doi.org/10.62683/SINARG2025.114

Research paper

STRUCTURAL CONDITION ASSESSMENT AND REHABILITATION PROPOSALS - CASE STUDY PARTIZAN SPORTS COMPLEX IN MOSTAR

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Abstract

In this paper structural assessment of Partizan sports complex in Mostar, Bosnia and Herzegovina, is presented. The sports complex was damaged during 1993., and since then did not had significant rehabilitation activities. The complex is composed of three parts: main building, sports ground and locker rooms. Main building and locker rooms are from Austro-Hungarian period and were used as administrative buildings prior to 1920. Afterwards it was used as a sports complex, and a sports ground was added in the middle of the last century. According to UNESCO plan of rehabilitation this complex has high priority for rehabilitation, considering location. Only the sports ground is still in active use, since it did not experience significant damage. The complex was entirely detailly inspected, first by visual inspection, followed by in-situ test to evaluate quality of the materials. In the end, the rehabilitation proposal for the buildings and sports ground with appropriate strengthening methods and new design is presented.

Key words: *rehabilitation, assessment, stone, damage*

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1. INTRODUCTION

Due to its geographical location, the city of Mostar represented an extremely important military and strategic stronghold as early as the period of Ottoman period in Bosnia and Herzegovina. Mostar remained a military center during the period of the Austro-Hungarian Monarchy, the Kingdom of Serbs, Croats and Slovenes and Yugoslavia. Known as the "Military Camp," Mostar had, by the end of the 20th century, four military camps within the city itself (Northern, Southern, Eastern or Konak and Western) [1]. During four decades of Austro-Hungarian period, new modern barracks and fortifications sprang up on the surrounding hills, which to this day remain true marvels of craftsmanship — showcasing near-luxury and extravagance in white dressed stone [2]. The core of the city's defense consisted of the defensive barracks Nordlager (Northern Camp – today Dzemal Bijedic University of Mostar), as well as the Sudlager (Southern Camp, which also housed the military hospital), Westlager (Western Camp — today the University of Mostar) and Ostlager (Eastern Camp — Konak) [1].

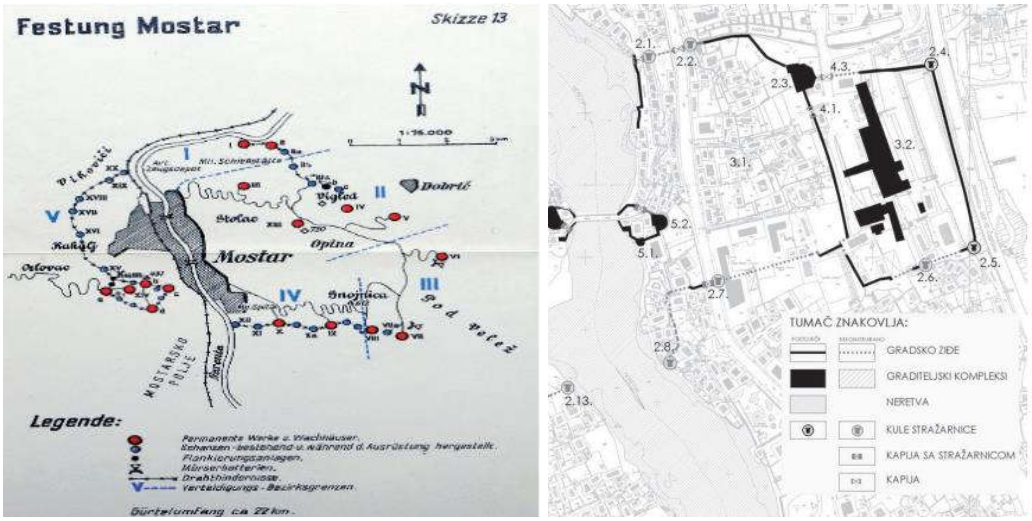

Figure 1. Barracks in Mostar and Konak [1]

The Mostar Konak is a complex that housed the military until the 1990s. Today, the complex — more precisely, its largest building — is home to the Secondary School of Civil Engineering and the Secondary School of Economics. The surrounding buildings, those that have not been abandoned, serve various purposes: an Archive, a Veterans' association and others. The surrounding towers and the open spaces are devastated. The Partizan sports field is located within the Konak complex.

The materials used for the construction of all types of buildings from this period were traditional, such as stone, fired clay products (brick, roof tiles), wood, sheet metal, lead, iron, gypsum, lime and others [3]. Stone, brick, wood and iron (iron beams — traverses) were used as the main materials for the construction of the building's vertical and horizontal load-bearing structures. The stone used for building construction was quarried from local sites (Mukoša), primarily from Tenelija and Miljevina, although for special needs of representative buildings, stone was imported from Brač or from Austria-Hungary [4].

The building was constructed between 1893 and 1901 as part of a higher girls' school. It was built by a businessman, and later the then-mayor of Mostar, Mujaga Komadina, and was

subsequently sold to the municipality. The building served educational and administrative purposes [1].

The Partizan complex is a traditional masonry structure from the Austro-Hungarian period, built from stone and mortar. Parts of the buildings also include sections made of brick and wood, which were used for the construction of the roof and floor structures. The exception are the stands, which were made of concrete. The types of stone found at the Partizan sports field include limestone ("živac") Tenelija and Miljevina stone.

The entire complex consists of four separate parts that together form a single unit. The complex of the Society for Sports Recreation and Physical Education "Partizan" covered an area of 2027 m², of which the courtyard occupied 173 m², the administration building 486 m², the gymnastics hall 242 m² and the field and stands 1126 m².

The structure of the buildings consists of massive stone walls built with lime mortar, with thicknesses ranging from 40 to 60 cm. The floor structures were made of timber, characteristic of the construction period. The building was significant damage and fire during the 1992–1995 period and there were also subsequent fires. Some parts of the complex underwent certain interventions, but it is unclear at which stages they were carried out and for what purpose.

2. CONDITION ASSESSMENT OF THE BUILDINGS

2.1. Visual assessment

The easiest way to collect data about a building is by reviewing the existing project documentation. However, for buildings from the Austro-Hungarian period, such as this one, the documentation is often lost or destroyed. Moreover, due to numerous interventions over the years, the original project no longer accurately represents the current state of the building. Visual assessment of the damaged structures includes precise measurements, a detailed description of observed damages, an assessment of their severity and the conclusion regarding the possibility of continued use of individual parts of the structure [5].

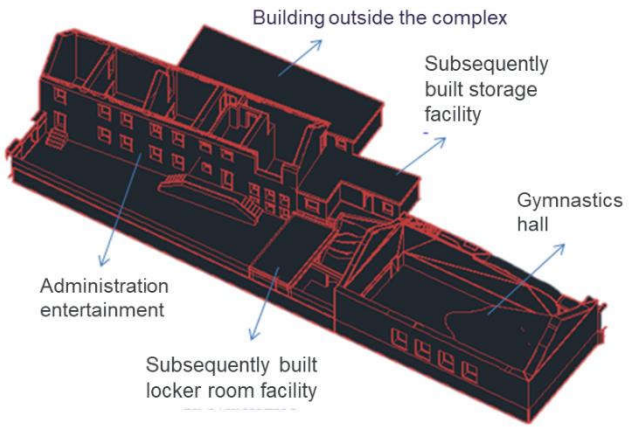

Figure 2. The current state of the Partizan complex

The building, which is assumed to have served for administrative purposes, has a rectangular base with an additional L-shaped part that forms a single unit. The second unit consists solely of the sports field with stands, next to which is another building, for which there is no data regarding its function, but it is assumed that it housed the locker rooms. The administrative buildings are connected to the rest of the complex by stairs leading to the sports field, which is in the courtyard of the third building, i.e., the locker rooms.

Due to the complexity of the "Partizan" complex, we will introduce the following designations for the units:

- Building A – The sports field with stands
- Building B - The administrative building
- Building C – Building intended for the locker rooms

2.1.1. Damage of building A

Upon entering the sports field area, it is evident that there are numerous damages caused by various factors. The stands have various physical damages that occurred from grenade impacts during the war, while the remaining significant damages are due to large tree roots that have destroyed much of the stands. There are mechanical damages as well as significant material loss. The entire wall shows signs of joints washout, the crown (top layers of stone) and the wall cap are missing. The most notable damage on the wall is the damage to the buttress and the damage at the window location—both areas have been identified with dense vegetation, such as trees (Fig.3). The stands consist of concrete slabs 15-20 cm thick, laid on a foundation of compacted earth (Fig.3). An additional issue regularly encountered is the runoff rainwater that flows from the surrounding area, accumulating on the field and causing problems for adjacent buildings. The field is made of concrete slabs, which have been better preserved than the stands, but there are still damages to the surface layers and cracks.

Figure 3. Damage to the wall and stands of building A

2.1.2. Damage of building B

The administration building has significant damage from a fire to which the building was exposed. The eastern and northern external facades do not show major structural failures, except for localized detachment of stone blocks (Fig. 4). The walls are stable and in relatively good condition. The building also shows damage from vegetation that has covered its interior, so the true condition of the building could only be assessed once the rubble and vegetation are removed. However, localized damage around the windows and wall cornices is present throughout the entire wall. Around some windows, the detachment of stone blocks is visible (Fig.4). The detachment of blocks is also visible on the cornices beneath the roof. The existing mortar is in very poor condition, with large sections of the building either missing or damaged, and in some places, it is visibly detached from the wall.

Figure 4. Damage to the walls and interior of building B

The roof of this building was destroyed during the fire and because of the collapse of the wooden structure that it rested on, the material at the support points was crushed. Remnants of the wooden structure are inside the building and the effects of the fire are visible on them. The floor structure also suffered from the effects of the fire and was completely damaged.

2.1.3. Damage of building C

The stone walls are in good condition; however, further testing will determine their actual state in terms of mechanical properties. A large part of the building is missing the mortar and sections of the wall (Fig.5). As for the roof structure and the floor structure, they are completely destroyed. The interior of the building is filled with rubble and vegetation.

Figure 5. Damage of the building C

2.2. In-situ and laboratories testing of materials

An in-situ and laboratory testing of the stone from the interior of the walls were carried out on the Partizan complex with the aim of determining the load-bearing capacity of the existing walls.

In situ analysis with rebound hammer was carried out on B and C buildings, on eight positions, on each building four position with five samples (table 1).

Table 2 presents the results of the testing of the physical and mechanical properties of miljevina stone from the buildings.

Table 1. In situ analysis with rebound hammer

Location/building	1C	2C	3C	4C	5B	6B	7B	8B
Compressive strength (MPa)	22.0	11.8	16.4	19.8	16.0	17.4	18.2	23.2

Table 2. Mechanical properties of miljevina stone

Property	Density (kg/m3)	Compressive dry strength (MPa)	Compressive strength water-saturated (MPa)	Flexural dry strength (MPa)	Absorption (%)	Porosity (%)
Average	1834.45	24.84	17.30	3.18	12.50	22.92

The ultrasonic testing method was applied to the walls of all three buildings in order to assess the uniformity of the material structure, detect voids, cavities and cracks, the obtained results are presented in Table 3.

Table 3. Ultrasonic testing

Sample/building	T	L	v (km/s)
A1	0.00007440	0.00014300	1.92
A2	0.00014400	0.00016200	1.12
A3	0.00007550	0.00012500	1.66
A4	0.00007150	0.00012400	1.73
A5	0.00009610	0.00014800	1.54
A6	0.00007910	0.00012500	1.58
A7	0.00019720	0.00030000	1.52
A8	0.00012600	0.00026000	2.06
B1	0.00003710	0.00005148	1.39
B2	0.00005220	0.00012748	2.44
B3	0.00006740	0.00011000	1.63
B4	0.00011240	0.00021000	1.87
B5	0.00009340	0.00019000	2.03
C1	0.00007300	0.00012700	1.74
C2	0.00004200	0.00011300	2.73
C3	0.00005800	0.00013400	2.30
C4	0.00005600	0.00013500	2.41
C5	0.00004000	0.00007600	1.93
C6	0.00005500	0.00020500	3.73

The results of the testing of Miljevina stone indicate a decline in mechanical properties, caused by exposure to weather conditions over a period of 30 years, as well as by the fire to which Buildings B and C were exposed. To preserve the load-bearing walls in the reconstructed building, it will be necessary to strengthen them or to develop a new load-bearing system, while retaining the existing walls as facade – decorative elements.

3. REHABILITATION PROPOSAL

Following the complete diagnostic assessment of the building—which included collecting existing documentation, an on-site visual inspection, building measurements, and testing of material samples both in-site and in the laboratory—the next step in the restoration of the “Partizan” Sports and Physical Education Complex is the proposal for reconstruction.

The proposed reconstruction of the complex aimed to restore the former glory of the “Partizan” Sports and Physical Education Society, wrapped in a new appearance. The main goal of the reconstruction was to preserve the significance and spirit of the complex, while restoring its original function through modernization [6].

The entire complex is located in the central old zone of the City of Mostar, which is a very demanding site, and it is necessary to ensure access for machinery for clearing and further construction work. Partial demolition of Building B is required and must be rebuilt afterward in order to allow machinery to move freely and clear the site. Demolition is also necessary for the reconstruction of Building A (the stands).

In terms of the construction and repair sequence, the first step is the wall behind Building A, which will be supported with buttresses to stabilize it. Once the retaining wall is reinforced, the reconstruction of the stands will follow, along with the partial demolition and then construction of the playing field. Due to proximity and practicality, the first building to be reconstructed around the field will be Building C, followed by Building B.

Building C is located adjacent to the playing field and will function as a service building for the field, with its original purpose being locker rooms for the two teams on the ground floor (Fig.6). The attic is designed as a gym. The load-bearing issues of the stone walls is solved with designed a skeleton system of reinforced concrete columns and slabs. When renovating the walls, the existing mortar needs to be removed from the surfaces beforehand. Due to the completely destroyed roof, a new wooden roof structure has been designed. The calculation for Building C has been fully performed using the Tower8 software.

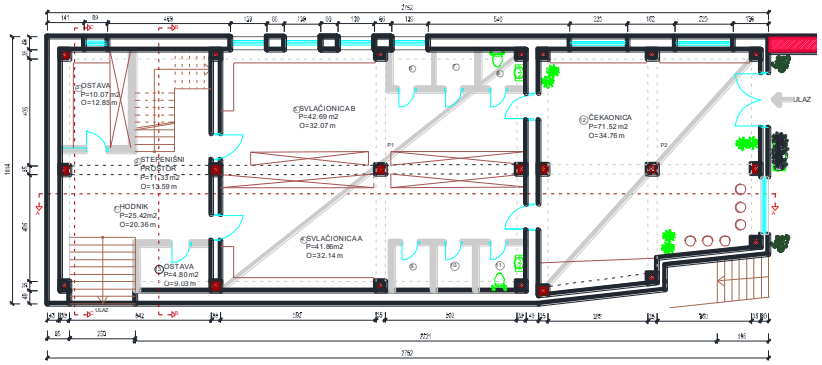

Figure 6. Floor plan of building C

At the entrance to the complex is the largest building, Building B, which is designed as a combination of administrative space and functional space that could be used for various activities. The space on the next floor is envisioned as a gallery space and office area, which would be equipped with a cafeteria and seating area. As with Building C, a skeletal load-bearing system of reinforced concrete columns and slabs, with a wooden roof structure, has been designed. It is also necessary to remove the mortar from the existing facade walls (Fig. 7).

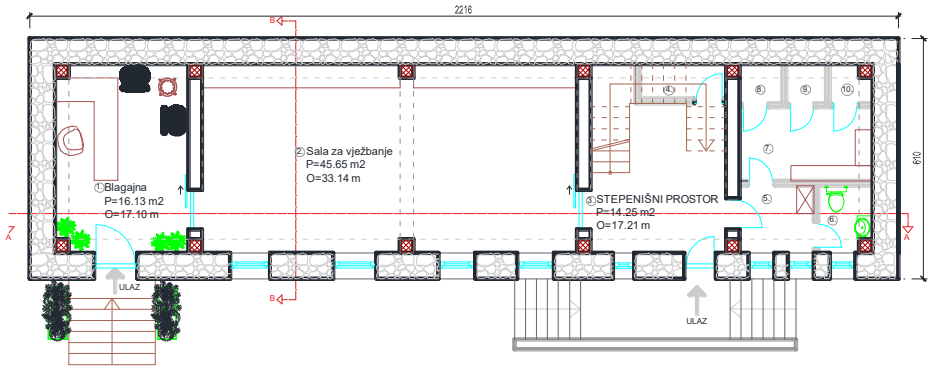

Figure 7. Floor plan of building B

4. CONCLUSION

The paper presents assessment and a proposal for rehabilitation measures for the existing structure of the "Partizan" complex in Mostar. The complex was built during the Austro-Hungarian period and consists of two high-rise buildings and a sports field with stands. The inspection of the buildings and laboratory testing of the stone indicate that the current condition of the structure is low, and that appropriate interventions are necessary before beginning rehabilitation work. The proposed rehabilitation measures include certain modifications to the foundations, load-bearing walls, and floor structures, while the repair of the staircases and the roof is proposed to be carried out as close as possible to their original appearance. The biggest modification involves the floor structures, as they need to be completely rebuilt. In this way, the current masonry structure, which has been exposed to external influences over time and whose load-bearing capacity has been reduced, would be completely relieved; it would only support its own weight, while all additional loads would be carried by the new reinforced concrete structure.

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