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ДРУШТВО НА ГРАДЕЖНИТЕ КОНСТРУКТОРИ НА МАКЕДОНИЈА

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PALACE OF GOLUBAC FORTRESS

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ABSTRACT

The Golubac Fortress was built at the very entrance of the Iron Gates gorge, at the point where the Danube is the widest in its course and transitions into the narrow passage of the Carpathian Mountains. The fortress represented an important medieval military border stronghold, strategically constructed due to the military significance of the location. Because of its position, during the 14th and 15th centuries, bordering countries, Hungary and Serbia, and later the Ottoman Empire, fought to conquer the Golubac Fortress in order to gain control and power over the state border.

There are no exact records of who and when initially built the Golubac Fortress. The first mention in written sources is from the year 1335, in a Hungarian charter from 1337, which states that the nobleman Nikola Banfi resided in Golubac in 1335. Until the dissolution of the Dušan's Empire, Golubac Fortress status remains unchanged according to historical sources, and it remains in Hungarian possession.

At the beginning of the 21st century, the town of Golubac was in very poor condition, neglected and inaccessible. Reconstruction of the entire Golubac Fortress began in 2011. The reconstruction was officially completed in 2019. However, some minor reconstruction and revitalization work is still ongoing today.

The foundation of the Golubac Fortress was adapted to the terrain's configuration and consists of 9 towers connected by the ramparts and the Palace. As part of the restoration efforts, all the towers, ramparts, and the Palace were reconstructed.

The paper depicts the reconstruction of the entire Palace, including its foundations and a new roof structure made of glued laminated timber.

Keywords: Golubac Fortress, Palace, Reconstruction, Jet Grouting, Glued laminated timber.

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1. INTRODUCTION

The layout of the Golubac Fortress is adapted to the terrain's configuration and consists of 9 towers connected by the ramparts and the Palace (Fig. 1). Based on the architecture and construction period, the fundamental division of the stronghold into two parts is evident: the Inner, with the tallest Donjon tower, known as the Hat Tower, and the Outer, which was the first target during the times of war. The Inner stronghold's Upper Town is the oldest in terms of construction time, while the construction of the Palace with its defending tower, as well as the system of towers and ramparts of the outer stronghold, is attributed to subsequent phases and the reign of Despot Stefan Lazarević. The entrance to the Fortress was from the western side through the Main Gate, which had a wooden bridge over the water-filled moat. The Fortress originated during the era of cold weaponry; however, during the Ottoman Empire, a cannon tower was constructed for the defense of the harbor, and additional walls were added to the towers of the Outer stronghold. These walls served as reinforcements and for easier cannonball ricochets, as firearms came into use from the 15th century onward, necessitating architectural adaptation to the new methods of warfare.

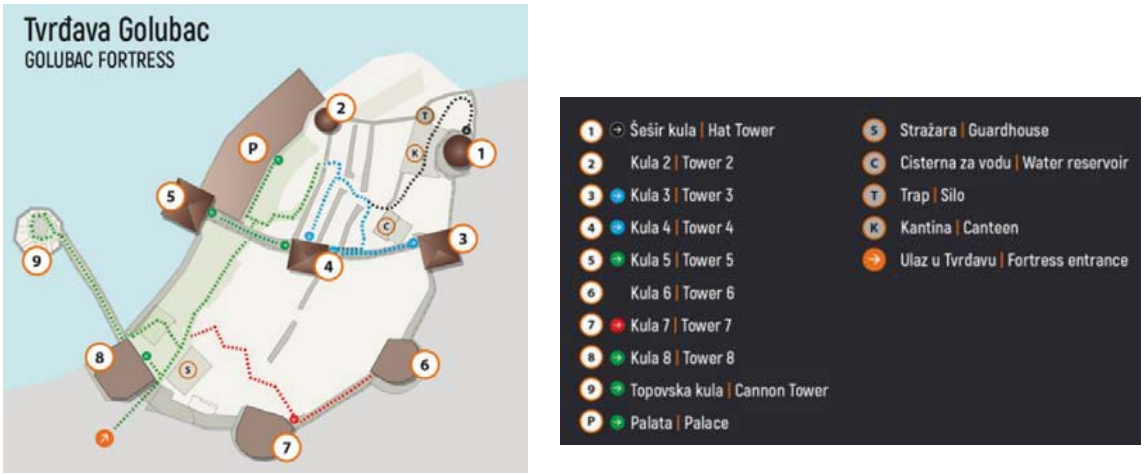

Fig. 1. Golubac Fortress

2. DESIGN AND CONSTRUCTION OF THE PALACE

The Palace was a monumental, multi-story structure that architecturally belonged to the Lower Inner stronghold. It falls within the second phase of construction, corresponding to the reign of Despot Stefan Lazarević. The Palace comprised three levels: the basement, which served as a storage area, the ground floor, containing a large hall for public functions and chambers for the residence of the city commander, and the second floor, where the palace garrison was stationed.

The Palace had two entrances - gates. Adjacent to the main entrance with a semi-circular ending, stairs led down to the lower, ground-floor rooms, which are now submerged due to the Danube's reservoir and which divided the entire palace space into two parts. New archaeological research has also revealed the access route to the Palace from the cliffside.

The reconstruction project for the Palace included two types of work. The first type of work involved the repair and reinforcement of existing foundations, as well as construction of new foundations. The second type of work involved the construction of new wall structures, floors and roof structure.

The repair and reinforcement of existing foundations and construction of new foundations were carried out using the jet grouting method. Reinforced concrete floor slab, 16 cm thick, was placed over these strengthened and newly constructed foundations.

The new walls of the Palace, in one section facing the Danube, were constructed as a glass façade, while the remaining walls were built of stone.

The new roof and floor structure in one section, between axes 1 and 6, of the Palace were built using traditional solid (monolithic) timber, while in another section, between axes 6 and 14, the roof structure was made of glued laminated timber (Fig. 2).

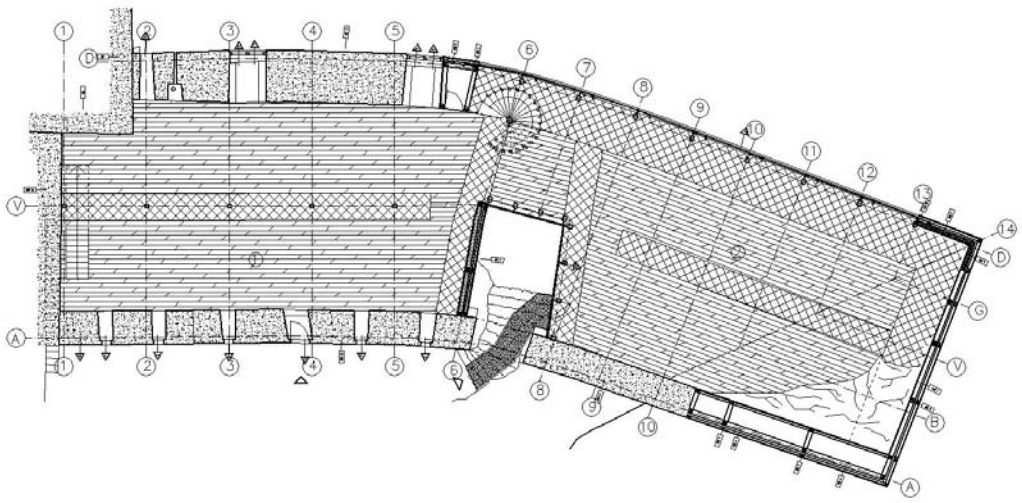

Fig. 2. Layout of the Palace

2.1. Repair of existing foundations and construction of new foundations

The remains of the Palace, the foundations of which needed to be repaired and reconstructed, are shown in Fig. 3.

Fig. 3. The Palace remains before repair

As previously mentioned, the repair of existing foundations and construction of new ones were carried out using the jet grouting method, which is a modern geotechnical technology (Fig. 4 and 5). The fundamental characteristic of jet grouting is that pressurized cement grout is injected into the soil through drilling to the required depth. The grout is mixed with degraded soil and soil particles, forming a column with much greater strength compared to the existing soil.

Upon reaching the designed drilling depth, cement grout is injected through the drilling tool, which is simultaneously rotated and raised. The process is pre-programmed and executed automatically. The injection pressure is around 400 bars. Upon withdrawing the drilling rod and bit, a cylindrical body - the column - is formed, which can have varying diameters. There are three basic methods of jet injection: single-fluid, two-fluid, and three-fluid. Since the soil of the Palace, where injection was

performed, consisted of alluvial silty sand, sandy gravel, and gravelly sand, the methodology of two-fluid jet grouting was adopted, with columns having a diameter of 1 m. The columns were constructed vertically in one section and at a slight inclination of 5° in another section (Fig. 4 and 5). The progress of the repair and reconstruction work on the foundations is shown in Fig. 6 and 7. After completing the foundation repair work, efforts proceeded to the above-ground part of the Palace (Fig. 8).

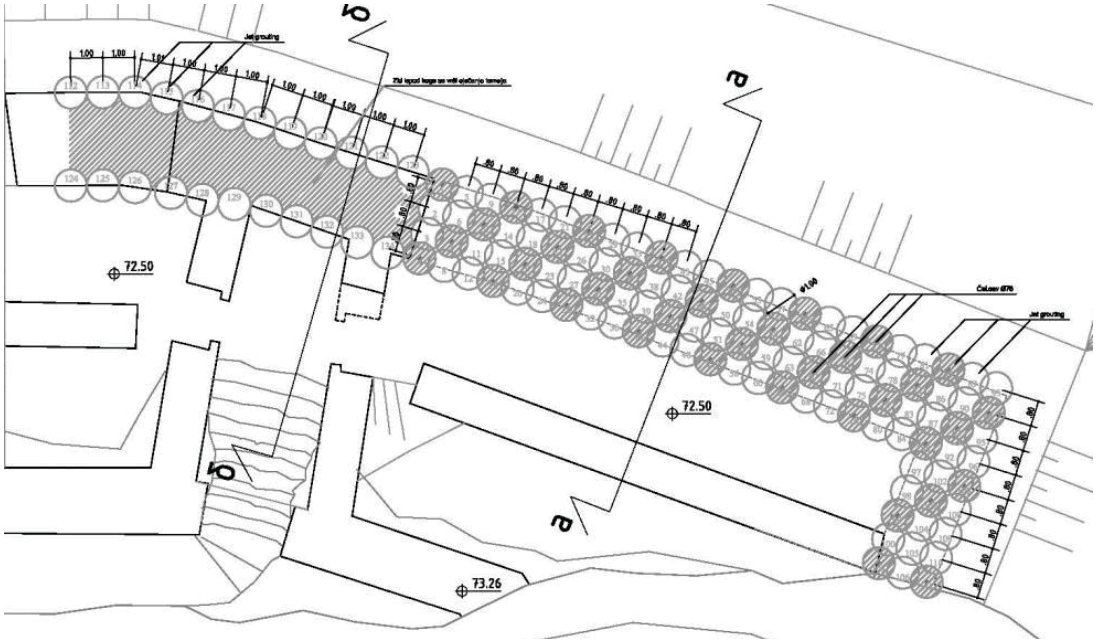

Fig. 4. Layout of jet grouting columns

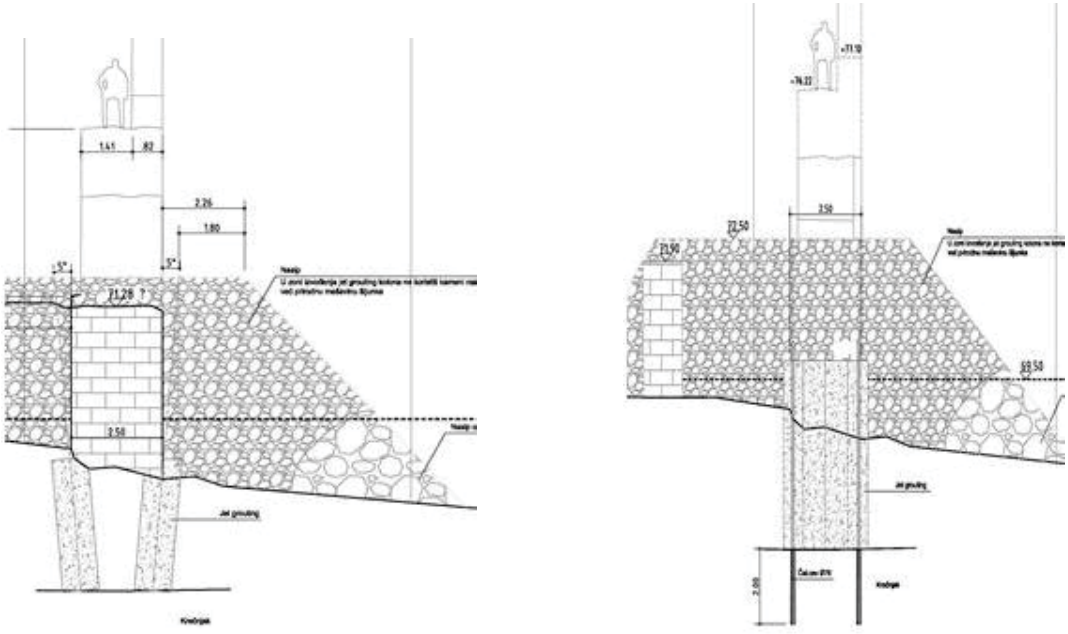

Fig. 5. Left, strengthening of existing foundations; right, construction of new foundations

Fig. 6. Execution of jet grouting columns

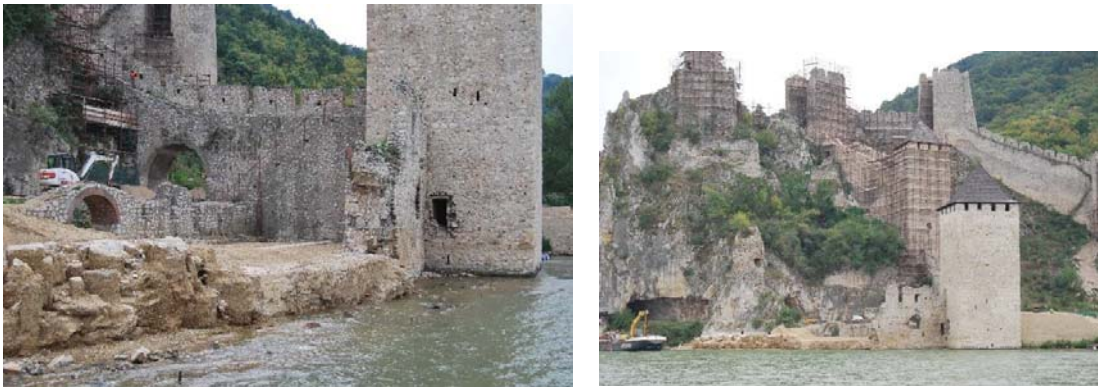

Fig. 7. The Palace foundations after jet grouting repair

2.2. The new above-ground structure of the Palace

The above-ground section of the Palace, structurally, consists of two parts - the section where remains of old walls exist and the section where there are no remains of old medieval walls. In this context, a new structure has been designed and calculated.

In the part where remains of old walls exist (between axes 1 and 6, Fig. 2), a new roof and floor structure of solid (monolithic) timber has been designed. The roof structure is traditional cut roof. The rafters, spaced 80 cm apart, rest on longitudinal stone walls via purlins, and in the central section, they are supported by purlins and ridge beams.

The timber structure in this section consists of ceiling joists, spaced 80 cm apart, over which a plank flooring made of 4.8 cm thick planks is placed. The ceiling joists are supported on their ends by massive stone walls and in the middle by a longitudinal timber beam. This beam is supported on columns via foot plates.

In the Palace section between axes 6 and 14, Fig. 2, a modern glued laminated timber structure has been designed, with timber frames spaced 2.85 m apart. Over the frames, purlins are placed at 80 cm intervals. The girder of the frame is supported on one side by reinforced concrete curtain walls (RC walls) and on the other side by a glued laminated timber column. The columns are connected at the top and approximately at mid-height by horizontal beams. The lower horizontal beam also serves as the support for the gallery, which is suspended from the main roof girder. The gallery floor is composed of 4.8 cm thick planks.

The facade wall of the Palace between axes 6 and 13, facing the Danube, is designed as a glass facade, while the wall in axis A is designed as a double wall. The outer part of this wall consists of perforated blocks with appropriate thermal insulation and a veneer wall made of solid bricks, 12 cm thick. The inner part is made of solid bricks, also 12 cm thick. These two parts are vertically connected by reinforced concrete panels and connected at the top by a horizontal RC slab. In the corner of the Palace between axes 13 and 14, and G and D, a reinforced concrete wall with a thickness of 20 cm has been designed, with appropriate thermal insulation and a veneer wall of solid bricks, 12 cm thick.

The floor slab of the Palace is 16 cm thick and made of C25/30 concrete, double-reinforced with Q524 mesh reinforcement. In the section of the Palace in axis D, between axes 6 and 13, the floor slab is supported on a robust concrete foundation. In this part of the foundational structure of the Palace, as mentioned earlier, soil reinforcement using the jet grouting method was performed, resulting in a soil bearing capacity of around 7 MPa.

All structural elements of the Palace have been designed to withstand appropriate loads in accordance with relevant standards - Eurocodes.

The Palace upon completion of the repair and reconstruction work is depicted in Fig. 8-14.

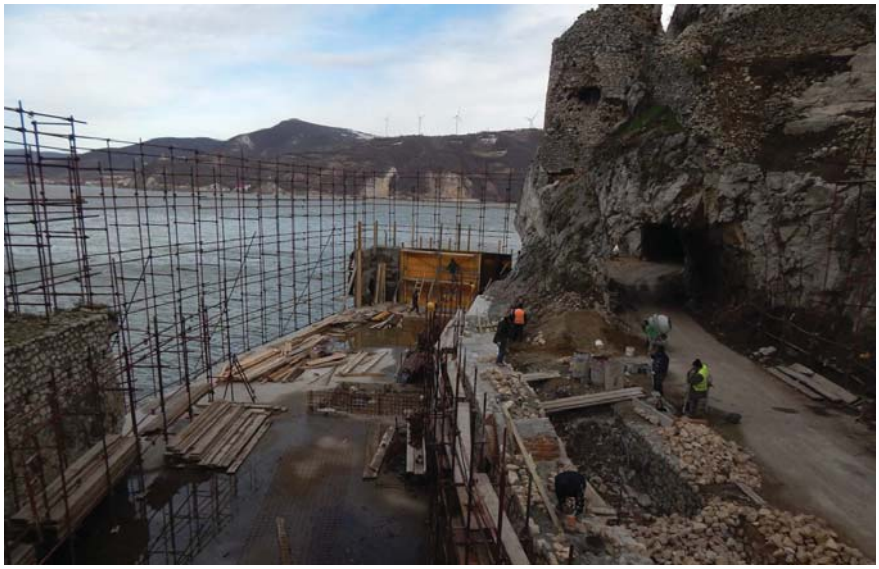

Fig. 8. Commencement of work on the above-ground part of the structure

Fig. 9. Assembly of glued laminated roof structure

Fig. 10. Assembly of glued laminated roof structure

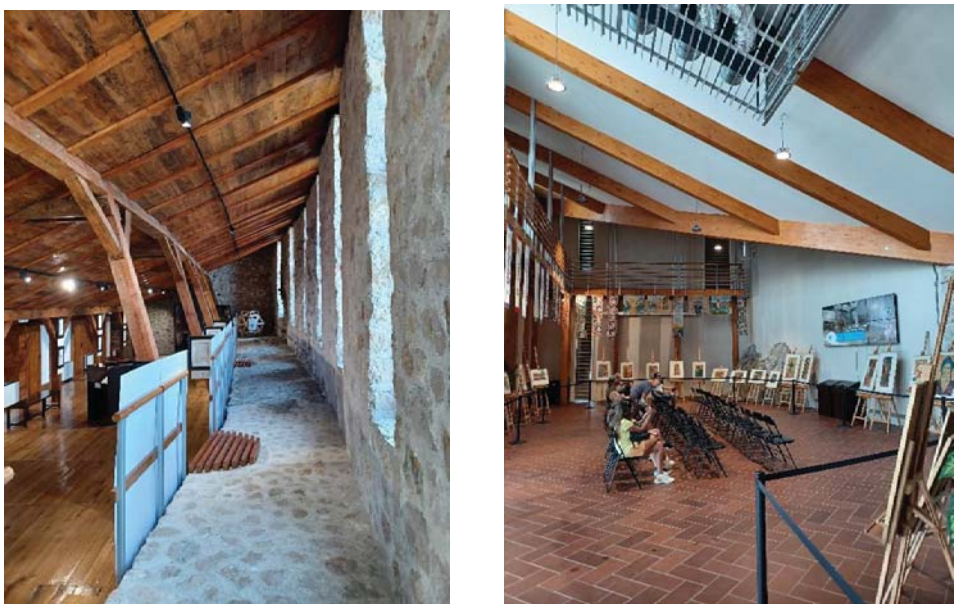

Fig. 11. Current interior of the Palace. Left, traditional timber structure; right, modern glued laminated timber structure

Fig. 12. The Palace before reconstruction

Fig. 13. The Palace after reconstruction

Fig. 14. The Palace after reconstruction