Assessment of masonry structure "Radnički dom" in Mostar

Amra Šarančić-Logo, Marko Ćečez, Merima Šahinagić-Isović
Dzemal Bijedic University of Mostar

E-mail: marko.cecez@unmo.ba

Abstract. The paper presents the assessment of the building “Radnički dom” (Workers' Home) in Mostar, which was built in the Austro-Hungarian period, and represents one of the buildings of cultural and historical significance, located in the area of the historic urban core of the city. The paper explains the steps in assessing the condition of the existing structure, which include the collection of existing documentation, structural inspections, tests and calculations, and the assessment and decision on further action. The paper presents the drafts and gives descriptions of the performed visual inspection and the performed static calculation of the existing structure. At the end of the paper, recommendations are given for the rehabilitation and consolidation of the walls of the building: classical methods (injection and grouting) as well as modern methods (carbon strips). The paper points out the complexity of the procedure for the restoration of cultural and historical heritage buildings, the need for valid expertise of the condition and causes of building degradation, the importance of designing details of new structural elements and their corresponding and adequate connections with the original structure of the object.

1. Introduction
The historic urban core of the city of Mostar abounds in buildings from different historical periods, from the pre-Ottoman, Ottoman to Austro-Hungarian periods. All these objects have experienced, for various reasons, a significant degradation of the basic constructive elements. More recently, there has been an increase in tourism as the leading tertiary activity in this region. The area of the historic urban core, recognized as a cultural monument in the middle of the 20th century, has been revalorized in the last 15 years from the point of view of cultural and historical heritage protection, and appropriate protection measures have been defined by national heritage protection institution. Part of the area of the historic core was inscribed on the UNESCO World Heritage List in 2005 (https://whc.unesco.org/). From 1998 to 2004, the renovation of buildings in the historic urban core took an active part. The conservation of a number of buildings from all historical periods continues today, but with a different approach, more precisely with the different attitude towards heritage.

Challenges in the conservation of cultural and historical heritage (conservation meaning general approach and not particular technique) are numerous, such as the choice of original, identical or modern but appropriate materials, preservation, as much as possible of the traditional way of construction, and similar conservation-constructive challenges and aspects of performing the necessary works. In addition to the above, there are a number of requirements and restrictions, especially in the process of adapting buildings to new purposes and requirements for use. Namely, it is very important that during the intervention, in the process of planning and execution, there is no damage or loss of those characteristics.
of the object that give it importance or make its values, affect the authenticity, integrity and / or originality.

In the current practice of working on objects of cultural and historical heritage and in historical cores, certain principles and principles of action have crystallized. Some of the relevant ones for this paper can be formulated as follows [3]:

- not to "invent" or "falsify" the historical features of the object / environment,
- not to copy the heritage of other environments and cultures,
- ensure a clear legibility of the intervention, i.e. without conspicuous emphasis on the new as well as without changing the authentic and original,
- ensure readability and presentation of the historical stratification of buildings,
- not to adapt the objects of cultural and historical heritage to new contents, but to adapt the content to the given space and construction,
- use, as far as possible, materials identical to or identical to those found on the building.

In the area of the historic urban core of Mostar there are a large number of buildings of cultural-historical and / or ambient values, in which the basic elements of the structure are largely damaged by war destruction or degradation during a long period of lack of maintenance and / or exposure to atmospheric influences. The approach to conservation may be similar for several buildings; although there are common elements in all buildings, the solution to each problem is individual and depends on a number of specific details [1]. Solving these problems considers following steps: determination the characteristics of the basic materials of the building, and the possibility of applying new materials, in the spirit of the original construction of the building [3]. In this way, in compliance with all conservation guidelines, we conserve or restore buildings as much as possible on the original condition. Buildings become not only new polyvalent spaces in the city center, but also make a significant contribution to the appearance of streets in the historic urban core. Proper approach to conservation directly contributes to the preservation and presentation of the values and significance of the historic urban core of the city, the rehabilitation of buildings as well as ambient values of the streets and, ultimately, life in them.

Figure 1. West facade of the "Radnički dom" building

The procedures and tests of structures themselves require a multidisciplinary approach, observation of the building in the construction, urban, conservation and architectural aspects [2]. In a number of examples in the area of Mostar, the approach was one-sided, so we have witnessed how during the "renovation" some of buildings lost their originality, values, and some became inconsistent with the environment, threatening the monumental features of the historic core.

The basic principle in working on objects of cultural and historical heritage is to respect the existing or original and authentic condition, which we determine through authentic documentation [1]. Respect refers primarily to design, construction and construction details, and materialization. This can be quite difficult, be-cause for most buildings from the 19. century or older, generally do not exist or it is difficult
to find the original designs and photographs, and the buildings are often more or less changed over time. In conservation practice, the application of the principle of analogy in some cases is a solution for buildings that have been significantly changed or damaged over time, and there is no authentic documentation on their original appearance. The application of the principles must be based on detailed research and analysis and clearly explained in the project documentation. During conservation works, it is necessary to use materials of the same or identical origin as much as possible, and to return the original material back to the building if the decomposition procedure was necessary. Of course, the application of new materials and construction techniques is also possible. The degree of application of new materials as well as the type of the same directly depends on the degree of authenticity and integrity, i.e., the values of the object on which it operates. For buildings such as the Radnički dom building, since its basic value lies in the exterior design and streetscape, new types of mortars and grouting methods can be used to consolidate the walls and inject agents to create an anti-moisture barrier. When forming the slabs, foam concrete or granular slab structure with gypsum boards or similar can be used (drywall). On the other hand, however, it is necessary to preserve as much as possible the elements of the building that characterize the facades, especially the street one. Profiles (in stone or mortar), due to the exceptional degradation of the elements over time, need to be upgraded with elements of similar composition, and the joint should be reinforced with graphite or other sticks. During the procedure, it is necessary to fully preserve the design of the profile and its position on the facade. Plaster, as one of the key parts of the appearance of the building from the Austro-Hungarian period, must be examined in detail with regard to mechanical and chemical characteristics, as well as color. Testing is necessary in order to be able to determine the properties of the material from which the new plaster will be made or to repair the old ones in places, and to define the color of the object. It is also necessary, if new hydrophobic coatings and new binders are used, to determine their compatibility according to the chemical composition of the stone as the basic raw material from which the walls are built.

Only if it is not possible to repair the damaged element with this or similar repair, the stone or part of the facade can be replaced with new materials and elements.

The aim of this paper is to present the assessment of the building Radnički dom (Workers' Home) in Mostar in Maršala Tita Street (Figure 1). The building is today a neglected and abandoned building, of which only the outer structure of the walls remains visible. The ground floor of the building was walled up for security reasons, so it was not possible to see the entire interior of the building during investigation work. Therefore, the work is based on the basic methods and principles of facility rehabilitation.

2. Construction assessment
The main goal of structural assessment is to provide answers to questions about the condition of the observed structure on the basis of measurements and tests. It is necessary to determine the critical elements of the structure since the overall condition of the building dictates the condition of its weakest part. The assessment sequence for existing buildings can be divided into several steps [2, 5]:

− collecting or reconstructing existing documentation,
− inspecting the building,
− testing and calculations,
− evaluating and deciding on next steps.

The first historical sources and documents about the building, which was later named Radnički dom, date from 1890. The first preserved written documents about the Radnički dom building, that is, the original drawings of the building designed by the famous builder Miroslav Losse dates from September 1927. A historical review shows that this building has served several purposes throughout history and over time, various reconstructions, finishing and adaptations have been made on it (Figure 2).
During the war in Bosnia and Herzegovina, the building suffered extensive damage. In the Radnički dom building, on July 19, 2012, a fire occurred (Figure 3), during which the interior of the building was additionally destroyed, on which adequate rehabilitation and adaptation had not been done for years. The fire caused additional damage to the building. The roof of the building burned in the fire, and great material damage was done on the first floor of the building.

The Radnički dom building has a simple, rectangular floor plan, with approximate dimensions of 24.50m x 9.40m. The building is oriented with a longer façade to the west. Height is two floors (ground floor and first floor). The facility is currently not used. All visible exterior facades of the building have plastered facades. Major damage to the plaster is visible on the facades.

The base of the ground floor of the building is lined with carved stone. All openings on the facades are framed by stone chambers. All the carpentry of the building is visibly damaged, and the openings of the ground floor are walled up with concrete blocks. Due to the inaccessibility of the interior space of the slabs, this condition of the interior has not been examined in detail.

2.1. Damage analysis
After making the architectural drawings of the current condition of the building, a detailed review of the existing condition has started, and all identified damages were identified and positioned on the drawings.
During the detailed visual inspection of the structure, special attention was paid to: appearance and differences in the color of the structure surface, cracks, their size and arrangement, signs of material degradation on the structure surface, deformations on the structure, and places of leakage or water retention, i.e. on wet surfaces. Going out on the field, the following was established (Figure 4):

- greater damages to the plaster are visible on both facades,
- all the carpentry is visibly damaged, and the openings on the ground floor are walled up with concrete blocks,
- there is no roof and floor structures,
- local cracks and decay of plaster are visible all over the facade,
- damage to the cantilever part is visible on the parts of the cornice,
- inspection of the yard does not show traces of cracks or differential subsidence of the building,
- there are mostly local damages on the windowsills.

![Figure 4. North (left) and south (right) facade](image)

2.2. Testing methods
As part of the construction assessment, the next step is testing and calculations. Within the testing methods non-destructive and destructive testing can be used and should be carried out on the site of the building or in the laboratory [2]. Some common non-destructive tests that can be performed on these types of buildings are: rebound hammer, pull-out, ultrasonic, thermography, radiography etc. [6]. Since the building is in an extremely dilapidated condition, a decision was made not to test the material, and the assessment of further action was made based on previous experiences on similar structures [5].

The calculation model on which the calculation of the existing structure is performed should most adequately show the behavior of the structure, the resistance of its parts and the loading on the structure in accordance with the actual condition of the existing structure. The available documentation on the Radnički dom building did not contain data for the design of the structure.

Structural calculation refers to the design of critical points on the structure and the calculation of the entire system with realistic parameters, determined through the review and characteristics of the basic material. Based on the above, it was necessary to make a calculation of the roof structure, slabs and stairs in the program Tower 6 (Figure 5).
2.3. Assessment and decision on further action

The course of construction assessment ends with an answer to the question of what steps should be taken and how to deal with structures in the future. Recommendations for short-term and long-term activities should be made. After the analysis of the occurrence of damage, as well as the analysis of individual elements of the structure through the calculation of the existing structure, the proposal of intervention was prepared:

- Reconstruction of the slabs between the ground floor and the first floor
- Roof construction reconstruction
- Reconstruction and extension of stairs
- Conservation and consolidation of walls

2.3.1. Reconstruction of the slabs between the ground floor and the first floor. The new construction is designed as a series of IPE 360 steel girders that carry a span of approx. 860 cm and are spaced apart with a span of approx. 140 cm. A 10 cm thick reinforced concrete slab is made between the girders. The girders are not calculated as composite, but the coupling is performed to achieve a quality fit of the plate. The girders are made in the minimum class of steel S 275 J0, and the reinforced concrete slab of concrete C25/30 (Figure 6).

2.3.2. Roof construction reconstruction. The roof is designed as a gabled roof (gabled with sloping roofs). The rafters are made on an axial grid of approximately 89 cm and are made in class C30 wood. The dimensions of the rafters are 14 cm x 26 cm. The rafters of the east-west orientation rest on horizontal...
beams that rest on the wall (16cm x 10cm). The rafters of the north-south orientation rest directly on the wall. The masonry is anchored in a new reinforced concrete horizontal circle, which is performed along the perimeter of the entire building. Horizontal beams have a dimension of 14cm x 26cm and are made of wood class C30. All other wooden beams are also made of C30 class wood (Figure 7).

![Figure 7. Detail of the connection between the roof rafter and the lower girder]

2.3.3. Conservation and consolidation of walls. Which type of strengthening method will be applied depends on type of the structure, quality of the material of the existing structure, availability of adequate equipment and workers' skills and knowledge, and above all its seismic resistance [7]. Dilapidated, weakened or insufficient quality walls are strengthened depending on the nature of the damage. The basic remedial intervention to strengthen the walls is the appropriate treatment of joints. When the binder in the joints is missing or extremely dilapidated, the restoration of the joints is a much more effective remedial intervention than it seems at first glance, both in terms of ensuring the durability of the wall, and in a static sense. The work should be done with quality and appropriate materials. This requires that the joints be cleaned to a depth of 2 to 3 cm and a new binder installed [3]. It should be a lime mortar possibly with the addition of white cement. Mortar is installed in joints with mason's spoons, but there are also aids by which the mortar is pressed with a pressure nozzle. Such equipment ensures better filling of especially narrow joints (Figure 8).

![Figure 8. Mortar injection under pressure]

The next commonly used procedure for repairing and strengthening walls is ‘grouting’ [3]. It can also repair cracks and the entire structure of the wall structure. These can sometimes be separate jobs (cracks - wall structure), and some-times it can be done at the same time. Injection is most often performed through a series of injection wells arranged in the so-called chess scheme. The number of wells is calculated approximately - one well per 1 -2 m² of wall. The expected consumption of the
injection mixture ranges from about 3 - 6% of the wall volume [3]. Weakened corners of the walls of their collisions, etc. we can effectively strengthen it by installing rod anchors. Rod anchors are usually made of ribbed reinforcement (stainless steel reinforcement should be used, i.e. ordinary reinforcement should be adequately corrosively protected). These are usually bars with a diameter of 14 to a maximum of 20 mm, and a length of about 1-2 m (rarely longer with this type of construction). Anchors are installed in previously drilled wells (diameter about 20 - 30 mm, length about 20 cm more than the length of the steel anchor). Drilling, especially of longer lengths, also requires appropriate drills - drilling accessories. After the anchor is installed, the well is filled with injection mixtures, from the bottom up. For this purpose, a suitable injection tube should be attached to the steel rod. When the damage to the stone wall is pronounced and where it is not possible to apply the described method, the only remaining solution is rebuilding, i.e., to dismantle (carefully decompose) the wall and rebuild it (re-composition) using the same stone. It must be borne in mind that a piece of new stone will also be needed. When rebuilding, the masonry style of the original decomposed wall should be respected [3].

The goal of each method, traditional and modern, is to make the body of the wall compact (grouting and pointing), and to allow additional materials (mortars, shotcrete or carbon strips) to give the wall in critical sections elements that can with-stand tensile stresses. More modern methods of remediation are based on new materials, primarily carbon strips and biaxial carbon panels (panels that carry in two directions) [5].

The existing building is built of stone walls. There is plaster on the outside of the building. If larger crack systems are detected during the removal of the plaster, one of the ways to fix the walls can be with carbon strips according to Figure 9.

![Figure 9. Strengthening with carbon stripes (www.akroterij.hr)](www.akroterij.hr)

Fiber-reinforced polymers (FRP) are composite materials, developed during the 1940s for military purposes and aerospace applications, and are now used to rehabilitate and upgrade existing buildings in the form of reinforcements. The application of these fibers in the reconstruction of old stone buildings was due to the conclusion that a large number of damages to the buildings occurred due to tensile stresses in the wall that can not be overcome by classical methods (mortars and grouting) [8]. In such cases, we resort to the method of strengthening the structure with a fiber grid (Figure 9).

3. Conclusion
This paper presents the procedure of construction assessment, rehabilitation and partial reconstruction that can be applied to buildings that have certain values and degrees of authenticity and integrity in the historic urban core of the city of Mostar. These procedures are carried out for the purpose of conservation and adaptation to the new purpose of these facilities. On the example of the building of the Workers' Home (Radnički dom) in Maršala Tita Street, a building from the Austro-Hungarian period of Mostar architecture, the principle of assessment consisting of: collection of existing documentation and
drawings, visual inspections, tests and static calculations and finally evaluations and decisions and maintenance.

Methods for consolidating and strengthening stone masonry are presented, depending on the causes of degradation and/or cracking of the wall itself. Classical methods (joint treatment - grouting, grouting, wall reinforcement by plastering) are presented, as well as newer methods such as carbon strips as anti-seismic elements in wall reinforcement.

The paper aims to point out the complexity of the procedure in the conservation of historic buildings, the need for valid examination of the condition and causes of degradation of the structure, and the importance of designing details of new structural elements and their fit with the original structure of the building.

References
[1] Radić J 2010 Trajnost konstrukcija (Zagreb: University of Zagreb)
[2] Zlomušica E, Šahinagić-Isović M, Ademović N 2020 Elementi održivosti okolinskih infrastrukturnih sistema (Mostar: Faculty of Civil Engineering, Dzemal Bijedic University of Mostar)
[3] Živković Z 2015 Tradicijska kamena kuća dalmatinskog zaleđa (Zagreb: Ministarstvo turizma Republike Hrvatske Ministarstvo vanjskih i europskih poslova Republike Hrvatske)
[4] Španić M, Hadzima-Nyarko M., Morić D 2012 Strengthening of historical buildings with composite polymers Electronic journal of the Faculty of Civil Engineering Osijek e-GFOS 3 5 74-85
[5] Šahinagić-Isović M and Ćećež M 2017 Reconstruction of the municipal court, national monument building in Mostar Proceedings of the 1st International Conference on Construction Materials for Sustainable Future Zadar 718 – 723
[6] Glavaš H, Hadzima-Nyarko M, Haničar Buljan I, Barić T 2019 Locating Hidden Elements in Walls of Cultural Heritage Buildings by Using Infrared Thermography Buildings 9 2 32 doi:10.3390/buildings9020032
[7] Ademović N and Hadzima-Nyarko M 2018 Seismic Vulnerability, Damage and Strengthening of Masonry Structures in the Balkans with a Focus on Bosnia and Herzegovina Proceedings of 16th European Conference on Earthquake Engineering Solun 1-12.
[8] Šahinagić-Isović M and Ćećež M 2015 The application of fiber reinforced materials for cultural-historical heritage buildings 3rd International Conference The Importance of Place, Sustainability and heritage in a world of change Sarajevo B&H 92.