Centrum Rzeczoznawstwa Budowlanego

Inżynieria Bezpieczeństwa Obiektów Antropogenicznych 4 (2022) 1-11
https://inzynieriabezpieczenstwa.com.pl/

Inżynieria Bezpieczeństwa Obiektów Antropogenicznych

Bunker demolition located in a conservation protection zone in the light of technical, national defense, functional-utility and economic conditions

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Abstract

The paper presents a description of the technical condition of the Bunker building located at the port quay, which has been out of use for several decades. The direct reason for the cessation of exploitation was the deletion of Bunker from the Civil Defense records. The paper contains a detailed analysis of the Bunker's technical condition, also taking into account the national defense, functional and utility aspects and the issues of economics of carrying out renovation works. The paper shows that despite the location of the Bunker in the conservation protection zone, the optimal solution was its demolition and the final use of the area where the Bunker was located as a place for the construction of warehouse buildings with parameters adapted to the current needs and target transshipment capabilities of the port quay.

Keywords: renovation, conservation protection, bunker, demolition, assessment of technical condition.

1 Introduction

The economic development of the country and the constant need to create new places, both in terms of housing and service spaces, very often result in the need to change the way buildings are used. Sometimes the change of the way of use turns out to be insufficient for the newly designed way of exploitation, it is also often unprofitable for economic reasons [1]-[3]. Making a decision as to the possible demolition of a building that does not meet both the current and target expectations of the Owner is very difficult due to the fact that these objects are very often located in the conservation protection zone [4], [8], [10] .

The paper is a case study of the Bunker building, which has been out of operation for many years, and in recent years its technical condition has significantly deteriorated. Due to the earlier deletion of Bunker from the Civil Defense records, it became completely useless as part of the country's defense policy. Within this article, the following questions were answered [6]-[7], [9], [11]-[12]: a) whether, due to the current technical condition of the Bunker, it is possible to carry out renovation works in it, b) whether there are indications of the need to use the Bunker for national defense purposes, c) will it be possible to use the Bunker after the renovation and repair works

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https://dx.doi.org/10.37105/iboa.155
Received 15 December 2022
Available online 31 December 2022
ISSN 2450-1859, eISSN 2450-8721
Published by Centrum Rzeczoznawstwa Budowlanego

by the Owner of the area where it was located, d) will any renovation works be located within the economic profitability.

2 General information

The bunker was located in the seaport, in the immediate vicinity of the port quay. Based on publicly available information and on the basis of information obtained from the owner of the port quay, it was established that the bunker was built in the first years of World War II, probably in 1942, and was used as an air-raid shelter at the sea port quay. In the post-war years of the 20th century, the Bunker was registered in the Civil Defense records and in the event of warfare it was intended to be used as an air-raid shelter.

In the 1990s, the bunker was deleted from the Civil Defense records and was administered by the Owner's Technical Services, remaining completely out of use - in practice, the building has not been used since the 1990s.

To facilitate the characteristics of the Bunker, the following description of its walls has been introduced:

- north-west elevation: longitudinal outer wall on the land side,
- north-east elevation: external gable (transverse) wall from the land side,
- south-eastern elevation: longitudinal outer wall from the land/water side,
- south-west elevation: external gable (transverse) wall from the land side.

At the same time, the annexes (entry/exit zones to and from the Bunker) located at the top (transverse) walls of the Bunker were characterized as follows:

- annex at the north-eastern elevation: along the external gable (transverse) wall from the land side - right annex,
- annex in the south-west eleation: along the external gable (transverse) wall from the land side - left annex.

The following nomenclature has also been introduced:

- Bunker's floors were defined as levels: 0, +1 and +2.

The bunker was built as a reinforced concrete building in monolithic technology. In the plan view, the main body of the building had the shape of a square with side dimensions of ~21×21 m, single-storey annexes with dimensions of ~4×12 m adjoined the gable (transverse) walls. The bunker had 3 levels (0, +1 and +2). The floor above level 0 and +2 was made as a monolithic reinforced concrete floor, the intermediate floor above level +1 was made as a steel-reinforced concrete composite, with the use of a corrugated sheet in the bottom part of the floor slab. The bunker had an internal staircase. The interior of the bunker was divided into rooms by partition walls made of ceramic bricks.

3 Bunker's existing state

On the front elevation, numerous concrete damages were visible in the form of scratches, cracks and concrete losses, as well as multi-colored efflorescence in places of concrete discontinuity (cracks and cracks), caused by leaching of calcium compounds from the concrete and corrosion of the reinforcement (Photo 1a). Pores and capillaries were visible on the surface of the concrete, and the concrete had an open structure.

A single-storey annex adjoined the external gable wall on the left (Photo 1b). The condition of the left gable wall was similar to the condition of the front wall in terms of the extent of damage - there were numerous places (cracks and cracks) from which calcium carbonates were leached, especially intensive in the upper part of the wall (Photo 2).

A single-storey annex was also adjacent to the outer right gable wall (Photo 1c). The condition of the right gable wall was similar to the condition of the front wall and the left gable wall in terms of the extent of damage.

Entrances to the bunker were provided by openings in both annexes. Inside, at the basement level (level 0), on the lower surface of the ceiling above the basement, numerous cracks and scratches in the concrete were visible, from which the leaking water leaches calcium carbonate. Locally, defects in the concrete cover of the ceiling reinforcement bars above level 0 were visible. The walls had extensive cracks and scratches. Partition walls made of solid ceramic bricks were partly dismantled, fragments of the left walls were intensely damp. The floor at the ground level was collapsed and cracked, and in some rooms it was completely flooded with water.

The stairs leading to the +1 level in the staircase had numerous mechanical damages to the steps. Extensive cracks and scratches were visible on the walls of the cage.

The steel elements constituting the formwork and protection of the ceiling above the +1 level were made of high-profile corrugated sheet metal, which was heavily corroded.

Moisture stains were visible on the ceiling and wall elements caused by water leaks from the upper floors (floor +2 and from the roof).

The extent of damage to the walls and ceiling on the +2 storey level was similar to the damage on the 0 and +1 storeys.

4 Analysis of the condition of the existing Bunker

On the basis of verbal information obtained from the Owner, it was established that in the last decade in the area adjacent to the Bunker building covered by this study, no trees of significant dimensions in terms of trunk diameter and height that could affect the change in the distribution of ground moisture near the Bunker were removed.

Also, no new medium- and high-stem trees or shrubs were planted. Thus, there was no basis for concluding that the root system of the stand could have contributed to damage to both the structure of the Bunker and that the roots of the stand could have contributed to the disturbance of soil and water conditions in the area directly adjacent to it, in accordance with the mechanism described in [5].

Based on the analysis of the Bunker's technical condition, a preliminary thesis was formulated that the defects and damage found were not caused by the location of the object in question in the immediate vicinity of the communication system loaded with intensive traffic of motor vehicles - a radius equal to the height of the Bunker was assumed as the immediate vicinity of the intensive traffic, and in this zone there was an internal port road on which trucks moved.

On the walls of the bunker, no characteristic damage caused by vibrations generated by the movement of motor vehicles, characteristic scratches and cracks with a typical morphology of the letter X or ½ X were found.

During the site inspections, no perceptible vibrations of the ground around the Bunker were found. Thus, the measurement of ground vibrations was abandoned, assuming that they would not provide significant information for further analysis of the technical condition of the object in question.

Below is an analysis of the condition of the existing Bunker building, carried out due to the conditions:

- technical,
- related to national defense,
- functional and utilitarian,
- economic.

4.1 Analysis of the technical condition

Foundations

The Bunker was placed directly on the ground through a foundation slab. On level 0, there were no external signs on the floor that would indicate uneven subsidence of the Bunker building as a whole. Damage to the floor (its deformation and cracks) was caused by the lack of ongoing maintenance and prolonged flooding with water. There are no signs on the external walls that could indicate uneven settlement of the structure.

Reinforced concrete elements (ceilings, columns, walls)

Based on the tests of concrete samples taken from the structural elements of the bunker (core boreholes), it was found that:

- the ceiling above the ground floor was made of C45/55 class concrete,
- walls made of C35/45 concrete.

On the basis of engineering practice, a thesis can be formulated that it is highly doubtful to obtain concrete with such high strength classes as obtained on the samples taken in the 1940s. Probably the bunker's structural elements (ceilings and part of the walls) were strengthened or rebuilt in the previous years.

Due to numerous scratches and cracks in concrete, its chemical corrosion (very low pH and leaching of calcium carbonates) and corrosion of reinforcement bars, according to the currently applicable standard guidelines (Eurocode EC2), Bunker's structural elements do not meet the durability requirements. As is well known, the depth of carbonation in hardened concrete can be estimated using the phenolphthalein method, the methodology of which is presented in [15]. According to the recommendations for this test method, the test material is taken by chiselling concrete or drilling a series of holes. After cleaning of dust and loose particles, but without the use of water and abrasion, a solution of phenolphthalein is applied to the surface of fresh fractures. In accordance with the standard requirements, it is recommended to measure the color change of the non-carbonated zone to red-violet within 30 seconds of wetting with the solution. It should be emphasized that the color change of the concrete fracture from colorless to red-violet occurs at pH ≈9.0. At the pH value = 11.8, corrosion processes of the reinforcement are initiated. Thus, determining the extent of the carbonation front using the phenolphthalein method may significantly overestimate the extent of the zone of deteriorated protective properties of concrete against the reinforcement.

More convenient to use than the phenolphthalein solution are system sets of reagents designed to determine the depth of concrete carbonation. One of the more well-known system fluids is Rainbow Indicator which, when sprayed on a fresh concrete fracture, causes different colors of concrete depending on the pH value (Photo 3). The assessment of the depth and degree of carbonation is made by comparing the color of the sprayed sample with the template. It is assumed that the transition of the color palette from violet to green (pH = 9) signals a sharp decrease in pH and indicates a potential corrosion hazard of the reinforcement.

On the walls of Bunker, based on chemical tests, high carbonation of concrete, i.e. low pH value (~10 pH) was found (Photo 4). This means that the concrete cover has lost its natural ability to protect the reinforcement against corrosion, which results in the acceleration of the destruction of the concrete structure on the one hand, and on the other hand, it means that the process of corrosion of the reinforcement bars is active and progressing, which was confirmed by brown-rust tarnish on the concrete surface. Photo 5 shows the study of the degree of concrete carbonation on the external wall in the place of a wet crack.

Due to the numerous scratches and cracks in the concrete (on the outer surface of the Bunker walls) and the high heterogeneity of the concrete found visually, sclerometric tests with the Schmidt hammer were not performed. The differentiation of the concrete structure on the walls, visible both from the façade side and from the inside of the building, had a negative impact on the load-bearing capacity of the Bunker's structure (walls) and its durability as a whole.

The results of the humidity test showed that the greatest dampness occurred in the external walls and was caused by the capillary rise of water from the ground, water standing on the floor and splashing rainwater in the ground zone. The degree of moisture found allowed to classify, on the basis of the measured mass humidity um, wall elements as wet (in the zone close to the ground at level 0) ($u_m \geq 2{,}3\%$), as damp (locally at level 0, at +1 and +2 levels) ($1{,}8\% \leq u_m < 2{,}3\%$) and dry (only locally in the +2 level as dry ($u_m < 1{,}8\%$).

During the analysis of the Bunker's technical condition, comprehensive thermal and humidity calculations were abandoned.

On the one hand, the visible traces of freezing on the inside of the external walls, despite their considerable thickness of up to 250 cm, sufficiently confirmed their excessive thermal conductivity (insufficient thermal insulation), which allowed to formulate the thesis that the external walls did not meet both the requirements set out in already withdrawn, but still widely used, standard [14] ($k_{real} >> k_{max}$), as well as in [13] ($U_{real} >> U_{max}$).

On the other hand, it should be remembered that the bunker was an object which, due to the current specificity of use, was not supposed to provide high operational comfort, therefore, direct application of standard requirements is not an approach determining the usefulness of the partition here.

Woodwork

The steel door joinery has been dismantled.

Pipe and line installations

Industry installations: pipe (water supply system, sewage system) and cable (electrical installation) have been dismantled. Industrial installations related to the use of the facility as an air-raid shelter have also been dismantled.

4.2 National defense analysis

In the post-war years of the 20th century, the Bunker was registered in the Civil Defense records, intended for final use as an air-raid shelter in case of possible military operations. The shelter was intended to ensure the safe stay of people (employed) in the port, in particular those staying in the area of the port quay where it was located.

The Bunker was deleted from the Civil Defense records in the 1990s. Currently, it was also not a closed military facility, it did not play any role of strategic military importance. It was also not used for military purposes as a place of activity for paramilitary organizations.

The Bunker was also not an object of worship, whether historical, patriotic or religious. The available information clearly showed that the Bunker did not have the status of a monument.

4.3 Functional-utility analysis

The Bunker was never used by the Quay Owner who was also its Administrator. Due to the difficult access, the width of the staircase and the functional and utility layout of the rooms, the Bunker was completely useless for the owner, who could not use it as a storage space.

The location of the Bunker caused significant communication and maneuvering restrictions for vehicles moving in the area adjacent to the quay and made it difficult to expand the transport and storage system along the quay in accordance with the long-term (long-term) development program of the seaport.

4.3 Economical analysis

In Tabl. 1 contains an analysis of the degree of decapitalization of the Bunker building, carried out using a simplified method, commonly used in engineering practice, based on a visual assessment of the degree of wear of its individual elements.

Based on the assessment, the estimated degree of depreciation of the Bunkier building is ~96% and thus exceeds 75% of the replacement value of the building, which is usually assumed as the threshold of economic profitability for the implementation of the investment project in the form of renovation, reconstruction or modernization.

Therefore, it can be concluded that in the case covered by this study, the major renovation of the facility, which is the Bunker located at the quay of the seaport, is beyond the scope of economic profitability.

It cannot be ruled out that if a decision is made to carry out a major renovation of the facility at the stage of construction works, the real costs of work will increase significantly in relation to the initially assumed costs, which is characteristic of construction works of a renovation nature carried out in buildings from the 1940s age (~30%). In addition, at present it is difficult to estimate what impact the necessity to equip the Bunker with equipment related to its original function - filters, ventilators, separators, i.e. devices and apparatus characteristic for the military function of the Bunker - will have on the increase in renovation costs. However, these considerations should be treated in the category of theoretical considerations, because as it was mentioned earlier, the bunker was deleted from the Civil Defense records in the past years and in practice remains an unused object, the so-called vacancy.

At the same time, it should be noted that the object covered by the study was located in an area under conservation protection (protected by the Provincial Conservator of Monuments) and thus economic dependencies as the basis for further engineering activities were not directly applicable here, understood as decisive, when planning activities related to possible major renovation of the facility. In the planned works, it was necessary to take into account conservation conditions.

Particularly noteworthy is the fact that in the event of a decision on a major renovation, the finally received facility (renovated Bunker) will not be a facility useful to the Owner in any way due to functional and utility limitations and the inability to use the facility for current and future utility needs (warehouses).

Thus, the degree of use of the Bunker over time will be negligible, in practice none, which for the Owner completely disqualified the potential investment in the form of a major renovation in terms of economic profitability.

5 Conclusions

The direct reasons for the current technical condition covered by the study of Bunkier as a whole were:

- imperfections of the technical solutions used during its implementation - the bunker was built as a military facility, characterized by the lack of protection of reinforced concrete elements against the negative impact of external weather conditions,
- a long period in which the facility was out of operation,
- lack of regular periodic repairs,
- no major overhaul carried out so far.

For **technical** reasons, the complete renovation of the Bunker, which is the subject of the study, was **theoretically possible**.

For reasons **related to the defense of the country**, any works related to the general renovation of the Bunker covered by the study were not justified. In the past, the facility was excluded from the resources of the Civil Defense and ceased to function as an air-raid shelter, and in its current state it did not have any military function in the country's defense system

For **functional and utility** reasons, any works related to the general renovation of the bunker covered by the study were **extremely unprofitable**. A possible change in the way of use and the use of the building's volume as a warehouse were completely useless for the Principal due to the limitations in use and the current, as well as planned in the future, target way of using the quay's transshipment capacity.

For **economic** reasons, the implementation of the investment measure involving the renovation of the Bunker was **completely unprofitable**:

- the estimated degree of depreciation of the building was ~96% and was higher than 75% (96% >> 75%) customarily accepted in engineering practice as the upper limit of the economic viability of renovation of the building,
- the implementation of renovation works and the related costs of restoring the Bunker to full technical and operational efficiency are difficult to estimate in practice due to the renovation nature of construction works and the cost of specialist installations, which are difficult to estimate, should a decision be made to reuse the Bunker as an air-raid shelter, which was only a theoretical consideration due to the fact that it was removed from the Civil Defense records,
- as a result of possibly carried out renovation works, after incurring costs that are difficult to estimate and a possible change in the way of use, a facility with exploitation limitations significant for the Owner is obtained, in practice making its use impossible.

In the opinion of the Authors, the optimal solution, taking into account the above-mentioned technical, national defense, functional, utility and economic conditions, was the demolition of the Bunker and the adaptation of the land obtained to the current operational needs and expectations of the Owner.

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a)

b)

c)

Photo 1: Bunker building elevations: a) south-east: external longitudinal (front) wall from the land/water side, b) south-west: external gable (transverse) wall from the land side (left), c) north-east: external gable wall (lateral) landward (right)

Photo 2: Examples of calcium carbonate leaks on the south-west elevation (external gable (transverse) wall from the land side (left)) of the Bunker building

pH value:
• 11-13 - concrete free from carbonation effects,
• 11 - limit value (reduced cover ability to protect reinforcement),
• ↓9 (< 9) - reinforcement corrosion hazard,
• ↓7 (< 7) - corrosion of reinforcement bars.

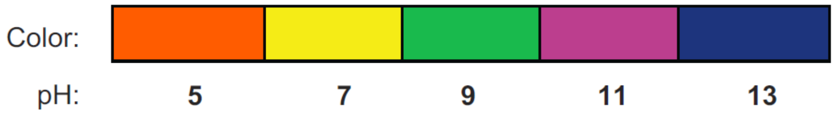

Photo 3: Interpretation of Rainbow Test results using Rainbow Indicator Fluid

a)

b)

Photo 4: Discoloration of concrete after the Rainbow Test in the place of forging the concrete cover to a depth of 2 cm in the corner of the left annex - view of the test site: a) before, b) after the test: purple-green coloration indicates advanced carbonation of the concrete cover and its reduced capacity to protect the armament

a)

b)

c)

Photo 5: Discoloration of concrete after the Rainbow Test on the concrete surface, in the place of a crack on the wall of the right annex - test site after the test: a) view, b), c) close-up: green-violet coloration indicates advanced carbonation of concrete and its reduced ability to protect the reinforcement, the orange color indicates advanced carbonation of the exposed concrete surfaces, washing out of calcium carbonates is visible in the area of cracked concrete fragments

Tabl.1: Estimated (simplified) assessment of the degree of depreciation of the Bunker building

No	Building elements	Item share in the facility [%]	Degree of decapitalization of the element [%]	Degree of decapitalization of the object as whole [%]
1	Foundations	5,02	50	2,51
2	Structural Walls (Level 0, +1, +2)	43,62	98	42,75
3	Interfloor ceiling above level 0	6,32	98	6,19
4	Interfloor ceiling above level +1	4,81	98	4,71
5	Roof (flat roof) (floor above level +2)	13,56	98	13,29
6	Staircase	1,84	95	1,75
7	Walls	1,08	98	1,06
8	Internal plasters	3,24	100	3,24
9	Door joinery	1,26	100	1,26
10	Painting works	2,25	100	2,25
11	Floors and floors	3,53	100	3,53
12	Electrical installation	1,48	100	1,48
13	Water and sewage installation,	0,99	100	0,99
14	Heating installation	0,82	100	0,82
15	Specialized installations	10,08	100	10,08
16	Miscellaneous items	0,1	100	0,10
	Σ	**100,00**		**96,01**