

Analysis of causes of damage to masonry walls in the historic barrack No. B-115 in the former KL Auschwitz II – Birkenau camp

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Abstract. The brick barracks in the former German Nazi Concentration and Extermination camp KL Auschwitz II-Birkenau hold historical importance and are protected by law through their inclusion in the register of historical monuments. They are also inscribed on the World Heritage List. One of these barracks is known as B-115. It was originally constructed as a temporary building during the autumn and winter of 1941 and 1942. The materials used for its construction were obtained from dismantled houses in nearby villages. The walls of barrack B-115 have sustained damage in several areas. The exterior walls have experienced corrosion due to exposure to environmental factors. Inside the barrack, there are cracks and areas where the walls are breaking apart. The most severe damage is seen in the gable walls, which have become deformed and detached from the lateral walls. Additionally, there are extensive damages in the connections between the lateral walls and external longitudinal walls. The partition walls have also cracked, and concentrated forces have caused further cracks in certain areas. By analysing the documented types of damage and their causes, the repair plans aim to address and eliminate the identified sources of damage. The renovation is designed to minimize intervention in the historical layers of the barrack while preserving its documentary value. It will also ensure that visitors have safe access to the site.

1 Introduction

The concentration and extermination camp Auschwitz-Birkenau was functioning in the years 1940-1945 [1] Construction of the Birkenau camp began with some haste in the autumn of 1941. The buildings at section BI were erected in poor atmospheric conditions and the construction material was taken from dismantling houses of nearby villages [2, 3]. During the time of the camp functioning in the sector BI, which was divided in addition into BIa and BIb, there were more than 80 buildings. Until today 45 brick barracks (Fig. 1) have been preserved. They were built according to the same site and concept plan.

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The barrack, currently identified as B-115 and historically known as number 3, is one of the remaining barracks in sector BIb. This building served multiple functions within the camp. From 1941 to 1942, it functioned as a housing barrack for prisoners. In the years 1941-1942, it was used as a housing barrack for prisoners, and in 1943 several cells were added inside for punishing prisoners. They were so called standing cells.

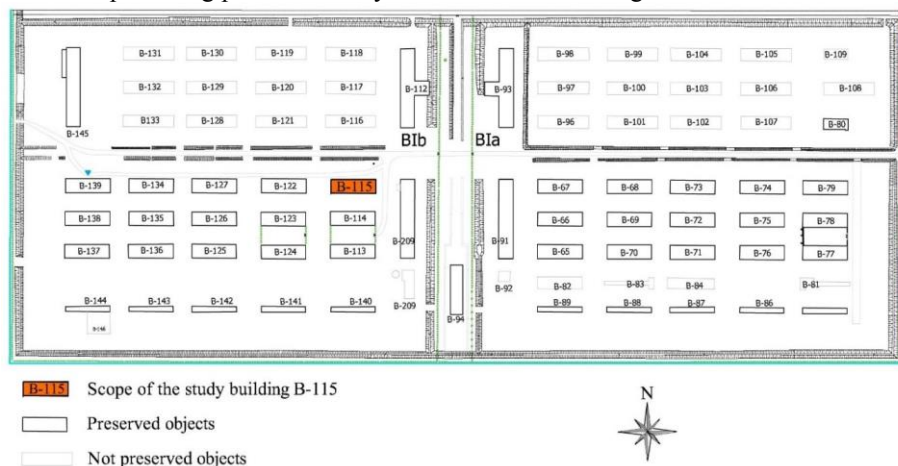


Fig. 1. Barracks in the sector BI.

Currently, due to its historical and cultural significance, this area and the remains of the former camp are under different types of heritage protection. In 1947, the Auschwitz-Birkenau State Museum in Oświęcim was established to protect and preserve the grounds of the former KL Auschwitz-Birkenau camp, along with its buildings and installations. In 1979, the former camp was inscribed on the UNESCO World Heritage List, and it was added to the Polish register of monuments in 1995.

Immediate construction work performed in the post-war years protected the barracks against total destruction but did not stop the process of aging and destruction. Currently, barrack B-115 is unavailable for visitors due to poor technical conditions.

This paper presents the main recognized kinds of damages in the brick walls of the barrack and the analysis of their causes. The performed inventory and analysis of causes were the basis for developing the project of the comprehensive conservation of the barrack. The projects also take into consideration the results of long-term tests on the buildings of section BI in terms of the state of preservation, structure of construction, plasters, and elements of the interior.

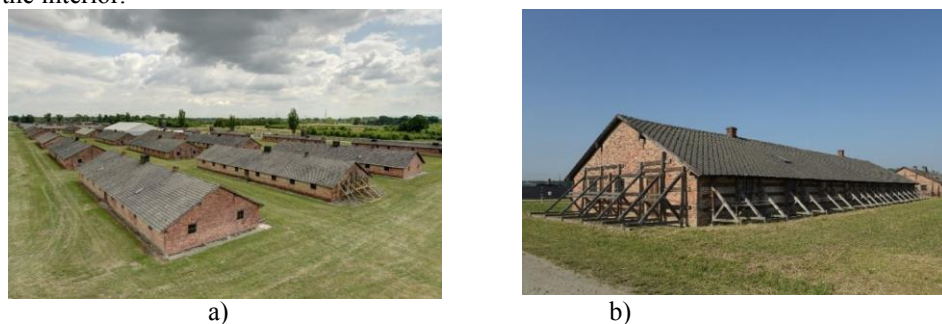


Fig. 2. Barracks on the grounds of Auschwitz-Birkenau camp: a) the sector B1, b) the barrack B-115.

2 Description of the barrack

The barrack B-115, like the other barracks at the campsite, has a simple structure [4]. It was built on a rectangular plan measuring $36.33 \text{ m} \times 11.57 \text{ m}$ (Fig. 3) and consists of a one-story masonry and wooden structure without basements. The gable roof is covered with diamond-shaped cement tiles. The main entrance is located in the central part of the building, on its north side. On the east side, a second entrance leads to separate additional rooms. The external walls of the barrack have a depth of 0.8 m to 1.1 m. The bottom part of the foundations consists of a concrete strip footing measuring 0.28 m in width and 0.4 m to 0.6 m in height. The top part of the foundations, measuring 0.25 m in width, is made of three to four layers of bricks. The footing and lower parts of the foundations are made of concrete. The foundations below the internal walls were constructed in the same way as the external walls, but at a depth of 0.7 m. The external longitudinal walls and internal lateral walls have a width of 0.12 m and are built from bricks with cement and lime mortar. Only a section of the external south longitudinal wall between axes 8-10 and 5-6 has a width of 0.25 m. Pilasters measuring $0.25 \text{ m} \times 0.25 \text{ m}$ were constructed on the longitudinal walls from axes 2 to 9. The external front walls in axes 1 and 2 were extended with pilasters measuring $0.38 \text{ m} \times 0.38 \text{ m}$. These pilasters are located in axes B and D and serve as support for the outer columns of the timber roof truss system. Partition walls, 2 m in height and arranged in the transverse direction, were placed on the flooring to divide the interior into partitions with prisoners' bunks and communication tracks. Timber beams, supporting planks forming the bunks, are placed on these walls. Inside the barrack, at the main entrance, on both sides of a small mudroom, there are two separate rooms. These rooms have a timber beam and slab system to which planks and suprema are attached. The wooden ceiling is also present above the mudroom. The building also has two chimneys measuring $0.52 \text{ m} \times 0.52 \text{ m}$, made of brick with cement-lime mortar, which extend above the roof plane.

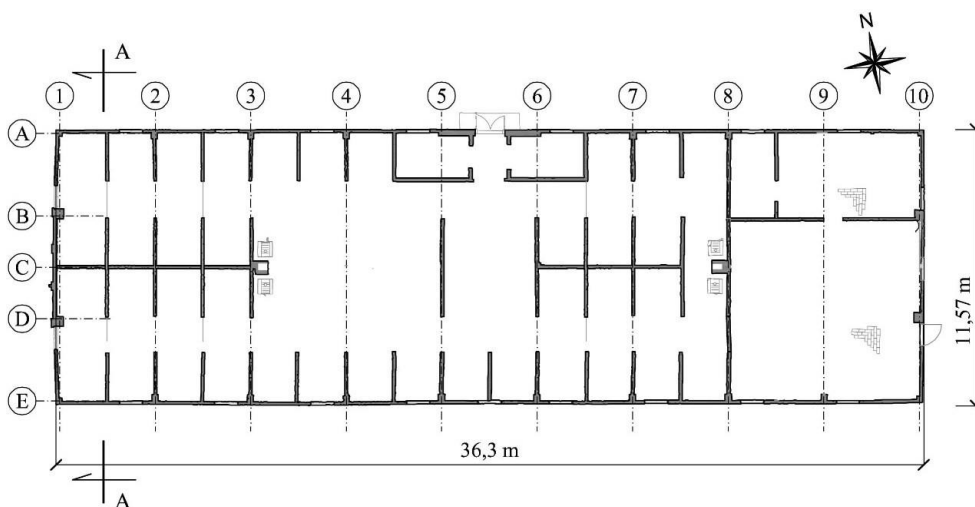


Fig. 3. The barrack B-115 plan.

The building has two types of roof structure. The majority of the building is covered with a purlin frame with doubled collar and rafter ties, which were implemented due to the considerable span of the building (Fig. 4). The rafters have different types of sections, with predominantly circular cross-sections. In this structural feature, the load is transmitted from the rafters to the purlins, and then to the columns, wall plates, and external walls.

Another roof structure is present in the eastern part of the building, which consists of three separate rooms. This roof structure does not have bottom rafter ties but includes additional restraints that form the frame system. The floors in the entire building, except for two rooms at the main entrance, are made of cement directly poured on the soil. In the two mentioned rooms, there are brick floors. On top of these floors, timber floors are placed on sleepers. The windows and doors are also made of timber. In total, there are 21 sealed windows, including 17 on the longitudinal walls and two on each front wall. There is no functioning rainwater drainage system around the building, which has contributed to its current condition.

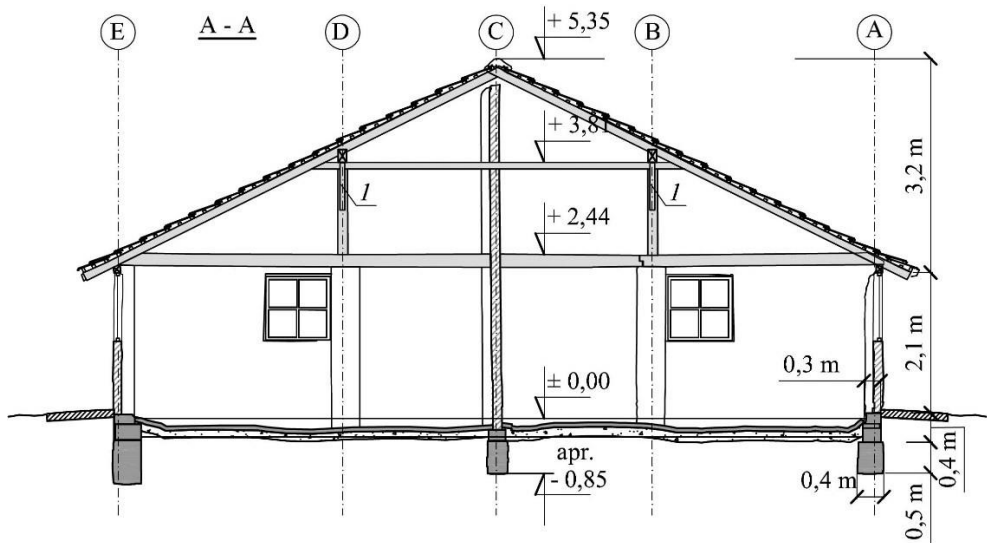


Fig. 4. Section of the barrack B-115 – its position is illustrated in Fig. 3.

3 Damage to brick walls of the barrack

The barrack B-115 is in poor condition, like the majority of brick barracks in sector BI, and is closed to visitors. There are many damaged structural and non-structural components. Specifically, there are cracks and walls breaking apart with a width of up to 79 mm, and the walls and roof elements are deteriorated. The position of five representative types of damage to the walls of this barrack, marked as "A", "B", "C", "D", and "E", is shown in Fig. 5. The aforementioned types of damage and the analysis of their causes are described below.

The most serious damage was found in the front walls, which were deformed and detached from the lateral walls. An example of such damage (damage "A", Fig. 6a) occurred at the connection between the walls in axes 10 and B. The connection between these walls is extended by the pilaster, which supports the column that acts as the outer support for the timber purlin in the roof structure. This column transmits the load to the pilaster through the horizontal beam (bottom chord) at the level of +2.29 m. Debonding was found between the pilaster and the wall in axis B. The widest debonding is approximately 80 mm at the level of +2.29 m, which is 2/5 the height of the wall from the support on the masonry foundation. The gable wall in axis 10 is deformed. This wall is bowed in the shape of an arch segment. The net deflection of the bowing is 79 mm and is at the level of the bottom chord. Debonding is observed along the entire height of the gable wall. The gradual deformation of the wall poses a risk to its structural instability. To prevent further degradation, the wall was protected with a timber retaining structure (Fig. 2b) built on the outside.

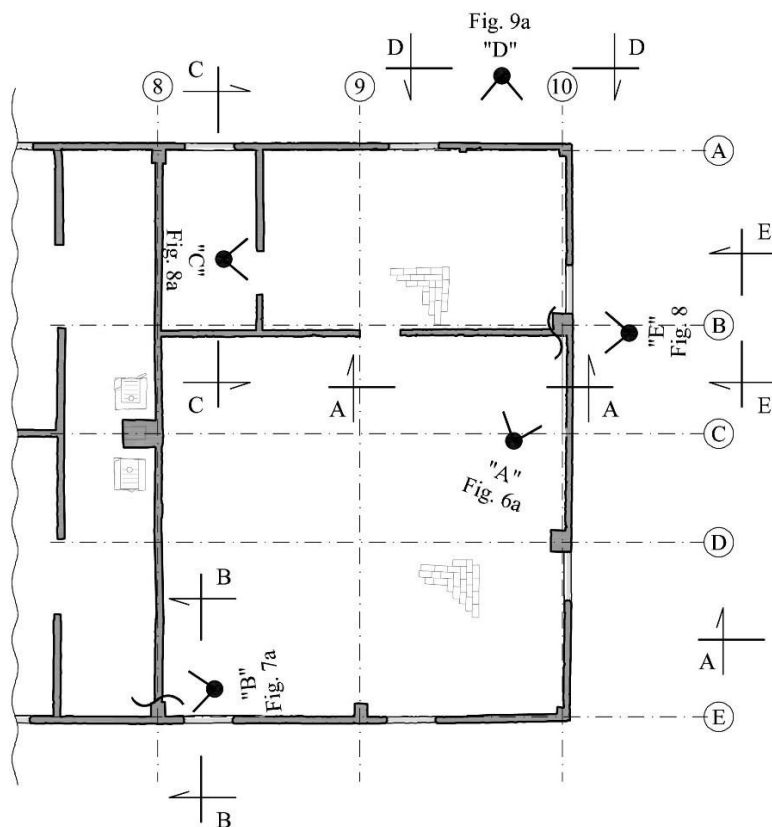


Fig. 5. Position of damage marked as “A”, “B”, “C”, “D”, and “E”.

The original cause of damage "A" is the applied construction, in which a column of the roof structure transmits the eccentric load "e" to the wall in axis 10 (Fig. 6b). As a result, the gable wall is loaded with bending moment. Tensile stresses are observed in the horizontal mortar joints of this wall, on its outer side. They cause cracks and significantly reduce the wall stiffness. Consequently, the walls are deformed and the inclination of the column of the roof structure is changed. As a result, the horizontal force Q_x is generated and acts perpendicular to the plane of the gable wall. This load results in greater deformation of the system and accelerates the reduction of the pilaster stiffness. In this situation, the connection between the pilaster and the wall in axis B is responsible for balancing the force Q_x . However, this connection did not have sufficient load-carrying capacity and was destroyed. The resulting crack propagates from the place where the force Q_x is applied to the bottom of the front wall and its top edge, but the crack disappears in these places. This is because the wall is neither displaced at the level of the support on the foundations nor at the top edges, where it is supported by elements of the roof structure - purlins and roof battens. However, the front wall has been considerably deformed at its half-height and is currently protected against structural instability with the temporary retaining structure.

It should be emphasized that similar damage is observed in another gable wall in axis A and front walls in the majority of brick barracks in sector BI on the premises of the museum.

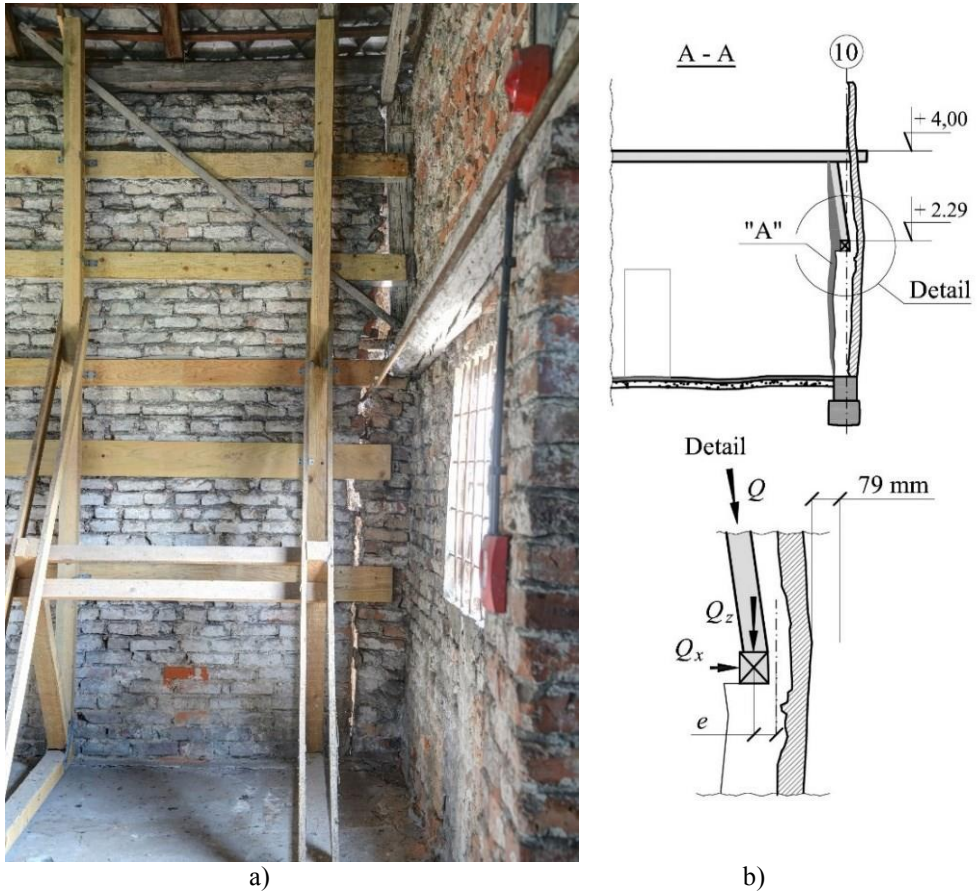


Fig. 6. Damage “A” in the place of connection between the walls in the axes 10 and B: (a) photo of the damage as shown in Fig. 5, (b) the mechanism of damage occurrence.

The second specific damage observed in the barrack is cracking in the connections between the lateral inside walls and external longitudinal walls. An example of such damage, marked as “B,” is shown in Fig. 7a. The characteristic of this damage is that the crack's widest point, measuring 43 mm, is at the level of the support of the wall plate on the masonry at +2.29 m. Additionally, this crack fades near the brick foundation of the wall. The external wall is deflected from the vertical plane, but no significant bowing has been observed.

The cause of damage “B” is the impact of the roof structure on the longitudinal wall. Sections of elements of the roof system are small, and concrete tiles impose a significant load. As a result, the elements of the roof system, particularly the collar and rafter ties, are deformed. This deformation is marked as “ ε ” (Fig. 7b). At the same time, the long wall of the barrack, supported on the foundation and not effectively connected with other walls, cannot respond to this deformation. Consequently, the longitudinal wall rotates on the foundation and is deflected from the vertical plane (marked as “ u ” in Fig. 7b). The lack of significant inflection of the wall is caused by the vertical reaction (Q_z) transmitted from the roof. Due to this reaction, compressive stresses are observed in all bed joints.

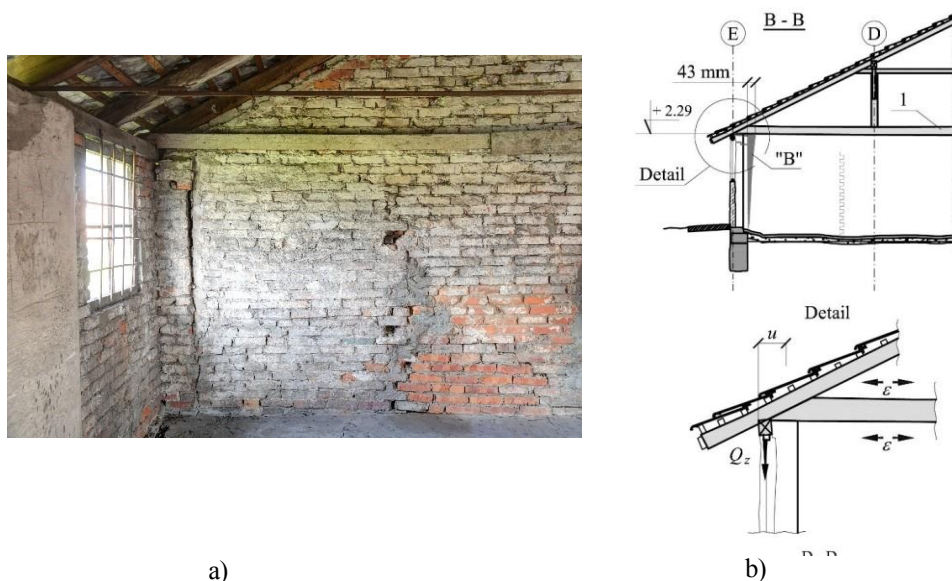


Fig. 7. Damage “B” to the walls: (a) photo of the damage as shown in Fig. 5, (b) the mechanism of damage occurrence; 1 – collar beam.

Very extensive damage, marked as "C", is on the lateral wall located between axes A and B (Fig. 8a). This damage is composed of cracks that run through the entire thickness of the wall and are arranged in a convex-shaped arch. The widest cracks, up to 10 mm, are in the middle of the wall between axes A and B. These cracks, which run towards the longitudinal walls in axes A and B, become narrower and eventually disappear in these walls. Crack "C" runs along joints and rarely goes through bricks.

To analyze the causes of this damage, the wall system in barrack B-115 was compared with the system of longitudinal walls in other barracks. This comparison indicated that originally this wall was shorter, approximately 2 m high, and served as the dividing wall between bunks. There were no foundations below the walls separating the bunks, which were placed directly on the floors. When this part of the barrack’s function changed, the existing wall was extended to separate rooms. As a result, the floor was heavily loaded, causing it to deflect. Consequently, a system of stresses was created in the wall, and the paths of the main stresses σ_2 overlapped with the direction of the observed cracks. Thus, the cracks are perpendicular to the main stresses σ_1 . The wall material has almost zero tensile strength and cannot absorb the stresses σ_1 . That is why a specific arrangement of cracks is observed, which can be described as the effect of crack bridging. The fading of cracks near axes A and B indicates that there are foundations below these walls, providing support for both the analyzed lateral wall and the longitudinal walls.

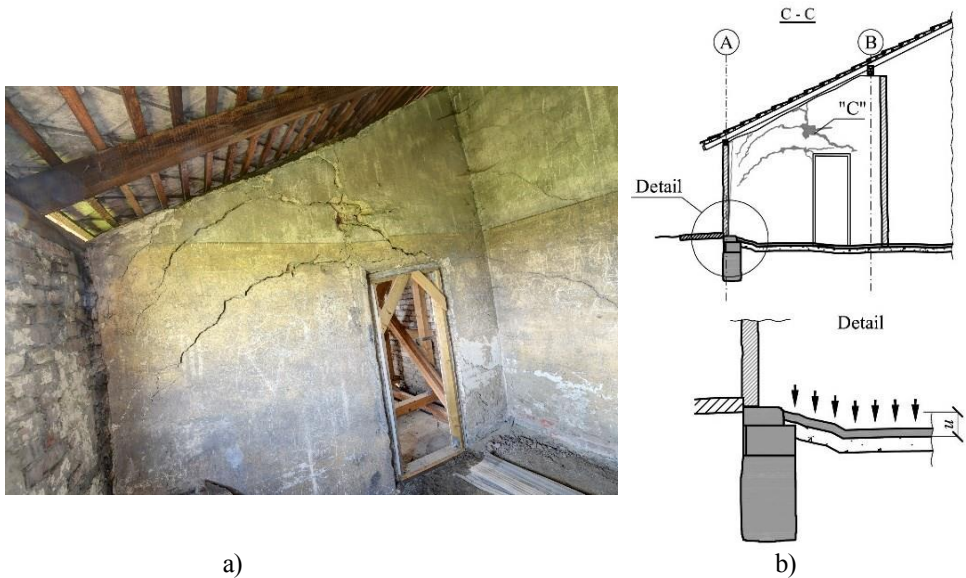


Fig. 8. Damage “C” to the wall between the axes A and B: (a) photo of the damage as shown in Fig. 5, (b) the mechanism of damage occurrence

Another damage observed in the barrack wall includes cracks with a width of up to 3 mm in the longitudinal wall, near the north-eastern corner (the damage "D" – Fig. 9a). The resultant direction of the crack path is at an angle of approximately 45 degrees, while the cracks propagate in the bed and head joints and do not go through individual bricks. Visual examination of this fragment of the barrack reveals that the walls at the north-eastern corner have been partially repaired, and the described damage reoccurs. It is the result of lowering this corner of the building, which is caused by two factors acting simultaneously. The first factor includes deformation of bricks in the bottom part of the masonry, which is in contact with the ground. These parts of the wall show the most serious signs of degradation, which are caused by the lack of efficient drainage of runoff water collecting around the barrack. The lack of a gutter system and drainage of runoff water outside the barrack plan amplifies this effect. Moreover, capillary rise of water expands the area of damp wall. It is particularly noticeable on the northern exterior wall of the barrack. Moisture retained in the wall during lower temperatures causes thawing of bricks and their degradation, which increases the degradation of this part of the wall as a result of transmitted vertical loads. In addition, the damp part of the wall creates good conditions for the growth of moss and lichen that increase deterioration. The second probable reason for lowering the north-eastern corner of the wall is less favourable conditions of foundations of this part of the barrack.

The last analyzed damage to the walls of the barrack B-115 includes cracks with a narrow width of up to 0.3 mm propagating in the gable walls, below the support for purlins (damage "E" – Fig. 10a). Probably the following mechanism is responsible for the occurrence of this type of damage. Originally, the whole reaction of purlins was taken by timber columns placed on pilasters. However, the columns were subjected to degradation over time due to corrosion and rheological deformations. The force in the columns was decreasing, and the force transmitted through the purlin directly to the front wall was increasing. The wall response to the load Q_2 was accompanied by main horizontal stresses σ_1 acting on the wall (Fig. 10b). The wall is cracked as it has limited capacity for taking tensile stresses. These cracks are perpendicular to stresses σ_1 , which means they are vertical cracks.

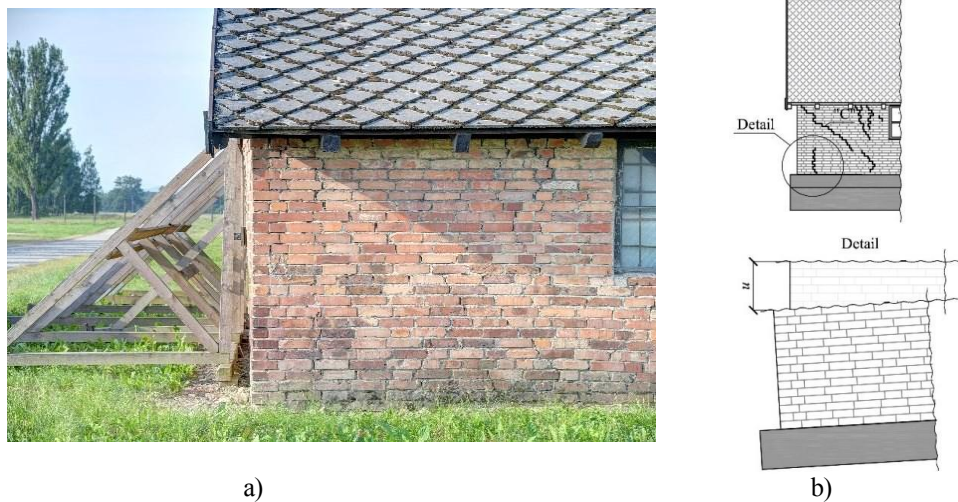


Fig. 9. Damage “D” to the wall in the axis A: (a) photo of the damage as shown in Fig. 5, (b) the mechanism of damage occurrence.



Fig. 10. Damage “E” to the wall in the axis 10: (a) photo of the damage as shown in Fig. 5, (b) the mechanism of damage occurrence.

4 Conservation of the building

While preparing the comprehensive conservation of the barrack in such a special place, that is, on the premises of the former German Nazi Concentration camp KL Auschwitz-Birkenau, it should be taken into consideration that the work is intended to secure reinforcement of construction and, at the same time, the work should be performed in a way that gives priority to the preservation of the historical fabric of the building. As a result, the work secures safe access for visitors to experience the contact with authentic remains of the camp's history.

For the brick walls of the barrack B-115, works will be performed to eliminate the causes of damage and damage itself.

Since some parts of the inside walls have no foundations and the foundation conditions are often heterogeneous, new foundations will be performed under all the walls and existing foundations. New strip footings with a rectangular section and variable height have been designed. They provide stable support at the level of -1.25 m and variable width from 0.25 m to 0.7 m. They will be made of concrete with fiber reinforcement. After providing new foundations, perimeter drainage will be performed to collect run-off water and groundwater. The foundations will be cleaned and undergo conservation works. Depending on the state of preservation, some joints may be replaced with new ones. The lateral walls will be rectified in several steps. A temporary retaining structure will be constructed outside the barracks. Then, hydraulic jacks will be placed between the wall and this temporary structure. By gradually displacing these jacks, the front walls and deflected external longitudinal walls will return as close to their original position as possible. Then, the walls will be anchored to other walls with adhesive reinforcement in joints.

The successive comprehensive conservation of brick barracks of section BI of the former Birkenau camp is one of the tasks anticipated under the Master Plan for Preservation, developed in 2009 and realized by the Auschwitz – Birkenau State Museum team [5].

5 Conclusion

The brick barracks in sector BI, including the analyzed building with historical number 3 and inventory number B-115, are in poor condition. It is likely that their lifespan was originally expected to be short, as they were constructed as temporary structures in poor atmospheric conditions. Additionally, the construction material was taken from dismantled houses in the nearby village of Brzezinka. Some of the work was done by unskilled prisoners. Currently, this area and the remnants of the former camp are protected under different heritage regulations due to their historical significance.

Due to its poor condition, barrack B-115 is closed to visitors. Many structural and non-structural components are damaged, including cracks and walls breaking apart with widths of up to 79 mm. Furthermore, elements of the walls and roof are corroded. The assessment of damage to the barrack and the analysis of its causes were the basis for planning the repair works. The planned repairs will address both the causes of the damage and the damage itself, while preserving the historical integrity of the barrack. Access for visitors will be secured.

Acknowledgments

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