

PROBLEMS OF PLANTS REVITALIZATION IN THE EAST OF UKRAINE AFTER THE WAR

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Abstract

The article is devoted to the actual problem of reconstruction and repurposing of war-ravaged industrial territories in the East of Ukraine. Given that these are industrial areas, the revitalization experience of recent years was analyzed using the example of the multifunctional complex "Fabryka Norblina" in Warsaw. The authors of the article investigated the situation with the destruction of objects in the combat zone and during the years 2018 – 2022 investigated the construction process of the "Fabryka Norblina". On the basis of the conducted research, proposals were formulated regarding possible options for using the industrial territories in the East of Ukraine in the process of post-war reconstruction.

Keywords: Ukraine; War; East of Ukraine; Industrial areas; Revitalization; Restoration

Introduction

The relevance of the presented research is determined by the need for proposals for the post-war reconstruction of Ukraine. As the Russians have been deliberately destroying Ukraine's industry and critical infrastructure facilities in recent months, it is becoming obvious that one of the primary issues of post-war reconstruction will be the question of what to do with industrial enterprises, some of which are functionally obsolete, and some of which were destroyed or damaged by Russian shelling. There is no single absolutely correct answer to this question. Undoubtedly, those industrial enterprises that are not subject to restoration and do not represent historical and cultural value will be dismantled, and either new enterprises or buildings with a completely different function will be built on their site. At the same time, it is necessary to understand the need to preserve the monuments of industrial architecture – and there are quite a lot of such objects in the East of Ukraine. That is why the authors tried to present their vision of ways to solve this problem. The peculiarity of this study is that the one author is a directly fighting officer and personally investigated the nature of the destruction in the East of Ukraine, supplementing them with the author's photo fixation. Another author

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studied the Polish experience of revitalization in recent years. Thus, the problem itself was studied on the basis of Ukrainian material, and one of the options for its solution – on the basis of foreign experience.

The main goal of the study was to identify the problems that the war brought to industrial areas, to determine possible directions for solving these problems in the post-war reconstruction of the industrial areas of the East of Ukraine, and to argue their proposals with concrete examples of the revitalization of industrial architecture objects. "Fabryka Norblina" in the Wola district in the centre of Warsaw was chosen as such an example, as this implemented project was awarded many professional awards.

Scientific sources were elaborated in the following areas:

1) the issue of preserving the historical environment as a "place of memory" – publications by *P. Spiridon et al.* [1], *I. Sandu* [2];

2) problems of revitalization of industrial areas – articles by *A. Dmytrenko et al.* [3], *M. Dyomin and O. Ivashko* [4], *M. Dyomin et al.* [5, 6], *O. Ivashko* [7], *J. Kobylarczyk et al.* [8], *M. Orlenko and O. Ivashko* [9], *M. Orlenko et al.* [10], *K. Stefański et al.* [11];

3) problems of interaction between the object and the surrounding are analyzed in the article by *O. Sleptsov et al.* [12];

4) general issues related to restoration technologies – publications by *M. Orlenko and Y. Ivashko* [13], *L. Luvidi et al.* [14], *M. Furtak et al.* [15], *I. Sandu et al.* [16];

5) the issue of improving the properties of cements and concretes in different conditions – articles by *O. Kovalchuk et al.* [17], *P. Krivenko et al.* [18–20], *R. Runova et al.* [21].

The authors based on the key theses of the predecessor articles, which also became the key theses of the presented article. The first thesis is about the need to preserve the "memory of the place", which is especially relevant for Ukraine against the background of the war, because it is no accident that the Russian invaders are methodically destroying the traces of their crimes in the occupied territories. Here, the authors were based on the articles of *P. Spiridon et al.* [1], *I. Sandu* [2]. The second thesis – about the economic feasibility of revitalization measures, taking into account all the components that determine it, is based on the publications of *A. Dmytrenko et al.* [3], *M. Dyomin and O. Ivashko* [4], *M. Dyomin et al.* [5, 6], *O. Ivashko* [7], *J. Kobylarczyk et al.* [8], *M. Orlenko and O. Ivashko* [9], *M. Orlenko et al.* [10], *K. Stefański et al.* [11].

A separate group of analyzed sources consisted of articles devoted to specific exploitation problems. These questions were investigated by *V. Glyva et al.* [22 – 24]. The problem of the operation of historical industrial and public buildings is their non-compliance with modern standards for electromagnetic safety, noise protection and microclimatic indicators. Therefore, in the process of restoration of destroyed and damaged historical buildings, it is advisable to implement measures to normalize these factors of anthropogenic technogenic origin. The least expensive is the use of appropriate modern facing and finishing materials. The article [22] shows the possibility of adjusting the levels of electromagnetic fields of a wide frequency range with composite metal-polymer materials. Their advantages are small thickness (1–3mm), flexibility and the ability to cover the surface of large areas. In addition, it is possible to manufacture materials with the required protective properties for a specific building, taking into account the external electromagnetic environment. These materials also reduce acoustic noise levels by 10–25dBa. In cases of surfaces with complex configurations, it is possible to use liquid shielding compositions [23]. They have a small thickness (up to 0.3mm) and do not distort the surfaces on which they are applied. Their advantage is the ability to shield electromagnetic fields of anthropogenic origin while ensuring stable wireless communication.

In most industrial buildings, including historical ones, a large amount of computer equipment is used, therefore, in the process of restoration it is advisable to ensure conditions that correspond to international standards for the use of personal computers (TCO, MPRII). This is possible on a comprehensive basis, taking into account all critical factors, such as electromagnetic fields, noise, air ionization [24].

Studying the existing source base proved that they did not analyze the latest examples of revitalization of industrial territories abroad, and the realities of the war in Ukraine require the correction of many proposals. At the same time, it is necessary to analyze the economic profitability of the reconstruction of industrial enterprises destroyed by the war, their value as an object of architecture. In the case of the option of repurposing as an object of public purpose, it is necessary to take into account the characteristics of the space where such an object is located, since the space actively determines the efficiency of functioning and directly affects the perception of the object, which was emphasized in the publications of *O. Ivashko* [7] and *O. Sleptsov* [12].

Materials and methods

The specificity of the research topic determined the choice of scientific methods. The main ones used were the analytical method for researching the scale and specifics of the destruction in Eastern Ukraine, the comparative analysis method for analyzing the effectiveness of using foreign (in this case, Polish) latest revitalization experience, and the forecast method, which made it possible to express certain judgments about possible options for reconstruction and use of damaged and destroyed industrial areas. In particular, the author's recording of the nature of the destruction in the East and the visual inspection of the destroyed objects of various functional purposes proved that in most cases the statics of the buildings are violated, and the building structures are in a state of emergency – walls, columns, inter-floor ceilings and trusses. This proves that post-war reconstruction should begin precisely with the elimination of these emergency states of structures and buildings as a whole (Figs. 1 and 2). It should be taken into account that most of the enterprises are of the Soviet era, with long-span structures.



Fig. 1. Buildings of the industrial enterprise in Bakhmut (Donetsk region).



Fig. 2. The damaged workshop of the enterprise in Bakhmut (Donetsk region).

Results and discussion

The issue of reconstruction of industrial buildings in destroyed cities of Ukraine

Industrial territories in the war zone in Eastern Ukraine are actively used by military units from both sides, and, accordingly, are subjected to heavy shelling and destruction. Some industrial zones are so destroyed that the expediency of their restoration requires additional technical and economic substantiation (Fig. 3).



Fig. 3. Ruins of the industrial zone at the entrance to Bakhmut (Donetsk region).

Each industrial facility requires a separate technical expert review and conclusion regarding its further restoration and operation. This article discusses the main factors and directions of restoration or reconstruction of such objects.

In the case of minor destruction and the possibility of rapid reconstruction, as well as the placement of industrial facilities in the habitable zone of cities in order to preserve the historical appearance, such facilities can be reconstructed for housing, while preserving the facades and appearance. In this way, it is possible to create not only individual houses, but also whole neighborhoods with public centres, cultural and educational institutions. Large industrial areas can make these residential quarters energy-independent (use of water/sun/wind energy, depending on the location of the areas) and energy-efficient (use of heat pumps, modern boilers, etc.). Also, such objects can be reconstructed at minimal costs into innovative technology parks with autonomous infrastructure, residential, office and public buildings. Just as in the previous version, they can immediately be performed energy-independent, energy-efficient and ecological. If such objects have historical value, then it is possible to revitalize the territories into landscape parks of the Meiderich Hütte type in Duisburg-Nord [25] with the arrangement of art institutions and shopping and entertainment centres in reconstructed former industrial buildings, with the arrangement of art institutions and shopping and entertainment centers in reconstructed former industrial buildings. Also, such territories and buildings can be used to restore production with the use of science-intensive, more modern equipment, provided they are environmentally friendly.

In the case of significant destruction and placement of industrial facilities in the agricultural zone of cities, it will be more rational to use these territories for the construction of new urban buildings, both residential and public – commercial, entertainment, and office, which must be substantiated by special technical and economic studies on restoration and further development of the city. Taking into account the factor of destruction of housing and other funds of cities, this can provide an opportunity for the rapid construction of new residential neighborhoods with all the necessary infrastructure for people and subsequent slower recovery of damage to the city's housing stock.

In case of significant destruction and placement of industrial facilities in the industrial zone of the city, it will be more rational to restore industry. This is due to the fact that, despite the destruction of above-ground structures, often all underground structures and foundations, including foundations for equipment, are actually not damaged and can be reused, which will significantly reduce the costs of building a new similar industrial area object. It is clear that enterprises that will be able to restore their capacities and be profitable should be restored. This also requires additional scientific research and certain technical and economic justification.

Recent examples of revitalization: the experience of Warsaw

Poland has extensive experience in the revitalization of large industrial areas, where a part of historical buildings must be preserved and, most importantly, the so-called "memory of place". That is, the old plant or factory is not completely demolished for the sake of new construction, but a part of the industrial building is preserved, which is complemented by a stylistically close modern building. In previous articles [3, 8, 10, 11], we analyzed in detail the experience of the revitalization of factories in Łódź, and in this article we will analyze an example of the revitalization of recent years – the Norblin factory (Fabryka Norblina, Bracia Buch and T. Werner) in Warsaw.

Since 2017, one of the authors of the article has been investigating the site of the Norblin factory in the process of construction activities, which began in 2008 (Figs. 4 and 5). The activity of the factory began in the first half of the 19th century and focused on applying protective coatings to metal products. Before the First World War, the factory "Norblin, Bracia Buch and T. Werner" was a leading metallurgical plant in the Kingdom of Poland (a semi-autonomous Polish state within the Russian Empire from 1815 to 1915, a successor to Napoleon's Duchy of Warsaw). The factory was damaged during the defense of Warsaw in 1939 and during the Warsaw Uprising in 1944. In the post-war years, it worked under a different name until 1982, after which its territory gradually declined.



Fig. 4. One of the "Fabryka Norblina" buildings in the process of revitalization.



Fig. 5. The "Fabryka Norblina" plot is in the process of reconstruction.

The industrial plot with an area of two hectares is located at the intersection of Żelazna, Łucka and Prosta streets. Initially, the plot was bought by Capital Park Group. Construction work began in November 2017 and ended four years later in November 2021. The main investor was the Warbud company, the project was developed by PRC Architekci, Soletanche Polska, Maat4, TKT Engineering, Monument Service participated in the implementation of the project. Such a wide range of performers was due to the multi-functionality of the public complex, which is difficult to implement, so separate sections included projects for foundations, sanitary and mechanical installations, as well as a separate section for the restoration of historical industrial buildings and equipment as part of the exposition.

The first problem during the construction work was related to the geological properties of the construction site and the properties of the soil and the level of groundwater.

It was decided to turn the former factory into a multifunctional complex in the centre of Warsaw. It had to combine the modernity of functions and image and the preserved "historical memory of the place", which was to be facilitated by the harmonious combination of old and new parts and the transformation of factory equipment into exhibition elements. 50 units of factory equipment were restored, 42 of which were entered into the monument preservation register. These mechanisms were placed both in open spaces and in interiors (Fig. 6).



Fig. 6. Factory equipment in the interiors of public spaces.

A four-story parking lot, a movie theater, public catering establishments, and office space were planned. Ten historical buildings of the factory were reconstructed, and one historical one was recreated (Fig. 7).



Fig. 7. General view of the complex. Combination of old and new parts.

At the level of the underground parking lot for 720 cars, 106 trees with a height of 4–10 metres were planted in pots. The first parking lot for cyclists in Poland with 95 spaces was planned here, which was opened in the spring of 2022. Separately, 200 bicycle parking spaces for office workers were provided on the territory of the complex.

If we assess what the main difficulty was in the implementation of the project, then it is the construction and engineering equipment of the underground part of the complex and restoration work on historical buildings and ancient equipment. A single historical hydraulic press 1000 tons, located in the exposition, weighs 50 tons. In addition, it was necessary to ensure the reliability of the foundations under the historical buildings, to give them a modern look by combining them with completed parts.

For example, for the Soletanche Polska company, participation in the project became one of the most difficult foundation design and implementation projects in the company's history due to the complexity of the hydrogeological conditions on the site and the location of the site in the midst of dense urban development. The works continued in three stages:

- 1) ensuring the statics of the walls of historical buildings;
- 2) construction of underground parking walls and foundations under the ground structure;
- 3) use of micropile structures in houses numbered B-17 and B-18.

In more detail, each of the three stages looked as follows.

First of all, it was necessary to ensure the stability of the walls of the historical buildings of the factory. At this stage, foundation works were carried out under 10 historical buildings. The historical foundations were reinforced with jet grouting columns to a depth of up to 17 metres. The column system was made from both the outer and inner sides of the walls of the buildings. A total of 446 columns were used to strengthen the base (soil on the site) and 977 columns directly to strengthen the foundations of the old buildings. The difficulty was also limited space for moving modern equipment, which increased the duration of the works.

Most of the historic workshops of the former Norblin factory were built with new volumes using "pin" barrettes, designed to transfer vertical and horizontal loads from the structure of the building to soils with significant bearing capacity. They are usually made in the form of a single set of reinforced sections of the diaphragm wall. They can take the form of the letter L or T depending on the task, that is, on the loads to which they will be subjected. This type of foundation turns out to be especially economically justified for high-rise construction in areas of high building density, since one set of fasteners can be made for diaphragm walls and this does not limit the size of the construction site.

Such barrettes do not allow the structure to influence neighboring buildings and, accordingly, allow the construction of skyscrapers of considerable height on small areas. Such a system of barrette foundations was used in most skyscrapers in Dubai, where in some cases the barrettes are buried 150 metres.

A barrette foundation is a type of bored piles installed in trenches dug with a grapple in cohesive-dispersive soils or with a cutter in rocky and semi-rocky soils, so they are actually walls in the soil. For this, under the protection of the suspension, a trench is cut into which the reinforcing frame is lowered during the installation of reinforced barrettes and concreting is carried out. The technology of installing barrettes is similar to the technology of installing one "wall in the soil" division. They are very expensive and labour-intensive, but their bearing capacity, both in terms of material and soil, is much greater than other types of deep foundations. Barrette foundations proved themselves well in the modernization of the historical buildings of the Norblin factory, transferring the load from the ground parts to the lower reliable layers of the foundation. They were used in the construction of underground parking structures and ensured the stability of the above-ground part above the historical buildings. In some barrettes, temporary steel poles were installed for excavation. A total of 200 barrettes were installed at a depth of 24 metres.

A separate stage of the works was connected with the installation of a 4-level underground parking lot with the use of diaphragms, which at the stage of the works performed the role of lining the pit, and after the completion of construction became the walls of the four-level parking lot.

In particular, 557m of diaphragm walls with a thickness of 80cm to a depth of up to 48 meters were installed in the area of Prosta Street, quite close to the tunnel of the Second Metro Line. For the construction of the diaphragm wall, building number 15, which prevented this, was moved. It was a truly unique job to move the 900 tonne Edvard Luckfield factory building by 15 metres, allowing the diaphragm wall installation to move between the buildings and complete the underground parking lots. Later, the historical building was returned to its place.

Most of the strengthened buildings are located outside the contours of the parking lot, but a few had a parking lot underneath. Two historic buildings – a former mechanical laboratory and a 19th-century tempering shop, which together weighed 750 tons, were "suspended" with the help of injection micropiles strengthened by steel profiles on which the buildings stood. This design made it possible to make a pit for the parking lot, strengthen and fill the slab, on which the B17 and B18 buildings were eventually placed. 84 micropiles reinforced with HEB sections were used. At first, the floor of the zero level was built; the next floors were covered, up to level – 4, where the base slab was supported, which connected with the barrettes. This process lasted a little less than a year.

In the final version, the maximum building height of the former factory territory is 44m, the maximum depth of the premises is 40 metres, on two hectares of territory. The historical building was modernized with 8 floors of modern architecture. The complex accommodates 41 thousand m² of office space, 24 thousand m² of spaces for entertainment, cultural, trade and service functions and catering facilities. 87 million zlotys were spent directly on restoration works. During the construction process, several unique works were carried out, in particular, moving a historical building weighing 900 tons and "hanging" two historical buildings weighing 750 tons. Here, for the first time in Poland, an underground automatic bicycle parking lot with 95 spaces was installed.

From the beginning, the reconstructed site of the Norblin factory was conceived as a multifunctional complex with a cultural and artistic function, the cinema "Kinogram" with seven halls was also opened here. The cinema is located on the floor above the high plinth, where the BioBazar, a market with ecological products, is located in a historical hall integrated into a reinforced concrete structure. The cinema can be reached by an escalator, one of the longest in Poland.

Since the main philosophy of the revitalization project was to preserve the historical memory of the place, the museum of the Norblin factory became an important component of the revitalized complex. This is an unusual museum of historical mechanisms and equipment, free to visit and located in both open and closed areas. According to the project, the museum and commercial parts of the building are interconnected. Here you can see the historical buildings, machines and mechanisms, as well as the products of the Norblin factory, get acquainted with the history of this area from the 18th century to the post-war times, when the factory was called "Walcownia Metali Warszawa" and until the closure of the enterprise in 1982.

The Norblin Factory Foundation was organized, which aimed to combine business, philanthropy and the cultural and artistic component under the slogan "Long live art!". That is why one of the directions of the foundation has become the support of young artists and designers, the organization of creative competitions and exhibitions, educational projects related to the history of this district. Concerts of prominent musicians take place on the territory of the complex.

On the territory of "Fabryka Norblina" is located the largest in Warsaw catering complex "Food Town", whose establishments are located in 5 historical spaces and on open areas in front of the buildings.

Thus, the Norblin factory complex is designed for three groups of people: those who deliver products, tenants and visitors, which affected the number of parking spaces and the layout of the premises. The complex is an open space with round-the-clock operation, which adds to its special popularity. As an example of the Norbin factory can be seen in figure 8.

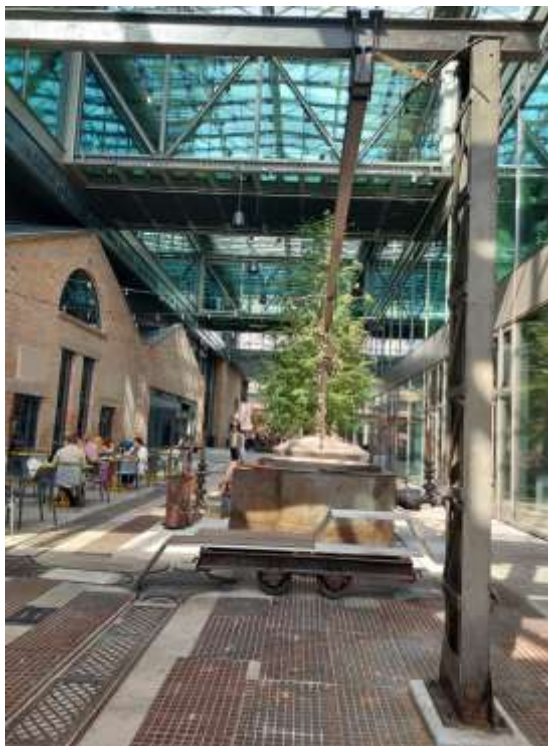


Fig. 8. The closed public space of the Norblin factory. Winter Garden.

Conclusions

The war in Ukraine led to the destruction of many industrial enterprises in the areas of active hostilities in the East of Ukraine, and therefore it is no coincidence that even before the end of the war there are proposals for their post-war reconstruction. Each such object should be subject to a separate analysis from the point of view of the feasibility of restoration or reconstruction or complete demolition and new development of this territory from a technical and economic point of view, for which special studies should be conducted and a technical and economic feasibility study made.

In our opinion, the example of reconstruction with the restoration of the Norblin factory in Warsaw can be particularly useful, as investors, designers and builders managed to give a historical place a modern sound by applying the latest technologies and materials. On the sites of industrial enterprises in the East of Ukraine, in large cities, similar measures can be implemented, although not so expensive, turning abandoned or destroyed areas into modern public spaces, following the example of the Norblin factory in Warsaw (Fig. 8).

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Received: October 03, 2022

Accepted: May 10, 2023