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Tetyana Zhydkova*
PhD in Engineering, Associate Professor
National University "Kyiv Aviation Institute"
03058, 1 Lyubomyr Huzar Ave., Kyiv, Ukraine
https://orcid.org/0000-0001-7903-7073

Integration of protected spaces into the structure of residential buildings in the face of constant military threat

Abstract. In the context of a constant potential threat to the civilian population, housing acquires the functions of a primary security environment, which requires a revision of the principles of its spatial planning organisation. The purpose of the study was to substantiate approaches to integrating protected spaces into the structure of residential buildings and determine the principles of their functional zoning in the context of long-term military threats. The study used methods of analysis of scientific sources, comparative analysis of planning decisions, generalisation of statistical data, spatial and functional modelling, and the method of included (participant) observation. The necessity of revising the conventional scheme of functional zoning of apartment premises under conditions of constant military threat was substantiated. It was proposed to adapt the spatial and hierarchical model of protected areas developed in the author's previous studies to the structure of a multi-storey residential building. The use of the structural core of the building as a basis for ensuring the evacuation and safety of engineering systems was justified. The expediency of redistributing the functional purpose of premises with the transfer of night stay zones to a zone with a high level of protection, close to the structural core of the building, was substantiated. The role of the internal buffer zone (bathrooms, dressing rooms, corridors) as spatial elements that reduce the impact of shock waves and debris was determined. It was proved that the facade area has the lowest level of protection and is used as a day space. An additional level of protection can be provided by applying an external energy-absorbing layer (balconies, loggias, facade systems). It was shown that the proposed approach contributes to the development of a more compact planning structure, which positively affects the energy efficiency of buildings, creating prerequisites for improving the energy efficiency of buildings. The scientific originality of the study consists in adapting a multi-level spatial and hierarchical model of protected areas of buildings to the structure of the residential environment and improving the principles of functional zoning of housing in accordance with the level of security of premises. The practical significance of the study lies in the possibility of applying the results obtained in the design of new residential buildings, adapting the existing housing stock, and in developing recommendations for improving the level of safety of residents by integrating protected spaces into the structure of residential buildings

Keywords: spatial and hierarchical model; residential environment; protection of the civilian population; functional zoning; protected space; multi-storey residential buildings

INTRODUCTION

The years of the Russian-Ukrainian war (2014–2026) have shown that residential buildings in Ukraine are increasingly viewed not only as places to live, but also as environments designed to provide a basic level of protection in the event of a military threat. The experience of operating housing stock in the face of air alarms, rocket

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*Corresponding author (*zhydkova@npp.kai.edu.ua*)

and drone attacks revealed problems related to the safety of residents and the possibility of their rapid movement to protective structures. These problems are particularly acute in multi-storey buildings, a significant part of which was designed without considering the long-term impact of military risks. This makes it necessary to find new approaches in which protected spaces are considered as a component of the building structure, and not as a separate element of the civil protection system.

The nature of contemporary military threats has led to a rethinking of the role of the residential environment as a space not only for living, but also for security. A. Chudzińska *et al*. (2025) noted the need to create new standards for protected spaces that combine the requirements of safety, sustainable development and everyday use. In Ukrainian studies, considerable attention was paid to the use of existing housing stock to increase the level of protection of the population. A. Bochkovskyi *et al*. (2025) explored areas for improving civil protection structures based on modern construction technologies, structural solutions, and life support systems. A significant amount of research was devoted to architectural, planning, and structural solutions of protective structures. H. Getun *et al*. (2023) defined the basic principles of spatial planning organisation of shelters, functional zoning, and their placement in the structure of buildings. M. Kyryliak *et al*. (2024) noted that contemporary approaches to the design of civil protection structures should focus on flexible spatial solutions adapted to different types of buildings and use cases.

In international studies on the war in Ukraine, protected spaces are increasingly considered as part of the everyday environment. A separate area of research is devoted to the international experience of organising the protection of civilians. S. Lee & S.-Y. Kim (2024) noted differences in approaches to integrating shelters into the structure of buildings and cities. M. Shapiro & N. Bird-David (2017) showed that in Israel, protected areas have become an integral part of the living environment. S. Malliiani & O. Slietsov (2025) and M. Chodorowski (2026), analysing the experience of Ukraine, Finland, and Israel, confirmed the prospects of Integrated protected spaces as one of the areas of development of contemporary residential typology. Studies of integrated approaches to civil protection also confirm the effectiveness of this area. A. Bubela & A. Osadchyi (2026) noted that integrating protected spaces into the structure of buildings reduces the time to reach a secure location. A. Jörgen *et al*. (2025) identified spatial accessibility, rapid shelter achievement, versatility, and adaptability to various threat scenarios among the basic principles of such systems. M.A. Jurczak & M. Tunkiewicz (2026) noted that improving the level of public safety requires not only new construction, but also risk-based reconstruction of existing shelters and integration of protective functions into the existing urban environment.

Further development of this area is presented in studies on the integration of protected spaces into residential buildings. O. Filonenko & D. Nikolaienko (2025) substantiated the feasibility of installing individual protective premises in extensions to multi-storey residential buildings, and M. Bordun *et al.* (2024) proposed the concept of multi-storey residential buildings with safety capsules integrated into the housing structure. The proposed approaches confirmed the gradual transition from the design of individual protective structures to the integration of the protective function into the residential environment. Despite a significant amount of research devoted to the organisation of shelters and civil protection structures, most of them consider such spaces as separate engineering objects or underground structures that function independently from residential development. A significant part of contemporary research focuses on the humanitarian, psychological, regulatory, or technical aspects of protecting the population, while the issues of integrating protected spaces directly into the functional and planning structure of residential buildings and their impact on the development of modern housing typology remain insufficiently studied.

The purpose of the study was to substantiate the principles of integrating protected spaces into the structure of residential buildings and determine their role in the development of modern housing typology in the context of long-term military threats. To achieve this goal, the following research objectives were defined: to analyse the current conditions of functioning of the residential environment in conditions of constant military threat; to investigate the international and Ukrainian experience of integrating protected spaces into residential architecture; to determine the principles of functional zoning of residential buildings considering different levels of space security.

MATERIALS AND METHODS

The study was carried out within the framework of an architectural and typological approach, according to which a residential building is considered as a spatial system, the functional organisation of which changes under the influence of new operating conditions and safety requirements. The theoretical basis consisted in the concepts of integration of protected spaces into the living environment, international experience in designing security rooms and protective rooms, and a multi-level spatial and hierarchical model of protected areas of buildings and structures developed by the author (Zhydkova, 2026).

The source base of the study was made up of regulatory and technical documents of Ukraine in the field of residential building design DBN V.2.2-15:2019 (2019), DBN V.2.2-5:2023 (2023), DBN V.2.6-31:2021 (2021). These documents were used to assess the requirements for safety, functional zoning of housing, natural lighting, and energy efficiency of buildings when forming proposals for integrating protected spaces into the structure of the residential environment. The study also used international regulatory documents and recommendations regulating the organisation of protected spaces in the structure of buildings: FEMA 453 (2006), FEMA P-361 (2006), FEMA P-320 (2014), ICC 500 (2020), Civil Defence Shelter Act of

Singapore (1998). The Home Front Command's guidelines (2026) on the selection and organisation of sheltered spaces were used to analyse the Israeli experience.

The study was conducted in several consecutive stages. At the first stage, the analysis of the regulatory framework and scientific sources was carried out to identify contemporary approaches to organising the protection of the population in the residential environment. Special attention was paid to the requirements for the placement of protected spaces, the time of access to them, the conditions of people's stay, and the possibilities of integrating protective functions directly into the structure of residential buildings. Architectural and typological analysis was used to investigate the planning structure of residential buildings and identify potential areas suitable for performing protective functions. The analysis considered the location of the premises relative to the external facades, the nature of the structural scheme of the building, the possibility of autonomous functioning of individual premises, and the availability of escape routes. The comparative method was used to compare different models of integration of protected spaces into the living environment. The study compared Israel's MAMAD and MAMAK (Home Front Command, 2026), Singapore's Household Shelter and Storey Shelter, the American Safe Room and Shelter-in-Place approach (FEMA, 2019; FEMA P-361, 2021), and the Ukrainian practice of organising public protection. The comparison criteria were the level of integration into the structure of the building, functional use in peacetime, accessibility for residents, the length of autonomous stay, and the nature of threats from which protection is provided.

To assess the impact of military threats on the functioning of the residential environment, a generalisation of statistical data on air alarms on the territory of Ukraine was used. Analysis of data from Air alarm statistics in Ukraine (n.d.) allowed assessing the frequency and duration of periods of danger and characterise the conditions of functioning of the residential environment in conditions of constant military threat. At the final stage, spatial and functional modelling was applied, which was based on a multi-level spatial and hierarchical model of protected zones. Modelling determined possible levels of potential security of premises depending on their location in the building structure and form proposals for functional zoning of the residential environment. The level of potential security was considered as a relative characteristic of the space, which was determined by a set of indicators, including the location relative to external facades, the presence of structural protection, the availability of a protected area, and the possibility of people staying during short-term and long-term threats.

RESULTS AND DISCUSSION

In international practice, the term "safe room" is used to refer to a specially equipped, protected room designed for people to take shelter in for a short period during emergencies. In the United States, the requirements for such spaces are defined by FEMA P-361 (2021), FEMA P-320 (2014), FEMA 453 (2006), and ICC 500 (2020), which regulate their structural stability, performance, and human safety criteria. Unlike typical Cold War underground storage facilities, the American approach is largely based on the concept of a local protected space (safe room), integrated into a residential or public building and capable of providing "near-absolute life safety" during extreme events. The current FEMA guidelines also demonstrate the transition from an exclusively evacuation response model to a shelter-in-place concept. Research on decision-making between evacuation and shelter-in-place shows that in the dynamic development of a dangerous situation, staying in an internal protected space can be a safer alternative to evacuation (FEMA, 2019; He *et al.*, 2025).

The most consistent models for integrating protected spaces into the residential environment are implemented in Israel and Singapore. In Israel, a system of MAMAD-type shelters is in use – integrated safe rooms within the structure of a flat, which are used as ordinary living spaces in everyday life, most often as a bedroom or a room belonging to one of the residents. During an air alert, other residents of the apartment use this room as the main shelter space. In addition to individual MAMADs, collective protected floor-level rooms (MAMAK) are also used. The Home Front Command regulations define the requirements for the placement, design characteristics, and functioning of such spaces, effectively integrating protective functions into the structure of the residential typology (Home Front Command, 2026). A similar approach is used in Singapore, where household shelters and story shelters are integrated into the structure of residential buildings at the regulatory level (Civil Defence Shelter Act of Singapore, 1998). In most cases, the household shelter is located directly in the apartment and is used as a storage room or auxiliary utility room, combining the functions of everyday use and public protection (Singapore Civil Defence Force, 2021; 2023).

Along with the concepts of safe room and shelter-in-place, the term panic room is also used – a reinforced interior in the structure of a residential building, designed to temporarily protect people in the event of an external threat. In design practice, such premises are characterised by reinforced enclosing structures, autonomous life support systems, protected entrances, and the possibility of short-term sheltering-in-place (Panic Room Installation..., 2025). Panic rooms, as a rule, have an individual character and do not form a separate architectural and typological system of housing. They are mainly focused on local security scenarios and do not provide for a long stay of people or functioning in the face of large-scale military threats.

The modern war in Ukraine has actualised the issue of integrating protective functions into the residential environment and adapting buildings to conditions of constant potential threat. The regulatory framework for the organisation of civil protection of the population in Ukraine consists of the Code of Civil Protection of Ukraine (2012) and DBN V.2.2-5:2023 (2023), which define the requirements for the organisation of civil protection structures. The results of the analysis show that the key problem of the existing strategy for the protection of civilians is the focus on short-term emergencies. The strategy provides for the movement of the population during the alarm to normalised protective structures located within a certain radius of accessibility (300-500 m). However, the response time to an alarm, even in the western regions of Ukraine furthest from the enemy, does not exceed 5-6 minutes, according to the spatial model of the "war rose" proposed by A. Pleshkanovska & T. Zhydkova (2026). Under such conditions, moving to normalised protective structures becomes significantly more difficult, and for low-mobility groups of the population it often becomes impossible. This indicates that the existing defence strategy does not correspond to the real time, space and functional characteristics of the contemporary military threat. According to the statistics of the resource Air Alarm Statistics in Ukraine (n.d.), since the beginning of the full-scale invasion, as of April 24, 2026, the total number of alarms for the eastern regions of Ukraine, in particular Kharkiv, Zaporizhzhia, and Donetsk oblast, was more than 7 thousand (Fig. 1).

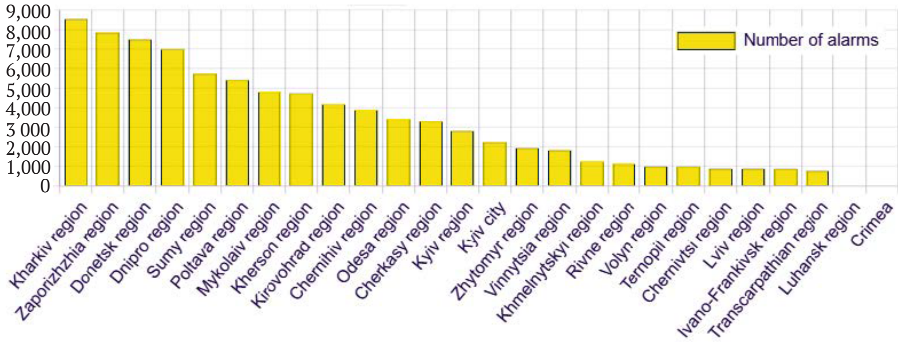

Figure 1. Number of air alarms as of 24.04.2026
Source: Air Alarm Statistics in Ukraine (n.d.)

The average duration of an alarm signal exceeds one and a half hours, and its repeatability on some days reaches eight times a day. A comparative analysis of the hourly number of alarms showed that a characteristic feature for all regions of Ukraine is an increase in the intensity of threats in the evening and at night (Fig. 2). This shows that the military threat is not episodic, but repeated and prolonged in nature and directly affects everyday scenarios for the use of the residential environment.

Figure 2. Number of air alarms hourly as of 24.04.2026
Note: a) Odesa Oblast; b) Kyiv Oblast; c) Lviv Oblast
Source: Air Alarm Statistics in Ukraine (n.d.)

Thus, the conditions of contemporary war form a different reality of human life: the threat is constant, repetitive, and unpredictable, which makes it impossible for housing to function according to the logic of "peaceful living + occasional shelter". Under these conditions, residents are forced to stay in their own apartments during air alarms and missile strikes. Under such conditions, residential buildings actually begin to perform the function of a primary security environment, which significantly increases the requirements for the level of security of their architectural and planning structure. In addition to the immediate threat to the life and health of the population, repeated air alarms significantly affect the daily functioning of the residential environment. A special feature of modern warfare is that the greatest intensity of threats occurs in the evening and at night, when housing performs the functions of rest and sleep. Long-term preservation of this situation changes the requirements for the organisation of living space, since a significant part of the population is forced to spend night time in conditions of increased risk or repeatedly move to protective structures. Under such conditions, safety ceases to be considered exclusively as a function of external protective structures and begins to influence the principles of forming the residential environment itself. This makes it necessary to review conventional approaches to functional zoning of apartments and integrate protected spaces directly into the structure of residential buildings.

The study by V. Hakala *et al*. (2025), K. Peltonen *et al*. (2025) and W. Carter (2025) showed that prolonged exposure to military danger is accompanied by a deterioration in the psychoemotional state of the population and requires the development of a safe environment for everyday stay. Under such conditions, not only civil protection structures are of particular importance, but also the level of protection of the residential environment itself. Thus, housing takes on a dual function, combining the living space and the basic security space. This makes it necessary to review the traditional principles of functional zoning and consider the level of potential security of premises when designing residential buildings. The spatial planning structure of most modern single-section multi-storey residential buildings is based on the presence of a central structural core, where vertical communications (staircase and elevator node) and the main engineering networks of the building are located. Access to apartments is provided through extra-apartment corridors. In the traditional scheme of functional zoning, living rooms – bedrooms, children's rooms, living rooms, and kitchens – are placed along the external contour of the building.

Previous studies have proposed a multi-level spatial and hierarchical model of protected areas of buildings and structures (Zhydkova, 2026). In this study, the concept of security level was used as a relative architectural and planning characteristic of a space. The proposed model is conceptual in nature and is not intended to determine the actual resistance of structures to explosive loads. As part of this study, it was used to analyse the location of premises in the structure of a building and identify areas with different levels of potential security depending on their position relative to the facade, the number of structural obstacles, and proximity to the structural core of the building. Issues of the actual level of protection require separate engineering studies.

According to the proposed model, the residential floor is divided into several zones, separated from each other by internal walls and partitions. The level of potential security of premises consistently increases from the facade of the building to the staircase and elevator node (Zhydkova, 2026) located in the central part of the building (Fig. 3). Analysis of damaged residential and public buildings in Kyiv and Kharkiv, carried out based on field surveys and included observation, showed that the nature of destruction of individual premises largely depends on the number of consecutive structural elements between the external environment and the internal space of the building. Therefore, balconies and loggias can serve as an additional buffer layer between the external environment and the apartment. That is why summer rooms are considered as an additional spatial level between the facade and the interior of the apartment. The nature of their impact depends on the design of the building, the type of damage, and the location of damage and requires further experimental and computational verification. In most modern monolithic-frame residential buildings, columns, pylons and inter-storey floors are load-bearing, while external walls perform mainly enclosing functions. Within the framework of the proposed model, rooms located along the facade are considered as those that are the first to perceive the influence of external damaging factors.

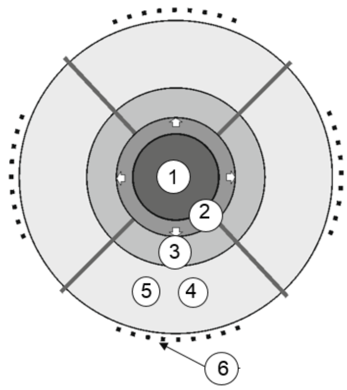

Figure 3. Spatial planning structure of existing multi-storey buildings (floor diagram)
Note: 1 – escape routes; 2 – extra-apartment corridors; 3 – entrance hall, dressing rooms, bathrooms; 4 – common area – kitchen, living room, study; 5 – private area – bedrooms, children's rooms; 6 – summer rooms (balconies, loggias)
Source: developed by the author

Sanitary and hygienic rooms are usually located in the interior of the apartment and are separated from the facade by other rooms. The availability of plumbing equipment, ceramic coatings, and glass elements does not give grounds to consider them as specially protected spaces without additional adaptation measures. According to the findings of previous studies (Zhydkova, 2026), the highest level of potential protection within a residential floor is provided by corridors outside individual apartments, separated by load-bearing walls, and areas directly connected to the stairwell and lift lobby. It is these spaces that can be considered as the basis for integrating protected areas into the structure of residential buildings. This zone is formed by the load-bearing structures of the building and is characterised by the highest level of protection, since it has minimal contact with the external environment and provides the possibility of evacuation of people in case of partial destruction of the building, provided that alternative power sources for elevators are available. This area also houses a network of internal building services with a horizontal distribution system to each appartment, which ensures that the water, heating and electricity supplies to the undamaged part of the building are maintained in the event of damage to part of the building. When using apartment-by-apartment distribution systems for engineering networks, this creates prerequisites for maintaining the functioning of intact parts of the building in the event of local damage to its individual sections (Fig. 4). During field surveys, cases were recorded when the external elements of enclosing structures suffered major damage, while the internal contours of the premises suffered less damage. In particular, in buildings with double glazing, the outer row of glass was destroyed in rare cases, while the inner row remained intact.

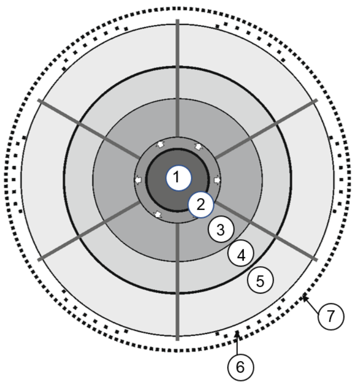

Figure 4. A spatial and hierarchical model of safety zones within the structure of a multi-storey building (floor plan)
Note: 1 – protected core (escape routes, utilities); 2 – intermediate zone (extra-apartment corridors); 3 – zone with a high level of protection (entrance hall, bedrooms, children's rooms); 4 – zone with an average level of protection (bathrooms, dressing rooms, storerooms, corridors); 5 – facade zone (kitchens, living rooms, offices) – low level of protection; 6 – summer rooms (balconies, loggias); 7 – facade systems
Source: developed by the author

A similar principle can be traced in the designs of balconies and loggias, which form an additional spatial layer between the external environment and living spaces. Within the proposed spatial and hierarchical model, balconies, loggias, terraces, and facade systems are considered as the external level of spatial protection of the building. This assessment is conceptual in nature and reflects the features of the spatial organisation of the building, and not the actual resistance of structures to specific types of damage, which requires separate engineering studies. In this study, additional glazing of loggias and balconies is considered as a protective shell – an additional structural layer located between the source of possible damage and the main structures of the building. Within the framework of the proposed concept, individual elements of such a shell can have a sacrificial character and be designed for local damage or destruction during external influence. It is assumed that this will allow localising some of the damage within the external contour of the building. These proposals are conceptual in nature and require further experimental and computational verification.

This approach allows ensuring the continuity of life of the civilian population in conditions of constant potential threat, combining the requirements of safety, functionality, and psychological comfort. Furthermore, in bedrooms and children's rooms, it is advisable to provide an alternative escape route from night stay areas. In everyday life, communication with all the premises of the apartment is provided through internal corridors, or directly, and in case of destruction of the premises of the facade zone, an evacuation exit close to the entrance door is used. Thus, within the residential floor, a hierarchical system of levels of protection of premises is formed, in which the safest rooms are located in the central part of the building surrounded by load-bearing structures, while facade and open spaces are characterised by the lowest level of protection. The presence of protected areas within apartments does not exclude the need to use specialised protective structures in case of high-intensity threats. However, it provides an additional level of daily security and reduces dependence on the need for immediate movement to shelters. The proposed spatial and hierarchical model has the potential not only to increase the level of protection of the residential environment, but also to improve its economic and energy characteristics. The development of a more compact planning structure and increasing the depth of the building helps to improve the ratio of the internal volume of the building to the area of external enclosing structures. Accordingly, the area of facades through which the main heat losses occur decreases, which is consistent with the general principles of energy-efficient building design laid down in DBN V.2.6-31:2021 (2021).

In addition, the concentration of more apartments around one staircase and elevator node allows one staircase and elevator node to serve a larger number of apartments. This contributes to a more rational use of communication spaces and engineering infrastructure, and also allows partially compensating for additional costs associated with increasing the level of protection of the residential environment. The introduction of a multi-level system of protected spaces allows distributing protection functions between different levels of the residential environment, depending on the nature and level of the threat. In this case, the protection of the population is provided not only through civil protection structures, but also through the use of internal spaces of the building with different levels of potential security. Simultaneously, civil protection structures remain the main means of protecting the population during long-term or most dangerous scenarios. Simultaneously, individual elements of the spatial and hierarchical system, subject to appropriate design, can potentially provide a level of protection comparable to the requirements for the simplest shelters, and in some cases – approach individual requirements for anti-radiation shelters. Final confirmation of this possibility requires separate engineering and calculation studies. Under such conditions, there is a need for a more flexible organisation of the public protection system and allows partially distributing protective functions between the building and specialised protective structures.

The results obtained indicate that the security factor is beginning to play the role of one of the determining factors in the development of the contemporary housing environment. If during the 20th-beginning of the 21st century, the development of housing typology took place mainly under the influence of social, demographic, economic, sanitary, and energy requirements, then present-day conditions of military danger form a new group of requirements related to ensuring the safety of the population directly in the place of residence. In contrast to the conventional approach, in which housing was considered primarily as a living space, and the protection function was assigned to separate civil protection structures, current conditions require consideration of a residential building as an element of a multi-level security system. In this case, not only the presence of a shelter becomes important, but also the spatial organisation of the building itself, the ability to quickly transition between zones with different levels of potential security, and the adaptation of functional zoning to conditions of constant threat. The proposed approach actually changes the traditional logic of functional zoning of housing. In most modern apartments, long-stay rooms, in particular bedrooms and children's rooms, are placed along the facade, since it is there that the standard indicators of natural light and insolation are provided (DBN V.2.5-28:2018, 2018). The results of the study indicate that from the standpoint of safety, it is most appropriate to place the premises of night stay closer to the structural core of the building. That is, the security factor begins to influence the principles of functional zoning of housing on a par with the requirements of insolation, lighting, comfort, and energy efficiency.

An important consequence of the proposed approach is a change in the role of internal communication and auxiliary spaces. Corridors, walk-in closets, storerooms, and other rooms that have conventionally been considered auxiliary take on the importance of buffer zones between the external environment and rooms where people stay for a long time. Accordingly, the role of the facade shell of the building is also changing, which is considered not only as a enclosing structure, but also as the first spatial level of protection. The results obtained allow considering the integration of protected spaces as one of the promising areas for further development of residential typology. This does not involve replacing civil defence shelters, but rather creating an additional layer of everyday safety through the rational spatial organisation of the residential environment. This approach is especially relevant for multi-storey buildings in large cities, where access to normalised protective structures is often limited, and a significant part of the population is forced to stay in their own homes during air alarms. The proposed model has a conceptual character and reflects primarily the architectural and planning patterns of the establishment of protected spaces. The issues of actual stability of structural systems to explosive loads, the effectiveness of protective shells and quantitative assessment of the level of protection require separate engineering studies and can become the direction of further scientific developments.

The results obtained are partially consistent with the conclusions of I.O. Yurchenko (2025), who considered the basements of residential buildings as a reserve for expanding the fund of civil protection structures, and A.V. Hasenko *et al*. (2025), who noted a significant shortage of protective structures and uneven location in existing residential areas. The study showed that in conditions of repeated air alarms and limited response time, the development of a network of underground shelters does not solve the problem of timely access of the population to protection. In contrast to these studies, the paper suggests considering the problem at the level of the architectural and planning structure of a residential building and using the building itself as an element of the civil protection system. The results of the study are also consistent with the findings of K. Brackstone *et al*. (2026) on the need to consider the specifics of development and the needs of different population groups. The analysis showed that the level of potential security depends on the location of the space relative to the outer shell and the structural core of the building, which gives grounds to consider a residential building as a system of spaces with different levels of protection. Conclusions of M. Howlett *et al*. (2025) on the use of underground spaces as elements of wartime social infrastructure was also confirmed. The results of the study indicate that in conditions of prolonged and repeated air alarms, protective functions cannot be limited only to underground structures, but should be integrated into the structure of residential buildings.

Thus, a comparative analysis showed that the problem of protecting the population in the face of military threats cannot be considered only through the expansion of the network of underground shelters. It is important to move from separate protective structures to an integrated system of safe spaces within a residential building. The most promising approach is that the architectural and planning structure of the house considers different levels of security of premises, depending on their location, accessibility, and connection with the structural core. This allows considering a residential building not only as an object of residence, but also as an element of the everyday civil protection system. In this context, security becomes one of the key factors for the further development of housing typology.

CONCLUSIONS

The study showed that the current conditions of constant military threat make it necessary to move from the traditional approach, in which the protection of the population is provided mainly by individual civil protection structures, to the integration of the protective function into the structure of residential buildings. The analysis of international experience confirmed the prospects of this approach for the development of modern residential architecture. Based on the results of the study, a multi-level spatial and hierarchical model of protected areas of a residential building was proposed, which includes seven levels of security. The main criteria for their development are the spatial position of the premises relative to the external contour of the building, the number of protective barriers between a person and the source of damage, the functional purpose of the premises, and the possibility of their use during various scenarios of military threat. In contrast to existing approaches, the proposed model allows assessing the level of security of the entire planning structure of a residential building, and not just individual protective rooms or structures.

It was established that the application of the proposed model changes conventional approaches to functional zoning of housing. Rooms of long-term stay of residents, primarily bedrooms and children's rooms, should be placed in areas with the highest level of potential security. Kitchens, storerooms, and other auxiliary rooms can serve as a buffer layer, while living rooms, loggias, balconies, and rooms along external facades require additional architectural and structural protection. Communication nodes are considered as the basis for forming the internal protected core of a residential building. Further research should be aimed at developing a methodology for quantifying the level of security of individual areas of a residential building, substantiating architectural and planning solutions for different types of housing, and adapting the proposed model to public buildings.

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CONFLICT OF INTEREST

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Тетяна Жидкова
Кандидат технічних наук, доцент
Національний університет «Київський авіаційний інститут»
03058, просп. Любомира Гузара, 1, м. Київ, Україна
https://orcid.org/0000-0001-7903-7073

Інтеграція захищених просторів у структуру житлових будівель в умовах постійної воєнної загрози

Анотація. В умовах постійної потенційної загрози для цивільного населення житло набуває функції первинного середовища безпеки, що потребує перегляду принципів його об’ємно-планувальної організації. Метою роботи було обґрунтування підходів до інтеграції захищених просторів у структуру житлових будівель та визначення принципів їх функціонального зонування в умовах тривалих воєнних загроз. У дослідженні використано методи аналізу наукових джерел, порівняльного аналізу планувальних рішень, узагальнення статистичних даних, просторово-функціонального моделювання, а також метод включеного (учасницького) спостереження. Обґрунтовано необхідність перегляду традиційної схеми функціонального зонування приміщень квартир умовам постійної воєнної загрози. Запропоновано адаптацію просторово-ієрархічної моделі захищених зон, розробленої в попередніх дослідженнях автора, до структури багатоповерхового житлового будинку. Обґрунтовано використання конструктивного ядра будівлі як основи забезпечення евакуації та збереження інженерних систем. Обґрунтовано доцільність перерозподілу функціонального призначення приміщень із перенесенням зон нічного перебування у зону з високим рівнем захисту, наближену до конструктивного ядра будівлі. Визначено роль внутрішньої буферної зони (санвузли, гардеробні, коридори) як просторових елементів, що зменшують вплив ударної хвилі та уламків. Доведено, що фасадна зона має найнижчий рівень захисту та використовується як простір денного перебування. Додатковий рівень захисту забезпечується шляхом застосування зовнішнього енергопоглинаючого шару (балкони, лоджії, фасадні системи). Показано, що запропонований підхід сприяє формуванню більш компактної планувальної структури, що позитивно впливає на енергоефективність будівель що створює передумови для підвищення енергоефективності будівель. Наукова новизна дослідження полягає в адаптації багаторівневої просторово-ієрархічної моделі захищених зон будівель до структури житлового середовища та удосконаленні принципів функціонального зонування житла відповідно до рівня захищеності приміщень. Практична цінність роботи полягає у можливості застосування отриманих результатів при проєктуванні нових житлових будинків, адаптації існуючого житлового фонду, а також у розробці рекомендацій щодо підвищення рівня безпеки мешканців шляхом інтеграції захищених просторів у структуру житлових будівель

Ключові слова: просторово-ієрархічна модель; житлове середовище; захист цивільного населення; функціональне зонування; захищений простір; багатоповерхові житлові будівлі