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Analysis of spatial planning solutions for civil protection structures according to regulatory requirements

The article presents an analysis of the normative-legal documentation regulating the construction and reconstruction of civil protection shelters in countries such as Israel and Ukraine. A comparative analysis method was employed to identify the differences in shelter requirements between the two countries. Specific technical requirements that significantly impact the design and construction process were highlighted. The study compared the approach to determining the required area of shelters in both countries for various facilities. An overview and description of the requirements for ventilation systems, water supply, drainage, and electrical connections were provided. Additionally, the general approach to selecting finishing materials and types of coverings for internal and external structural elements was described. Significant discrepancies in the requirements and approaches to the construction or reconstruction of shelters in these countries were identified. The findings can be used to enhance the efficiency of shelter design and construction in Ukraine, which is particularly relevant in the current context of increased risks to the civilian population.
Keywords: DBN of Ukraine, shelters, dual-purpose structures, Israel's standards

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Introduction

The modern challenges faced by Ukraine constantly introduce new demands for protecting the population from military threats. The issues of construction, reconstruction, and modernization of civil defense shelters are highly relevant and urgent. State regulatory documents governing these processes must be continuously improved, drawing on both contemporary Ukrainian experience and the practices of other countries.

Review of the research sources and publications

State requirements for civil defense shelters are outlined in [1], while Israel's regulatory documents are presented in [2-3]. The study [4] examines the improvement of national legislation in the field of civil defense under martial law. Several scientific studies address the legislative regulation of civil defense issues during the pre-war period, including amendments to Ukraine's Civil Defense Code. The authors of [5] highlighted shortcomings in the approach to forming the protective properties of civil defense structures and the criteria defining them. They analyzed statistical data on the functioning of such structures in Ukraine and the level of protection provided per one thousand people.

Definition of unsolved aspects of the problem.

Although the requirements for civil defense shelters in Ukraine were updated in 2023, numerous unresolved issues remain. These issues lead to increased time and resource expenditures for design and construction. In some cases, they also impose additional financial and economic burdens on the state budget.

Problem statement

The aim of this study is to analyze the spatial and planning solutions for civil defense structures based on the regulatory requirements of Ukraine and Israel. The

review of Israel's requirements is conducted with the goal of potentially adopting certain technical aspects that could significantly improve and accelerate the design and construction processes, as well as enhance cost-efficiency in the implementation of such projects.

Analyzing spatial and planning solutions in both countries allows for the identification of key differences and similarities that can be valuable when adapting modern design methods for various conditions, particularly in situations with limited resources and the need for rapid execution of work.

Basic material and results

Let us consider the regulation of certain technical issues based on Israeli legislation.

In Israel, protective structures are divided into several types based on volume and area, such as A-1, A-2, B-1, B-2, C-1, and C-2, as well as into groups by purpose. These include shelters like K1, K2, K3, "forward shelters" or "frontline shelters," "bomb shelters" or "rear shelters," "protected space," "residential safe space," "protected premises in healthcare institutions," "public protected space," and "floor-protected premises." In Fig. 1, a safe space on the premises of a private house is presented. The type and area of a shelter are determined according to the building's purpose and the settlement classification, which is explicitly stated in regulatory documents.

Each type of shelter has both general and specific requirements, ensuring the appropriate use of certain materials or technologies for each type. It is specified that the design of a shelter, its contents, and the characteristics of floor-level and apartment-level protected spaces, including ventilation and filtration systems, sanitary facilities, electrical and communication equipment, must strictly adhere to the examples outlined in state regulations.

Figure 1 - A safe space on the premises of a private house.

Clear minimum and maximum area limits are defined. If a shelter is used as a multipurpose space, the primary area may be increased to accommodate equipment or furniture, provided that this additional space does not exceed 20% of the shelter's main area and does not require significant deviations from standard solutions, except for increasing the number of ventilation and lighting systems, markings, and signage.Table 1 provides an example of how area standards are organized for different building types. Shelters are typically constructed using B-30 concrete, with B15 concrete used for flooring. Walls are 20-40 cm thick, and all interior walls are also made of reinforced concrete. During the casting process, samples are collected for testing in a licensed laboratory to ensure the concrete's strength. In Fig. 2, the method for testing the compressive strength of concrete is illustrated.

Figure 2 - The method for testing the compressive strength of concrete.

After casting an underground shelter, a water-tightness test is conducted by flooding all underground components of the structure with water up to the ceiling. The water remains in the structure for 48 hours, and any detected leaks must be repaired before further work proceeds.

Special attention is paid to ventilation systems. During threats, filtered air is supplied, while natural ventilation is used in peacetime. One supply and one exhaust air duct are designed for every 25 m² of space. The equipment is calculated based on a density of 0.4 m² per person and at least 16 air exchanges per hour.

In Fig. 3, the elements of a ventilation system are depicted.

In A-1 type shelters, there is no obligation to install sinks and faucets. In other shelters, one sink and faucet with running water are installed for every 50 square meters of the main area or any part thereof. Wastewater disposal is generally done by gravity, except in cases where this is not possible. For buildings equipped with a generator, and where the competent authority confirms that gravity drainage is not feasible, wastewater may be removed using pumping systems. Appropriate measures are taken to prevent backflow, including mechanical devices.

A drinking water storage tank is installed in each shelter, calculated at 5 liters per square meter of the shelter's main area. The capacity of a single drinking water storage tank must not exceed 500 liters.

A clear categorization of shelter types in Israel allows for the standardization of required electrical connections.

Table 1. Shelter Area Standards for Different Building Types in Israel

Building Type	Required Protected Space Area	Minimum Protected Space Area, m²
Office Building	3% of the main area	10
Laboratories	3% of the main area	10
Banks	2% of the main area	10
Post Offices	4% of the main area	10
- Courtrooms	5 m² per courtroom	10
- Offices	3% of the main area	10
Religious Buildings:		
- Synagogues	1% of the main area	10
- Ritual Buildings	1% of the main area	10
- Mosques, Churches	1% of the main area	10
- Prayer Halls	1% of the main area	10
Protected Housing and Nursing Homes	2.5 m² for residential units with up to 2 rooms	10
Hotels, Sanatoriums, Guesthouses	1 m² per residential unit	10
Dormitories, Boarding Schools	20% of the main area	-
Clinics, Mother and Child Rooms, etc.	3% of the main area	10
Community Centers, Youth Clubs	2% of the main area	10
Industrial Buildings:		
- Offices and High-Tech Industry	3% of the main area	10
- Production Workshops	2% of the main area	10
- Warehouses	0.8% of the warehouse area	10

For instance, it is explicitly stated that A- 2 and B-1 type shelters must be connected to a single- phase power supply with a capacity of 40 amps. B-2 type shelters must be connected to either a single-phase supply of 40 amps or a three-phase supply of 25 amps. C-1 type shelters without central ventilation and filtration rooms are connected to a three-phase power supply of 25 amps. For C-1 shelters with ventilation rooms and C-2 shelters, the power requirements are determined by the designer. In shelters equipped with power generators, switching between power sources is done manually. To monitor the generator's load, ammeters are installed in the premises, marked with a red line indicating the maximum allowable current.

Regarding finishing works, the regulations specify that the concrete surface must be smooth after casting. Plastering, stone cladding, or the use of tiles of any kind is prohibited. Only painting or the application of decorative coatings with a layer no thicker than 2 mm is allowed. PVC panels are permitted on slopes.

Exterior wall surfaces above ground level can either remain as painted concrete or be plastered. Stairs, emergency exits, and access routes, excluding floors, are whitewashed with lime or synthetic lime or painted in white or other light shades at the designer's discretion.

The use of materials other than those specified in the standard is allowed only with the approval of the relevant defense ministry authorities. Elements such as entrance doors, airtight doors, soundproof doors, windows, steel pipes with a diameter of 4" or more, and all connecting elements, as well as floor hatch covers, must be certified and bear approval marks from the Standards Institute. Fig. 4 presents an example of the implementation of a protected window opening, Fig. 5 shows the results of testing doors that do not meet the requirements.

The concept of "Owner" in Israeli legislation is defined as the recipient or the person entitled to receive income from a property, or who would receive income if the property generated it, as well as those with ownership rights or acting as trustees. This applies regardless of whether the owner is registered. In the case of leased properties with a fixed lease term of 25 years or more, the lessee is considered the "Owner."

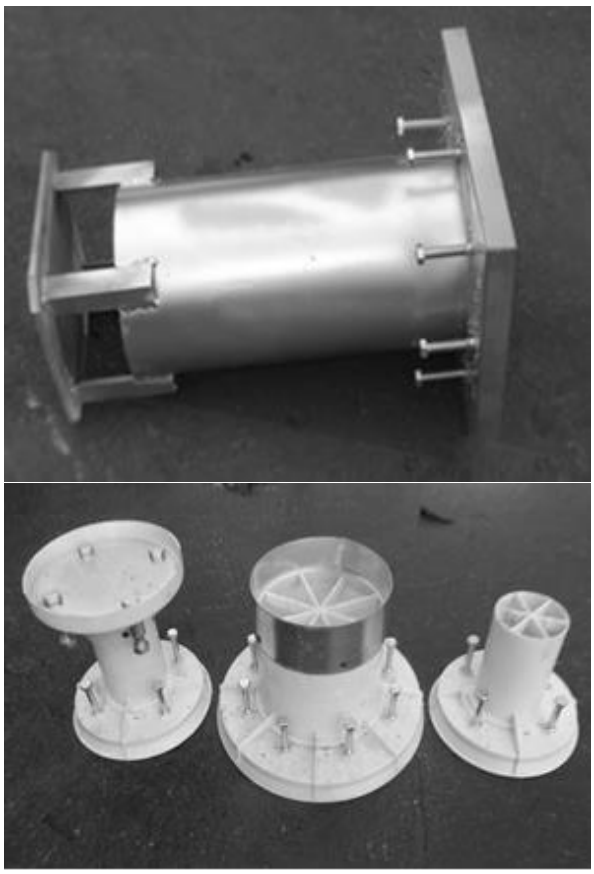

Figure 3 - The elements of a ventilation system.

Thus, the responsibility for maintaining shelters falls not only on property owners but also on those using the building or deriving income from it. Additionally, if a building lacks a shelter, the owner is obligated to arrange one within or near the building at a time and location specified by the local authority through written instructions.

Figure 4 – Example of the implementation of a protected window opening.

Exemptions from the obligation to build or expand a shelter may be granted if it is proven that construction or expansion is impossible at the site. In such cases, the applicant must contribute to a fund dedicated to creating, improving, or expanding public shelters. The contribution should not exceed the costs of constructing or expanding the shelter on-site. Exemptions may also depend on the presence of an existing shelter accessible to users of the building or factory.

Expenses incurred by the owner for equipping, repairing, or reconstructing a shelter can be partially recouped from building occupants, ranging from 25% to 50% depending on specific conditions.

Let’s return to the regulatory documentation of Ukraine.

In 2023, Ukraine approved DBN V.2.2-5:2023 "Protective Structures of Civil Defense," which replaced DBN V.2.2.5-97 "Protective Structures of Civil Defense," which, in turn, was based on construction norms from the USSR in the 1950s and 1970s, with certain changes and revisions over time. During this period, some provisions were canceled, while others were modified or supplemented.

In Ukraine, the following types of civil defense structures are distinguished: shelters, radiation protection shelters, dual-use structures with shelter properties, dual-use structures with radiation protection shelter properties, primary (mobile) shelters, and the simplest shelters. Each of these types has general requirements according to state norms. Each shelter is designed considering its purpose, location, structural, and other technical issues, which are individually resolved by the designer for each project.

Civil defense structures and dual-use structures are designed and constructed in such a way as to create appropriate conditions for the accommodation of people requiring shelter and to provide the necessary level of protection from the anticipated impacts of hazardous factors that may arise as part of dangerous events during emergencies, military (combat) operations, and terrorist acts. These structures are designed to support the presence of people for up to 48 hours.

The required number and capacity of each protective structure and dual-purpose structure are determined during the design phase, based on the estimated number of people needing shelter. For educational institutions, shelters must accommodate 100% of the participants in the educational process and other staff members. However, during the reconstruction or new construction of separate or attached protective structures or dual-purpose structures within the grounds of existing educational institutions, the capacity of the protective structures may be reduced to 50% of the total capacity of the institution, provided that sheltering is available for all individuals who may be in the building at the same time, according to the institution's operational schedule during the most populated shift. The total capacity of protective structures and dual-purpose structures in public buildings is determined by the possibility of sheltering 100% of the estimated number of people who periodically stay on the premises (calculated according to DSTU 8855), residential buildings – 100% of the estimated number of people who permanently stay on the premises, and buildings intended for production, storage, and administrative and household purposes – 100% of the estimated number of people who periodically stay on the premises.

The minimum area of the main and auxiliary rooms of shelters and dual-purpose structures with shelter properties is specified in the current DBN, while the upper limit is not restricted.

For the construction of concrete, reinforced concrete, and steel-reinforced concrete structures for protective structures and dual-purpose structures, heavy concrete with a density of at least 2000 kg/m³ and a class not

Figure 5 – Results of testing doors that do not comply with the requirements.

lower than C12/15 should be used. For columns and beams, the class should not be lower than C20/25. Concrete blocks for walls should be designed from concrete with a class not lower than C8/10. The mortar for sealing the walls of prefabricated reinforced concrete structures must not be lower than C8/10.

There is a provision concerning the airtightness of shelters, which states: "External enclosing structures (foundations, floors, walls, ceilings, and roofs), along with their waterproofing, must protect the shelter from the negative impact of groundwater, flooding, and ensure the airtightness of the shelter." However, no detailed testing requirements are provided.

Ventilation systems must meet the needs of people for clean air for 6-48 hours, depending on the ventilation mode (I, II, or III). Air intake must be cleaned of solid particles and dust by installing coarse air filters. The minimum air exchange rate in the rooms where individuals will be sheltered should be 6-10 air exchanges per hour, depending on the functional features of the room.

There is a requirement to install at least one washbasin for every 200 people, but no fewer than one per sanitary unit. Wastewater discharge can be handled either by gravity or by using a pumping station for pumping (if gravity discharge is not possible) with the installation of a valve inside the structure.

The reserve of drinking water in containers is calculated at 3 liters per day per person who is to be sheltered.

Regarding electrical connections, it is recommended that the power supply for electrical receivers be provided from a network with a nominal voltage of 230/400 V. The reliability of the power supply for electrical receivers used in peacetime is determined according to the relevant norms for such a type of structure. The power capacity for connection is not standardized and not limited.

There are general requirements for finishing works; the use of suspended ceilings, false floors, glass cladding, ceramic tiles, or other materials that could create sharp fragments when broken is prohibited.

Conclusions

Modern realities impose continuous adjustments that are far from final. Therefore, existing regulatory documents must evolve, be supplemented, and optimized further. The integration of advanced technologies, the experience of other countries, and contemporary requirements for civil defense will contribute to improving the efficiency and timeliness of constructing protective structures.

The ongoing process of improving the regulatory framework is essential to ensure an adequate level of protection for the population and infrastructure in the face of modern threats. This will help reduce resource costs, enhance design quality, and accelerate the adoption of innovations in the field of civil defense.

References

1. Мінрегіон України. (2023). *ДБН В.2.2.5-2023. Захисні споруди цивільного захисту* (120 с.). Київ: Мінрегіон України.
2. Israel Defense Regulations. (2024*). Official text as of 2024*. Retrieved from https://www.nevo.co.il/law_html/law01/125_020.htm#Seif274
3. Israel Civil Defense Regulations. (2024). *Official text as of 2024.* Retrieved from

1. Ministry for Communities and Territories Development of Ukraine. (2023). *DBN B.2.2.5-2023. Civil protection shelters* (120 p.). Kyiv.
2. Israel Defense Regulations. (2024). *Official text as of 2024*. Retrieved from https://www.nevo.co.il/law_html/law01/125_020.htm#Seif274
3. Israel Civil Defense Regulations. (2024). *Official text as of 2024*. Retrieved from

https://www.nevo.co.il/law_html/law01/125_020.htm#med0
4. Бойко, О. (2022). Державне управління у сфері цивільного захисту: подальше вдосконалення законодавства в умовах дії воєнного стану. *Науковий вісник: Державне управління*, (2)12, 195–217. https://doi.org/10.33269/2618-0065-2022-2(12)-195-217
5. Некора, В., Ніжник, В., Поздєєв, С., Луценко, Ю., & Михайлов, В. (2023). Особливості та перспективи ефективного функціонування захисних споруд цивільного захисту в умовах бойових дій. *Науковий вісник: Цивільний захист та пожежна безпека,* (1)15, 149–157. https://doi.org/10.33269/nvcz.2023.1(15).149-157
6. Джеджула, В. В. (2023). Особливості влаштування вентиляції в захисних спорудах цивільного захисту. *Сучасні технології в будівництві*, 35(2), 185–189.
7. Sobchenko, T., Kin, O., & Vorozhbit-Gorbatyuk, V. (2023). Creation of a safe educational space in educational institutions under the conditions of martial state. *New Collegium*, 3(111), 39–42. https://doi.org/10.30837/nc.2023.3.39
8. Sehida, K., & Chekhov, S. (2023). Spatial analysis of provision the population of Kharkiv with civil defense facilities. *Human Geography Journal*, 34, 14–26. https://doi.org/10.26565/2076-1333-2023-34-02
9. ASME. (2023). Features in civil defense facilities. *ASME Journal of Nuclear Radiation Science*, *10*(4). https://doi.org/10.1115/1.4065463
10. Glasstone, S., & Dolan, P. J. (1977). *The effects of nuclear weapons* (3rd ed.). United States Department of Defense and United States Department of Energy.
11. Al-Maliky, S. J. (2008). Basic concepts for the design of nuclear shelters and the calculation of wall thickness against a nuclear explosion of 20 kT. *Journal of Engineering and Development*, 12(2), 17. https://jeasd.uomustansiriyah.edu.iq/index.php/jeasd/article/view/1659/1319

https://www.nevo.co.il/law_html/law01/125_020.htm#med0
4. Boiko, O. (2022). State management in the field of civil protection: Further improvement of legislation under martial law. *Scientific Bulletin: Public Administration*, (2)12, 195–217. https://doi.org/10.33269/2618-0065-2022-2(12)-195-217
5. Nekora, V., Nizhnyk, V., Pozdeyev, S., Lutsenko, Yu., & Mykhailov, V. (2023). Features and prospects for the efficient functioning of civil protection shelters under combat conditions. *Scientific Bulletin: Civil Protection and Fire Safety*, (1)15, 149–157. https://doi.org/10.33269/nvcz.2023.1(15).149-157
6. Djedzhula, V. V. (2023). Features of ventilation arrangement in civil protection shelters. *Modern Technologies in Construction*, 35(2), 185–189.
7. Sobchenko, T., Kin, O., & Vorozhbit-Gorbatyuk, V. (2023). Creation of a safe educational space in educational institutions under the conditions of martial state. *New Collegium*, 3(111), 39–42. https://doi.org/10.30837/nc.2023.3.39
8. Sehida, K., & Chekhov, S. (2023). Spatial analysis of provision the population of Kharkiv with civil defense facilities. *Human Geography Journal*, 34, 14–26. https://doi.org/10.26565/2076-1333-2023-34-02
9. ASME. (2023). Features in civil defense facilities. *ASME Journal of Nuclear Radiation Science*, *10*(4). https://doi.org/10.1115/1.4065463
10. Glasstone, S., & Dolan, P. J. (1977). *The effects of nuclear weapons* (3rd ed.). United States Department of Defense and United States Department of Energy.
11. Al-Maliky, S. J. (2008). Basic concepts for the design of nuclear shelters and the calculation of wall thickness against a nuclear explosion of 20 kT. *Journal of Engineering and Development*, 12(2), 17. https://jeasd.uomustansiriyah.edu.iq/index.php/jeasd/article/view/1659/1319

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Аналіз об’ємно-планувальних рішень споруд цивільного захисту за нормативними вимогами

В статті представлено аналіз нормативно-правової документації, яка регулює будівництво та реконструкцію укриттів цивільного захисту таких країн як Ізраїль та Україна. У дослідженні використано метод порівняльного аналізу для ідентифікації розбіжностей у вимогах до укриттів між країнами. Було виділено конкретні технічні вимоги, які мають вагомий вплив на процес проєктування та будівництва. Проведене порівняння підходу до визначення необхідної площі укриттів в обох країнах для різних об’єктів. Зроблено огляд і опис вимог до систем вентиляції, водопостачання та водовідведення, електричних підключень. Описано загальний підхід до вибору оздоблювальних матеріалів та типів покриттів внутрішніх та зовнішніх конструктивних елементів. Виявлено значні розбіжності в вимогах та підходах до будівництва чи реконструкції укриттів в цих країнах. Результати можуть бути використані для підвищення ефективності проєктування та будівництва укриттів в Україні, що є особливо актуальним у сучасних умовах підвищеного ризику для цивільного населення.
Ключові слова: ДБН України, укриття, споруди подвійного призначення, норми Ізраїля
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