



Volume 16, Issue 2, 2025: 1195-1212

DOI: 10. 36868/IJCS.2025.02.28

TECHNICAL AND ECONOMIC FEASIBILITY STUDY FOR THE **RESTORATION OF A RESIDENTIAL REAL ESTATE PROPERTY**

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Abstract

As a result of the military aggression of the Russian Federation in Ukraine, a large number of buildings and structures have been damaged or destroyed. The issue of assessing the extent of material losses and damage in a short time, as well as substantiating the economic feasibility/infeasibility of reconstruction, is more relevant than ever. To restore normal living conditions in areas that were under occupation or in combat zones, it is necessary to take a number of measures: first, damage assessment followed by inspection of damaged buildings and determination of the resources needed for real estate restoration. Using an example of the property damage caused by the military aggression of the Russian Federation in Dnipro, an analysis of the economic feasibility or inexpediency of restoring the real estate that has become unsuitable for its intended usage was conducted. An algorithm for determining the economic feasibility/infeasibility of restoring an object has been developed and implemented in Sobornyi district of Dnipro. The developed procedure for assessing the feasibility/infeasibility of restoration can be applied to determine the category of destroyed real estate objects. The algorithm was developed and tested in the Sobornyi district of Dnipro. The calculation results enabled residents of the affected property to get housing certificates for compensation for the destroyed property.

Keywords: Economic feasibility; Destroyed real estate objects; Gross development value; Market value

Introduction

As a result of the military aggression of the Russian Federation in Ukraine, many buildings and structures have been damaged or destroyed. These objects are real estate properties located in Ukraine that have become unsuitable for use for their intended purpose as a result of hostilities, terrorist acts, sabotage or other consequences of the armed aggression by the Russian Federation against Ukraine; their renovation through routine repairs or major renovation, reconstruction or restoration is either impossible or is considered economically infeasible [1].

Terrorist attacks have a particularly strong impact on buildings and engineering structures. The damage is related to both external and internal finishing elements and structural

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elements. The most dangerous impact of attacks during warfare is related to explosions and their impact, especially on structural elements. Depending on the weapon used, these explosions differ in strength and degree of destruction of objects [2-4]. An important element is the assessment of the destruction of objects caused by explosions of different strengths in terms of construction [5, 6], which can directly affect the analysis of the profitability of repair. The assessment of the degree of destruction of objects after explosions is relatively complicated because it is a multi-dimensional assessment from many fields. The assessment of the degree of destruction due to dynamic impacts [7, 8] and fire impacts [9] is particularly important. The assessment of the impact of various adverse impacts also depends on the type of object, the material from which the structural elements are made and the technologies used [10-13].

Given that any building can be restored through routine or major repairs, reconstruction or restoration, determining the economic feasibility of restoring such objects has become extremely relevant.

The purpose of the study is to determine the economic feasibility of restoring real estate objects that have become unsuitable for their intended use due to hostilities, terrorist acts or sabotage caused by the armed aggression of the Russian Federation against Ukraine, using an example of an object affected in the city of Dnipro. In the article, in order to determine the economic profitability of repair, the calculations were divided into three stages: assessment of the costs of demolishing part of the structure, assessment of the repair costs and finally determination of the Gross Development Value and comparison with the cost calculations estimated in the first two phases.

The calculation of replacement cost/determination of replacement cost

The economic feasibility of restoring objects damaged or destroyed as a result of hostilities, terrorist acts or sabotage caused by the armed aggression of the Russian Federation against Ukraine is determined by comparing the costs of their restoration with the costs of constructing a new object that performs similar functions.

In fact, these costs of restoration through new construction or proposals for building new objects to replace those that have been damaged or destroyed are economically equivalent to the concept of Gross Development Value (GDV), as defined by the Methodology [14]: Gross Development Value is the price that can be obtained as of the valuation date when selling a completed development (construction) of the real estate object in the market. This value corresponds to a monetary amount sufficient to cover the costs of land acquisition and its development, including the cost of financing these expenditures and the developer's profit.

It should also be noted that, according to Section V, Clause 2 of the Methodology [14], Gross Development Value (GDV) is determined by the sum of the future value of a land plot sufficient for the placement and operation (maintenance) of the construction object and the future value of direct and indirect costs for its improvement, using modern design solutions, materials and technologies. The replacement (reproduction) cost includes direct costs (the cost of construction) and indirect costs (fees for consultants and marketing expenses) sufficient to create (acquire) the relevant improvement. This aligns with Clause 90.6 of the IVS 410 (International Valuation Standards), "Real Property with Development Potential," which states the following: "The following basic elements require consideration in any application of the method to estimate the market value of development property and if another basis is required, alternative inputs may be required. a) Completed property value, (b) Construction costs, (c) Consultants fees, (d) Marketing costs, (e) Timetable, (f) Finance costs, (g) Development profit, (h) Discount rate."

To determine the scope (valuation) of the needs for restoring damaged and destroyed real estate, it is proposed to assess the Gross Development Value specifically.

An acceptable market procedure for determining Gross Development Value is the cash flow compounding model, which is based on the principle of unrecovered investment; within this framework, the GDV is determined by the sum of the future value of the land plot, sufficient for the placement and operation (maintenance) of the construction object and the future value of direct and indirect costs required for its improvement, using modern design solutions, materials and technologies.

When determining the gross cost of development, it is essential to consider the inherent risks associated with real estate development: unforeseen complications that increase construction costs; slow delivery and failure to meet work deadlines; setbacks in finding buyers or tenants for completed real estate projects; the impact of inflation; and others.

These risks should be considered in one of the following ways: by including the relevant expenses in the replacement (reproduction) cost of improvements, covering risks for all construction participants, additional costs related to inflationary processes, consultant fees etc. or by adjusting the compounding rate.

The replacement (reproduction) cost includes direct expenses, the construction costs and indirect expenses, in particular consultants' fees and marketing expenses, sufficient for the creation (acquisition) of the relevant improvement. The construction costs represent the monetary amount for which a contractor agrees to fulfill the construction order in accordance with the project documentation provided and taking into account the risks that cannot be eliminated.

The mandatory components of construction costs include: direct expenses necessary for the development of project documentation, construction (reconstruction) of the primary building projects, landscaping and site finishing of the area; associated expenses related to construction site preparation, construction of auxiliary and service facilities and networks within the land plot (if they are not subject to separate valuation), erection and dismantling of temporary buildings and structures, covering the costs of the customer and contractor construction organisations related to the construction, as well as for certain types of work performed during the construction, maintaining the customer's service and engineering services; estimated profit; funds to cover administrative expenses of construction organizations; funds to cover the risks of all participants in the construction process; funds to cover additional expenses associated with inflationary processes; taxes, fees and mandatory payments established by law and not included in other components of construction costs.

The total construction cost is reduced by the amount of recoverable funds from the reuse of temporary buildings.

The calculation of replacement (reproduction) cost [14] suggests the possibility of using aggregated indicators of construction costs determined by the Ministry for Communities and Territories Development of Ukraine, with appropriate adjustments (if necessary) for discrepancies between the comparison objects and the object being evaluated in the main comparison elements. However, a system of such indicators has not been developed or published yet.

Research methodology

The inspected apartments are located in a 10-story residential building that is in an emergency technical condition (Figs. 3-5). The damage category is 3, i.e., the apartments are unsuitable for their intended use, with damage to load-bearing and enclosing structures. The extent and nature of the damage indicate the risk of structural collapse. Urgent measures are recommended, including demolition (removal) of the building.

To determine the economic feasibility/infeasibility of restoring an apartment, it is necessary to calculate its construction cost and indirect expenses sufficient to create an equivalent improvement. The indirect expenses will include the following components:

- determining costs for the demolition of dangerous structures and the preparation of the construction site and networks;
- determining costs for restoring the apartment's structural elements, common areas and essential structural components of the building required for the building to pass from condition 4 (emergency) to condition 2 (satisfactory and suitable for use);
- determining the gross development value (the price that can be obtained as of the valuation date when selling a completed development (construction) real estate object in the market);
- analyzing residential real estate costs in the secondary and primary markets;
- defining market value (the value for which the object of valuation can be transferred in the market of similar properties as of the valuation date, under an agreement between the buyer and the seller, following appropriate marketing, provided that each party acts knowledgeably, prudently and without coercion) and appraisal value (the appraisal value is the value determined based on a predefined algorithm and a set of input data) of a real estate object;
- determining the amount of compensation for the destroyed real estate object;
- reconciliation by direct comparison of the gross development (restoration) value of an apartment and the market value of the property.

The analyzed real estate object is located at the address Dnipro, Shevchenkivskyi District, 24A Vykonkomivska Street, code (779/24-TZ), performed by FOP Protasenia A.I. in 2024. The building is presented in Figs. 1-5. The condition of the building before the destruction is shown in Figs. 1 and 2.



Fig. 1. General view of the building with vertical axes 2-2 and 5-5 [15]



Fig. 2. Satellite view of the top of the building with horizontal axes A-A, B-B and C-C [15]

The spectrum of destruction is presented in Figs. 3-5.



Fig. 3. General view of the destruction from the main facade along row "A" within axes "2-5"



Fig. 4. General view of the destruction from the courtyard facade along row "C" within axes "2-5"



Fig. 5. Fragment of wall destruction in row "A" on the side of axis "5" from the technical floor to the 4th floor. Collapsing hazardous sections of the building

The first stage of determining the costs of demolition works

The first stage involves determining the costs of demolition work for dismantling hazardous structures and preparing the construction site and networks. According to the preliminary report on the inspection and assessment of the technical condition of the building structures of the residential building located at the address Dnipro, Shevchenkivskyi District, 24A Vykonkomivska Street, code (779/24-TZ), performed by FOP Protasenia A.I. in 2024, the technical condition of the residential building A-10 was classified as hazardous, with damage category 2. Part of the second entrance, within axes 1-5, rows A-B-C (Figs. 1 and 2), is deemed unsuitable for its intended use and subject to partial demolition.

For the proper operation of the building as a whole, it is necessary to carry out urgent repair and restoration work, to temporarily reinforce the structures within the hazardous condition of levels 6-10 and the technical floors of the residential building and to dismantle the destroyed elements, which involves:

- installation of safety racks for floors 5-10 outside the destruction zone as well as when the demolition of structures progresses;
- demolition of destroyed structures from the technical floor to the 5th floor within axes 2-3-5, rows A-B-C, including the dismantling of parapets, part of the roof and the staircase covering within axes 2-4 of entrance 2, after the development of a demolition work project.

To enable further operation of the building, it is necessary to dismantle hazardous structures in the destroyed areas of entrance 2 within axes 2-5, rows A-B-C, following a safe sequence of demolition, taking into account the characteristics and technical condition of the building's supporting systems. This should be done while preserving the structures necessary to maintain the stability of the remaining part of the building – entrance 1 within axes 5-9, rows A-B-C.

The estimated volume of destroyed structures and the demolition zones of structures up to the 5th floor within axes 2-3-5 of rows A-B-C were calculated based on the design drawings.

Dimensions are as follows: in axes $2 \cdot 3 \cdot 5 - 18.0$ m, axes $3 \cdot 5 - 15.075$ m, axes $3 \cdot 4 - 1.880$ m, axes $2 \cdot 3 - 2.940$ m, rows A-B-C - 14.6m, height from the technical floor to the 5th floor, from elevation 14.0 to elevation 36.1 - 22.1m.

Thus, the estimated volume of destroyed structures and the demolition zone is calculated as $18.0 \times 14.6 \times 22.1 = 5,808 \text{ m}^3$.

The volume of the destroyed part, according to the preliminary report and design data, amounts to $3651.5m^3$ (Tab. 1). Thus, the demolition volume of the destroyed structures from the technical floor to the 5th floor within axes 2-3-5 of rows A-B-C, including the dismantling of parapets, part of the roof and the staircase covering in axes 2-4 of entrance 2, makes $5,808 - 3,651.5 = 2,156.5m^3 + 10\%$ for unaccounted parts of parapets, part of the roof and staircase coverings = $2,382m^3$.

The estimated cost of the demolition work is 1,738,985 UAH, including VAT. Or per 1 m² of the total apartment area in the building, these costs amount to 294.28 UAH.

The final costs for demolition and restoration work can only be determined after the development of a demolition work plan and a restoration project.

Floor Level	Area of the Destroyed Section, m ²	Volume, m ³
levelling 13.1	25	82.5
levelling 16.4	28.3 + 48.9 = 77.2	254.8
levelling 19.7	28.3+82.6=110.9	366
levelling 23.0	61.1 + 81.7 = 142.8	471.2

Table 1. Calculation of the volume of the destroyed part

Floor Level	Area of the Destroyed Section, m ²	Volume, m ³
levelling 26.3	110+61.1 = 171.1	564.6
levelling 29.6	110 + 82.6 = 192.6	635.6
levelling 32.7	117.8 + 82.6 = 200.4	661.3
levelling 35.0	165+21.5=186.5	615.5
Total	1,106.5	3,651.5

The second stage of determining the costs of demolition works

The second stage involves determining restoration costs. As an example, let us consider one of the destroyed apartments. The subject of inspection is apartment No. 55, with a total area of 76.2m², located on the 8th floor of the building in the second entrance, within axes 1-5, rows A-B-C. Date of analysis: 09.09.2024.

For the proper functioning of the apartment and the building as a whole, it is necessary to restore the main load-bearing structures of the object under inspection and the common areas.

In general terms, costs can be determined based on the indicators of the indirect cost of residential construction by regions of Ukraine [16] or other aggregated indicators of restoration works or construction cost estimates for analogous objects.

The indicator of the indirect cost of residential construction as of July 1, 2024, for the Dnipropetrovsk region is UAH 21,520 per 1m² of the total apartment area in the building (including VAT). This indicator does not take into account many factors, such as the year of construction of the object, the materials of the structural elements, the number of floors, the ratio of residential to non-residential areas and other variables. As an indicator of the cost of residential construction, the data that is available in the public domain on the platform [17], where full detailed construction packages and cost documentation can be found, can be used. For example, in [18] there is information on "New construction of a multi-apartment residential building on Maksyma Diya Street in the city of Dnipro, carried out in 2024." This building is similar to the surveyed object in terms of structural characteristics and the number and area of apartments. According to the project and estimate documentation, the construction cost is UAH 162,000,000 (UAH 30,055 per 1m² of the total area of the apartments in the building). It is possible to use the current regulatory framework combined with actual market data, provided that the Reference System of Cost Indicators is applied, particularly in situations requiring prompt economic decision-making. For a generalized cost assessment of demolition and restoration works, data from the Consolidated Cost Indicators (for multi-story residential developments with similar structural and planning solutions, as of 01.01.2014) were used [19].

Thirteen projects of 8- to 15-story residential buildings were selected as comparison objects (Table 2), an analysis was conducted and average cost indicators for constructing $1m^2$ of the total apartment area were obtained.

The results of the analysis are presented in Table 3. Thus, the construction cost per $1m^2$ of the total apartment area is 33,040 UAH. This cost already takes into account the fact that it is a new development constructed after 2000, with structural characteristics and spatial-planning solutions matching those of our surveyed object. However, it represents the cost of restoration to the "after-developers" stage, meaning it does not include repairs, interior finishing or the presence of plumbing and electrical appliances in the apartment.

No	The number of floors in the residential building project	The number of apartments	Construction volume, m ²	Useful building area, m ²	Area of apartments, m ²	Cost of construction, 1 m ² of apartment area UAH
1	9-storey building	48	22121.0	4399.60	3994.70	19268.4
2	10-storey building	52	18015.0	3285.50	3061.90	21434.7
3	10-12- storey building	52	19503.0	3560.50	3251.60	24926.9
4	12-storey building	52	17463.0	3281.40	3003.60	23445.9
5	9-storey building	64	40602.0	8419.20	7109.30	31986.8
6	9-storey building	70	16873.0	6249.10	5991.40	18908.4
7	11-storey building	118	40319.0	8053.90	7289.40	27053.9
8	8-9-storey building	64	31645.0	8498.30	5424.60	35240.4
9	9-10-storey building	71	31874.0	6282.60	6091.70	28176.1
10	10-14-storey building	285	113022.0	22876.9	18430.7	29459.0
11	10-15-storey building	248	80624.0	16154.8	14537.4	29147.2
12	10-13-storey building	172	65127.0	14105.1	10019.3	32102.0
13	10-storey building	88	33989.0	8271.70	7394.30	24128.5

Table 2. Calculation of the volume of the destroyed part

Table 3. Results of the analysis of residential building value

	Volumo	Ar	·ea, m ²	Cost of construction, 1 m ²	
Indicator	cubic metres	useful	of apartments	of apartment area UAH, without VAT	
Average value of objects	40860	8726.0	7353.81	26559.9	
Object under examination	36246	9691.6	5909.2	33040.0*	

* The cost is calculated considering the average value, taking into account the coefficient reflecting the differences in the average area of apartments and the apartments in the building: 7353.81/5909.2 = 1.244

According to the analysis of [20], the cost of renovating a one-room apartment with rough finishing usually amounts to approximately 30% of the sale price of the apartment. However, to ensure additional reserves and avoid unforeseen expenses, it is recommended to add another 10-15% to this amount. Rough finishing involves basic work essential for comfortable living. The cost of renovating a two-room apartment amounts to approximately 40-50%. This is due to a larger scope of work and the greater area of the apartment. The final cost also depends on the choice of materials and the services of builders.

For generalized calculations, a cost indicator for repair works at the level of 40% was applied. The fact should also be considered that the building was constructed in 2004 and the repairs in the apartments had an estimated wear of approximately 10%, according to the owners.

The determined restoration cost indicator is an average value of the construction cost per $1m^2$ of the total apartment area, which amounts to 33,040+33,040x(40-10)/100=42,952 UAH/m².

Third stage of determining indirect costs of the Gross Development Value

The third stage involves determining the indirect costs (according to Clause 90.23 of the current IVS 410, these include expenses for legal and professional services required by a market participant at various stages until the project is completed).

When buying or selling apartments, the commission fee for a realtor or agency ranges from 3% to 5% of the transaction amount. For luxury property, it can be as high as 10%. In the

rental segment, realtors charge 50% to 100% of the monthly rental cost [21]. Therefore, the minimum amount of indirect costs to be considered is 5% or UAH 2,147.6 per $1m^2$.

Determination of Gross Development Value. If there is insufficient market evidence to determine the market value of a particular land plot, the gross development value is calculated using situational classes; each class corresponds to the share of land in the gross development value, assuming that the size of the land plot meets the regulatory standard (1):

$$V_0^{GDV} = \frac{V_c \times (1+i)^{0.5}}{1 - L \times (1+i)'},\tag{1}$$

where: V_0^{GDV} is the Gross Development Value of a destroyed real estate object; V_L is the value of a land plot; V_C is the cost of replacement (reproduction) of improvements; *i* is the compounding rate; and *L* is a land share in the Gross Development Value corresponding to a certain situational class.

The calculation of the gross development value of multi-apartment residential real estate according to this methodology allows for the use of generalized indicators for the land share in the Gross Development Value, depending on the situational class of the property unit. This class corresponds to the location of the object within settlements of different sizes, as outlined in Appendix 7 of the Methodology [14].

The determined cost of replacement (reproduction) of improvements V_C makes 42,952 UAH/m².

The compounding rate *i*, determined by the duration of construction (development), expressed in the number of months *h*, is calculated based on the annual compounding rate i_A (2):

$$i = (1 + i_A)^{h/12} - 1, (2)$$

The value of the annual interest rate i_A , which ensures the investor's interest (financing cost) i_F and the developer's interest (developer's profit) i_D , s calculated using the following formulas (3) or (4):

$$i = i_A = (1 + i_F) \times (1 + i_D) - 1,$$
 (3)

$$i = i_A = i_F + i_D + i_F \times i_D. \tag{4}$$

For the purposes of the Methodology [2], the cost of financing as of the valuation date is calculated as an interest rate based on data from the Global Rates website [22] regarding the annual LIBOR rate in US dollars, with the value increased by a country risk premium.

The LIBOR rate is an average interest rate for interbank lending in the international market. In this case, the value of the annual LIBOR rate, available at [22], is selected as the average for February 2022, which is the month immediately preceding the beginning of the Russian Federation's full-scale military aggression and corresponds to the market situation before the aggression began. This value is 0.077%.

The country risk premium (CRP) serves as an additional compensation (relative to the LIBOR rate) for systematic risks in a specific country or market. The value of the CRP is calculated as the average difference in yields between U.S. Treasury bonds with a 10-year maturity (10Y YTM), according to [23] and Ukrainian Eurobonds issued for a comparable term (Ukraine, 2032), available at [24] for February 2022, prior to the start of full-scale aggression of the Russian Federation (Table 4) and was subsequently set at 8.35 %.

Date	YTM Ukraine, 2032 (EAVEX)	YTM 10 Yr, USA	CRP
07.02.22	10.0%	1.92%	8.08%
14.02.22	9.9%	1.98%	7.92%
22.02.22	11.0%	1.94%	9.06%
Average:			8.35%

Table 4. Rate calculation

The developer's interest (developer's profit; risk premium associated with real estate development) is determined based on market information, proceeding from comparing the income from the sale of a completed real estate object with the amount of expenses (taking into account the time factor and the duration of development) related to its development. The quantitative value of this parameter in Ukraine is, firstly, non-public information, typically known only to the developer and secondly, it largely depends on the organization of the developer's operational and financial activities, the type of property and others. According to indirect estimates from experts, as of the beginning of 2022, the developer's profit ranged from 8% to 15-20% per annum. For the property being evaluated, this value is set at 10%. Additionally, this value can be supported by the following considerations. The risk premium associated with real estate development is usually a few percent higher than the cost of financing (borrowed capital) for the construction of similar facilities. According to the data from [25], the construction loan interest rate was 8-9% in USD and EUR. Therefore, a risk premium value of approximately 10-11% is considered quite reasonable.

Results

The duration of the construction (development) period is determined based on DSTU B A.3.1-22:2013 "Determination of the duration of construction projects" [26] in the case of construction or development (major repairs). The initial data indicates that, as of the date of the survey, the legally required procedures for developing design and estimate documentation from the date of the damage occurrence had not been completed and conservation or preparatory work had not begun; i.e., the period for completing restoration work in accordance with the approved design and estimate documentation (DED) will take from 8 to 10 months. Considering the time required for drafting and approving the DED, this is another 2 months and therefore at least 12 months. The calculation of the compounding rate is provided in Table 5.

Indicators	Source	Value
LIBOR USD, February 2022	Global-Rates.com	0.077%
Country risk premium (%), CRP	Eavex.com.ua; treasury.gov	8.35%
Investor interest (%), iF, total:	Calculation	8.43%
Developer's interest (%), iD	Calculation	10.00%
Annual compounding rate (%), iA	Calculation of Clause 3.9 of Section III of "Methodology"	19.27%
Construction duration (months)	DSTU B A.3.1-22:2013 "Determination of the duration of construction of objects,"	12
× ,	Appendix A [26]	

Table 5. Calculation of the compounding rate

Given that the value of the land plot is indirectly included in the total value when determining the amount of compensation for the destroyed property, the value of the land plot was not separately calculated in all calculations by applying the regional coefficient (region: Dnipro region, location: Shevchenkivskyi district, Dnipro).

Thus, the gross development cost per $1m^2$ will be:

 $V_0^{GDV} = (42,952+294.28+2,147.6) \times (1+0.1927)0.5/1-0.23450 \times (1+0.1927)=49,574.74$ UAH.

Thus, the estimated gross development cost of a two-room apartment, No. 55, with a total area of $76.2m^2$, a living area of $36.6m^2$, located on the 8th floor of a 10-story building commissioned in 2004, located in Dnipro, 24A Vykonkomivska Street, is UAH 3,777,595 (UAH 4,575 per 1m²).

According to the analytical materials of the Joint Venture UVECON [27], the average offer price in the secondary residential property market for all classes is \$863 per $1m^2$, the average bidding size is 10% and the average offer price in the secondary residential property market for all classes for the Volodarskyi neighborhood, Shevchenkivskyi district, is \$1,019 per $1m^2$ (Tables 6 and 7).

Table 6. Residential real estate market of economy	, comfort and business class,	Dnipro, July	2024
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Research period: July 2024					
Dnipro	July	Percentage decrease %			
economy, comfort, business class	Average cost per 1m ² , 811\$	-0.61%			
Administrative districts	July Average cost \$ per 1m ² of residential property	Decrease in dollars \$% June-July 2024	Percentage decrease % June-July 2024		
Amur-Nyzhniodniprovskyi	757	-5.0	-0.66		
Shevchenkivskyi	820	-5.0	-0.61		
Sobornyi	906	-5.0	-0.55		
Industrialnyi	771	-5.0	-0.64		
Tsentralnyi	944	-5.0	-0.53		
Chechelovskyi	807	-5.0	-0.74		
Novokodatskyi	766	-5.0	-0.65		
Samarskyi	719	-5.0	-0.69		

Table 7. Primary residential property market comfort, business class, Dnipro, July 2024

	Research period: July 2024					
Dnipro primary market comfort, business class	July Average cost per 1m². 1196\$	Percentage decrease % -0,42%				
Administrative districts	July Average cost \$ per 1m ² of residential property	Decrease in dollars \$% June-July 2024	Percentage decrease % June-July 2024			
Amur-Nyzhniodniprovskyi	1143	-5.0	-0.44			
Shevchenkivskyi	1190	-5.7	-0.47			
Sobornyi	1434	-5.0	-0.35			
Industrialnyi	978	-5.3	-0.54			
Tsentralnyi	1478	-6.0	-0.40			
Chechelovskyi	1217	-5.7	-0.46			
Novokodatskyi	1089	-5.0	-0.46			
Samarskyi	1039	-4.7	-0.45			

Based on the data of the residential real estate market analysis, the following conclusion was made about the value of the residential real estate of the survey object:

- the cost of residential property in the secondary market of comfort business class in Dnipro, Shevchenkivskyi district, is \$820-1,019 per 1m²;
- the cost of residential property in the primary market of comfort, business class in Dnipro, Shevchenkivskyi district, is \$1,190 per 1m².

Thus, the estimated cost based on the market analysis of the two-room apartment No. 55, with a total area of 76.2m², a living area of 36.6m², located on the 8th floor of a 10-story building commissioned in 2004, located in Dnipro, 24A Vykonkomivska Street, would be:

- For a secondary market property, \$62,484 (UAH 2,562,894, UAH 33,634 per 1m²);
- For a primary market property, \$90,678 (UAH 3,719,321, UAH 48,810 per 1m².);
- For a secondary market property in the specified neighborhood of the apartment location, \$77,648 (UAH 3,184,864, UAH 41,796 per 1m²).

Determination of the appraised value of a real estate object

For the purposes of calculating the income of an individual taxpayer from the sale (exchange) of real estate, as well as income received by the taxpayer as a result of inheritance or gift of property (except in cases of inheritance and/or gift of property whose value is calculated at a zero rate), income received under other deals within which the ownership of real estate is transferred and income under which is subject to taxation in cases provided for by the Tax Code of Ukraine, it is necessary to determine the appraised value of the real estate or the market value of the real estate.

To determine the appraised value of a real estate object, the Unified Database of Appraisal Reports generates an electronic certificate of its appraised value (e-Certificate), which is valid for 30 calendar days from the date of its generation by the Unified Database [28].

According to the technical passport provided by the owner, a certificate of the appraised value of the real estate object was obtained. The appraised value of the two-room apartment No. 55 with a total area of $76.2m^2$, a living area of $36.6m^2$, located on the 8th floor of the 10-story building commissioned in 2004, located in Dnipro, 24A Vykonkomivska Street, makes UAH 3,526,167 (UAH 46,275 per $1m^2$).

An electronic certificate of the appraised value of a real estate object is a document generated at the request of an individual or legal entity on the basis of the data on a real estate object entered into the Unified Database of Appraisal Reports via the Internet and containing the appraised value of such an object calculated by the module for electronic determination of the appraised value.

Registration in the Unified Database is carried out on the basis of compliance of the market value of the appraised property with the acceptable 25 percent range of values for comparable real estate objects, information on which is contained in the Unified Database, defined by the Module.

The information basis for determining the appraised value of a real estate object by the Module is formed through using open access information sources, in particular, data from Internet resources that systematically publish announcements regarding property listings; data on prices specified in real estate sale and purchase agreements entered by notaries into the Unified Database; and data on the market value of real estate objects entered into the Unified Database on the basis of appraisal reports.

The estimated value is in the range of UAH 2,644,625–4,407,709.

Determination of the market value of the property. The market value of the property was determined using a comparative approach based on the market prices for the sale of real estate, which were determined based on the data on offerings for sale in the relevant segment of the market for the sale of commercial real estate in Dnipro. When choosing the comparison objects, particular attention was paid to the design and technical characteristics that correspond to the object of valuation, location and consumer qualities. The prices for the comparison objects were taken from the following internet resources and marketplaces: [29, 30].

The analogues selected for the calculations are apartments in residential multi-story buildings located in the Shevchenkivskyi district of Dnipro that meet the definition of similar property – property that is similar in its characteristics and/or properties to the object of valuation, taking into account the differences of the object of valuation and has the same investment attractiveness.

The differences between the object of valuation and comparison objects were quantified using the difference coefficient K_{di} , the introduction of which allows identifying differences and properties that are important for a given market. The value of the coefficient of difference of the *i*-th factor is determined by the formula:

$$K_{di} = \frac{(x_0 - x_a)/(x_a - x_0)}{10} 100\%,$$
(5)

where: x_a is a quantitative or scoring indicator of the comparison object; x_0 – the relevant indicator of the object of valuation.

The adjusted price of the comparison object is determined by the formula:

$$B = K_{di} \cdot Ca, \tag{6}$$

where: K_{di} is the adjustment coefficient; Ca is the market price of the comparison object.

The determined market value of $1m^2$ (as the price that can be obtained as of the valuation date when selling a completed real estate object in the market) is UAH 46,699.

In order to determine the market value of residential property, the comparative approach is used to adjust the prices of properties offered for sale for differences with the comparison object. Adjustments related to bargaining, rights and time of sale were applied first, followed by other adjustments. The first three adjustments are made sequentially. Each subsequent adjustment is made to the previous adjusted offer price. The remaining adjustments are made on an independent basis by adding and subtracting percentages and adjusting for the total percentage. No adjustments were made if the characteristics of the comparison object and the appraisal object were identical.

To perform valuation based on the comparative approach, research and analysis of the residential property market in Dnipro were conducted. 4 comparison objects were selected that most closely match the appraisal object in terms of their purpose, characteristics and properties; location; space and planning characteristics; and investment attractiveness. The sources of information are given in the table below. The calculation tables show the values of the market prices of the objects offered and the market prices of the premises in UAH/m² rounded to the nearest whole number.

Thus, the market value of the two-room apartment No. 55, with a total area of $76.2m^2$ and a living area of $36.6m^2$, located on the 8th floor of a 10-story building commissioned in 2004, situated in Dnipro, at 24A Vykonkomivska Street, is UAH 3,558,464 (UAH 46,699/m²).

Determination of compensation for a destroyed real estate object. The amount of compensation for a destroyed real estate object is calculated in accordance with Cabinet of Ministers Resolution No. 600 dated May 30, 2023 [31], using formula (7) for destroyed apartments and other residential premises within a building (hereinafter referred to as "apartments"):

$$V_i = V_{av} \cdot K_r \cdot K_{room} \cdot K_{vear} \cdot S_{des} \tag{7}$$

where: V_i is the amount of compensation for a destroyed real estate object (apartment), UAH, V_{av} is the amount of compensation for a destroyed real estate object (apartment) UAH, K_r is the regional coefficient accounting for the price difference per 1m² based on the location of the destroyed real estate object (apartment) - the region provided in Appendix 3 is the Dnipropetrovsk region, location – Shevchenkivskyi district in the city of Dnipro. $K_r = 1.079$; K_{room} is the coefficient accounting for the price difference per 1m² based on the number of rooms in the destroyed real estate object (apartment) and is provided in Appendix 4 (for a two-room apartment, $K_{room} = 0.9307$). K_{year} is the coefficient that accounts for the difference in price per 1m² depending on the year of construction of the destroyed real estate object (apartment). the year of construction given in Appendix 5 [31] is 2004, $K_{year} = 1.03$, S_{des} is the area of the destroyed real estate property in square meters, but not exceeding 150m² for an apartment and not exceeding 200m² for a detached house, a garden house or a summer house. The apartment area is 76.2m². The amount of compensation for a destroyed real estate object is determined and equal:

 $V_i = 36,422.33 \times 1.079 \times 0.9307 \times 1.03 \times 76.2 = \text{UAH } 2,870,721 (37,674 \text{ UAH/m}^2)$

Conclusions regarding the economic feasibility/infeasibility of apartment restoration. To determine the economic feasibility/infeasibility of the restoration, we will compare the results obtained (Table 8).

No.	Indicator	Cost, UAH
1	Gross Development Value	3,777,595
2	Approximate cost of residential real estate according to the	2,562,894 -
2	market analysis: from - to	3,719,321
3	Estimated value of the property from to	2,644,625 -
	Estimated value of the property: from - to	4 407,709
4	Market value of the real estate object	3,558,464
5	Compensation value for the destroyed real estate object	2,870,721
(Economic feasibility (item 1. < item 4) / infeasibility (item 1. >	Economic restoration is not
0	item 4) of restoration	feasible

Table 8. Determination of the economic feasibility/infeasibility of apartment restoration

According to market analysis, the approximate value of residential real estate is provided to confirm the accuracy of the calculation of the market value of the property. In this case, the market value corresponds to the range of the market analysis.

The appraised value of the real estate object is used only for the purpose of calculating the income of an individual taxpayer from the sale (exchange) of real estate, as well as the income received by the taxpayer as a result of inheriting or receiving the property as a gift (except in cases where the inheritance and/or gift is taxed at a zero rate) and the income received from other transactions involving the transfer of property ownership, where such income is subject to taxation in cases provided for by the Tax Code of Ukraine. If a person does not agree with the results of the automatic valuation of the appraisal value of the real estate object, he or she has the right to apply to an estimating entity (appraiser) to determine the market value of such an object. The market value of the real estate object is UAH 3,558,464. The gross development value amounts to UAH 3,777,595.

Thus, taking into account the fact that the two-room apartment No. 55, with a total area of 76.2m², including the living space of 36.6m², located on the 8th floor of a 10-story building commissioned in 2004 at 24A Vykonkomivska Street, Dnipro, is in a critical condition and unsuitable for its intended purpose due to damage caused by hostilities, terrorist acts, sabotage and the armed aggression against Ukraine and given that its restoration is economically unfeasible, it is classified as a destroyed real estate object.

It should be noted that restoring the apartment is currently economically infeasible due to the ongoing war, when the real estate market in Dnipro is experiencing a negative trend, while the costs of construction materials and labor are increasing due to inflation and a shortage of workforce. For instance, after the end of hostilities, this imbalance of indicators may be leveled out, potentially making restoration viable. However, under the current conditions of economic uncertainty, it is impossible to predict when such circumstances might arise. Nevertheless, this scenario remains theoretically possible.

Similarly, calculations were performed for thirteen destroyed 1-, 2- and 3-room apartments in the 10-story residential building located at 24 Vykonkomivska Street, Dnipro. The calculations revealed that the total difference between the gross development value (the cost of restoring the apartments) and the market value of the apartments amounts to UAH 5,376,628. The results are presented in Figs. 6 and 7.



Fig. 6. Graphical representation of the range of appraised value and market value



Fig. 7. Graphical representation of the range of appraised value and market value

According to the calculations and the graph in Fig. 6, the market value of the surveyed apartments (row 3) is within the range of the assessed value determined using the Unified Database of Appraisal Reports [32], considering the allowable 25% range.

According to the calculations and the graph in Figure 7, the Gross Development Value is higher than the market value and is within the range of analytical data of the real estate market.

Conclusions

The authors proposed and implemented determination of the economic feasibility of restoring real estate objects that have become unsuitable for their intended use as a result of hostilities, terrorist acts and sabotage caused by the armed aggression of the Russian Federation against Ukraine.

The total difference between the Gross Development Value (the cost of restoring the apartments) and the market value of the apartments amounts to UAH 5,376,628. All the apartments are in a state of disrepair and unsuitable for their intended use as a result of damage caused by hostilities, terrorist acts and sabotage as a result of the armed aggression of the Russian Federation against Ukraine. Their restoration is economically infeasible and the apartments are classified as destroyed real estate objects.

Thus, based on the practical research, an applied mechanism for formulating the category of destroyed real estate objects has been developed, based on the criterion of economic infeasibility.

References

Y.O. Kirichek, Y.O. Lando, K.K. Bielieva, *The mass appraisal models for residential real estate*, Ukrainian Journal of Civil Engineering and Architecture, 4(016), 2013, pp. 91-100. http://uajcea.pgasa.dp.ua/issue/view/17138 (in Ukrainian). https://doi.org/10.30838/J.BPSACEA.2312.290823.91.975.

- [2] J.P. Xu, H. Wu, L.L. Ma, Q. Fang, Residual axial capacity of seismically designed RC bridge pier after near-range explosion of vehicle bombs, Engineering Structures, 265, 2022, Article Number: 114487. DOI:10.1016/j.engstruct.2022.114487.
- [3] B. Mi, X. Bai, A novel FEM-FVM coupled method of evaluating the explosion shock wave of a thermobaric bomb on the internal and external flow characteristics of aircraft, Aerospace Science and Technology, 126, 2022, Article Number: 107558. DOI:10.1016/j.ast.2022.107558.
- [4] C. Li, B. Lei, R. Pang, J. Xiao, M. Kuznetsov, T. Jordan, *Effects of ignition location on CH4/air explosion characteristic in a spherical bomb*, Thermal Science and Engineering Progress, 50, 2024, Article Number: 102539. DOI:10.1016/j.tsep.2024.102539
- [5] V.A. Kozechko, V.I. Kozechko, Combined Ultrasonic–Mechanical Treatment, Metallofiz. Noveishie Tekhnol., 46(9), 2024, pp. 851-860. DOI:10.15407/mfint.46.09.0851.
- [6] R. Li, J. Yu, X. Zhou, A rapid damage assessment framework for regular RC frame structures under external explosions, Structures, 68, 2024, Article Number: 107104. DOI:10.1016/j.istruc.2024.107104.
- [7] M. Major, K. Kuliński, I. Major, Dynamic analysis of an impact load applied to the composite wall structure, MATEC Web of Conferences, 107, 2017, Article Number: 00055. DOI:10.1051/matecconf/201710700055
- [8] M. Major, K. Kuliński, I. Major, Thermal and Dynamic Numerical Analysis of a Prefabricated Wall Construction Composite Element Made of Concrete-polyurethane, Procedia Engineering, 190, 2017, pp. 231-236. DOI:10.1016/j.proeng.2017.05.331.
- [9] K. Yurkova, M. Major, I. Major, J. Gondro, D. Jończyk, Numerical Thermal-Mechanical Analysis of Passively Protected Steel Structures Under Fire Conditions, International Journal of Conservation Science, 15(4), 2024, pp. 1731-1754. DOI: 10.36868/IJCS.2024.04.10.
- [10] L. Guan, F. Zhao, Q. Lu, D. Zhang, B. Zhu, Y. Wang, Centrifuge modeling of dynamic response of underground concrete silo against adjacent buried explosion loads, International Journal of Impact Engineering, 200, 2025, Article Number: 105256. DOI:10.1016/j.ijimpeng.2025.105256.
- [11] J. Wang, Y. Xu, S. Wang, W. Zhang, X. Ji, B. Zhang, Effect of high-strength rebar and ultra-high-performance concrete on blast resistance of slabs under contact explosion loads, International Journal of Impact Engineering, 198, 2025, Article Number: 105230. DOI: 10.1016/j.ijimpeng.2025.105230.
- [12] H. Qian, J. Li, Y. Pan, Z. Zong, Ch. Wu, Blast performance of precast segmental utility tunnel against ground surface explosion. Part 1: Experimental analysis, Structures, 71, 2025, Article Number: 108192. DOI:10.1016/j.istruc.2025.108192.
- [13] L. Gan, Z. Zong, M. Xia, Z. Chen, H. Qian, Experimental and numerical study of stiffened steel plate-concrete composite panels under explosion, Journal of Constructional Steel Research, 227, 2025, Article Number: 109358. DOI:10.1016/j.jcsr.2025.109358.
- [14] * * *, Order of the SPFU and the Ministry of Economy No. 3904/1223 dated 18.10.2022 'On approval of the methodology for determining the damage and amount of losses caused to enterprises, institutions and organizations of all forms of ownership as a result of destruction and damage to their property caused by the armed aggression of the Russian Federation, as well as loss of profit from the impossibility or obstacles to conducting business activities' (in Ukrainian)
- [15] * * *, https://www.google.com/maps
- [16] * * *, https://mtu.gov.ua/documents/2521.html

- [17] * * *, https://prozorro.gov.ua
- [18]* **, https://prozorro.gov.ua/tender/UA-2024-05-17-009634-a
- [19] * * *, https://sites.google.com/view/elitsmeta/
- [20] * * *, https://riel.ua/ru/blogs/skilki-koshtuye-remont-kvartiri-v-novobudovi-v-ukrayini
- [21] * * *, https://www.epravda.com.ua/publications/2024/08/7/717665/
- [22] * * *, https://www.global-rates.com/en/interest-rates/libor/american-dollar/2022.aspx
- [23] * * *, https://home.treasury.gov/resource-center/data-chart-center/interest-
- rates/TextView?type=daily_treasury_yield_curve&field_tdr_date_value=2022
- [24] * * *, https://www.eavex.com.ua/ukr/research/
- [25] * * *, https://index.minfin.com.ua/ua/banks/nbu/rates/
- [26] * * *, DSTU B A.3.1-22:2013 "Determination of the duration of construction projects"
- [27] * * *, https://uvecon.ua:8080/account/int_report/int_report_2023_2024_koatuu/
- [28] * * *, https://evaluation.spfu.gov.ua
- [29] * * *, https://www.olx.ua
- [30] * * *, https://www.dom.ria.ua
- [31] * * *, Cabinet of Ministers Resolution No. 600 dated May 30, 2023
- [32] * * *, Website: https://evaluation.spfu.gov.ua

Received: January 09, 2025 Accepted: May 24, 2025