

Analysis of stabilisation method of gable walls of a barrack located at the section BI of the former KL Auschwitz II-Birkenau

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Abstract. The subject of the article is an analysis of the stabilisation method of the western gable walls of a barrack with the inventory number B-123, situated at the section BI of the former German Nazi concentration and extermination camp Auschwitz II-Birkenau. The barracks of the former Birkenau have a documentary and historical value and are subject to protective conservation. A barrack with inv. no. B-123 had been erected in the last months of 1941 as a residential barrack, then it was used as a hospital facility. The barrack walls are characterised by low stiffness, because with the building's plan of 36.17 m × 11.39 m, the walls are only 0.12 m thick. Gable walls have been greatly deformed, as a result they have detached from longitudinal walls and their deflection is up to 120 mm. The construction of the walls is at risk, because a bad-quality wall is loaded with horizontal and vertical forces transmitted from the roof, on the eccentricity reaching 120 mm. Deformations are progressing as a consequence of such forces and the walls must be stabilised. In case of the western wall, it was decided to stop its further deformation and to increase the local carrying capacity by stabilising with steel elements connected with ties anchored in the ground. Given the historical value of the plasters with paint coats layers covering the wall, it was decided not to remove the wall deformation mechanically. For the eastern wall, which is not covered with plaster and was partly reconstructed after the war, the removal of its deflection by rectification was designed.

1 Introduction

The German Nazi concentration and extermination camp Auschwitz II-Birkenau operated in 1940 – 1945. The complex of barracks was started to be erected in Birkenau in autumn 1941 [1] and over time it has become the largest German concentration camp. The Auschwitz-Birkenau State Museum in Oświęcim was established in 1947 on the site of the former camp. The former camp site and its remnants were entered into the UNESCO World

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Heritage List in 1979. The area, together with all the remnants of the former camp, were entered into the register of monuments in 1995.

The barrack, with a current inventory number B -123 (camp number, Fig. 1), was built in the last months of 1941. Initially, it had been a residential barrack, and then, in the second phase of the camp's existence, it was used as a camp hospital. Some of the internal walls are covered with original plasterwork of high historical importance. The barrack's gable walls have been largely deformed, by being detached from the inner stiffening wall, with the deflection of up to 120 mm. The deflection has been constantly growing, hence it is necessary to stabilise the walls.



Fig. 1. View from the west of residential barrack with a current inventory number B -123.

A standard approach to deflected walls [2] involving their disassembly and reconstruction in a vertical position, is not possible due to the building's and the site's unique and historical character. These types of solutions are inconsistent with ethical principles and conservation practices followed by the Museum. Conservation guidelines for the Museum's structures define that the purpose of any activities within the structures is solely to protect and prolong the preservation of the historic substance. The solutions applied are so selected as to fulfil both, the rule of minimal interference in the historical substance of the objects, and to meet the requirements. For the western gable walls, deflection removal by applying pressure with hydraulic jacks cannot be used because there is no satisfactory control over such process for historical plasterwork with paint layers, and there is the risk that plasters with covering paint layers can be detached or even damaged.

The procedures described in [3, 4] provide way for the removal of a building deflection as a whole, not for its particular components. It is thus necessary to use a non-standard way of handling the barrack's gable walls.

2 Barrack overview

The barrack has no basement, a rectangular plan of $36.37\text{ m} \times 11.43\text{ m}$ and a height of 5.27 m . The roof structure is made of wooden rafter framing with a queen post system. The main trusses consisting of posts, a pair of rafters and a pair of collar tie, are in the axes 2 – 9, spaced every about 4 m (Fig. 2). The rafters installed between the main trusses are spaced 0.80 m apart. The purlins rested on posts and supported with angle braces run in the axes B and D. The roof is covered with concrete tiles. The 0.12 m thick barrack walls are made of full brick. Pilasters with the section of $0.38\text{ m} \times 0.38\text{ m}$ were formed in the outer gable walls (the walls in axes 1 and 10) and pilasters with the section of $0.25\text{ m} \times 0.25\text{ m}$ were formed in transversed inner walls (the walls in axes 2 - 9). The roof rafter posts are supported on those pilasters.

The purlins rest on posts and, supported with angle braces, run in axes B and D. Wall plates are placed on the outer longitudinal walls (walls in axes A and E), to which rafters are mounted. The inner longitudinal wall (the wall in the axis C) act as a stiffening wall. The other barrack walls act as partition walls.

The bearing walls are founded on foundation walls made of full ceramic bricks with the section of $0.25 \text{ m} \times 0.25 \text{ m}$ and on concrete footings located below, having unsteady section. Window and door openings are located in the outer longitudinal walls. Wall plates are used as window and door lintels. Two window openings with masonry lintels made above them are located in the gable walls.

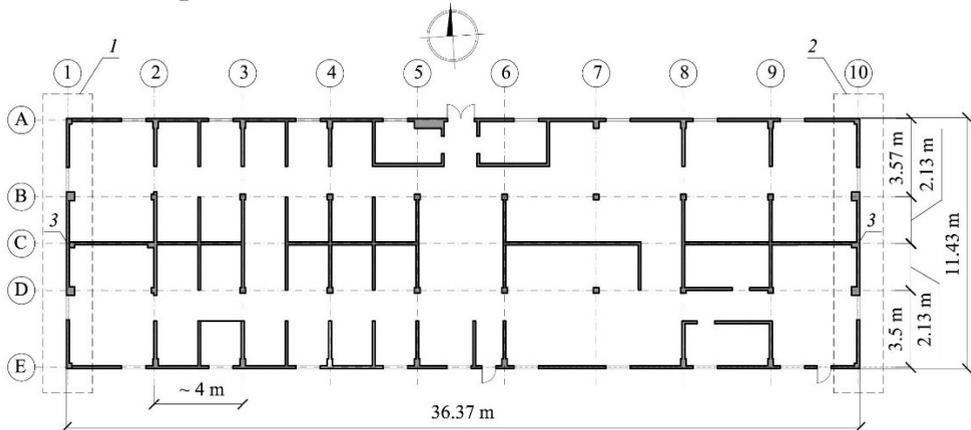


Fig. 2. View of residential barrack with gable walls marked: 1 – western wall covered with original plasterwork, 2 – eastern wall locally converted (after 1945), 3 – bending of gable walls and their detachment from longitudinal wall in the axis C.

1.1 Main barrack damages

The structural and non-structural elements of the barrack are characterised by numerous damages. Up to 10 mm wide wall cracks and splits are dominant as well as corrosion of the wall and roof rafter components. The gable walls have the most severe damages, however.

The walls in the axes 1 and 10 have detached from the axis C inner longitudinal wall (Fig. 3). Moreover, the walls have been deformed to such an extent that their bending in the out-of-plane direction, at mid-way along their length, is characterised by the deflection u_{\max} of 120 mm (Fig. 4b). It should be noted that the lower edge of the walls supported by foundations, has not been displaced. The upper edge of the eastern gable wall is slightly displaced towards the inside of the building. Generally the upper edges of the gable walls are restrained by the purlins and by the ridge beams of the rafter framing.

The primary cause of the gable walls' damage are second-order deformations. The deformations were initiated by horizontal load applied the wall through the rafter angle braces (4 Fig. 3). The deformed wall was exposed to vertical loads transmitted eccentrically from the roof rafter posts (3 Fig. 3). The rheological effects are taking place in the wall material as well. All this created the secondary static system of the gable walls after their detachment from the longitudinal walls (5 Fig. 3). As a consequence of the advancing rheological processes, eccentricities are increasing, under the influence of the vertical forces, thus with the increase in eccentricity, increase of the out-of-plane deflection of the wall accelerates.



Fig. 3. The residential barrack of inventory no. B-123. Connection of longitudinal wall with gable wall and rafter framing components: 1 – deformed gable wall, 2 – longitudinal wall, 3 – rafter framing post, 4 – rafter framing brace, 5 – detachment of gable wall from longitudinal wall.

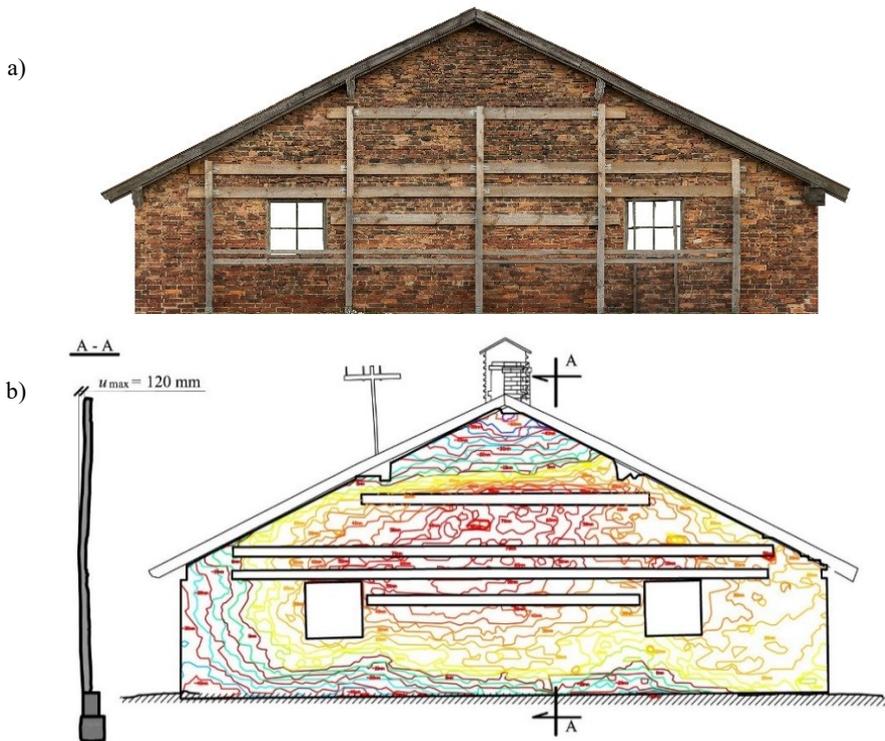


Fig. 4. The residential barrack of inventory no. B-123 .Western gable wall (wall in axis 1 in Fig. 1):
a) view (wall supported with temporary wooden framework – state before conservation works),
b) isolines of horizontal displacements obtained based on laser scanning.

1.2 Executed conservation works

The initial securing works on the site were carried out in the 60's. Numerous provisional repairs were made over the next years; the rafter framing and roof covering were repaired, the wall elements were rehabilitated.

A pilot project for comprehensive multi – stage conservation of the barracks B-123 and B-124, wholly financed by the Auschwitz-Birkenau Foundation, was launched in 2015. Its aim is also to gather experience, develop solutions and set the standards for effective conservation and protection of brick barracks on the area of the former Birkenau camp in consistency with the adopted assumptions.

The pilot project was preceded by the research on the state of preservation of the building, in particular of the load bearing elements and materials; moreover, the original elements as well as those introduced later were identified. Design solutions reflecting the data obtained were developed on the basis of the research.

For the project, a tent erected over both the barracks, to protect them for the time of conservation and strengthening works (Fig. 5a).

The works were started by repairing and securing the foundations, a perimeter drainage was made, longitudinal walls were rectified and stabilised (Fig. 5b), the roof rafter was renovated and conservation of the roof covering was performed. A number of typical conservation works were carried out at the same time such as consolidation and strengthening of plasters, and reinforcement of the paint layers, etc.

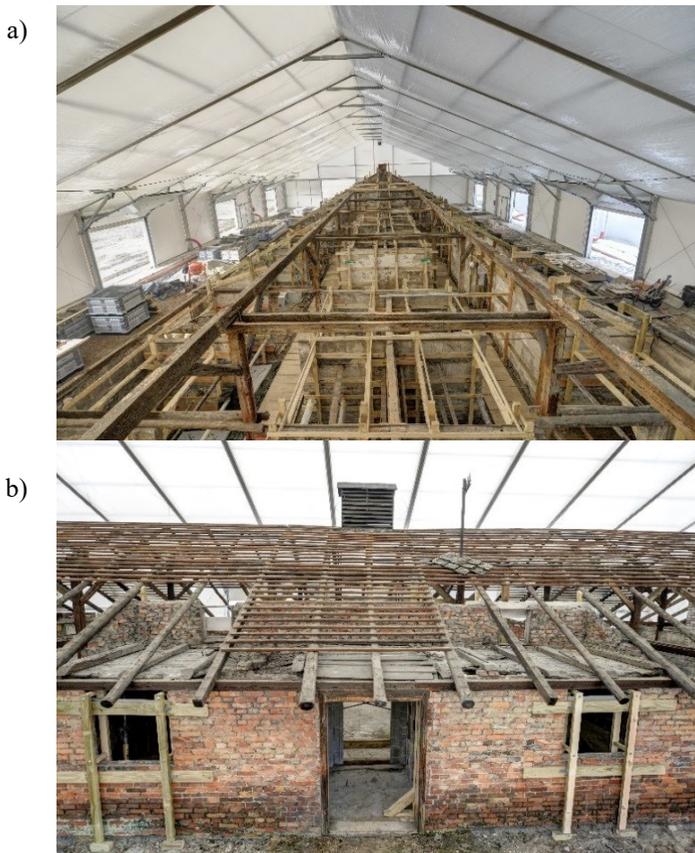


Fig. 5. The residential barrack of inventory no. B-123 during conservation works: a) barrack interiors and tent spread over the barrack, b) south, longitudinal wall (previously rectified).

3 Stabilisation of the western gable wall

Sanitary facilities were located in the rooms contiguous to the western gable wall when the camp was functioning. There is original plasterwork on this wall and on part of the contiguous longitudinal walls A, C, E (Fig. 2), and the plasters should be preserved in a possibly unchanged condition. The purpose of conservation works is to reinforce the construction in such a way that the reinforcement elements interfere as little as possible with the existing original walls and plasterwork. It was thus decided to strengthen the existing walls by supporting them (Fig. 6) and at the same time a reinforcement was introduced to bed joints to a minimum degree, only in the external part of the walls, allowing to protect historical plasters inside (Fig. 6).

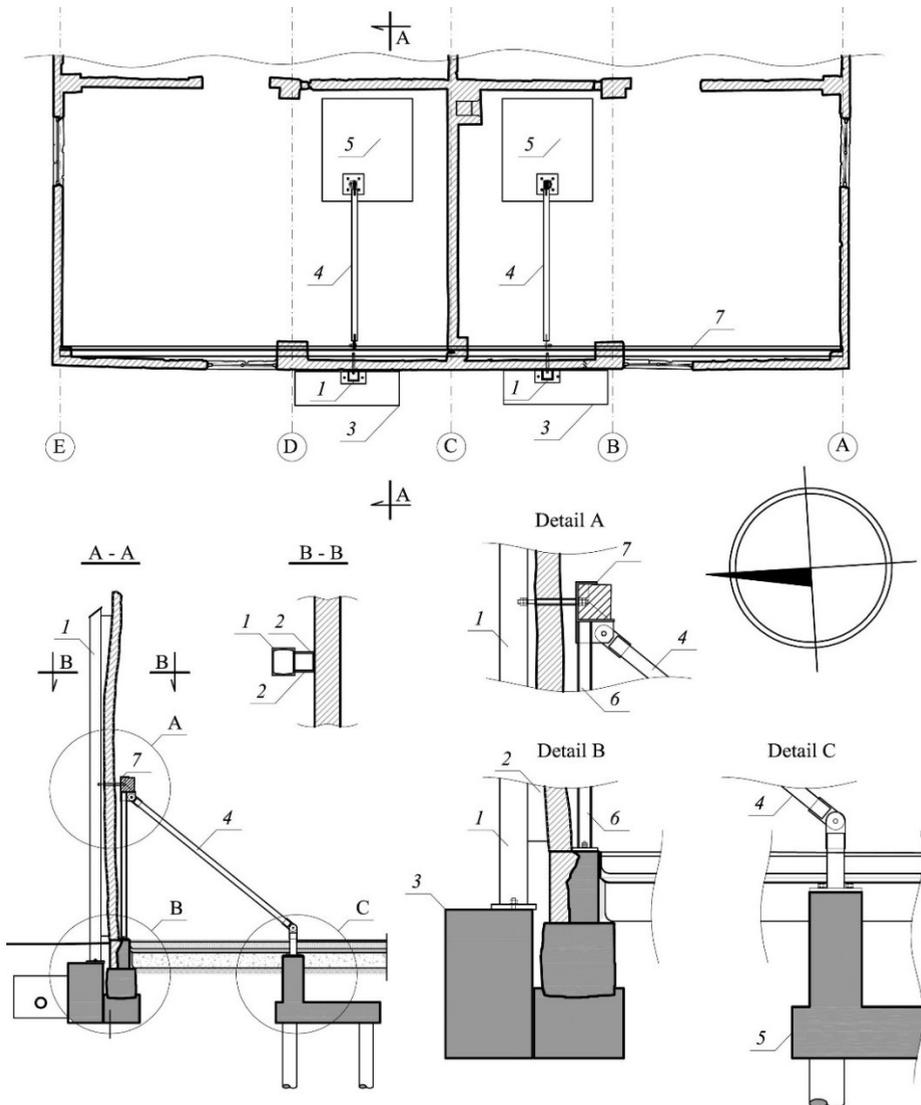


Fig. 6. Structure of the eastern gable wall's support: 1 – steel component supporting the wall, 2 – metal plates with the shape adapted to the profile of the wall cut-out, 3 – reinforced concrete foundation outside the barrack, 4 – stretched steel strut, 5 – reinforced concrete foundation inside the barrack, 6 – steel post, 7 – steel beam.

It was proposed that the steel components running in the vertical direction would be installed in the outside face the wall (*1* in Fig. 6). Their task is to reduce the progressing wall deformation in the form of a distinct bend in the horizontal direction. Due to the fact that the wall is strongly deformed, it was assumed that metal plates would be welded to rolled profiles (*2* in Fig. 6), whose shape will match the deformed wall. A vertical reaction of the elements *1* will be transmitted onto a reinforced-concrete foundation (*3* in Fig. 6), made directly by the wall outside the building. The element *1* will be connected with a stretched strut (*4* in Fig. 6), whose task is to reduce the span of the steel component supporting the wall (element *1*). The strut will be mounted to a foundation (*5* in Fig. 6) made in the centre of the barrack. It is planned to construct reinforced concrete piles under the foundation to ensure that the foundation is transmitting the tensile forces transferred by the strut. It was also assumed that the posts (*6* in Fig. 6) increasing the structure stiffness and a steel beam (*7* in Fig. 6) would also become part of the presented system. This beam acts as a tie beam of the wall and reinforces a wooden tie beam.

The following procedure was applied to estimate the value of the load acting on the steel components supporting the wall (*1* fig 6). It was assumed that an eccentrically applied load, a horizontal load and the existing wall imperfection, in the form of a distinct bend, would lead to higher wall deformation over the successive years of the building's usage. It was assumed that the deflection would manifest itself as a virtual increase in wall deflection in the middle of the wall length by the next $u_{\max} = 120$ mm. The reinforcement should therefore transmit the horizontal reaction q_{sup} resulting from such increase in deflection. A numerical model of a lateral wall was created to determine such reaction. The model's line supports correspond to the support of the wall on the foundation (*1* Fig. 7a) and to the support ensured by the walls in axes A and E (*2* Fig. 7a). On the other hand, local supports (*3* Fig. 7a) correspond to the roof structure horizontal elements (purlins in axes B, D and a ridge board in axis C). It was also assumed that a modulus of elasticity of the wall made of the low-quality brick and mortar, subjected to destruction processes, equals to 1 GPa. A substitute uniform surface load q_{eq} (Fig. 7a) was applied to the model. The load value was increased until reaching a maximum wall displacement in the horizontal direction of $u_{\max} = 120$ mm (Fig. 7b). The so obtained substitute load $q_{\text{eq}} = 8.71$ kN/m² corresponds to the effect of all forces and phenomena causing the deformation of walls. This load, in particular, corresponds to the existence of a horizontal load transmitted by rafter angle braces, to the second-order effects caused by an eccentric load on the walls by the roof structure components and to geometrical and material imperfections of the wall itself.

The load q_{eq} , determined this way, was applied to a model of the reinforced wall (Fig. 8). The model considers the existence of additional supports such as steel rolled profiles. The reaction q_{sup} , transmitted by such supports, depends on the coordinate z and varies between -5.10 kN/m and 36.24 kN (Fig. 9a). The average value of this reaction $q_{\text{sup,m}}$, understood as the integral of $q_{\text{sup}}(z)$, divided by the support's length, is 32.63 kN/m (Fig. 9b). Such a load value was a basis for dimensioning the elements of the reinforcement construction (Fig. 9c).

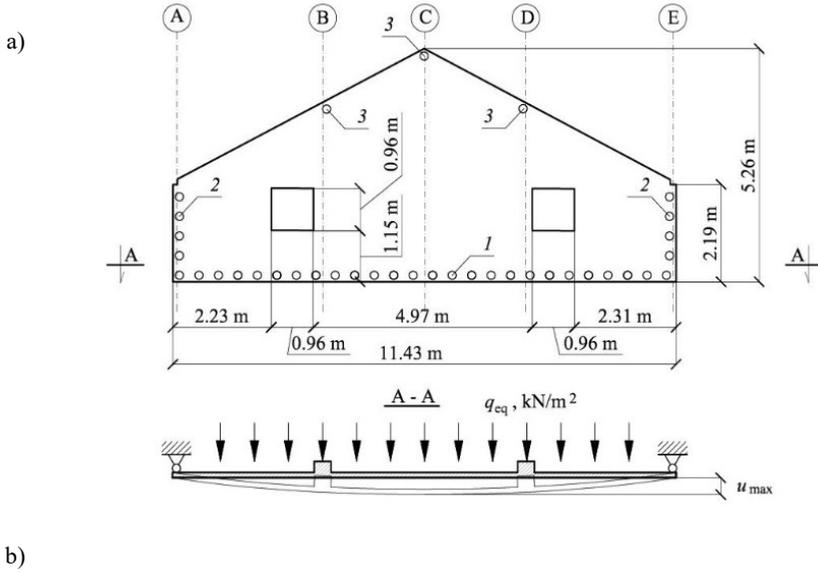


Fig. 7. Determination of substitute horizontal load q_{eq} causing horizontal displacement u_{max} of the wall: a) scheme of wall, b) model deformation corresponding to the displacement $u_{max} = 120$ mm.

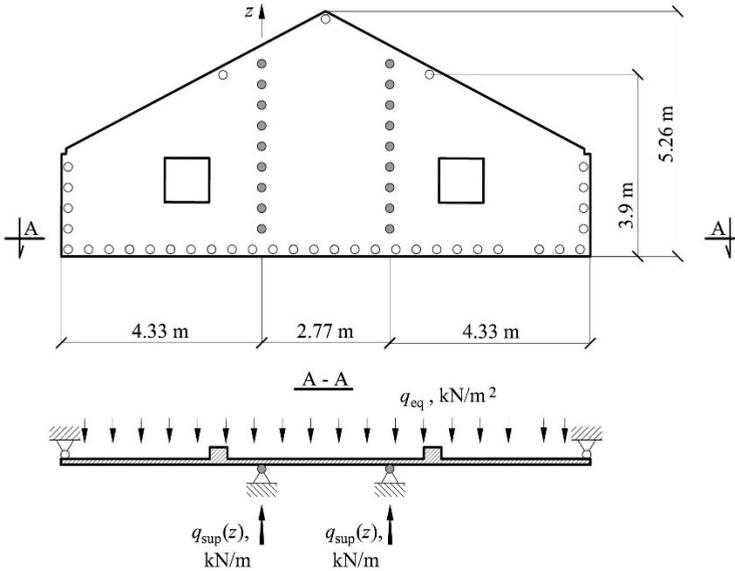


Fig. 8. The scheme assumed for determination of the load q_{sup} of steel components supporting the wall.

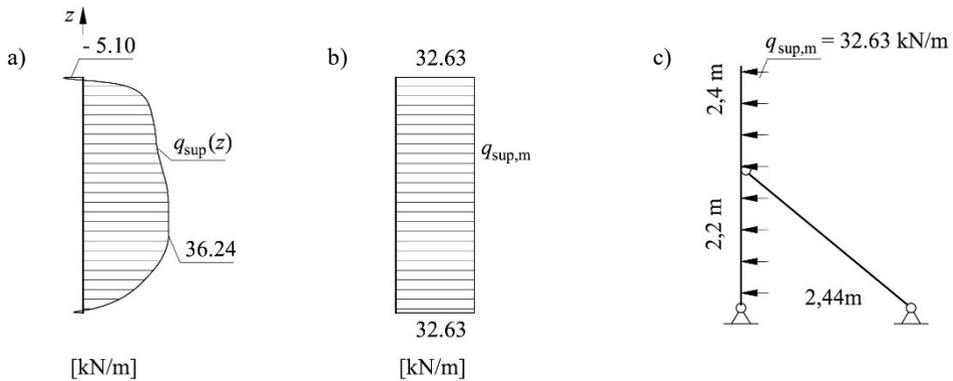


Fig. 9. a) distribution of load q_{sup} , b) average value $q_{sup,m}$ of load q_{sup} , c) scheme adopted for dimensioning the elements of reinforcement.

4 Different solution proposed for the eastern gable wall

The eastern gable wall (the wall is axis 10) was partly reconstructed in the past and is not covered with plaster of historical importance. It was therefore assumed that it would be straightened, and then stabilised in the new shape. It was proposed that the straightening be done through forces applied perpendicular to the wall surface.

After the performed wall straightening by rectification, bed joints will be refilled, and the gable wall will be anchored to the longitudinal wall in the axis C.

5 Summary

Vertically deflected or largely deformed walls are usually repaired by their disassembly and then rebuilding in the vertical position. Such activity, for the western gable wall of the barrack with inv. no. B-123, was not possible on the area of the former KL Auschwitz II - Birkenau. Both, conservation ethics as well as protective conservation standards and practices of the Auschwitz – Birkenau Museum exclude such kind of intervention or rather destruction of the historical structure of the original fabric of the buildings. Also for those reasons, it was decided not to rectify the wall curvature mechanically, as it entailed the risk of damaging substantially the historical plasters and paint layers.

Solutions were adopted providing a stop to the deformation process. The process is to be stopped by installed steel reinforcement. The reinforcement will consist of vertical elements mounted on the external side of the gable wall. Those elements will be supported on a foundation constructed along the outside perimeter of the barrack. An additional support of those elements is provided by ties anchored to the foundation inside the barrack. Such a procedure will ensure minimum interference with the original plasterwork of the structure.

For the eastern gable wall, not having the historical plaster cover, it was proposed that it be straightened with a system of forces acting perpendicular to the wall surface. It is expected that when an outcome of such interaction is manifested, in the form of wall splits in bed joints, the joints will be filled; the wall will be anchored to the lateral wall.

The presented procedures differ from a traditional procedure used for repairs of wall structures; they are, however, in line with the standards of protective conservation applied in the Auschwitz – Birkenau State Museum in Oświęcim and allow to secure both, the historical fabric of the barracks as well as a system of the structure's chronological layers, while ensuring their safe operation as places available for visiting.

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