Centrum Rzeczoznawstwa Budowlanego

Inżynieria Bezpieczeństwa Obiektów Antropogenicznych 1 (2024) 1-12
https://inzynieriabezpieczenstwa.com.pl/

Inżynieria Bezpieczeństwa Obiektów Antropogenicznych

Protective structures as a device of ensuring the safety of victims in a war situation

Aleksandra SKRABACZ [1*iD], Franciszek WOŁOCH[2]

[1] *Military University of Technology, Warsaw, Poland*
[2] *Stowarzyszenie Instytut Budownictwa Ochronnego, Military University of Technology, Warsaw, Poland*

Abstract

Interest in protective structures is steadily increasing as the armed conflict in Ukraine unfolds. Experience shows that shelters and hiding places are the most effective form of protection for civilians from conventional and unconventional war threats. Meanwhile, there are no guidelines and rules for the construction of public and private shelters in Poland. The problem is a big one, especially in view of the war that is taking place in the close vicinity of Poland. The purpose of the article is to review Polish and foreign legal and organizational solutions in the field of protective constructions and to indicate the technical requirements necessary to meet in a situation of war danger, with particular emphasis on the use of nuclear weapons. The authors put forward the thesis that in the face of military and non-military threats, the effective way to protect and defend the life and health of the population are properly maintained and managed protective structures, including shelters and hiding places and places of temporary shelter. However, the basic problem remains the question of legal regulation in this regard and the responsibility for their financing and maintenance, which involves the issue of ownership (private and public shelters). In Poland, the experience of other countries that have adopted a variety of solutions should be a guideline for forward-looking activities in the area of protective structures.

Keywords: protective structures, shelters, hiding places, war

* **Corresponding author:** E-mail address: (aleksandra.skrabacz@wat.edu.pl) Aleksandra SKRABACZ

https://dx.doi.org/10.37105/iboa.198
Received 3 December 2023
Available online 31 March 2024
ISSN 2450-1859, eISSN 2450-8721
Published by Centrum Rzeczoznawstwa Budowlanego

1 Introduction

The end of the Cold War, the prospect of the so-called "end of history" and several decades of peace in Europe have caused societies (not only Western ones) to push the threat of war and its consequences out of their consciousness. With the exception of the war in the Balkans, natural disasters and catastrophes, terrorism, civilization phenomena and climate change have been the leading themes in the analysis of threats affecting Europe. The transformation of the Russian Federation's aggression into a full-scale war on February 24, 2022 brought the specter of war and the threat of its consequences back. The sense of danger was further reinforced by threats of nuclear (www.rp., 2023a) and radiological (www.rp., 2023b) weapons. And although more than 70 years have passed since the end of World War II, nothing has changed in the essence or philosophy of the ongoing war in Ukraine. We are witnessing warfare that, in addition to military force, also draws civilians of all ages and genders into the vortex of battle, becoming helpless victims of the invaders.

Given the experience of the war in Ukraine and the two world wars, a fundamental and currently unresolved issue is the problem of civilian security in the face of hostilities, including the provision of safe places to stay in the event of an armed attack and during hostilities (Baryłka, et all, 2023). This problem is all the more important because: firstly, the adversary uses conventional and unconventional weapons to conduct military operations, secondly, the state of protective structures in Poland is disastrous, providing only for 4% of the total population a reasonably safe shelter, thirdly, despite the already several years of experience coming from across the eastern border, no effective measures have been taken in Poland to solve the problem of protective structures and thus increase the level of security of the population. Hence, there is an urgent need to draw the attention of scientific, political and social circles to the issue of creating a stock of protective structures in Poland, their proper management and maintenance in readiness for use at the time of danger.

A review of the Polish and foreign literature indicates that interest in the topic of protective structures increased, along with the threat of war between Russia and Ukraine. A variety of issues of shelters and concealments are addressed in international publications. There are articles on the role of shelters in a military emergency (Chester, Zimmerman, 1987), shelter design (Bashawri, et all, 2014), technical requirements (Weidlinger, Hinman, 1987) and location (Napii, Souza, 2015; Nappi, et all, 2019;), as well as surge protection capabilities (Caçoilo, et all, 2023). In the scientific space, there is also the International Journal of Protective Structures, which publishes high-quality research papers related to the protection of civil infrastructure from natural or man-made shock and impact loads (https://journals.sagepub.com).

Among the Polish authors falling problems of resilience of critical infrastructure, including anthropogenic objects to military and non-military threats are Zbigniew Szczesniak (2011, 2019), Adam Baryłka (2023), Jerzy Obolewicz (2021, 2023), Władysław Harmata (2023).

The purpose of the article is to review Polish and foreign legal and organizational solutions in the field of protective constructions and to indicate the technical requirements necessary to meet in a war emergency, with particular emphasis on the use of nuclear weapons. The authors put forward the thesis that in the face of military and non-military threats, the effective way to protect and defend the life and health of the population are properly maintained and managed protective structures, including shelters and hiding places and places of temporary shelter. However, the basic problem remains the question of legal regulation in this regard and the responsibility for their financing and maintenance, which involves the issue of ownership (private and public shelters).

In Poland, the guideline for perspective actions in the area of protective structures should be the experience of other countries that have adopted a variety of solutions. Wanting to scientifically lead to the solution of the above issues, the authors decided to use a variety of research methods, including the analysis and synthesis of legal regulations in the allied, EU and national dimensions. Using the method of exemplification, they indicated the solutions that have been adopted by selected countries of the world in the management of protective resources and verified them for implementation in Poland.

2 Formal and legal conditions for the creation of protective construction resources

In the face of the growing threat from the Russian Federation, the countries of the North Atlantic Alliance have taken a number of measures to increase their military capabilities and their ability to deter the enemy (Harmata et all, 2023). However, the issue of civil protection has remained in the background, so to speak (Nappi, Souza, 2015), despite the fact that its role has been recognized both in the North Atlantic Alliance and the European Union. In the case of the Alliance, however, we are dealing more with thinking from the perspective of a military actor rather than

one responsible for protecting the population (NATO, 2023). The European Union's civil protection mechanism, on the other hand, focuses mainly on countering the effects of natural disasters. However, in recent years one can observe a lot of activities within its framework, they concern threats typical of peacetime, such as fires, floods or earthquakes. There is little mention in official documents of preventive initiatives taken jointly by member countries to counter the effects of potential military threats (www.consilium, 2023). Another European document is the CER Directive, but it only has reference to critical infrastructure facilities (EU, 2022). In contrast to civilian documents for detailed technical requirements, there are military documents: instructions (ATP-70, ATP-3.8.1) and NATO standards (STANAG 2280; STANAG 4623) and national defence standards (NO-02, 2015; NO-42, 2011; NO-54, 2011; NO-54, 2018).

Non-military construction documents are only in the early stages of development. In July 2023, an ISO series standard was issued, which will be the first step in the development of standardization in the field of protective construction. In addition, standards covering requirements for explosion-proof doors (PN-EN, 2002; PN-EN, 2004) and filtering elements (PN-EN, 2029) are exceptions to standardization.

As for civil protection at the international level, the Geneva Conventions of August 12, 1949, and in particular the First Additional Protocol of June 8, 1977 (1977) remain the point of reference. The preparation and organization of shelters is one of the primary tasks of Civil Defense in addition to evacuation, rescue or warning. Thus, it is clear that protective structures are treated at the level of international law as one of the primary means of protecting the population in a situation of armed conflict.

Turning to Poland, after World War II, along with the specter of nuclear war, there was an increase in the stock of protective structures, both plant and public, intended for the population. The last guidelines issued under the People's Republic of Poland (Ministry of Construction, 1986) were a study presenting a high level of content, not deviating from the level of guidelines in force in Western countries. The earlier guidelines became invalid on March 30, 2001. Thus came a period of almost 20 years without any guidelines for protective structures.

The first attempt to re-regulate protective construction, with half-success, was the issuance of guidelines with an appendix by the Head of the State Fire Service in 2018 (Szef OCK, 2018). Unfortunately, they were repealed with the enactment of the Law on Homeland Defence in March 2022 (Laws, 2022). Contrary to expectations due to the outbreak of war in Ukraine, there was no quick enactment of new legislation. Attempts to amend the 1994 Construction Law during the Eighth Legislature of the Parliament to introduce definitions of shelter and concealment at the statutory level failed. It was intended to issue a regulation on the technical conditions to be met by home shelters and temporary shelters with a usable area of up to 35 m2 and their location (Project, 2023). Unfortunately, the legal solutions only covered backyard facilities. The fate of the key regulation for protective structures in Poland (Project, 2023) is unknown at the time of publication of this article.

The Construction Law states that a construction object should be designed and built in accordance with the principles of technical knowledge, ensuring: the protection of the public, in accordance with the requirements of civil defence (1994). The 2003 Law on Spatial Planning and Development indicates that spatial planning and development shall take into account, in particular, the needs of state defence and security (2003). Unfortunately, these provisions have remained dead for many years, and this is because they are not enforced by any public administration bodies (Obolewicz, 2023).

The solutions adopted by the states both on the European continent and in other regions of the world indicate that the focus is on both the creation of resources of protective constructions of a public and private nature. Reviewing the state of protective constructions in the perspective of the solutions adopted, it is possible to distinguish at least several ways of solving this issue, adopted by certain groups of countries (Solowin, 2011).

The first group can include states that have adopted the goal of protecting the life and health of the entire population living in the country. The construction of shelters is mandatory, the legislation precisely defines the obligations of the various entities in terms of construction, operation and financing methods, and the regulations are ruthlessly enforced. This group is formed by the richest countries such as Sweden, Denmark, Finland and Switzerland, where the degree of provision for needs reaches about 90% (or even more) of the population. It is worth adding that the financing of the maintenance of protective structures rests with the local government, and the shelters have a dual use (in peacetime public places for sports or entertainment, in times of danger adapted to the requirements of protection).

In the second group should be placed countries such as Slovakia and Germany, which, due to financial constraints, do not build new protective structures (Slovakia), but place emphasis on upgrading existing ones (Germany currently has about 599 public shelters) and are working on modern methods of strengthening underground parking lots, subway stations and basements to dedicate them to shelter spaces (www.gazeta.prawna, 2022).

The third group consists of countries where protective construction is organized on an optional basis, primarily by private owners. Government activity is limited to legislating. Examples of such countries are Hungary, Czech Republic (www.legislacja.rcl, 2023).

Another group of countries can include Israel and the United States of America. The former country, due to geopolitical considerations, relies on mixed solutions - shelter construction remains both in the state and private domain. In the US, on the other hand, the so-called preppers movement is growing in popularity, i.e. people whose goal is to survive in situations of various kinds of danger, and it is they who take it upon themselves to prepare protective places for themselves and their families (www.pap.pl, 2023). There is also a growing interest in services where, for an annual subscription, one can buy a place in a well-equipped and fully staffed shelter (www.tygodnikplus.com, 2023) . Also characteristic of the U.S. is the emphasis in the civil protection authority's nationwide guidelines on pre-disaster issues. In turn, U.S. standards and guidelines created by the Department of Defense are a reference for NATO as a whole and are often implemented as allied documents (ATP-70, 2009; ATP-3.8.1-3, 2011).

3 Effectiveness of protective constructions in light of the use of conventional and unconventional weapons

In a situation of warfare, the civilian population is exposed to means of destruction, both in the areas directly affected by hostilities and throughout the country that is a party to the war (Weidlinger, Hinman, 1988). In the classical approach to the design of protective structures intended to protect the population, they are not designed to survive the effects of a direct hit by means of destruction. This is the approach used in both archival Polish guidelines (Ministry of Construction, 1986), the latest draft regulations on technical conditions (Project, 2023 a; Project, 2023b) as well as Swiss guidelines (TWK, 2017) or Finnish regulations (Finströms Kommun (2012). This is justified by the fact that under the International Law of Armed Conflict, civil protection facilities cannot be the target of direct strikes. Of course, in the reality of conducting hostilities, there are direct hits on civilian objects. However, it is impossible to clearly determine when such incidents are the result of deliberate action, and when they are the result of mistake or chance. In a situation of war, the threat comes not only from enemy means of destruction, but also from so-called “friendly fire”, which can take the form of a falling anti-aircraft system missile. For image as well as political reasons, however, this is not clearly communicated. Press reports hinted at such a possibility in the case of a missile strike on a multi-family building in Dnipro, which killed 45 people (www.rmf24.pl, 2023). Findings by Polish investigators also indicated that the missile that fell in Przewodowo came from Ukrainian anti-aircraft systems (www.rp.pl, 2023).

In this light, it makes economic sense to design facilities to protect the public against the indirect effects of conventional means of destruction. Among these are listed primarily the action of airborne shock wave, clutter, and the threat of shrapnel, as well as the threat of fires. However, experience and accounts of the war in Ukraine show that even buildings subjected to repeated and direct action by conventional means of destruction are able to provide protection for people in underground floors. It is observed here, consistent with theoretical expectations much higher resistance of slab structures (the so-called great slab) than column and plate structures, and especially masonry structures. The latter, have the least ability, to develop secondary load-bearing systems, protecting against disasters that progress in situations of exceptional impacts.

Walls and ceilings of slab structures, act analogously to explosion-proof (detonation) plates, thus protecting underground floors from destruction. The literature (Kobielak, 2005) indicates that a six-story building with reinforced concrete ceilings can provide the equivalent of an additional 3.1-4.0 meters of ceiling thickness for a shelter under such a building.

Of course, the described phenomenon has less impact in the case of high-penetration means of destruction or specifically designed to destroy infrastructure with fragmentation demolition bombs. An example of this is the Storm Shadow/SCALP EG missile strike on the Black Sea Fleet Command carried out by the Ukrainian Armed Forces on September 22, 2023. Media reports indicate significant damage to the building and the elimination of high-value personnel targets (https.//zbiam.pl, 2023). However, the recalled missiles are a means of destruction designed for the precise destruction of fortified targets with the ability to penetrate 2-4 meters of reinforced concrete. As mentioned earlier, normative documents intended for the design of civil protection facilities do not assume the design of buildings for this type of impact. However, it is necessary to ask whether the objects for the protection of a large number of people should not have increased resistance also to the direct action of classical means of destruction. The dependence of a facility's resistance on its capacity is present, for example, in Finnish regulations, where for shelters with a surface area of more than 4,500 m2, they are required to be made in rock and to provide increased resistance

to airborne shock waves and increased thickness of shields (Finströms Kommun (2012). It is not explicitly indicated, but the use of such solutions automatically increases the facility's resistance to direct action from missile agents as well. While the requirement to base shelters in rock is, due to Polish geological conditions, inapplicable in the country, the increased resistance to direct action of conventional means of destruction of large-scale objects should be considered when formulating new legislation. In the proposed legislation, the problem of resilience of facilities with a capacity of more than 300 people has been given cursory consideration. In the opinion of the authors, the provisions should specify exactly which means of destruction objects with a capacity of more than 300 people should be designed for and indicate the methods of design. They are not indicated in the current wording of the regulations, nor are they widely known, since there are no widely available calculation tools on the market (except for highly specialized computer methods developed in academic centers), and Polish-language sources in this area are based on publications from several decades ago (Archremienia, 1989).

Turning to the effects of unconventional weapons, their term is used to refer to weapons of mass destruction that act by means other than through the interaction of kinetic or explosive energy (with the exception of nuclear weapons). These impacts are collectively referred to as CBRN or CBRN-E. Among the factors included in CBRN-E impacts, one can distinguish those whose use would be characteristic of terrorist groups, so-called hybrid actions or false flag operations, as well as those whose use belongs to the domain of the armed forces of countries with the necessary technical capabilities. The first group may include the use of biological weapons, radiological weapons and improvised explosive devices (IEDs). The second group includes the use of nuclear weapons. A special case is chemical weapons, which have been used both during regular military operations (the first effective use of chemical weapons by the Germans at Ypres on April 22, 1915, by spraying chlorine) and by terrorist groups (the Sarin attack carried out by the Aum Shinrikyō sect on March 20, 1995 in the Tokyo subway).

When considering the role of protective structures as a component of the civil protection system, it is natural to focus among the factors mentioned on those whose impact will be widespread. Such factors may include chemical, nuclear and radiological weapons.

Of the weapons of mass destruction, unquestionably the palm of primacy in terms of public awareness as well as the potential for destruction has been held by nuclear weapons since their invention. From the point of view of civil protection, what is of most interest is not so much the technology of producing nuclear weapons as the spectrum of anticipated threats from their use (Chester, Zimmerman, 1987).

The factors of nuclear weapons flare are airborne shock wave, seismic wave, thermal (light) radiation pulse, penetrating radiation (primary, especially gamma and neutron radiation), electromagnetic pulse and radioactive contamination of the area(gamma residual radiation) (Solarz, 2016). For the planning of protective structures intended for the protection of the public, the threat of radioactive fallout and airborne shock wave is of primary importance.

In the case of radioactive fallout, its effects cannot be linked linearly to the site of the explosion. They depend not only on wind direction and speed, but also on the power and type of charge. Simulation for charges of 200 kT (the warhead carried by the Ch-55 missile, which was found in Zamość near Bydgoszcz) indicates a radioactive fallout range, for radiation doses above 1 cGy/h of the order of 250 km, and a contamination area of 9,280 km2 (https://nuclearsecrecy.com, 2023). The simulation is purely illustrative, as the actual area of contamination would depend on many different factors. It does, however, show the scale of the problem. For comparison, the range of an airborne shock wave with a pressure of more than 0.03 MPa (the resistance of P-category shelters) is about 2.5 km (an area of destruction of 22.5 km2).

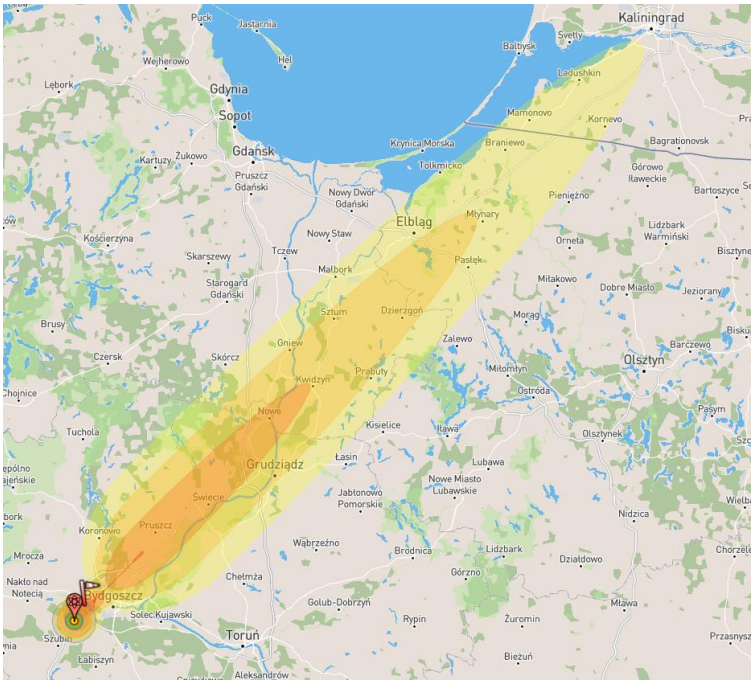

Figure 1. *Simulation of the range of the radioactive cloud from a 200 kT charge detonated near Bydgoszcz* (https://nuclearsecrecy.com, 2023)

In this context, it is also worth mentioning radiological weapons, otherwise known as “dirty bomb”. The essence of its operation is the propagation of a radioactive substance. The war in Ukraine has shown that radiological weapons can not only be a tool in the hands of terrorists, but also be a means of intimidation used in a classic war. Indeed, emerging reports of the bombing of the Zaporizhia nuclear power plant (www.rp.pl, 2023) should be qualified as a threat to use radiological weapons precisely. The possible consequences of blowing up a Ukrainian nuclear power plant are difficult to assess due to discrepancies about its wartime status. However, regardless of the nature of the consequences (local or regional) the detonation of explosive charges on the reactors would have to qualify such an event, as the use of radiological weapons.

4 The protective function of shelters and hideouts

Turning to the concept of protective structures, it is not widely represented in the literature. A protective structure is “a room or set of rooms designed to protect persons, equipment, material stocks or other material goods from the effects of military action, extreme weather events, environmental, industrial disasters or other hazards” (OCK, 2018). Another definition, accepted by military fortification specialists, defines protective structures as “a structure or a separate part of a building designed to protect persons, equipment, material stocks or other material goods from the effects of armed actions, ecological, industrial disasters or other hazards” (Szcześniak, 2011). Generalizing, it can be assumed that protective structures are building structures or specially prepared parts of them, in which people and/or material objects (equipment, supplies, etc.) can find safe hiding places from various types of threats.

Of course, when defining protective structures in this way, several caveats must be made: first, they should be specially prepared, but in an emergency situation anything can be used that will provide people with at least a minimum of safety. Second, not every protective structure will do its job for every emergency. A different type of structure will be advisable for use in a nuclear emergency and another in the event of a flood or strong hurricane (Nappi, et all, 2019).

Hence, the basic division used in the typology of protective structures is the division into shelters and hideouts. In general terms, a shelter is a protective structure with a structurally closed, airtight enclosure that provides protection for people, equipment, material stockpiles or other material goods against assumed agents of destruction acting from all sides (Bashawri, et all, 2014).

On the other hand, a shelter is a protective structure that is not hermetic, equipped with the simplest installations, providing protection of persons, equipment, material stocks or other material goods from the presumed agents of destruction acting from certain sides (Szef OCK, 2018). The researchers note that there is no definition of so-called protective structures in the current technical and construction regulations. The possibility to erect only aboveground dual-function objects without a permit is disadvantageous, since such objects generally have less resistance than objects completely sunk in the ground (Obolewicz, et all, 2021).

Thus, a shelter is a free-standing structure or part of a building (a separate room) specifically designed for the protection of persons and property. It can be used in times of peace, crisis and war. Drawing on the experience of Scandinavian countries, it is worth noting that a protective structure should have the possibility of dual purpose and use. In "normal" time, there could be a gym, a stroller or bicycle storage area, or a sports hall. In a situation of growing crisis - whether non-military or military, the room can be adapted within a short period of time to protective rigor, ensuring the safety of the population seeking shelter. On the other hand, underground transportation (subways, parking lots), commercial, service, storage facilities can be used for hiding. These will be stationary hides. A different type of concealment, are ad hoc, that is, those that are related to the terrain or the place where the person happened to find himself (such as a drainage ditch, a tree, a road tunnel), as well as ad hoc construction facilities not originally designed to perform a protective function (Szcześniak, Lalka, 2019, pp. 52-58) .

A separate issue is a relatively new category of protective structures, which are the so-called Places of Emergency Shelter. The State Fire Service, which introduced this category of facility, did not define technical parameters in any document. The classification of rooms into this category was not preceded by an analysis of the technical condition or determination of the strength of structural elements. It is worth adding that the inventory of protective structures in Poland took place from October 2022 to February 2023 (KG PSP, 2022), and firefighters carried out activities under the so-called operational reconnaissance related to crisis management and civil protection issues. State Fire Service officers each time contacted the owners of building structures to obtain consent to conduct an inventory and to receive data on the purpose of the facility. The inventory process was voluntary, and the physical inventory was carried out with the consent of the owner, manager or person authorized to provide information about the facility (www.gov.pl, 2023). In total, 234,735 building structures were inventoried in the country. They were classified as protective structures, i.e. shelters and hiding places in accordance with the classification of the Geneva Conventions, and places of temporary shelter, i.e. those that can be used against the effects of extreme weather phenomena (KG PSP, 2023).

Therefore, it can be assumed that Temporary Shelter Places can only serve as hiding places for ad hoc preparations and cannot be considered a modern protective structure, meeting modern technical requirements. Will they fulfill their function in the event of various types of threats? In the case of extreme weather conditions, e.g. a hurricane or a tornado, this seems to be the case. However, there are at least two conditions: firstly, the building (it may be a basement or a multi-car garage) will structurally withstand a given event. Secondly, the weather anomaly cannot last more than a few minutes. In a situation where the threat will be long-term (several/several hours/days), a room of a dozen/several dozen people of different ages, with different psychophysical condition and health status in a room without a sanitary facility, ventilation or heating is a serious challenge for them. safety. The matter will worsen significantly in a situation where we are dealing with a war threat of a conventional nature (the example of Ukraine), not to mention a nuclear or radiological threat.

5 Calculation example

Protective structures provide protection thanks to mechanical resistance, geometric parameters, functional layout, technical, installation and technological solutions. Only a facility designed taking into account all these areas can provide effective protection against the assumed factors of destruction. Shaping functional systems and designing protective structures is the subject of extensive literature on the subject (Krauthammer, 2008; Szafrański, Wołoch, 2023; Szcześniak, 2012). However, several key aspects can be distinguished.

Only shelters, as hermetic facilities equipped with filtering and ventilation devices, provide protection against the entire spectrum of threats. Devices equipped with combined filters provide protection against CBRN agents - chemical, biological, radiological and nuclear, with the exception of combustion products (Harmata, et al., 2019). At the same time, the shelter technology ensures airtightness of the facility and operation in full isolation from the external atmosphere for a predetermined period of time. A fully equipped shelter is therefore the only building facility that allows for effective protection against contamination and long-term external fires. The latter are not a threat to the structure of the shelter, which, embedded in the ground, has a fire resistance many times exceeding even the

highest standard requirements (PN-EN, 2006). The main threat in the event of long-term fires accompanying nuclear attacks is strong air contamination with combustion products and high temperature of the air sucked in by the shelter's ventilation system.

A non-hermetic object, but providing protection against debris, air shock waves, fragments or residual radiation, will be a hiding place. A characteristic element of both shelters and hiding places is, in addition to mechanical resistance, providing an emergency exit located outside the debris zone. As the experience from the war in Ukraine shows, the problem of debris contamination is important. The resistance of a facility to debris is not only determined by the strength of the ceiling, which can be quickly and easily increased by temporarily strengthening the structure. The factor that determines the survival of users of a protective structure is the ability to escape after an attack and blocking of the primary exit. For structures located under buildings, the existence of a backup exit can be a matter of life or death.

In order to visualize the scale of the problem, also in the context of possible adaptation of e.g. underground garages or basements to a hidden function, a simple estimate of the loads affecting the ceiling of the underground floor in the case of debris accumulation was made below. The air shock wave load was omitted due to the fact that the mentioned MDS is closest to category II or III concealments, which do not have to protect against the overpressure of the air shock wave (Szef OCK, 2018).

The following assumptions were made:

Number of above-ground floors: 4

Debris load: 20 kN/m^2

Ceiling load category: A (residential)

Usable load acting on the ceiling: 2 kN/m^2

In accordance with Polish Standards and the draft regulation, the load caused by debris should be treated as an exceptional load. Hence, the load above the self-weight of the ceiling structure for the exceptional combination without taking into account debris (normal use) will be:

$$(1)\ E_d = \psi_{1,1} \cdot Q_{k,1} = 0{,}50 \cdot 2{,}0 = 1{,}0\ kN/m^2$$

The load above the self-weight of the ceiling structure for the exceptional combination, taking into account debris, will be:

$$(2)\ E_d = \psi_{1,1} \cdot Q_{k,1} + A_d = 0{,}50 \cdot 2{,}0 + 20 = 21{,}0\ kN/m^2$$

From the comparison of the values obtained in equations (1) and (2), we obtain for the exceptional combination the multiple of the exceptional load, taking into account debris, amounting to: n=21.

The calculations compared the loads for an exceptional situation for which the fire resistance of the ceiling was checked. It is therefore clear that the safety criterion cannot be fire resistance itself, as was done by representatives of entities responsible for civil protection, but the analysis of the structure and the loads acting on a given structure in given circumstances.

5 Conclusions

International obligations undertaken by the Republic of Poland oblige relevant state authorities to organize Civil Defence and take actions to protect the population. The characteristics of military and non-military threats and Poland's historical experience, as well as solutions adopted by other countries, indicate that protective structures were, are and should be an important element of the population protection system. The indicated formal and legal conditions show that it is necessary to reorganize this system and adopt urgent regulations regarding the technical, legal and organizational conditions for the creation and management of defence resources. Temporarily relying on places of emergency shelter, which, according to the calculations of the Ministry of Internal Affairs, will provide shelter for 140% of the Polish population is incorrect because these places are not adapted to the requirements of

modern threats. It is therefore justified to review the current methods and assumptions for designing protective facilities intended for Civil Defence. In particular, the protective requirements of large-area protective facilities against direct impacts and primary radiation require verification.

The universality of protective structures could also be helped by formulating requirements for facilities with a simplified structure intended to protect the population against radioactive fallout, contamination and debris. Similar solutions are used in Finland, where free-standing, dual-function buildings with reinforced concrete structures equipped with filtering and ventilation devices are built in suburban areas. Emphasis should be placed on the possibility of building home shelters for private use. This would solve the problem of population protection in less urbanized areas, with a predominance of single-family buildings. In the case of cities with a high degree of urbanization, with dense multi-family buildings, legal solutions should be provided to enable developers to erect protective structures as part of the construction of multi-story multi-family buildings, with financial participation from the state. A problem that should be solved at the statutory and planning level is the issue of using areas that are private property or intended for residents' parking spaces for public protection purposes. Planning the protective function at the design stage is the cheapest way to implement new protective structures. As Polish, limited experience shows, the increase in investment costs due to the implementation of the protective function is approximately 5% of the value of the entire project (e.g. Construction of Primary School No. 9 in Bydgoszcz). Attention should also be paid to the need for spatial planning that takes the issue of protective construction into real consideration. Planning assumptions should, in turn, be part of broadly understood defence planning at the strategic level.

The state of protective construction in Poland and foreign examples show that without modern technical requirements supported by a detailed and in-depth analysis of threats and systemic financial solutions, protective construction in Poland will remain the domain of the Armed Forces and a small group of people with the highest economic or political status.

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