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ARCHITECTURAL AND PLANNING DECISIONS FOR RESIDENTIAL BUILDINGS WITH SAFETY CAPSULES

Bordun M.[1], PhD, **Bevz M.** [2], Dr. Arch., Prof., **Savytskyi M.**[3], Dr.Sci.(Tech.), Prof.,
Nevgomonnyi H.[4], PhD, Assoc. Prof.
[1, 3, 4] *Prydniprovska State Academy of Civil Engineering and Architecture,*
[2] *Lviv Polytechnic National University*
[1] *bordun.maryna@pdaba.edu.ua;* [3] *ms@pdaba.edu.ua;*
[4] *nevhomonnyi.hryhorii@pdaba.edu.ua;* [2]*bevzmist@polynet.lviv.ua*

Problem statement. Since the beginning of the full-scale invasion, the Russian Federation has been consistently waging an undeclared terrorist war against the civilian population of Ukraine. The Russian army is constantly shelling Ukrainian populated areas, destroying infrastructure. As a result, there are significant human casualties, destroyed and damaged buildings, and crippled enterprises and networks for electricity and heat supply. Most people perish from rocket fragments injuries rocket fragments or other ammunition types due to shelling, or they become buried alive under the rubble of destroyed buildings.

Therefore, today, the state's top priority is not only conducting defensive-offensive operations aimed at liberating Ukrainian territories from aggressors, but also is protection and security of its citizens.

The military aggression of the Russian Federation against Ukraine has proved the critical necessity of implementing new principles in the planning and design of residential and public buildings. Today to protect the population, building and structures must design with protective structures which are able to defend from external attack, namely, special autonomous protective structures (shelters) or structures and dual-purpose elements.

Civil protection facilities in Ukraine are designed in accordance with the relevant rules and regulations [1; 2]. These regulatory documents are mainly devoted to the design and construction of large-capacity collective civil defence facilities.

In July 2022, the Law of Ukraine No. 2486-IX “On Amendments to Certain Legislative Acts of Ukraine on Ensuring Civil Protection Requirements in the Planning and Development of Territories” was approved. This law is aimed at rapidly establishing a modern network of civil protection facilities to enhance the level of citizen protection. According to this law all new building and reconstructed building must have reliable shelters [3].

Despite that regulations are existence, there aren`t protective premises in mostly Ukrainian residential building. To happens also that protective premises are existence, but conditions for people to stay during danger aren`t ensured. Therefore, residents such building have to use collective civil defence shelters, which were built in Soviet times. The main problem this defence shelters is location. Usually such collective shelters were built one shelter per some buildings, and often one shelter per district and its located outside the zone of quick access to them. For this reason, most Ukrainians ignore air raid alarms or, in better cases, use the “two walls” rule and try to find safer places in their apartments.

Purpose of this study is to develop an architectural and structural solution for civil population protection in a multi-storey residential building by creating a safe space of immediate accessibility.

Maine results. The main types of protective structures include [4]: specialized protective structures such as shelters or anti-radiation shelters; non-specialized structures that include dual-purpose structures, and the simplest shelters.

The first individual shelters were built during the Second World War in Great Britain. The first individual shelters were built during the Second World War in Great Britain. The

main aim these shelters was protection of London habitants against bomb fragments and blast waves. Particularly popular were the Anderson shelters, Stanton shelters, and the Morrison shelter [5; 6]. These shelters could accommodate one or several individuals, up to six, and were utilized in almost every household.

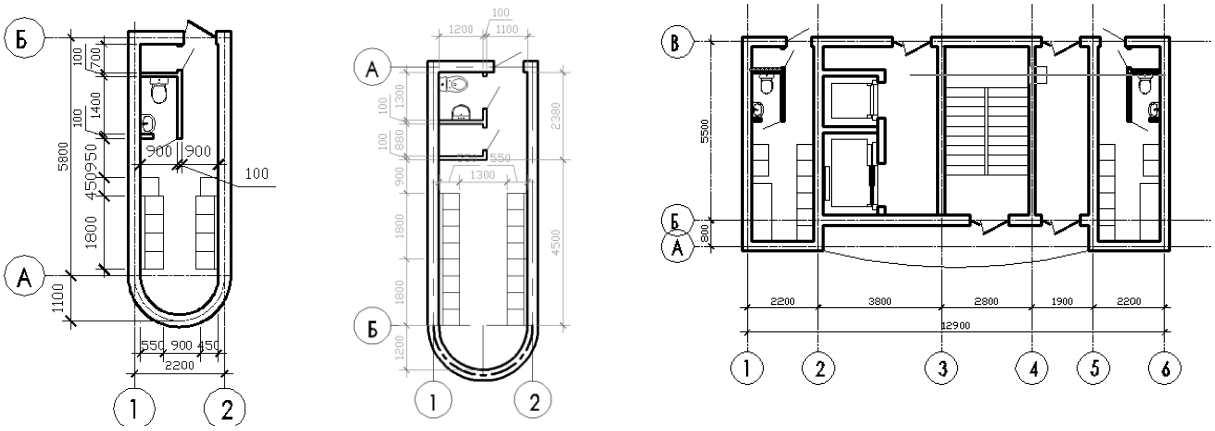
Another interesting solution was bomb shelters by designing Leo Winkel and Paul Zombeck (Germany) [7]. “Winkel” bunkers are above-ground structures designed to protect staff at large industrial enterprises and important institutions within the territory of Germany, and also for the nearby residential building’s inhabitants. Their structural feature is the conical shape of the building, with small dimensions in plan up to 30 meters in diameter, making it less vulnerable during air attacks. They have thick walls ranging from 1.5 meters at the base of the building to 1.0 meter at the top.

Modern bomb shelters are protective structures designed for collective or individual use, equipped with various autonomous engineering systems to protect the population from various types of hazards over a certain period of time. Significant attention to the construction and operation of civil defense shelters is paid attention by countries such as Switzerland, Finland, Israel, and Singapore. At the same time, individual shelters are more popular in Israel and Singapore. A series of regulatory acts were adopted in these countries that provide for the design and construction of civil defense shelters in each building or apartments. Reinforcement through increased thickness of wall and ceiling structures, separation of shelter premises from the facade of the building, and the use of doors made of protective steel are included in the household or story shelters in Singapore. The reinforced concrete is the main material for bearing structures of the shelter. Technical requirements for the design of such shelters regulate the location of the shelter within the living space, as well as the distance to the external structures of the building. These shelters provide protection for residents from the effects of weapons, explosions, and shrapnel during emergencies. The greatest advantage of such shelters is their accessibility [8].

Today in Ukraine, Israel's experience of population protection is actively interrogated. There are three types of shelters In Israel: the “Merhav Mugan Dirati” or “Mamad” (safe room) − an individual room within an apartment; “Mamak” floor shelters − communal shelters in multi-apartment buildings; and “Maman” protective shelters − used in public buildings [9]. It is also should noting that underground public bomb shelters aren`t almost applied. On the contrary, preference is given to individual safe rooms. This decision is driven by many factors, but the main ones are the rational assessment of the most common threats during bomb attacks, as well as considering the time needed for civilians to seek shelter in real conditions. The minimum size of a safe room is no less than 9 square meters, with a ceiling height of no less than 2.5 meters. Safe rooms can be used as regular premises during peacetime, where technical rooms or children's bedrooms are located. However, to install kitchens and bathrooms in such rooms is prohibited.

Project solutions of universal “safety capsule” with a capacity of 10 and 20 people for multi-storey residential buildings have been developed based on past and present experience. Detailed planning of the interior space in these solutions was carried out with considering for the standardization of all dimensions. The safety capsule consists of a main compartment with two-tiered accommodation, where sleeping places constitute 20 % and of the available seats, and auxiliary premises − a bathroom and a room for additional equipment and storage of food and water supplies. An advantage of the project solution is the curved shape of the external wall of the safety capsule. This shape better perceives a load from the blast wave and projectile impacts. According to the project solution the safe spaces are located on each floor within the elevator-staircase zone of the building (Fig. 1).

The developed safety capsule variants were integrated into the architectural and planning structure of multi-story buildings, namely, into a typical section of a 12-story residential building with 60 apartments (Fig. 2) and into a two-section 16-story residential building that was designed according to an individual project with 126 apartments (Fig. 3).



a *b* *c*

Fig. 1. The project solutions for the universal “safety capsule”: a) safety capsule for 10 people; b) safety capsule for 20 people; c) safety capsules location in the floor plan of the building

Fig. 2. Integration of the safety capsule into the architectural and planning structure of a 12-story residential building

Fig. 3. Integration of the safety capsule into the architectural and planning structure of a 16-story residential building

Conclusion. The advantages of the developed project solution include:

− Quick access to shelter for building residents. The safety capsules are located on each floor of the building and are estimated for the number of residents.

− Structural independence. Safety capsule structural elements are independent of other structural elements of the building. Safety capsule has their own walls, reinforced concrete floors and spatially locates adjacent to the stairwell and elevator.

− Functional independence. Safety capsules have individual engineering networks that are connected to centralized systems. In case of emergency situations safe places are additionally equipped batteries for autonomous power supply, ventilation systems with air purification and have a water supply reserve calculated for 3 days for the number of users.

− Adaptability to the architectural-planning and functional building structure. The proposed safety capsules have standardized dimensions and can be easily applied to any buildings.

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