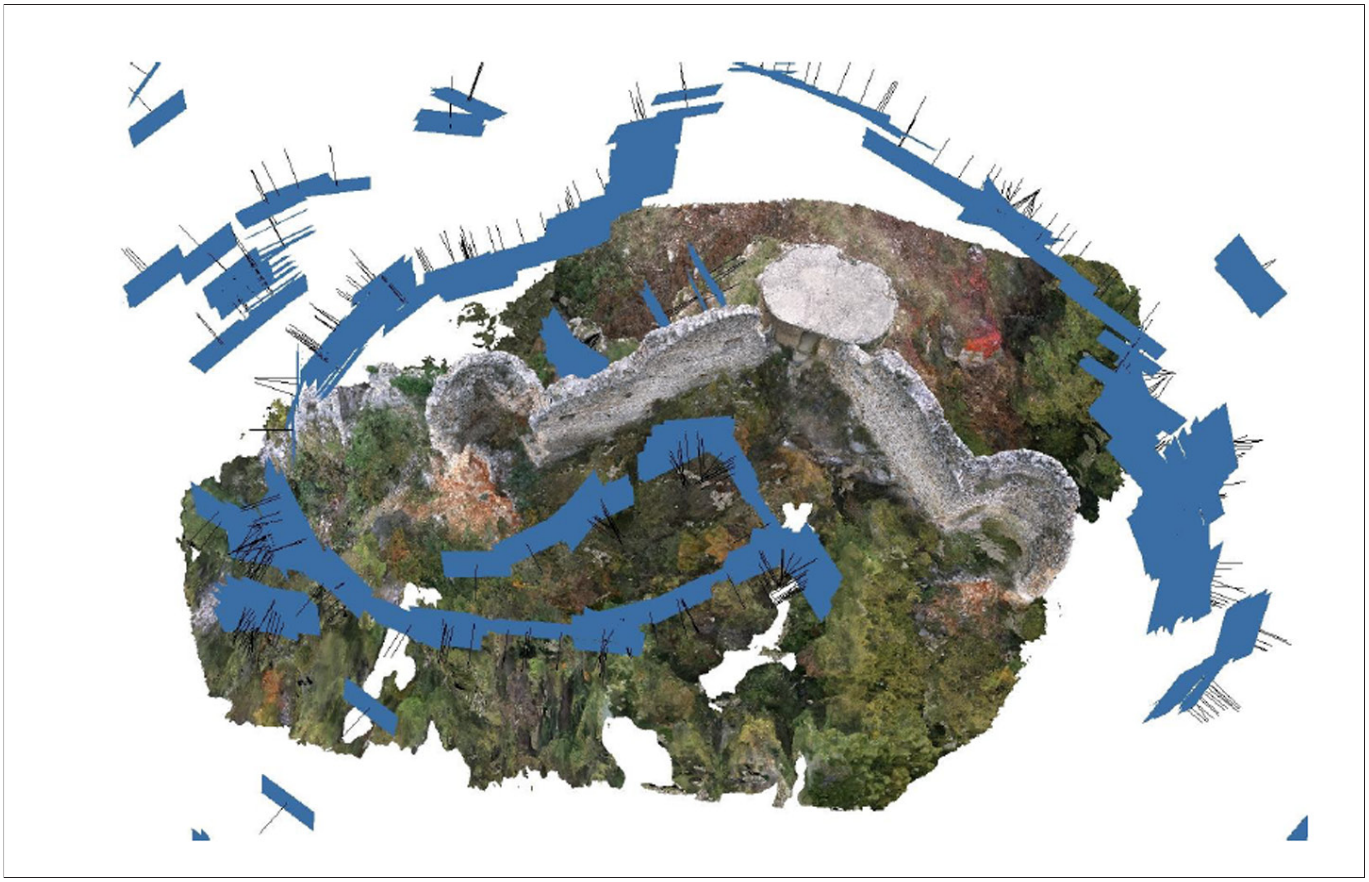

Figure 2. 3D model from UAV photos. (Made by: Vektra Ltd).

with geodetic equipment and terrestrial images yields a more cost-efficient alternative to 3D laser scans (Vuković and Mađerić 2015).

The stratigraphic analysis of standing structures

As already mentioned, archaeological structural survey is supplemented by structure analysis. Although documenting architectural remains discovered during field surveys is becoming more common, analysis of documented architectural remains is still not common practice. Data collected through an archaeological survey of any type is analysed to give comprehensive interpretation but architectural remains rarely get the same treatment from archaeologists in Croatia.

The archaeological research of architecture preserved in elevation is based on the stratigraphic analysis that enables the researchers to identify certain periods of construction and demolition as well as, the relationships of the past, present, and future. According to E. Harris, excavation is a stratigraphic procedure that can be applied to architectural remains. Unlike excavation, during which the layers are mechanically destroyed and their constituent parts revealed, the stratigraphic research of architectural remains preserved in elevation is limited to the depiction of the visible part without the possibility of breaking it up (Brogiolo and Cagnana 2017: 7). The stratigraphic method of architectural remains analysis has been used in English archaeology as well, primarily in the archaeology of churches, starting from the 1970s (Clark 2000: 17). The implementation of the stratigraphic method, which originated in the experiences of English archaeologists, was introduced to the analysis of architectural remains in Italian archaeology in the late 1970s and the first half of the 1980s, and to Spain and France a decade later (Italian: *Archeologia dell' archittetura*, Spanish: *Arqueologia del architectura*, French: *L'archéologie du bâti*) (Brogiolo and Cagnana 2017: 13-14, 18).[1]

1 The terminology in English language also nows the term analysis of standing buildings but this term is mostly used in the term of historical buildings still in use, that have a preserved roof.

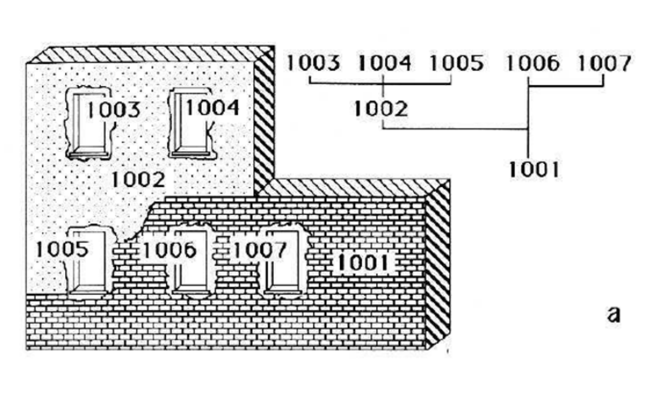

Figure 3. Stratigraphic sequencing of a standing wall (Brogiolo 1988: Fig. 16a).

In archaeology, stratigraphy includes the implementation of geologic principles in excavation techniques (Harris 1989). It is based on two concepts – the concept of space and the concept of time. It is thought that no item, structure, or object can be understood without taking its spatial and temporal context into account (Clark 2000: 20). Documenting a architectural remains depends on its degree of preservation and the documentation system can be adjusted according to it. Due to speed and cost-effectiveness, one should consider whether there is a need for the so-called total documentation of all details of a structure or a plan of specifically targeted parts should be made (Westman 2000: 108-109). Goal of structural analysis is better understanding of construction process and identification and interpretation of construction phases and architectural development through use of stratigraphic layers.

The vertical stratigraphy method can be applied in documenting architectural remains and the breakdown of their elements. It is done by identifying openings in walls, plaster remains, and different masonry techniques as new stratigraphic units. A stratigraphic unit is a basic unit in the analysis of standing architecture as well as in the research of underground structures. [2] They can be categorized as the units created during the construction and the units created during the destruction, i.e., dissolution. The first variety has a certain volume and is identified as the positive interface, while the second variety is identified as the negative interface (Brogiolo and Cagnana 2017: 25). During the analysis, architectural remains are broken down and the method of recording interface units subordinate to the stratigraphic unit of the wall is used (for instance, the wall plaster of wall SU 1003 is recorded as SU 1003.3) (Harris 2003: 11). This method implies putting the identified stratigraphic units in a chronological sequence by using the so-called Harris matrix (Harris 1989: 109-113) (Fig. 3). The use of the matrix yields a relative chronology and links the obtained results to other sources, primarily the written ones; legal acts and graphic historical sources, as well as the results of archaeological excavations and archaeometric analyses with the goal of ascertaining the absolute chronology (Brogiolo and Cagnana 2017: 25).

Examples

The high number of medieval castles in Croatia and their degree of preservation make them very good subjects for the implementation of an archaeological structural survey and stratigraphic analysis of preserved architecture. This paper presents the examples of two castles: Cesargrad in Hrvatsko zagorje and Grižane in Vinodol Valley (Fig. 4).

Cesargard

The remains of the Cesargad castle are situated on the western slope of the Cesargrad hill, above a narrow ridge of the Sutla river called Zelenjak, northwest of Klanjec. The spot was the site of a well-fortified castle core, while a moat served as additional protection. At the top, the architectural remains span east of the moat and combined with the two far-east peaks of the Cesargrad hill make up this complex castle. The whole position of this castle used to be surrounded by a defence wall which was reinforced by towers on the most protruding parts. The castle extends in the direction of southeast-northwest and is 225 m long (Janeš 2014: 197).

The site was documented with a Z+F Imager 50163D scanner[3] which resulted in a measurable 3D model in the form of a point cloud where every point is highly precisely identified in space and the coordinate system. Aside

[2] It should be pointed iut here that the researchers in certain countries, primarily in Italy, use a separate stratigraphic unit when analysing masonry structures – the stratigraphic unit of the wall (It. *Unitá stratigrafica muraria, USM*) (Brogiolo 1988: 13; Brogiolo and Cagnana 2017: 25).

[3] The technique of gathering data with the 3D laser scanner and photogrammetry has been explained in the paper by Grgurić and Novak 2018.

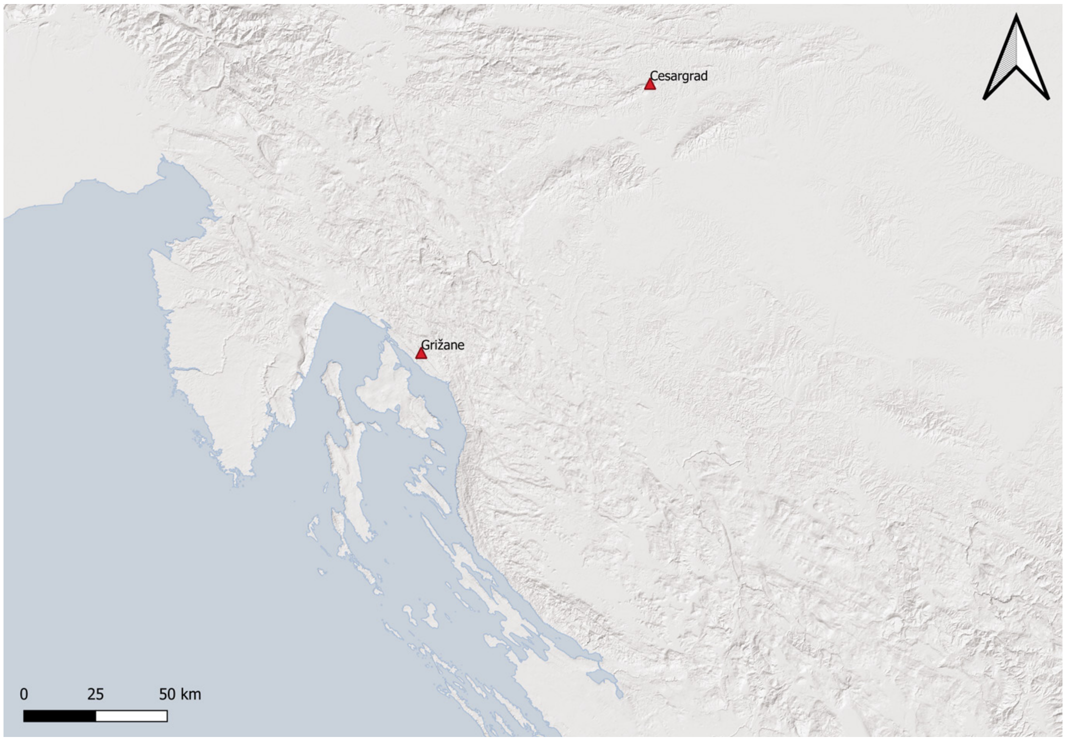

Figure 4. Locations of the sites. (Map by: A. Janeš).

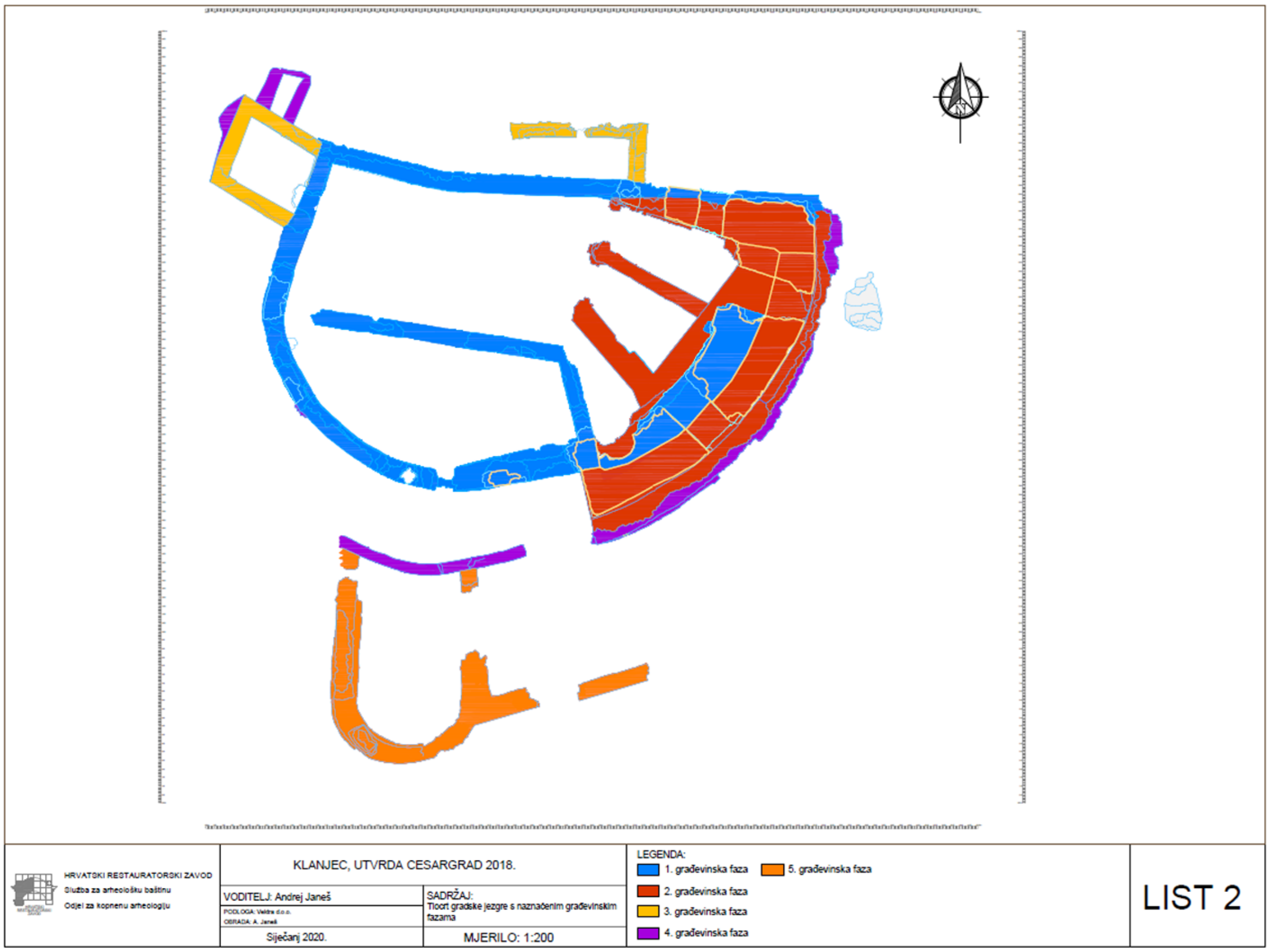

Figure 5. Cesargrad groundplan with construcion phases. (Plan by: Vektra Ltd, edited by: A. Janeš).

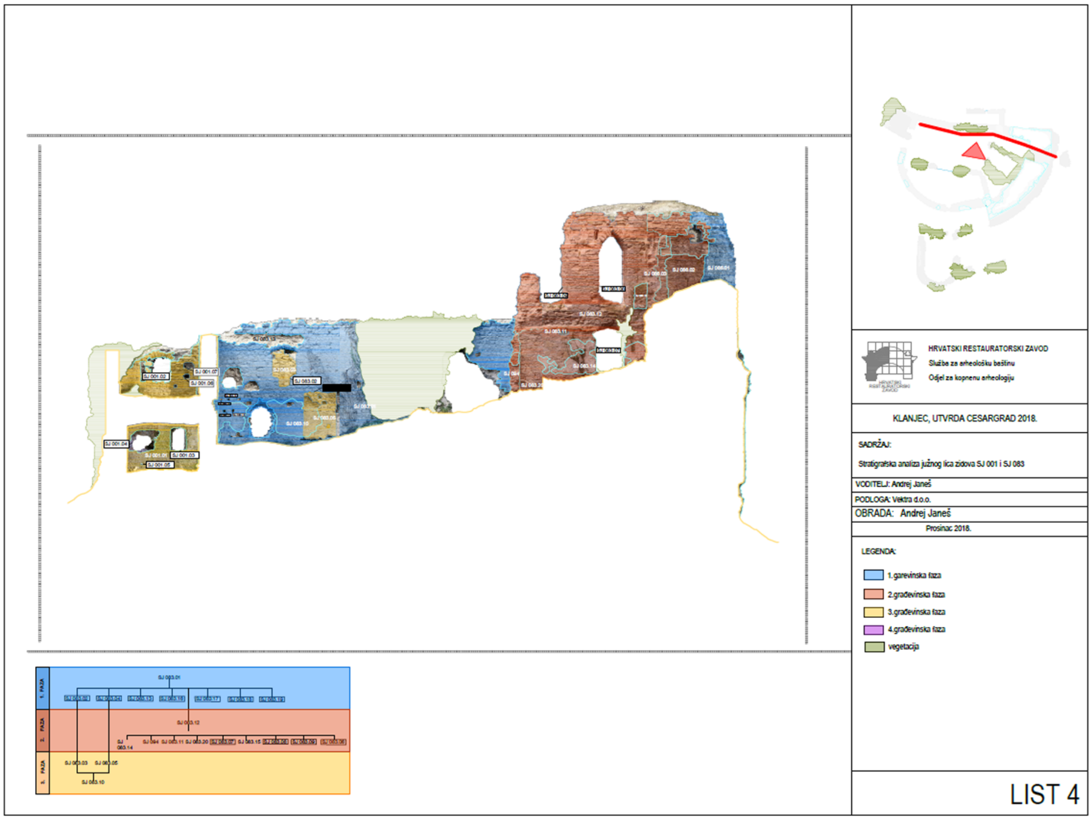

Figure 6. Stratigraphic sequencing of the northern wall of Cesargrad's centre with Harris diagram. (Plan by: Vektra Ltd., edited by: A. Janeš).

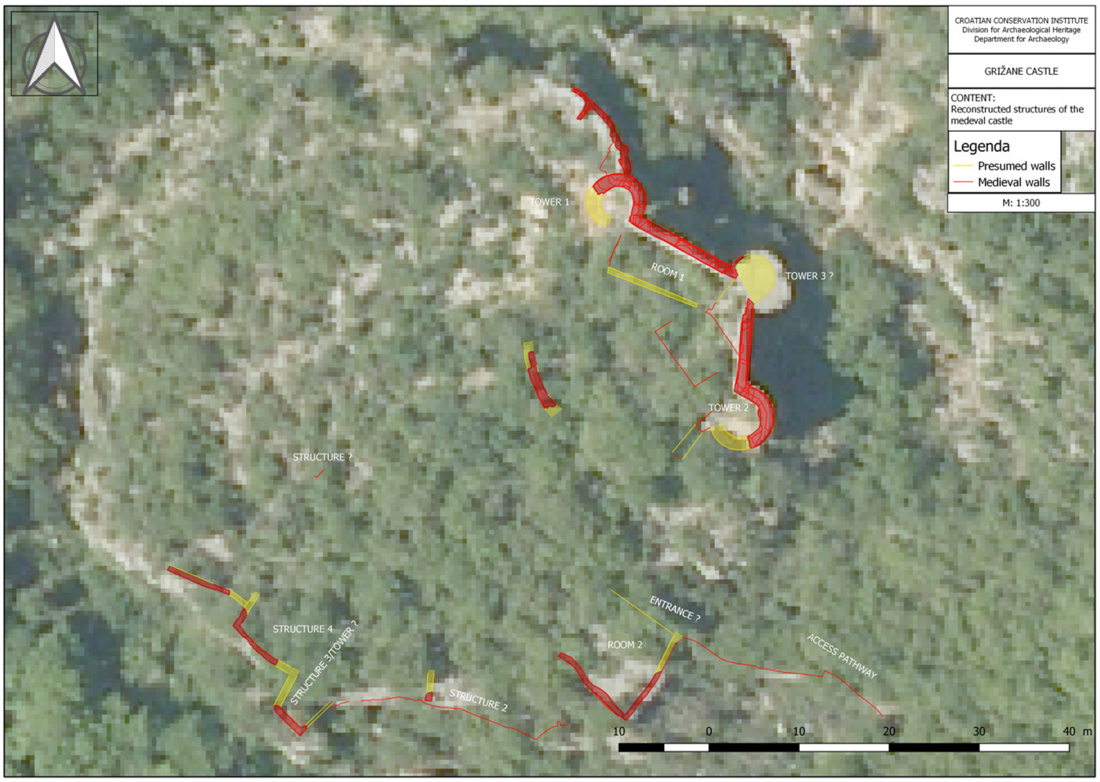

Figure 7. Grižane Castle, ground plan of the first construcion phase. (Map by: A. Janeš).

from the 3D scanner, images were acquired through the use of the Airborne Robotics XR6 unmanned aerial vehicle. The obtained 3D model was used for CAD drawings which included a layout of the site and faces of some walls preserved in elevation.

Five phases can be identified in the construction and architectural development of the castle. All of them are visible in the castle's core (Fig. 5). The first construction phase is identified by the remains of a smaller castle around the rectangular court with a room on the southern side. It was constructed during the 14th or maybe even the late 13th century. The second construction phase is said to include the reconstruction of the eastern portion of the castle. At that time, the eastern wing of the palas and the eastern defence wall were reinforced resulting in the formation of the so-called *Schildmauer* or shield wall. During the third construction phase, the entrance in the western wall was relocated eastward and reinforced (Fig. 6). A square tower was added to the north-western corner of the castle. The second and third phases can be dated to the time when the castle was owned by the Counts of Celje (1399-1456). In the fourth construction phase, the centre of the castle was reinforced in the east and the south, while the semi-circular artillery tower on the southern side of the centre was added in the fifth phase. These phases are dated after 1521 when the castle was owned by the Erdődy Family (Janeš 2020: 87-88).

Grižane

The remains of the Grižane castle are situated on a steep slope of a rock connected to the mountain massif of Podolje in the east, just above the village of the same name. Steep cliffs divide the slope from the rest of the Vinodol Valley. The terrain morphology influenced the layout of the castle; it encompasses the whole area of the circular slope. The slope is very steep, declining from east to west and south. The height difference between the highest and the lowest altitudes of the slope is 40 meters (Janeš 2021: 219).

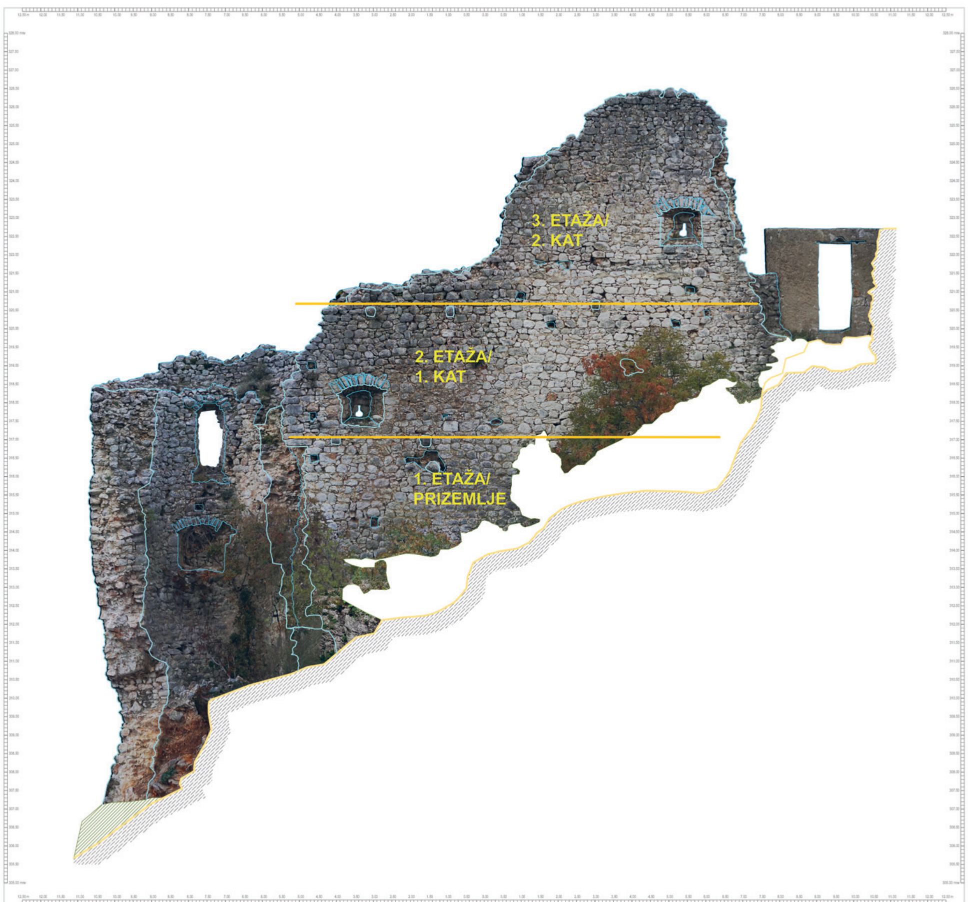

Figure 8. Grižane Castle, interpretation of the wall. (Plan by: Vektra Ltd., edited by: A. Janeš).

The Grižane castle was researched in two phases using a combination of two techniques. The remains of the central part of the castle are preserved at the highest point in the terrain (Fig. 7). The terrain is dominated by architectural remains of two eastern walls that have round towers on their western and southern borders. Two eastern walls come together at the highest point in the terrain at a 111º80“ angle. It is assumed that there was another round tower on this spot. Unfortunately, any possible traces of the tower are either completely gone or were covered by the construction of a concrete pillbox during the Second World War. In 2015, this part of the castle was documented with Z+F Imager 5010c 3D laser scanner and Airborne Robotics XR6, VEK1 unmanned aerial vehicle with Sony ILCE-6000 24 Mpx mirrorless camera. Orthomosaics were generated from the obtained 3D model and were used for CAD drawings which included top view positions and the views of the wall faces preserved in elevation (Janeš 2016: 463-465) (Fig. 8).

The remaining part of the castle spans over the slope to the west and south, to the edge of a deep cliff. In 2016, a structural survey of that part of the castle was conducted and 39 masonry structures from various periods were identified (Janeš et al. 2017). The area around the masonry structures that were documented with a camera and recorded with Leica Flexline TS06 total station was cleared out. The structural survey revealed the remains of an outer defence wall of the castle, which was constructed on the western and southern edges of the cliff. The position of the wall made it impossible to document with anything but the DJI Phantom 2 unmanned aerial vehicle (Fig. 9). The aerial survey yielded a number of images enough for the analysis in a computer programme and the production of orthomosaic. The total station recorded control points for georeferencing the obtained 3D model. The acquired orthorectified images of the view of the masonry structures of the castle were used for the production of CAD drawings of certain elements of the walls.

Figure 9. Grižane Castle, 3D model of the outer wall made from UAV photos. (Model by: A. Fundurulić).

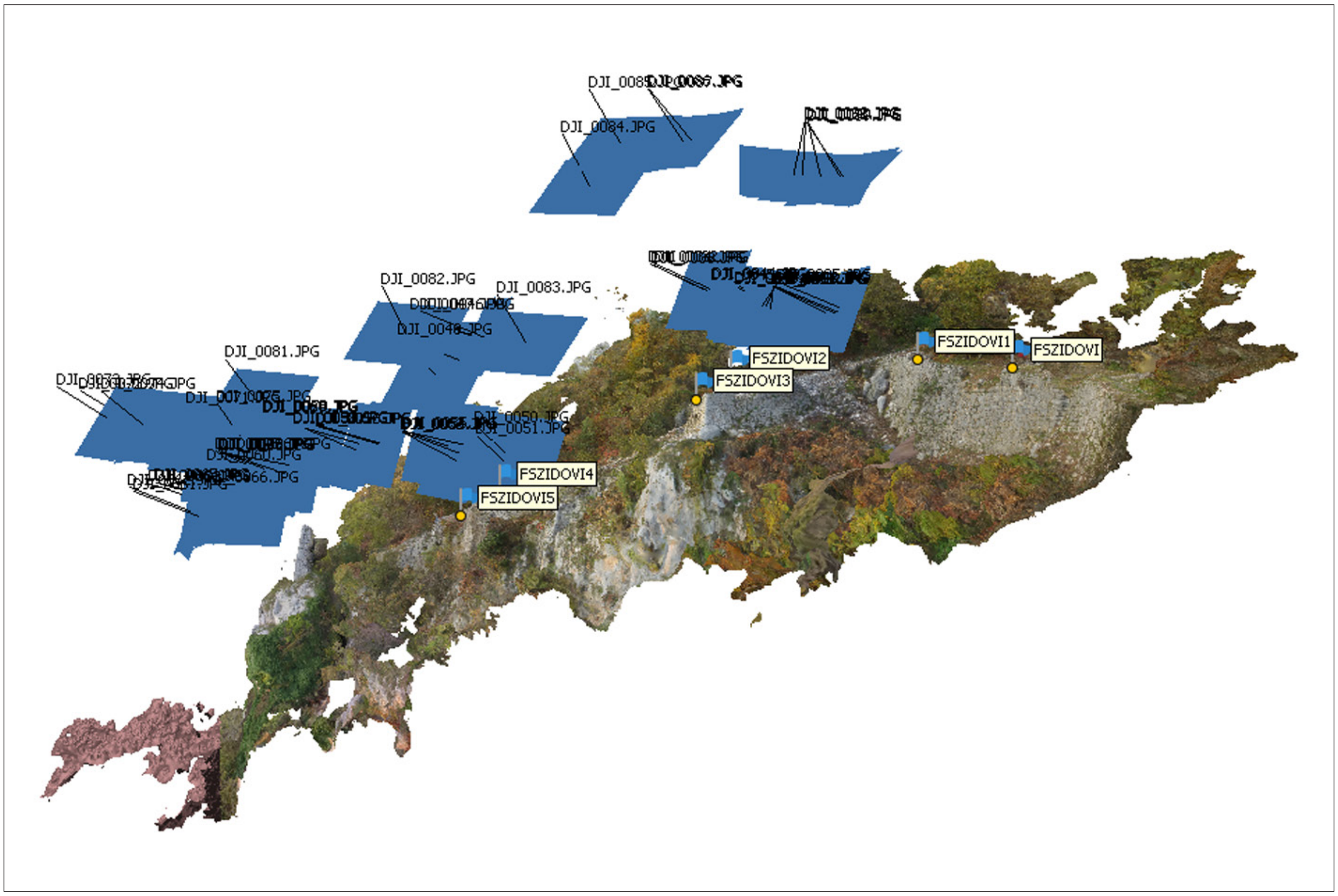

Figure 10. Osor, monastery of St. Peter, example of conservation of different construction phases. (Photo by: A. Janeš).

The analysis of the architectural remains revealed four construction phases of the Grižane castle. The first one was the most extensive and has to do with the castle's structures. The preserved architectural remains visible above ground did not reveal different structures and types of construction, leading to the conclusion that these are the remains of the original castle. The way it was built, round towers and built-in loopholes indicate that the castle can be dated to the 15th century. The second phase is represented by the walled-up openings, windows, and loopholes visible on the remains of the eastern defence walls and towers of the central fort. They can be roughly dated to the 16th or 17th century. The third construction phase is represented by the remains of the Second World War defence structures. The pillbox in question is oval and it is situated at the highest point in the terrain. There are also the remains of a square bunker in the western part of the central fort and the remains of a rectangular structure within the central part of the fort. The fourth construction phase includes all the documented dry stone structures that cannot be dated more accurately without excavation.

Conclusion

The use of the structural survey proved apt for gathering field data in the research of the architectural remains of the Grižane castle covered in thick Mediterranean vegetation. Given that the land of the site was never arable and was overgrown with thick Mediterranean vegetation, the classic systematic field survey that includes gathering movable finds was not possible. The economic and temporal limitations and the extreme terrain prevented the researchers from excavating the Grižane castle. The clearing of the terrain revealed architectural remains of the castle which were documented using the total station and the images obtained with the unmanned aerial vehicle. The aerial images were then used for the creation of an image-based 3D model, especially the remains of the outer defence walls whose data was impossible to gather via any other technique. The aim was to discover and document all architectural remains preserved above ground. Given the amount of analysed data, the use of the structural survey proved to be a cost-effective and very efficient technique for documenting the remains of a medieval castle.

The application of 3D laser scanners on architectural remains preserved in elevation proved to be a quick way of gathering large quantities of data in both aforementioned examples (Grižane and Cesargrad castles) despite being financially demanding. The analysis of various construction techniques and materials enabled the detailed analysis of all preserved remains.

The results of the structural survey and the recording of the architecture preserved in elevation were then analysed with the help of stratigraphic analysis of standing structures. They enabled a more detailed analysis of standing structures and identification of certain construction phases on the structures. The use of stratigraphic analysis of standing structures is important for a better understanding of the historical development of certain objects. The Cesargrad castle example indicates that the castle itself is older than the first mention in written sources testifies. Cesargrad was first mentioned in written sources in 1399, but the oldest structures in its core can be dated to the beginning of the 14th century, or maybe even earlier (Janeš 2014: 314). Likewise, certain construction phases can be linked to specific historical events or situated to the periods when the castle was owned by people that we know of thanks to the written sources. In the Grižane case, the analysis of the architectural remains of the castle indicates that the castle was (clearly) younger than its first mention in the written sources. The famous 1288 Vinodol statute mentions notable individuals from Grižane as one of the nine medieval municipalities in Vinodol. The Grižane castle itself is mentioned only in 1449 (Janeš 2021: 221). The architectural remains visible today do not reflect a large number of construction modifications and have all the characteristics of the 15th-century fortification architecture. Regarding the Grižane castle, it can be concluded that this castle was first mentioned in 1449 and has no clear link to the information from the Vinodol statute.

The stratigraphic analysis of standing structures can be just as important for making decisions about conservation works. The right use of the stratigraphic method in the analysis of standing structures shows a more systematic approach to the understanding of the building; it is an approach rooted in the concept of stratigraphy. This concept is the basic critical tool that makes a difference between archaeology and other disciplines involved in the analysis of masonry structures (Clark 2000: 20). The results of the analysis can be presented correctly on the preserved archaeological remains which would portray the historical tides of the object to all types of visitors in a better and more fitting way (Fig. 10). The understanding of the building is the first and the most important aspect of the conservation process. If we do not understand the building and its importance, we cannot evaluate any changes to it (Clark 2000: 17). The structural survey encompassed structures from all historical periods which resulted in a complete approach to the study of medieval castles from their creation to their abandoning and reusing in later periods. The georeferenced 3D models and orthographies enabled the measuring of the structures directly in the CAD, which means that they can also serve for calculating the amount of material necessary for the conservation and, consequently, the amount of financial resources needed for such works. The contemporary techniques of documenting architectural remains open the possibility of monitoring the situation of certain sites through the remains of the architecture preserved in elevation. Recording architectural remains in certain intervals can provide insight into the structure degradation which could help create conservation plans for certain sites and facilitate their proper protection.

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