

THE DESTRUCTION OF THE ESTABLISHED URBAN ENVIRONMENT OF BORODIANKA AND IRPEN AS A RESULT OF THE RUSSIAN-UKRAINIAN WAR

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Abstract

The article raises the problem of radical changes in the urban environment as a result of military operations. The history of the settlement of Borodianka and the town of Irpin, which suffered significant destruction in the first months of the war, is given. The on-site inspections of damaged objects – visual and instrumental – carried out by the authors of the article are described, and conclusions were obtained about the amount of damage and the results of the impact of various types of shelling on various types of structures. Given the large volume of buildings that cannot be restored, a radical change in the established urban environment is predicted.

Keywords: Destruction problem; Russian-Ukrainian war; Borodianka; Irpin; Urban environment; Transformation

Introduction

The events of the ongoing Russian-Ukrainian war led to the destruction of the established structure of the urban and rural environment of Ukraine. This process became especially noticeable – at the beginning of the invasion in 2022 – in Kyiv region and in the border areas of Chernihiv region, Kharkiv region and Sumy region, and later – in the South and East of Ukraine. During the first months of the war, the settlements of Hostomel, Borodianka, Irpin, Bucha were destroyed. The problem raised by the authors of the article is related to the impact of military actions on the fundamental change in the urban environment.

The experience of the previous world wars has shown that wars lead to a complete change of the so-called "face of the city", examples of which are Berlin and Dresden, where undeveloped empty areas remained for decades, sometimes until the 1990s. In many cases, significantly damaged buildings are not restored. A classic example of the reconstruction of a heavily destroyed historical part of the city, which has a symbolic meaning for the people, is the Old Town in Warsaw, which initiated the reconstruction of unique destroyed objects. Thanks to this practice, during the years of independence, according to the existing archival materials, the St. Michael's Golden-Dome Cathedral in Kyiv with the St. Michael's Bell Tower, the Church of the Virgin Pyrohoshcha in Kyiv, and the partially preserved Assumption Cathedral of the Kyiv-Pechersk Lavra in Kyiv were recreated literally "from scratch" according to existing archival materials. The legislation of Ukraine in the field of cultural heritage protection includes 14

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specific Laws, four of which were adopted before 2000, and 30 Laws from related fields. The main profile Laws "On the Protection of Cultural Heritage" dated June 8, 2000, and "On Culture" dated December 14, 2010, during their validity, underwent more than 50 amendments and additions, and their provisions were constantly clarified by subordinate legal acts.

The main Laws of Ukraine relating to the field of cultural heritage are the Law of Ukraine "On the Protection of Cultural Heritage", the Law of Ukraine "On Culture", the Law of Ukraine "On the Protection of Archaeological Heritage", the Law of Ukraine "On Museums and Museum Affairs", the Law of Ukraine "On List of monuments of cultural heritage that are not subject to privatization", Law of Ukraine "On export, import and return of cultural values", Law of Ukraine "On city planning", Law of Ukraine "On scientific and scientific and technical activities", Law of Ukraine "On state-private partnership", the Law of Ukraine "On Administrative Procedure" etc. The provisions of the Criminal Code of Ukraine, the Code of Ukraine on Administrative Offenses, and the norms of the Land Code of Ukraine also play an important role in the field.

The main emphases in the formation of codification priorities in the field of cultural heritage, taking into account the realities of the Russian-Ukrainian war, should be modified as follows.

In particular, it is necessary to attribute the protection of cultural heritage to the fundamental national interests of Ukraine and to promote the creation of a comprehensive system of cultural heritage management. It is necessary to present the objects of the tangible and intangible cultural heritage of Ukraine as an integral part of the world's cultural heritage.

Digitalization of processes related to cultural heritage occupies an important place, especially in times of war. Areas that require special attention: coordination and ensuring the functional activity of cultural heritage protection bodies at all levels, protection and preservation of UNESCO world heritage sites, control over the state of preservation, and use of monuments of national and local importance.

Losses of cultural heritage objects as a result of Russian military aggression are constantly being clarified, and measures are being developed for international mechanisms for the protection of cultural values in occupied and de-occupied territories and historical and cultural reserves.

Although the Russian-Ukrainian war is still going on, calculations of the losses of cultural heritage objects, historical environment, residential and industrial stock, etc. are already underway. According to some estimates, 863 objects of cultural heritage were destroyed or damaged in the period from 24.02.2022 to 25.11.2023, of which 119 are monuments of national significance, 674 are of local significance, and 70 are newly discovered monuments. As of January 25, 2024, 1,938 objects of cultural infrastructure and about 530 religious' buildings of various denominations in various regions were damaged or destroyed (Figs. 1 and 2).

Currently, more attention is paid to the destruction of the established historical environment and architectural monuments in cities such as Chernihiv or Odesa, while this problem also exists in cities with a smaller amount of valuable architecture. In the case of Odesa, 119 monuments of architecture and history were damaged and destroyed, some of which have the status of monuments of national importance. For example, such unique objects as the palace of Count Tolstoy – the House of Scientists, and the Transfiguration Cathedral were destroyed.

The main problem is the lack of funds for reconstruction and continued shelling of the city, which leads to new destruction. Part of the objects, such as the buildings of the Iverskyi Monastery, were restored at the expense of benefactors, in the case of the Savior and Transfiguration Cathedral, which was destroyed by a rocket (which penetrated the roof and ceiling and exploded in the basement), only conservation measures are being carried out with the installation of a new roof and drainage system. Funds are allocated by private individuals, the Odesa diocese, the Italian government promises to allocate funds through UNESCO.



Fig. 1. The ruined church in the village Prybuzke, Mykolaiv region.

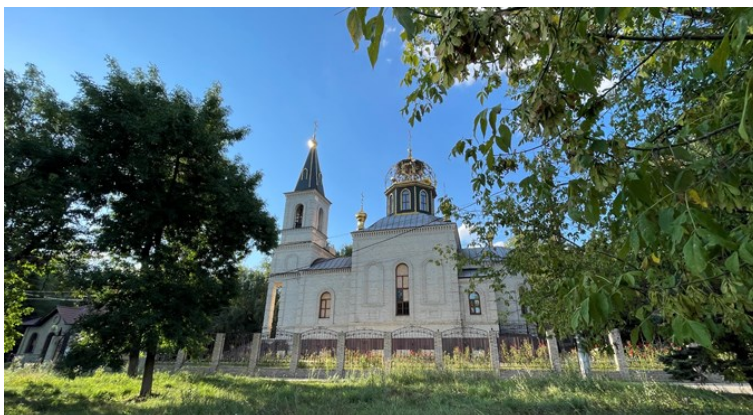


Fig. 2. The damaged church in Toretsk, Donetsk region.

On the other hand, restoration work has not yet begun in the House of Scientists. The measures taken were limited to closing windows with OSB plates and protecting authentic floors and stairs, protecting interior furnishings. All information about the object and the nature of the damage was sent to the World Monuments Fund and UNESCO.

Some lesser-known ruined buildings will be dismantled. First of all, these are objects of the so-called "background building", such as, for example, a three-story former profitable building at 14 Kartamyshivska Street, (part of the building collapsed after a Russian missile hit) or the already demolished two-story building at 25 Prymorska Street.

The complexity of the measures is determined by the continued shelling of Odessa and the lack of guarantees that the restored building will not be destroyed again. Concerning unique architectural monuments, the situation looks different, at least conservation measures are carried out if possible, but there are not enough funds for this.

We gave the example of Odesa, where there are well-known historical objects and unique architectural ensembles. On the other hand, if we talk about Hostomel, Irpin, Borodianka, Bucha, then it is more likely to talk about the aspect of "urban space as a memory of a place", since these settlements are known primarily for their ancient history, and not for a significant number of historical objects. These settlements have been at the epicentre of military operations since ancient times, which led to a constant change in the urban environment. As of the beginning of the Russian-Ukrainian war, it was mostly Soviet-era construction.

Since most of the destroyed cities in the East of Ukraine have the main buildings of the Soviet era, after the end of the war, an important problem will be how exactly these cities will change, if the previous urban structure was destroyed by the war and which cities will not be rebuilt in the previous place. Since there are already many such settlements with predominant Soviet buildings and their number is growing, the authors of the article focused on the settlements of the Kyiv region, where Soviet buildings prevail, which formed the urban space.

The purpose of the study was as follows:

- on the example of selected historical settlements, analyse the stages of formation of their urban environment;
- to analyse the destruction of the times of the modern Russian-Ukrainian war and how different structural systems react to shelling with different types of weapons;
- based on field and instrumental surveys, make assumptions about post-war changes in the urban environment.

The authors processed scientific sources in the following areas:

- problems of preservation and degradation of the urban environment – articles by V. Petrušonis [1], L. Pujia [2], P. Spiridon and I. Sandu [3], P. Spiridon et al. [4];
- "object-environment" interaction – articles by D. Chernyshev et al. [5], M. Dyomin et al. [6], Y. Ivashko et al. [7], Y. Ivashko et al. [8], T. Savchenko et al. [9], M. Orlenko et al. [10];
- restoration aspects – articles by P. Gryglewski et al. [11], D. Kuśnierz-Krupa et al. [12], M. Orlenko and Y. Ivashko [13], M. Orlenko et al. [14, 15], I. Sandu et al. [16];
- articles devoted to the war in Ukraine – publications by S. Belinskyi et al. [17], Y. Ivashko et al. [18], Y. Ivashko et al. [19], T. Kozłowski et al. [20], O. Molodid et al. [21, 24, 25, 26], A. Nadolny et al. [22], A. Pawłowska et al. [23] and S. Zosim et al. [27].

Studying the source base proved the need to pay attention to the changes that the historical environment of cities underwent during the war.

Materials and methods

The purpose of the study led to the choice of general scientific research methods: the historical analysis method made it possible to trace the history of the settlements selected for the study and the stages of development of the urban environment, and the comparative analysis method made it possible to compare the stages of development with each other, the statistical analysis method made it possible to determine the loss of the cultural fund during the Russian-Ukrainian war, the method of photo fixation, the method of field surveys, and the experimental method made it possible to objectively assess the extent of damage and destruction and what was the impact of shelling on various types of building structures.

Results and discussion

Borodianka settlement: history and events of the Russian-Ukrainian war

It is worth noting that a large number of settlements around Kyiv have a long history, as they belonged to the state of Kyivan Rus. The settlement of Borodianka in the Bucha district of the Kyiv region, known since 1190 under the name of Koziatychi, is no exception. In the annals, we find a mention of the fact that in 1240, the Mongol horde of Khan Batu passed

through this settlement, burning everything in its path. There is also a mention of Koziatychi in the Lithuanian metric (lat. *Acta/Metrica Magni Ducatus Lithuaniae*; pol. *Metryka Litewska*) from the chancellery of the Grand Duchy of Lithuania (1st half of the 15th century – 1794). In the Lithuanian metric, Koziatychi is mentioned as an estate, which in the 15th century, belonged to a prince Roman. It remains a mystery what kind of prince it was, about whom it is only known that during the invasion of Mengli I Giray in 1482, both of his sons were killed, and the only daughter inherited Koziatychi and other so-called Yasinetsky estates. It is known that she married a Lithuanian noble Vasentsevych. The next owner of the Koziatychi, already mentioned under the name Borodianka, was inherited together with Makariv as a dowry by the daughter of Vasentsevych, who married the Kyiv voivode Ivan Hlynskyi. However, Ivan Hlynskyi betrayed the Polish king, because of which the Polish king Sigismund I first took the property to the Polish treasury, and then gave it to the brothers of Ivan Hlynskyi's wife with his deed. Subsequently, the descendants of one of the brothers, Bohdan, became the owners of Borodianka. One of the descendants, Mykola Makarevych, was the deputy of the Kyiv voivode and advocated reforms.

In 1640, due to conflicts between the descendants, the Borodianka estate was sold in Warsaw to Andrii Drogojewski, and after he died in 1642, his widow remained the owner, who in every way contributed to the development of Borodianka and the increase of its population.

However, the period of the Cossack liberation wars, which covered these lands as well, led to a change of owners, in 1650 – 1654 the owner of Borodianka, by order of the Russian tsar, was already listed as the St. Michael Gold-Domed Monastery in Kyiv, although Drogojewski's widow remained the formal owner. Unable to legally defend her estate from the monastery, the owner pledged it to Hetman Ivan Vyhovskyi, who eventually took the estate from the monastery.

Further inheritance of Borodianka took place through the line of Drogojewski's son and his daughter, a Dominican nun in Lviv, who in 1681 gave Borodianka to her relative. However, not for long, because in 1693 the Cossack Fastiv colonel Palii took Borodianka along with other estates and settled Cossacks in it. However, soon the Cossacks were defeated by the Polish army, and the estate was again handed over to the noble heirs.

A detailed description of Borodianka, including the buildings, can be found in Lavrentiy Pokhilevich's "Tales about populated areas of Kyiv province" (1863). Borodianka is listed there as the residence of the landowner Poniatowski, and the neighboring villages of Druzhnia, Zagaltsy, Kachaly, Peskivka, Halenka, and Nova Buda were included in the Borodianka estate. At that time, Borodianka was a large, populated village with two water mills, linen and leather factories, as well as two wooden churches – the old one was repaired in 1728, and in 1797 a new St. Michael's Church was built in its place – also wooden.

An episode of the January Uprising of 1863 in Right Bank Ukraine is also connected with Borodianka. A battle took place here between the rebels and the Russian troops, where the rebels were defeated, and many houses were burned.

After that, the page of Borodianka belonging to the Russian Empire began, when it became the centre of Borodianka Volost. As of 1886, there was an Orthodox church, a Catholic chapel, a Jewish synagogue, a prayer house, eight boarding houses, and three mills. At the beginning of the 20th century, there was a Zemstvo hospital, a Zemstvo post office, a parish school, a pharmacy, a Rural Bank, a Savings and Loan Society, shops and benches, and fairs were held every month.

Borodianka has always been at the centre of political events and wars. During the Ukrainian Revolution of 1917 – 1921, according to the III Universal of the Ukrainian People's Republic, it entered Derevska land. During the armed conflict between Soviet Russia and the Ukrainian People's Republic in 1917 – 1918, battles took place here. After the formation of the Ukrainian state under the leadership of Pavlo Skoropadskyi, Borodianka became part of the Kyiv province. However, after 1919 Borodianka came under the control of the Bolsheviks, and

in 1923 it was transformed into a district centre. The events of the Holodomor of 1932 – 1933 also affected Borodianka.

During the Second World War, 103 estates were burned, and immediately after the liberation of Borodianka in November 1943, its reconstruction began.

In 1957, Borodianka became an urban-type settlement, and a branch of the Kyiv factory "Red Excavator" began operating here, which became an impetus for the growth of construction. The development of agricultural production also began, which led to the appearance of new housing estates, including during the years of Ukraine's independence.

In 2022, the main offensive of the Russian army on Kyiv took place through Borodianka, the first battles began in the city already on February 26. On February 28, a convoy of Russian troops passed through Tsentralna Street, shelling houses, and in early February, Russian planes dropped aerial bombs on eight multi-story buildings (Fig. 3). The occupation of Borodianka by Russian troops at the beginning of March 2022 led to further destruction of the environment and buildings and the death of the population.

After the liberation of Borodianka in April of the same year, in the course of technical surveys, it was established that 8 and 32 high-rise buildings were completely destroyed, 32 multi-story buildings were destroyed, 450 private houses were damaged and 500 were destroyed. The head of the monument to Taras Shevchenko on the square was shot through.

In November 2022, the famous artist Banksy left two murals on the walls of destroyed buildings – "Judoki" and "The Gymnast" (Fig. 4).



Fig. 3. The house destroyed by an aerial bomb, 353 Tsentralna Street



Fig. 4. Mural "The Gymnast", 353 Tsentralna Street

As a result of dropping aerial bombs and shelling, the established urban environment of Borodianka suffered significant destruction and the destruction of certain parts of the environment.

In 2022 – 2023, specialists of the Kyiv National University of Construction and Architecture conducted damage surveys of buildings with various load-bearing structures to determine the impact of explosive shock wave, fire, and bullet or shrapnel damage on them.

As a result, three groups of damaging factors were established: explosive shock wave, shrapnel and bullet injuries, and thermal effects including fire damage. The impact of each of these negative factors was expressed as follows:

1) from explosive shock wave – led to destruction, cracking, distortion, and declination from the axis of symmetry, damage to window glasses and frames; the destruction of brick buildings was manifested in knocking out (individual bricks or sections of the wall), protrusion (indentation) and displacement of masonry elements, cracks in masonry and spilling of seams between building elements;

2) from shrapnel and bullet injuries – manifested in through holes, splinters, damage to coatings and the roofing layer, jamming of structures, et cetera;

3) from thermal effects includes fire damage – manifested in irreversible thermal elongation of reinforcement and destruction of concrete; damage to the finishing layers; destruction of window and door frames and their filling; the collapse of the roof; destruction of wooden walls and ceilings.

An examination of the destruction and damage proved that the greatest destruction was caused by aerial bombs, which destroyed sections of high-rise buildings to their foundations, and by multiple launch rocket systems (MLRS).

The main purpose of the comprehensive surveys was to determine the possibilities of further operation of the buildings or their dismantling – complete or partial, and to identify the scope of repair and restoration measures.

All structures were divided into three groups:

Group 1 – load-bearing and enclosing structures that have some damage, but retain their load-bearing properties, are subject to repair of part or the entire building;

2nd group – supporting and enclosing structures have such damage and destruction that require the implementation of measures to dismantle a part of the building or structure, a capital repair of the building is necessary;

Group 3 – supporting and enclosing structures have lost their properties; the object is unusable and must be dismantled.

Thanks to this classification, the process of determining the order of restoration measures was optimized as much as possible, first of all, houses of groups 1 – 2 were examined. The most common types of damage were damage to the roof, roof structures and openings. In those cases when the possibility of sudden destruction of the object was detected, a calculation for progressive destruction was carried out with the help of a spatial model in a physically and geometrically non-linear formulation of the problem.

The conclusions obtained for each object were entered into the Register of Construction Activities of the Unified State Electronic System in the field of construction. In total, in the period from April to June 2022, specialists of the Kyiv National University of Construction and Architecture examined more than 50 multi-story buildings, 300 private houses, and more than 50 public buildings.

The features of the established urban environment in Borodianka are that it is mainly a building of the Soviet period, microdistricts and residential groups are formed by multi-story prefabricated panel and brick houses of the years 1970 – 2000, mainly with concrete block foundations, occasionally with pile foundations, with ceilings from prefabricated reinforced concrete slabs (Figs. 5 –7).

Instead, most administrative and private buildings are built of ceramic or silicate bricks. In some administrative buildings, the walls are made of foam concrete blocks, and the floors are made of hollow reinforced concrete slabs, in private houses, the floors are made of wood.

As already mentioned, the greatest destruction was caused by the hit of an aerial bomb, regardless of the type of structure. Such houses generally have to be completely dismantled. The shock wave also destroyed the filling joints between the structures.



Fig. 5. Panoramic shot of the development (with a note of the damaged buildings) around the Banksy's mural. Photo by O. Molodid, 2023



Fig. 6. Site plan of the area with damaged buildings marked around Banksy's mural. The scheme by O. Molodid



Fig. 7. A brick residential building with a floor made of precast hollow-core slabs at 429A Tsentralna Street after an air bomb hit. Photo by Y. Ivashko, 2023.

A characteristic example of an established environment in the centre of Borodianka is the area around Taras Shevchenko Square, which overlooks the Palace of Culture and three residential high-rise buildings (numbers 353, 355, and 359). As a result of a direct hit by aerial bombs, houses number 355 and 359 had to be dismantled. In the case of the Palace of Culture, damage was caused by a shock wave, deviation of the building from the vertical, displacement of supporting structures, and damage to window and door openings were recorded.

It has been established that over 400 objects suffered varying degrees of damage and destruction. The results of the damage caused by different types of weapons to different types of structures were summarized. Direct hits from bombs destroyed 1.25% of buildings, while 4% of buildings were damaged by shell hits. Approximately 6% of the buildings were affected by shelling, and around 6% were damaged by shells from APC. 9% of the objects were damaged by small arms, and 9% were damaged due to fire (Table 1).

Table 1. Destruction/damage to structures from the type of weapon that affected them

Destruction/damage to the structure	The type of weapon that affected the structure															
	Air bomb				Tank /artillery				APV				Small arms			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Chips / damage to the protective layer of concrete	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Damage to the finishing layer	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Holes					+	+	+	+	+	+	+	+	+	+	+	+
Cracking/ cracks	+	+	+	+	+	+	+	+		+	+	+				
Spilling of seams between building elements	+	+	+	+	+	+	+	+		+	+	+				
Destruction of individual elements	+	+	+	+	+	+	+	+		+	+					
Displacement (declination) from the design position	+	+	+	+	+	+	+	+		+	+					
Soaking as a result of damage to communications / waterproofing course	+	+	+		+	+	+		+	+	+					
Fire/ thermal damage	+	+	+	+	+	+	+	+								
Buckling of elements	+	+	+	+	+	+	+	+								
Complete/ partial destruction of the building	+	+	+	+		+	+	+								
Distortion/ deflections	+	+	+	+		+	+	+								
Cracks in the masonry	+	+			+	+				+	+					
Knocking out individual masonry elements	+	+			+	+			+	+						
Temperature elongation of reinforcement		+	+			+	+									
Destruction/damage to window and door frames and their filling		+				+				+				+		
Damage to the waterproofing course				+				+					+			

Notes: numbers "1", "2", "3", and "4" conventionally indicate the type of construction.

So: "1" - foundations; "2" – walls / partitions; "3" - ceiling; "4" - covering / roof.

The town of Irpin: history and events of the Russian-Ukrainian war

As in the case of the settlement of Borodianka, the main importance of the urban environment of Irpin lies precisely in the "memory of the place". There are still scientific disputes about the name of the town. According to one of the legends, the settlement appeared on the site of a felled large oak, near which they prayed to the pagan god Dazhbog. The second

version of the name is from the name of the river of the same name, turbulent in ancient times – Yerepen, Irpin.

Near Irpin, archaeologists discovered the remains of Bronze Age settlements dated to the 11th – 10th centuries BC and ancient Russian settlements of the 6th – 3rd centuries BC. In the days of Kyivan Rus, the border between the Polian and Drevlian tribes passed here, after the Tatar-Mongol invasion, these lands remained desolate until the 16th century. In the 17th century, the local population took an active part in national liberation competitions. After the entry of the territory near River Irpin into the Russian Empire in 1793, a new stage in the development of Irpin began. The opening of the Kyiv-Kovel railway line in 1898 and the appearance of the Irpin station near the railway bridge across the river had a significant impact on the development. It is this station that is considered the beginning of the modern city, since the buildings of previous periods have not been preserved.

At that time, the development took place without a clear urban planning plan, the paths for the streets were cut right in the middle of the forest. These streets received the names of the lines, and the location of the station in the middle of the forest turned it into a country resort. From those times, Chokolov's summer house and the Church of the Holy Trinity have been preserved.

Irpin was also affected by the events of the Ukrainian Revolution at the beginning of the 20th century when the city was annexed to Kyiv following the 3rd Universal of the Ukrainian People's Republic. In February 1918, battles of Ukrainian Sich Riflemen and Bolshevik units took place here. Later, Irpin was under Bolshevik occupation. After the establishment of Soviet power in 1923, Irpin was included in the Hostomel district of the Kyiv province, in 1928 – in the Kyiv district, and in 1932 – in the Kyiv region.

During the Second World War, from August 1941 to November 1943, Irpin was under German occupation. After the war, the development of the city began, in the late 1970s, the first high-rise buildings began to be built here.

At the beginning of the Russian-Ukrainian war, battles were fought here. As a result of an airstrike in March 2022, two missiles hit a residential building. On March 28, 2022, Irpin was liberated from Russian troops.

During this period, the city suffered severe destruction. In addition to the residential sector, service facilities were destroyed, during the Russian occupation, and the summer house of Kyiv manufacturer Ivan Chokolov at 20 Stelmakha Street and the park near it were damaged.

In addition to the Chokolov's summer house, the Holy Trinity Church, dated 1911, is a historical object.

Irpin is a suburb of the capital of Ukraine, Kyiv, and it is the proximity to the capital and the cheaper cost of housing that prompted its rapid development in recent decades. As a result of such development, entire residential areas or microdistricts with multi-story buildings, rarely low-rise buildings (2 – 3 floors – townhouses) appeared. Since the construction took place on free territories, it was assumed that the laying of new engineering networks, roads, footpaths, as well as park (green) areas, playgrounds, and other necessary infrastructure: shops, pharmacies, kindergartens, etc. At the same time, the architectural style of all buildings of a separate massif is similar and corresponds to modern trends. During construction, current energy efficiency requirements were met and modern construction materials and products were used.

In contrast to the Soviet-time development of Borodianska, the majority of high-rise buildings in Irpen are built according to monolithic frame or frameless schemes. When erecting houses according to the frameless scheme, ceramic hollow bricks were mostly used as wall material to improve the thermal insulation of the house, and factory-made circular hollow slabs were used for ceilings. All houses are insulated and equipped with decorative plasters followed by painting, or elements of industrial production (ventilated facades). In most cases, such houses have pitched roofs of various configurations with roofs made of metal tiles or bitumen tiles.

The main destruction fell on the housing stock. On the wall of one of the destroyed buildings on 158 Severynivska Street, the artist Banksy painted another mural "The Gymnast". In May 2023, the painting was dismantled for further exhibition, as the nine-story building is to be dismantled due to the extent of the damage (Figs. 8 and 9). Residential buildings were also significantly damaged (Figs. 10 and 11).



Fig. 8. House at 158 Severynivska Street



Fig. 9. Mural "The Gymnast" at 158 Severynivska Street



Fig. 10. A house at 1-K Novo-Oskolska Street damaged by a tank shell.



Fig. 11. The house at 1-K Novo-Oskolska Street after restoration

It should be noted that aerial bombs were not used in the town of Irpin in such volumes as in Borodianka, which is why there is a smaller volume of multi-story buildings that are subject to complete dismantling. New houses in Irpin suffered the greatest damage as a result of artillery and tank fire. As a result of the explosions, there were both mechanical damage to structures from fragments and ignition of flammable objects in residential premises. The flame quickly moved from one room to another through openings, risers for engineering networks, and exhaust shafts. Through the risers and shafts, the fire spread to the wooden structures of the roof, as a result of which such roofs burned to the ground. It is the destroyed roofs of new high-rise buildings that distinguish them from the old buildings, where the roofs are flat and are rarely damaged when the buildings are damaged in the same way.

As a result of thermal effects in such houses, the following are most damaged: the inner parts of the load-bearing walls, namely, their peeling and loss of strength; round hollow floor slabs – the protective layer peels off with subsequent loss of strength by reinforcement; damage to monolithic structures is also characterized by peeling of the protective layer of concrete and loss of reinforcement strength.

Conclusions

As a result of the inspections, it has been established that approximately 11% of the objects in Borodianka have been destroyed or damaged due to the impact of air bombs and various types of weapon fire. The distribution of all damaged objects into three groups allows for the optimization of the restoration process by immediately identifying the group of objects that have lost their load-bearing properties and are not subject to restoration. The example of Borodianka shows that there will be a radical change in the established environment of development, as entire blocks of large-scale Soviet-era development will be dismantled and new residential buildings will be erected in their place.

The development around Taras Shevchenko Square will undergo the biggest changes, as two high-rise buildings flanking the square will have to be dismantled due to an aerial bombardment (353 Tsentralna Street and 359 Tsentralna Street). Artist Banksy painted the mural "The Gymnast" on the wall of building 353 destroyed by an aerial bomb. The block with houses at 429A Tsentralna Street, 340 Tsentralna Street, 338 Tsentralna Street, 427A Tsentralna

Street, "Pinocchio" kindergarten located at 427B Tsentralna Street should also be dismantled. Banksy painted the mural "Judoki" on the wall of the destroyed boiler house.

As a result of the study of the urban environment of the settlement of Borodianka, it was established that most of the buildings are brick and prefabricated panel houses of the 1970s-1990s on strip foundations of shallow laying, sometimes pile foundations, with prefabricated reinforced concrete floors. Most of the administrative buildings, which also form the urban space, are made of ceramic or silicate bricks. Some newer houses are made of aerated concrete blocks, with ceilings made of round hollow reinforced concrete slabs. In some cases, ceilings in residential buildings are on wooden beams.

It was established that the degree of damage directly depended on the type of weapon used (explosive projectile or aerial bomb).

Field and experimental studies proved that the impact of the blast wave leads to destruction, cracking, distortion and deviation from the axis of symmetry, and damage to slots. In the case of brick structures: knocking out (individual bricks or sections of the wall), protrusion (indentation) and displacement of masonry elements, cracks in the masonry and spillage of seams between building elements.

Damage from shrapnel and bullet injuries manifests itself in the form of through holes, chips, destruction of coatings and roofing layer, jamming, etc.

The negative thermal effect affects the temperature elongation of the reinforcement and the brittle failure of concrete; destruction of the plaster and finishing layer; slots with filling, roofs, and wooden structures.

Since aerial bombs cause the most destruction, most of the destroyed buildings must be dismantled. Multiple launch rocket systems (MLRS), artillery weapons and tanks also cause devastating consequences.

The main recorded types of destruction from the blast wave were the destruction of enclosing load-bearing structures, internal non-load-bearing structures, violation of the stability of the building, damage to slots with fillings, and spillage of seams between structures (Fig. 12).

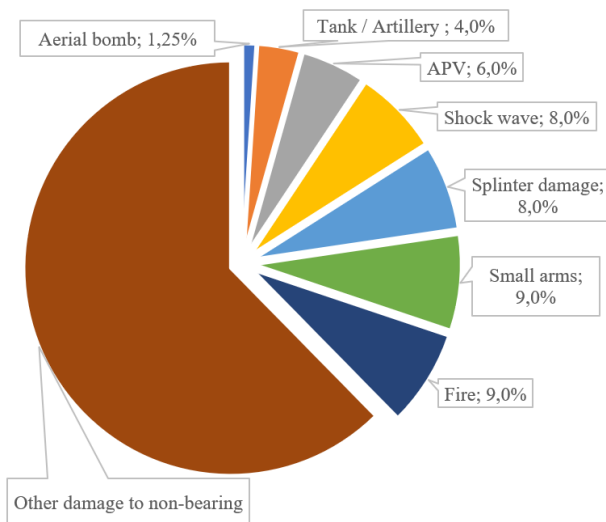


Fig. 12. Damage to construction sites with various types of weapons

The restoration of the environment of war-ravaged cities of Ukraine is considered in conjunction with the protection of all objects of cultural heritage, the protection of cultural heritage is outlined in the draft of the new Law "On Amendments to the Law of Ukraine "On the National Security of Ukraine" on the Preservation of the Cultural Heritage of Ukraine and

National Memory" No. 9072 dated March 2, 2023. The protection of cultural heritage and the preservation and restoration of national memory are also included in the priority measures of the National Security Strategy (approved by the Decree of the President of Ukraine No. 392/2020 of September 14, 2020) and the Military Security Strategy of Ukraine (approved by the Decree of the President of Ukraine No. 121/2021 of March 25, 2021) to implement innovations to the Law of Ukraine "On National Security of Ukraine". It is necessary to create a specialized unit within the Armed Forces of Ukraine for the protection of cultural values - the Cultural Property Protection Unit (CPP Unit).

An important issue, which was not resolved even before the war, is the actualization of the conclusion of protection contracts for cultural heritage sites of national significance with clear fulfilment of requirements for users.

The events of the Russian-Ukrainian war exacerbated the need to collect information on the state of preservation of cultural heritage monuments of national and local importance, destruction, or damage (except for the destruction or damage of monuments due to the military aggression of the Russian Federation). The issue of the geo-informative resource of the State Register of Immovable Monuments of Cultural Heritage was also raised.

Directly related to the topic of the article is the aspect of development and approval of boundaries and modes of use of historical areas of settlements, protection zones of cultural heritage monuments, and territories of historical and cultural reserves. The practice of digitalization of prominent objects is increasingly being implemented (<https://e-pamiatka.gov.ua/>).

Taking into account the large amount of destruction, it is proposed to create a Register of Destructions as part of the Register of Immovable Cultural Heritage and to activate the Program for the Restoration of Destroyed and Damaged Monuments.

The result of complex actions should be the State Strategy for the formation of post-war reconstruction and development of the cultural heritage of Ukraine until 2030.

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Received: June 02, 2023

Accepted: May 20, 2024