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Design of Shelters for Civilians in the Event of Armed Conflict: State of the Art and Contemporary Design Guidelines

Abstract

The tense international situation caused by the war in Ukraine and the increase in global armed conflicts has led to a greater need for civilian protection. Since Russia's attack on Ukraine in February 2022, neighbouring countries have taken measures to strengthen their defence, including civil protection initiatives. However, the availability and condition of shelter facilities in Central and Eastern Europe remain insufficient.

This article aims to analyse the status of civilian shelters in Poland in the event of armed conflict and to establish design guidelines for these facilities. The research was conducted using available literature, studies on the construction and operation of shelters, and an analysis of recent government documents.

When designing shelters for civilians, a comprehensive approach is crucial. Important factors should include the location, especially in urban areas, suitable functional and spatial planning, the potential use of shelters during peacetime, and their integration into a wider protection strategy.

Keywords: shelters, hiding places, protection of civilians, warfare

1. INTRODUCTION

The full-scale war waged by the Russian Federation against Ukraine for over three years, along with other international conflicts and tensions, such as the attack by Israel and the USA on Iran related to the conflict in the Gaza Strip, which is spreading to other Middle Eastern countries, the tense situation between the People's Republic of China and the Republic of China (Taiwan), the unstable situation in Afghanistan, and conflicts in African countries such as Sudan, Ethiopia, Somalia, Burkina Faso, and Cameroon – indicate an increasingly unstable global situation (Sperzel, Shats, O'Neil et al., 2024; Johnson, Dickinson, Mishra, 2024). As a result, many country leaders, especially those neighbouring conflict-affected states, have begun to implement measures to bolster their defence and protect civilian populations.

The Polish budget for 2025 allocates PLN 187 billion (4.7% of GDP) for defence measures (Cedro, 2024). This amount is expected to grow steadily until 2027. Additionally, on 5 December 2024, the Polish Parliament passed a law on population protection and civil defence (Sejm RP, 2024), the implementation of which in 2025–2034 is estimated at over PLN 130 billion, with the most significant portion, nearly PLN 40 billion, is to be allocated for the construction, modernisation, or renovation and maintenance of protective structures and infrastructure (Portal Mundurowy, 2024). Contemporary threats to civilians are categorised into non-military and military threats. Non-military threats include natural

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hazards and CBRN (Chemical, Biological, Radiological, and Nuclear) dangers. Military threats encompass the armament of ships, land forces, aircraft, helicopters, and unmanned aerial vehicles (UAVs) (Rogalski, 1984).

Measures aimed at protecting against threats cover both the population and its heritage, as well as strategic areas of operation, including infrastructure supporting food production, healthcare, energy, communication, and transport. As a result of military operations, civilians often become victims, even though they are not military targets (Szcześniak, 2011).

The draft regulation from the Minister of the Interior and Administration (MSWiA) on the technical conditions and technical conditions for the use of protective structures distinguishes between two types:

- Shelter: This is a protective structure that is closed and airtight, designed with a specific category of resistance (either basic resistance – P, or increased resistance – A). It is equipped with filter-ventilation devices and aims to protect occupants from both military and non-military threats. Shelters are typically located underground or partially buried, though in exceptional cases, they may also be constructed above ground.
- Ad Hoc Hiding: This refers to a structure that is non-hermetic and has a specific category of resistance (categories I, II, and III). This includes modified rooms in underground garages, buildings, tunnels, earth structures, excavations, protective covers, and other makeshift locations. Ad hoc hiding is used when it is not feasible to provide protection in a shelter (MSWiA, 2024).

The design and construction of shelters require a multi-faceted approach. This process involves assessing various risks, considering specific geographic and terrain factors, evaluating infrastructure and urban planning requirements, determining technical and financial feasibility, and examining factors that could lead to destruction. The ongoing conflict in Ukraine highlights that aerial attacks and artillery shelling pose a constant threat to modern cities. These cities often contain large buildings, which are easy to target during an attack. Therefore, it is essential to plan and locate shelters appropriately, ensuring they are accessible and can be utilised at a moment's notice (Jasiński, 2023, 44–55).

1.1. Objective

This article aims to analyse the status of civilian shelters in Poland in the event of armed conflict and to establish design guidelines for their implementation. The analysis is conducted within a historical context and includes an international perspective, presenting examples of civilian protection measures in selected countries. Furthermore, a thorough examination of the current status of civilian shelters in the Republic of Poland has been performed, along with the development of design guidelines based on the latest regulations and documents.

1.2. Methodology

The research methodology encompasses a thorough review of the literature on the history and development of defence, as well as the typology of protective structures. The study relied on existing publications on the topic, complemented by insights gained from one of the authors' postgraduate studies at the Military University of Technology (WAT) in 'Preparation and Operations of Shelters and Hiding Places for Civilians.' The methodology included several key components: a historical analysis of the evolution of shelters and military architecture, field research involving a visit to a training shelter at WAT, typological and functional analyses, and a comparative study of civilian shelters in Poland and selected countries worldwide. Twenty-six functional and spatial layouts of civilian shelters, accommodating capacities from 4 to 500 people, were examined. Based on these analyses, guidelines for shelter design were formulated, incorporating information from documents outlining the technical and location requirements for these structures.

2. PROTECTIVE FACILITIES

Publications on civilian protection mainly appeared during the World Wars and the Cold War. In Poland, the last notable interest in this topic occurred in the 1980s and 1990s. These studies often relied on American and Soviet manuals, and many publications from that period were subject to confidentiality agreements.

On 28 June 1984, the final amendment concerning protective structures was introduced, aligning with the high standards of other Warsaw Pact countries. However, this approach was soon abandoned due to high costs and difficulties in implementation. Ultimately, on 1 July 2004, the last regulation governing protective structures was repealed (Kozik, 2016).

Given the evolution of military threats – particularly the precision of strikes delivered by modern rocket systems and aerial bombs – the shelters used during World War II no longer meet the requirements of contemporary facilities of this kind.

For over 30 years, as no military threats were expected on European territory, civil protection became a secondary concern compared to economic development. However, Nordic countries and Switzerland were exceptions; they allocated significant financial resources for maintaining and developing shelters. Today, due to substantial geopolitical changes, the needs and importance of shelters have regained relevance (Kincl, Pupíková, Oulehlová et al., 2024, 139-148).

The Polish Ministry of Internal Affairs and Administration is responsible for the protection of the civilian population in Poland, including the construction and maintenance of shelters. However, significant issues exist regarding the capacity, technical condition, and maintenance of the existing shelters. The actual equipment, durability, and usability of these shelters remain inadequate. For example, the dismantling of sluices in the Warsaw underground has compromised the airtightness of rooms designated for civil protection. As a result, despite initial plans, these underground spaces cannot function as proper shelters (Kincl, Pupíková, Oulehlová et al., 2024, 139-148, NIK, 2024).

On 6th of April 2023, the 'Schrony' (Shelters) app was launched. This application provides information about inventoried buildings across Poland, categorized into three types:

- Places of Ad Hoc Shelter – These are locations that can serve as shelter from extreme weather events, such as gales, storms, and tornadoes, as well as from potential hazards like falling building elements or broken trees.
- Hideouts – These are protective, non-hermetic structures equipped with basic installations that ensure the safety of people, equipment, material reserves, or other goods against anticipated threats coming from specific directions.
- Shelters – These are protective structures with a hermetic enclosure that is completely sealed. They provide comprehensive protection for individuals, equipment, material stores, or other goods against potential destructive agents coming from all sides.

The State Fire Service has conducted an inventory of a total of 234,735 building structures located in Poland. According to the

service, the capacity of these facilities exceeds the country's population, with the potential to shelter more than 49 million people. Among these structures, the largest category consists of Places of Ad Hoc Hiding, totalling 224,113 buildings. Additionally, there are 8,719 designated Hideouts and only 903 classified as Shelters (Aplikacja 'SCHRONY', 2024). The inventory primarily focused on the buildings themselves, while the equipment within them was not evaluated, nor was their current functionality considered. As a result, some structures were assigned typologies that did not meet the necessary requirements. This includes shelters that have fallen into neglect, leading to a loss of airtightness and unusable emergency exits and installations (NIK, 2024). Similarly, Hideouts that are overcrowded with various items can accommodate far fewer people than intended, and Places of Ad Hoc Hiding may pose a risk, as airborne shockwaves and clutter could trap individuals inside. Furthermore, the inventory did not address the temporary availability of many facilities during night raids or the logistics of moving vehicles out of underground garages. The risk of burning fuel and emitting carbon monoxide can further increase the potential for fatalities in emergencies.

The Regulation of the Ministry of Internal Affairs and Administration on the criteria for recognising buildings or parts thereof as protective structures specifies which structures are classified as shelters and hiding places. These are existing protective structures that fulfil the protective functions specified for shelters and hiding places. For shelters, this includes protection against, among other things, airborne shockwaves, ammunition fragments, debris, falling objects, gamma radiation from radioactive fallout, external fires, chemical, biological, or radioactive contamination, and mechanical shocks. Shelters are divided into categories S-0, S-1, S-2 and S-3. The basic level of protection is S-0, and S-3 is the highest, designed to withstand an airborne shockwave of 0.3 MPa or greater. Hideouts are divided into 3 categories: U-1, U-2 and U-3. Hideouts are intended to provide protection only to a limited extent. U-1 – protects against: wind, debris, rubble. U-2 – additionally protects against radiation and fire, and U-3 – like U-2 with partial protection against airborne shockwave.

Private shelters can be seen as an alternative solution. Currently, numerous companies in Poland are focusing on the design and construction of underground shelters to address both military and non-military threats. The solutions offered typically rely on prefabricated steel or reinforced concrete components. Among the most popular options are ready-made structures based on shipping containers or prefabricated structures.

2.1. Shelters in the USA

In the United States, due to the prevalence of natural and human-made hazards, citizens have access to extensive information and expert support regarding shelter preparation. Public shelters play a crucial role in comprehensive emergency management, which is guided by the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The Federal Emergency Management Agency (FEMA) oversees shelter-related activities and provides support through a mobile app. Various organisations, including the American Red Cross, are involved in implementing shelter programs across the country (Kincl, Pupíková, Oulehlová et al., 2024, 139-148).

The Cheyenne Mountain Complex serves as a shelter for a wide range of hazards and is located at the Cheyenne Mountain Space Force Station (CMSFS) in Colorado Springs, Colorado (Ill. 3a). The concept for an underground command centre to support NORAD (North American Aerospace Defence Command) missions originated in the 1950s. The facility became fully operational in April 1966. Today, the Cheyenne Mountain Complex functions as an alternative operations centre for both NORAD and USNORTHCOM. At the centre of this complex, with a floor area of approximately 20 700 m², are fifteen buildings that are shielded by a mass of granite almost 3,000 m high, offering a high level of protection against airborne shockwaves, the impact of conventional weapons as well as protection from penetrating radiation (NORAD, 2024).

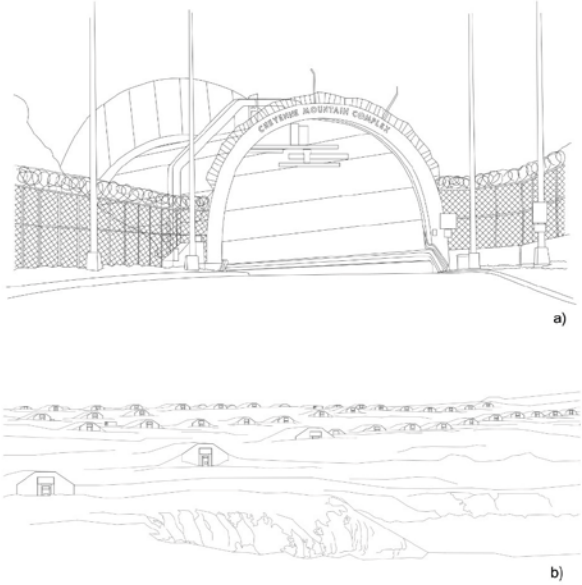
Terra Vivos X Point is a complex consisting of 575 shelters for the public, making it the largest civil defence establishment in the world, capable of accommodating up to 5,000 people. It is located in the Black Hills area of South Dakota. Between 1942 and 1967, the site functioned as a bomb and ammunition storage facility. After that period, the buildings became the property of the town of Edgemont and were later owned by local cattle ranchers. During their ownership, the shelters remained unused until the Vivos company acquired them. The project features partially underground structures with cradle vaults, enclosed by reinforced concrete gable walls. The facilities are laid out over a large area, organised along access roads that form a perpendicular grid, dividing the site into 12 clusters (Ill. 3b). The location's central position in the United States, makes it one of the safest areas in the country (Vivos Shelters, 2024).

2.2. Shelters in Europe

Switzerland is the best-organised country in Europe when it comes to shelter infrastructure. The country's shelters can accommodate nearly all of its 9 million citizens (data from 2023) (World Bank, 2023). Many of these shelters are designed to a high standard of preparedness (Pike, 2016, pp. 94-106). Since 1963, a network of nuclear-standard shelters has been developed following the establishment of legislative guidelines for shelter construction. This network comprises both private and public shelters, equipped with tunnels that lead to hospital sites, as well as additional hiding places located in the Alpine mountains.

Sweden also has well-prepared shelters, providing accommodations for 7.2 million people, which accounts for 81% of its

Ill. 1. Examples of existing shelters: a) Cheyenne Mountain Complex, b) Terra Vivos X Point. Elaborated by L. Kosztołowicz, D. Gromek based on: a) photos by Terravivos.com, b) photos by NORAD



population. In neighbouring with Russia, Finland, shelters are available for 3.4 million people, i.e. 70% of the population, where there is approximately 1m² of usable shelter space per person (Pike, 2016, pp. 94-106). In Helsinki, which has a population of roughly 660,000 people, around 500,000 can find shelter. The construction of shelters in Finland began in the mid-1950s, with a peak period from 1963 to 1982, when residential areas outside city centres were rapidly developed. Many shelters, both private and public, are situated in the suburbs. Finns place significant importance on the dual functionality of these shelters. They are most commonly used for storage, community meeting spaces, art, recreation, sports, or as parking lots (Kopomaa T., 2010, 1-7). Czech civil defence against airborne attacks began in 1935. From 1948 onwards, the construction of shelters designed to protect against conventional weapons started. Between 1960 and 1989, these shelters were further enhanced to withstand weapons of mass destruction, including blasts from airborne attacks, biological warfare agents, poisonous chemicals, penetrating radiation and heat, toxic industrial agents, and fuel-air explosives (Szcześniak, 2011). After 1990, the construction of shelters for military threats ceased. The infrastructure established during this period can accommodate 1.35 million inhabitants. Between 2013 and 2020, existing underground parts of transport infrastructure and improvised shelters were evaluated as potential options for safeguarding against military threats. Since 2023, the public has had access to information about shelters for Czechs through the Terinos app (Terinos, 2024). The registered facilities can shelter approximately 685,000 people, which accounts for 6.3% of the population. Most of these shelters are located in Prague. The Civil Protection Strategy, with an emphasis on 2025 and a focus on 2030, highlights the importance of improvised shelters (Kincl, Pupíková, Oulehlová et al., 2024, pp. 139–148).

In Germany, 1920 marked the start of efforts to protect civilians from aerial attacks. After World War II and throughout the Cold War, around 2,000 public shelters were registered, along with legal regulations governing their construction. However, following Germany's reunification in 1990, the issue of shelters was largely neglected. No new shelters were built, and maintenance of existing ones was discontinued. The public shelters in Germany were designed to protect against conventional weapons and to mitigate the effects of penetrating radiation. In light of the ongoing war in Ukraine, the current condition of these shelters has been assessed. There are 579 public shelters scattered unevenly across the country, with the capacity to accommodate nearly 500,000 people. This provides shelter space for just 0.6% of the population (Kincl, Pupíková, Oulehlová et al., 2024, 139–148).

2.3. Shelters in Israel

Israel has a shelter capacity for its population of approximately 66% (Pike, 2016, 94–106). Private or public shelters or hideouts protect air means of attack. Public bomb shelters (***miklatim***) are most common in cities, especially those considered particularly at risk from rocket fire (e.g. Ashkelon, Sderot). The shelters are reinforced above-ground and underground structures. Since 1992, new buildings, houses and apartments in Israel have had to contain a safe rooms (***mamad***), i.e., a separate and structurally reinforced airtight room with filtering ventilation and communication equipment (Shvartsur, Savitsky, 2024).

2.4. Shelters in Turkey

Civilian shelters, managed by AFAD and other authorities, are designed to protect against bomb attacks, natural disasters, CBRN (Chemical, Biological, Radiological, and Nuclear) threats. These shelters are often located in basements of public buildings schools, hospitals, and residential complexes, with specific legal requirements mandating their inclusion in urban building codes (Özdemir, Karataş, 2024). In high-risk regions, such as those near the Syrian border, local authorities have established additional shelters and emergency protocols to address threats like rocket attacks.

Shelters in Türkiye are categorized based on their users and purpose. Special shelters are built in homes, workplaces, and institutions for specific groups, while general shelters are constructed in high-traffic areas like markets and stations for public use. They are further classified as shockwave overpressure proof shelters, which protect against both the direct and indirect effects of CBRN threats, and fallout shelters, which shield against radioactive fallout and some other weakened effects of weapons.

Design standards for fallout shelters encompass specifications for size, wall thickness, ventilation, and hygiene, along with additional measures such as fire prevention and reinforced structures for protection against chemical and nuclear threats. These regulations, outlined in the "Shelter Regulation" by the Ministry of Public Works and Settlement, ensure shelters are equipped to safeguard civilians and maintain national resilience during emergencies (AFAD, 2025).

2.5. Guidelines for shelter design in Ukraine since the outbreak of war

On 1 November 2023, the Ordinance on Civil Protection Defence Facilities in Ukraine came into effect. It requires that protective structures be designed and constructed to provide adequate conditions for sheltered individuals to remain for up to 48 hours. They must be protected against clutter and be capable of attenuating radiation effects. No specific radiation attenuation multiples are provided, but depending on the shelter class, their resistance to airborne shockwaves from weapons of mass destruction ranges from 100 kPa to 500 kPa, and 100 kPa for conventional means of destruction.

Dual-purpose structures are recommended for rational use, to meet social or economic needs in accordance with the main functional purpose during times of non-emergency. They must simultaneously meet the requirements of the building regulations in accordance with both uses.

Maximum access radii to shelters have been set: 300 m for tall and high-rise buildings and up to 500 m for other buildings. The use of protective screens, tiered structures and gabions or bags filled with loose materials to reinforce protective facilities is permitted. However, the use of mixtures of aggregate fractions, pebbles and stones to reduce debris as a flare factor is prohibited. Depending on the affiliation of the planned shelter to the site, its capacity is expressed as a percentage of the number of persons anticipated to be in the facilities. Beds of 2 or 3 levels should be provided in the protective facilities (MIU, 2023). Ukraine has a multilingual Air Alert app that warns of air strikes (Alarmowa Mapa Ukrainy, 2025).

3. CURRENT GUIDELINES FOR THE DESIGN AND PROGRAMMING OF CIVILIAN SHELTERS IN POLAND

The last legal act regulating shelters is the Decree of the Council of Ministers of 28 September 1993 on civil defence, which was repealed on 1 July 2004.

In 2022, the following ceased to apply: Guidelines of the Head of Civil Defence of the Country dated 4 December 2018 on the principles of dealing with protective construction resources and the annexe to the above Guidelines – Technical conditions to be met by protective constructions. Although they are no longer in force,

they are still in use due to the fact that this is the last document of this type in Poland.
Efforts are ongoing to implement the Ministry of the Interior and Administration's regulation regarding technical conditions and terms for the use of protective structures (MSWiA, 2024).
The document that sets the framework of the state security policy is the National Security Strategy of the Republic of Poland. It is not a legal act, but it is an official strategic government document that defines the main objectives and directions of activities in the field of Poland's national security, including civil protection and civil defence (National Security Strategy of the Republic of Poland 2020). The construction of shelters must be carried out per the general principles of the Construction Law. Article 3 of the Building Law indicates that defence (fortifications) and protection facilities are considered to be structures and not buildings, but if these structures form part of a building, particularly in the case of multifunctional structures, the provisions relating to both must be taken into account (Building Law, 2024, 2–10).
The Act of 5 December 2024 on Civil Protection and Civil Defence defines for the first time the terms emergency aid, humanitarian aid, social resilience and civil protection resources. The law is not an operational document, but its purpose is to ensure the safety of citizens (MON, 2024). Among the tasks in the field of protection of the population, which during martial law or war becomes civil defence, the rules for the creation and use of collective protection facilities, including shelters, hideouts and ad hoc hidings, which are to counteract threats to the civilian population: chemical, biological, radiation and nuclear, as well as the elimination of their effects, have been established. Local authorities are responsible for organising ad hoc hidings and planning the capacity and number of collective protection facilities, as well as providing information on their location. In urban areas, collective protection facilities are intended to provide space for at least 50% of the population affected by the threat, in non-urban areas for 25% (Sejm RP, 2024).
The Regulation of the Minister of the Interior and Administration on Technical Conditions and Technical Requirements for the Use of Protective Structures defines general and specific safety requirements for collective protection facilities, their classification, capacity, surfaces, and mechanical resistance. There are categories of protective structures, fire requirements, requirements for functional zones located in these structures, as well as specific requirements for ventilation in shelters and hiding places. There are also requirements for utilities, equipment and installations, as well as ongoing operation and maintenance. The ordinance also sets out technical requirements for adapting underground rail transport systems and existing structures to the function of a protective structure. The regulation defines categories of protective structures, including basic resistance shelters that protect against airborne shockwave of $\Delta pm \geq 0.03$ MPa, and $\Delta pm \geq 0.1$ MPa for higher resistance shelters. Each shelter must have solutions that attenuate transmitted radiation by a minimum of 100 times (MSWiA, 2024)

4. DESIGN GUIDELINES

The purpose of fortification is to safeguard against expected means of destruction. Therefore, it is essential to understand how modern destructive weapons operate (Rogalski, 1984). With the increasing use of precise and hard-to-neutralise weapons before they strike their targets, it is crucial to consider the importance of concealment, especially in urban areas.
A facility that protects against conventional and unconventional weapons is a shelter. It is a closed, airtight structure equipped with explosion-proof valves.
One key factor in ensuring the safety of individuals is the time it takes to access a shelter or form of concealment, especially in proximity to potential threats. Additionally, the effectiveness of a shelter is influenced by the integration of its functional and spatial layout, its structural design, and its installations.
Protective structures are one of many components of civil protection or civil defence. Among the principles of grounding and dispersing protective structures, their camouflaging may also be important, especially in the case of hospitals and defensive structures, making it difficult for the enemy to detect them from the air (MON, 2013, 6-8). One of the advantages of underground shelters is their natural camouflage, which makes them difficult to detect using reconnaissance techniques from various heights (space, air and ground reconnaissance) (Zaborowski, 1982).

4.1. Examples of shelters

The functional layouts of 26 civilian shelters were analysed to determine design guidelines. The shelters can be divided into small (up to 25 occupants), medium (26–50 occupants) and large (51–500 occupants) according to the number of occupants. The above division used for the purpose of this article, while not found in official documents, allows shelters to be classified and the necessary infrastructure to be identified. Below are examples of three small shelters, including a training shelter from WAT. Larger shelters are essentially scaled versions of the functional layouts of small shelters, particularly regarding the primary and social zones, but they also have additional fire protection requirements. One factor that influences the equipment standards and size of a shelter is its target group of potential users.
A shelter designed for 4 to 6 people (see Ill. 2a) is compact and lacks both a water intake and a generator. It enables individuals to survive under minimal conditions through basic water management and manual filtering, if necessary. Without electricity, preparing hot meals or drinks is not possible. The duration of stay can be significantly extended if the shelter is connected to an external water and electricity source, though it is important to note that these utilities can be cut off during emergencies. Access to the shelter is provided through an airlock, which, in flat areas, is constructed as a staircase leading down to the underground section. Upon entering the vestibule, one arrives at the main room, which serves multiple purposes. This space includes seating, a kitchenette, and a filter-ventilation unit. The next room is a passable bathroom, with a bedroom, which can be escaped through an emergency exit.
Example of a shelter for 25 persons (Ill. 2b) – without special treatment point, without aggregation room. The shelter is dependent on the electricity grid, the back-up exit and access are on the same side of the shelter. In case of cluttering through, they may not be far enough apart. The main room is the core of the functional layout, and the perimeter layout of the core and social area rooms provides easy access and internal communication for protected persons.
The training shelter at WAT (Ill. 2c) contains rooms with installations that occupy a much larger area than the primary and social function areas together. This determines the increased resilience of the shelter and the longer safe occupation of the shelter. Due to the separation of the rooms and the extension of the entrance area to include a sanitary treatment point, acoustic comfort is maintained (less noise from running equipment), and it is possible to accommodate contaminated/sick people. There are two entry routes, via the vestibule to the clean area or via the sanitation point, the entrance for contaminated persons. For the protected persons, there is a main room and peripherally accompanying

Ill. 2. Functional layouts of exemplary shelters, elaborated by A. Jörgen: a) shelter for 4-6 persons, b) shelter for 25 persons. c) training shelter at WAT

rooms of the social and sanitary area.

4.2. Functional arrangements

When adopting design guidelines and determining the length of stay in a shelter, it is important to ensure adequate living conditions and activities for the people inside due to the potential for aggression associated with a sense of isolation, density of people and sudden change in functioning. For a short-term stay (up to 8h), such situations should not occur. This is influenced by a number of environmental and external factors.

During normal environmental conditions outside, the external air intake should be used with the filters bypassed (so-called period I). If there are toxins at the air intake, then switch to filter ventilation (period II), and the air taken in from outside passes through the filters. Suppose the shelter is fully isolated due to an external fire. In that case, there is a complete isolation from the external environment due to the carbon monoxide emitted and high temperature – the air intake is closed. Internal air circulation takes place using filters and compressed air (period III) (Mossor, Górniak, Skonieczna, et al., 1990). The fire generates a lot of heat, heating the ground. The additional heat from the people inside and the heat generated by the necessary equipment condition the time for full insulation of shelter facilities (Owczarek, Radzikowska-Juś, 2015, 49). Internal and external fires can spread and burn out of control. External fires are dangerous for external doors because they can cause deformation and result in a loss of tightness (in the case of airtight and protective airtight doors). External fires pose a hazard to generators and filters. One of the tasks of ventilation is to maintain an overpressure inside the shelter and to dissipate heat to the outside, hence during period III compressed air is supplied from tanks (Mossor, Górniak, Skonieczna, et al., 1990). The issue at hand is the increasing concentration of carbon dioxide (CO_2) in the air. While there are methods to chemically filter air and remove CO_2 – similar to those used in submarines – these solutions can be costly. It is important to note that individuals should avoid environments with a CO_2 concentration exceeding 0.2% for extended periods and no more than 0.5% for short durations. Additionally, maintaining a comfortable temperature inside the shelter is crucial, ideally not exceeding 26°C, with a maximum limit of 29–30°C. It is possible to use protective masks with filters instead of relying on filtered ventilation; however, this practice is not advisable due to several drawbacks. These drawbacks include facial pressure, altered circulation, difficulties with eating and drinking, and impaired medical rescue for individuals.

The operation mode and functional layout of the shelter are influenced by an eight-hour cycle, which involves taking turns to perform three activities per day: sleeping, sitting, and working (which includes housekeeping and maintenance tasks). This arrangement ensures the efficient use of all resources available in the shelter, which are critical for the survival of those inside.

The shelter should be managed by a competent person. His or her duties should include managing the people under protection (assigning tasks), controlling access, supervising the shelter's equipment, maintaining sanitary conditions, and ensuring appropriate climate conditions inside the shelter. Issuing commands via the shelter's telecommunications system should be transparent and simple (especially in the case of airlocks, where people spend a short time in the airlock). It should be characterised by a firm distribution of tasks among the protected persons and division into smaller groups of people entering the shelter in order to effectively coordinate activities and control the group. The organisation of operations is also important. Any additional luggage should be left outside the protected area.

4.3. Functional-spatial layout of shelters

The functional-spatial layout of the shelters consists of four zones (Ill. 3):

- entrance and internal circulation,
- basic activities
- social,
- technical.

Table 1: Zoning of the shelter

Clean zone rooms	Conventionally clean zone rooms	Conventionally dirty zone rooms	Dirty zone rooms	Dirty zone at risk of contamination
· main room · bedrooms, · control room, (if applicable) · surgery (if applicable) · shelter manager's room, · food storage	· kitchen and dining room · medical aid station / isolation room	· washrooms · dressing room at the sanitation point	· toilets, · combustion plant complex - generator room, fuel storage, · waste room, · ventilation room	· vestibules/sluices · changing room and showers for sanitary facilities, · passageway

The shelter rooms are categorised into core spaces, where protected individuals are housed, and auxiliary spaces that facilitate survival. The design of these shelters follows logical principles of zone grouping. This includes various functional, installation, acoustic, fire, and hygiene interrelationships that relate to the aerodynamics of the rooms and protection against contamination (Mossor, Górniak, Skonieczna, et al., 1990). As a result, five distinct zones are identified: clean, conventionally clean, conventionally dirty, dirty, and dirty with a risk of contamination (see Table 1).

4.3.1. Entrance and circulation zone

The entrance and circulation zone determines the accessibility of the shelter and also how it is protected from external conditions. This Zone contains the following elements:

- Access – stairs, shafts or a ramp or walkway. Access can be provided for both vertical and horizontal movement, depending on whether the shelter is located above ground or underground.
- Passageway – straight, elbowed or arched. Can be blind (open or closed). The vestibule is the ceiling, wall and foundation in front of the external door, providing protection.
- Vestibule and airlock (functions may be combined) – the vestibule must provide insulation and serve to increase the degree of airtightness and protect people from: airborne shock wave, external fires, radiation from outside, and BST. The airlock enables the movement of people to and from the shelter during emergency periods. An airlock can be a vestibule when it has a pair of protective, hermetic doors (Rogalski, 1989). The shape of the vestibule and the location of the first protective door determine the level of increase in positive pressure and the load on the vestibule and protective door itself (SSZiBGKWP, 1982).
- Duty station – nowadays the tasks of a duty station can be performed by the shelter manager with the help of an internal communication, diagnostic and control system, hence, a duty station is currently not required in civilian shelters.
- Sanitation point / special treatment – decontamination node – a sequence of rooms in the dirty and conventionally dirty zone for: deactivation (removal of radioactive contamination), degassing (removal of toxic warfare agents) and disinfection (removal of biological warfare agents). The decontamination node is designed in areas where movement after an attack is required, e.g., command posts (Rogalski, 1989).
- Spare exits - allows egress from the shelter in case the main entrance to the shelter fails. May provide an additional entrance to the shelter or an air intake.

4.3.2. Social zone / primary activity

Elements of the social zone – these are the rooms of the clean and conventionally clean zone that provide rest, food, maintenance of hygiene and well-being and also medical assistance (Rogalski, 1989). These may include:

- Bedrooms - the number of sleeping places depends on the purpose and capacity of the shelter. The starting point should be 1/3 of the personal capacity of the shelter. Bunk beds or triple beds should be firmly fixed in the floor and moved away from the walls in case the whole shelter is shaken. 4–6 bedded rooms are optimal.
- Bathrooms - equipped with washbasins, showers and toilets in an amount selected according to the capacity of the shelters.
- Kitchen with associated storage and waste rooms – rooms must provide for the preparation and consumption of meals, and at least once a day, the preparation of a hot meal and a drink. Eating should take place in a separate part of the shelter, and waste should be collected in sealed containers in the least usable, fire-safe area.
- Main room (used for sitting, talking, resting, etc.).
- First aid station / isolation room – a place to carry out emergency activities related to the most common injuries occurring in shelters: head injuries, cuts, hysteria, post-accident shock, suicide attempts, poisoning, other illnesses and childbirth.

4.3.3. Technical zone

The technical zone is responsible for life support systems and communications and communications. Elements of the technical zone:

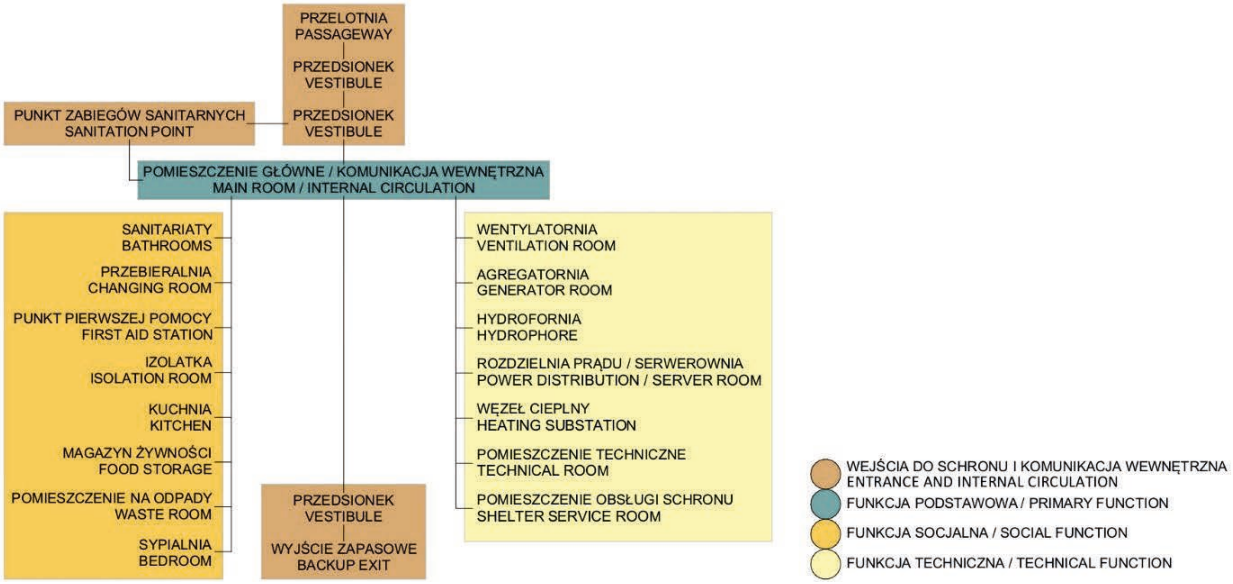
- Generator room - a power generator as a substitute source of electricity supply.
- Ventilation room and filter plant - depending on the operating regime (period I, II, III), there can be mechanical ventilation or mechanical ventilation with filters. The air is discharged through vestibules and toilets according to the direction of the zones from clean to dirty.
- Hydrophore with water intake - due to the possible failure of water supply and sewerage networks during military operations, it is necessary to provide a water supply and preferably a well providing good quality water for individual human needs, decontamination and technical functions (Rogalski, 1989).
- Electrical switchgear – allows control and safe switching off of electricity in the event of an emergency.

The airtightness of the protective structure is ensured by structural solutions together with appropriate utility solutions. Depending on the period, overpressure is maintained by ventilation or compressed air cylinders. To achieve autonomy of the shelter, it is essential to have a backup (alternative) power source and adequate supplies of water and food. Devices for monitoring the external environment, devices for communication with the outside world, lighting and a system of sensors constitute the basic installations.

The areas of the individual rooms are assumed on the basis of the length of the planned stay, the comfort of the users, and the number of installations in response to the designed protection against means and agents of destruction.

5. CONCLUSIONS

Growing global political and military tensions, especially in Eastern Europe and the Middle East, necessitate the development of protective infrastructure. The current state of shelter buildings in Poland, similar to that in the other Central European countries,



Ill. 3. Functional and spatial scheme of the shelter, elaborated by. A. Jörgen

does not meet standards and does not provide sufficient space. For this reason, it is necessary to take measures to adapt or renovate existing protective structures and build new ones, especially in urban areas, where the likelihood of military threats and their consequences is greater than in sparsely populated areas. These facilities should be connected to places where people gather, such as workplaces, public spaces and residential areas. In cities, protective facilities should provide space for 50% of residents located in the danger zone, compared to 25% in non-urban areas.

In Poland, most shelters are located in the capital city and protect a relatively small group of people. The distribution of shelter types should correspond to the potential threat, which is why in areas more vulnerable to attack, i.e., in the eastern part of the country, greater emphasis should be placed on providing shelters in public, commercial and residential buildings.

The design of a shelter should take a comprehensive approach, considering every aspect of protection from the moment the threat signal is announced until it is resolved. A reliable nationwide communication system between shelters is required, as well as an accessible system of information on the location of shelters, such as the Schrony or Terinos apps.

While shelters for the military may be more rudimentary, those intended for civilians should be easily accessible, particularly for people with disabilities, and equipped with features that minimise tension between occupants and support cyclical activity (sleeping – sitting – working).

Examples of solutions from abroad, especially from the Nordic countries, Switzerland, Israel, the USA, as well as Turkey and Ukraine, can serve as guidelines for designing shelters in areas not covered by national guidelines.

Ukrainian guidelines indicate that shelters should provide shelter for up to 48 hours, while Finnish shelters provide 1 m² per person.

Shelter planning should anticipate their peacetime use. It should be organised in such a way that, in the event of a threat, it can be easily and quickly adapted to perform protective functions. In the case of multifunctional protective structures, space outside the shelter should be provided for the relocation of items that constitute the equipment of these structures in peacetime.

In urban areas, subways, underground car parks and other underground infrastructure can be suitable hideouts or shelters. It is important to determine the risk of a direct attack and the resistance of these structures to the effects of the collapse of above-ground buildings, as well as the tightness of entrances, control and organisation among those seeking shelter, and ensuring adequate shelter management.

Since the pressure caused by an explosion decreases rapidly with distance, it is crucial to locate shelters, particularly hideouts, as far as possible from objects vulnerable to attack (Kobielak, 2005), including tall and high-rise buildings, which are easy targets.

The time and distance required to reach a shelter should also be considered. In Ukraine, the distance to shelters should be up to 300 m for tall and high-rise buildings and up to 500 m for other buildings. In Poland, the maximum distance to protective structures for building complexes is 500 m (MSWiA, 2024).

Above-ground shelters are less resistant to modern destructive factors than underground shelters. An airborne shockwave reaches much higher values than a wave propagating in the ground. On the other hand, above-ground shelters, such as safe rooms, allow for faster access and are more resistant to debris.

In the case of individual solutions, especially in non-urban areas, private shelters can be used. Prefabricated solutions available on the market can serve as an external basement and storage space in peacetime. Private shelters are a popular solution in Switzerland, the USA and Israel.

The size of the shelter and its functional and spatial layout should be adapted to the expected number of users. The anticipated means of attack and the resulting necessary resistance category of the shelter and its equipment should also be considered.

Depending on the size of the shelter, different functional and spatial zones are distinguished (entrance and communication, basic function, social and technical), whose relationships and layout should ensure safe evacuation and stay, control and assistance, including medical assistance, for the people staying in them. Proper design and zoning are critical to the usability and safety of the shelter. They should be arranged in a logical sequence from the clean zone to the dirty zone at risk of contamination.

The intention is to minimise the amount of space allocated to installations in relation to the space allocated for human habitation. An analysis of anticipated threats enables the determination of the shelter's level of autonomy and the necessary infrastructure, thereby optimising the usable space.

Legal regulations introduce guidelines, but it is essential to take a multifaceted approach, integrating shelters into existing or newly created buildings and developing a method of using protective structures in peacetime, enabling them to be converted into shelters in the shortest possible time. Therefore, despite many restrictions and technical issues, the design of protective structures should be based on in-depth spatial analyses and well-thought-out architectural solutions.

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Łącze

PROJEKT, KTÓRY STWORZONY ZOSTAŁ NA UKRAIŃSKIEJ ZIEMI, PRZESIĄKNIETEJ HISTORIĄ I KULTURĄ. POMYSŁ ZRODZIŁ SIĘ Z EMPATI W STOSUNKU DO SYTUACJI AKTUALNIE TOCZĄCEJ SIĘ W TYM MIEJSCU. INSPIRACJĘ DO STWORZENIA PROJEKTU BYŁO "POŁĄCZENIE". LUDZIE MOGĄ TU FUNKCJONOWAĆ RAZEM NICZYM JEDENA WSPÓLNOTA. W SYTUACJI RYZYKA SYSTEM OTWARĆ I ZAMKNIĘĆ BĘDZIE OSTRZEGAĆ MIESZKAŃCÓW, KTÓRZY DZIĘKI TEMU MOGĄ POZOSTAĆ W CIĄGŁYM KONTAKCIE ZE SOBĄ PODOBNIE JAK CZYNIĄ TO KWIATY ZWANE MIMOZAMI. DZIAŁKA NA KTÓREJ ZOSTAŁO ZAPROJEKTOWANE NASZE OSIEDLE JEST SERCEM CAŁEGO ZAŁOŻENIA ZBIOISHCHA.
W PROJEKCIE ZE SKALI MAKRO (OSIEDLE ZBOISHCHA) PRZECHODZIMY DO MIKRO (NASZEJ RELACJI Z BUDYNKAMI SĄSIADUJĄCYMI), AŻ DO SKALI NANO (POŁĄCZEŃ, KTÓRE UMIEŚCIŁYŚMY W NASZYM ZAŁOŻENIU). W PROJEKCIE POSTAWIŁYŚMY NAJWIĘKSZY NACISK NA OCHRONĘ ADAPTABILNOŚĆ ORAZ KOMFORT LUDZI.

ZESPÓŁ PROJEKTOWY
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MAGDA SIEMIENIUK
NATALIA OPOŁCZYŃSKA
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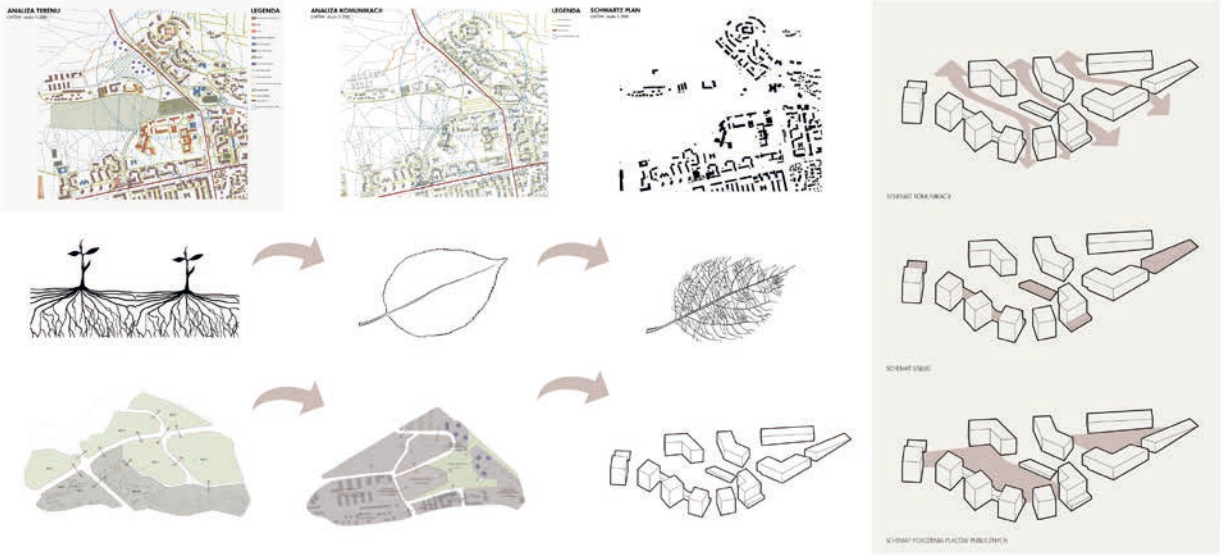
MGR INŻ. ARCH ANNA ZADOROŻNA
MGR INŻ. ARCH. MARCELINA TERELAK



ANALIZY I SCHEMATY

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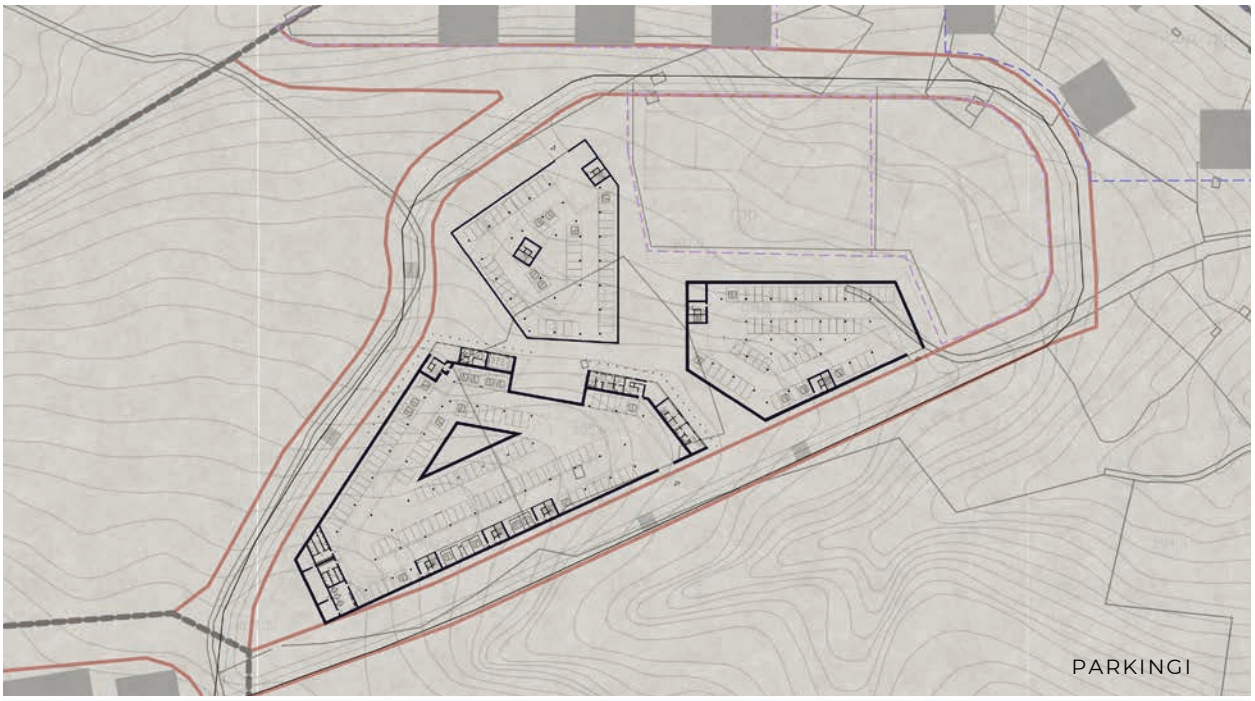


PRZEKROJE TERENU

AKSONOMETRIA

BUDYNEK N
TYP 1
MIESZKANIE PRZYSTOSOWANE DO POTRZEB OSOBY PORUSZAJĄCEJ SIĘ NA WÓZKU INWALIDZKIM, DLA JEDNEGO LUB DWÓCH MIESZKAŃCÓW. POSIADA SALON POŁĄCZONY Z KUCHNIĄ, PRZYSTOSOWANĄ ŁAZIENKĘ ORAZ DUŻĄ SYPIALNIĘ.

TYP 2
MIESZKANIE PRZEZNACZONE DLA RODZINY PIĘCIOOSOBOWEJ Z MOŻLIWOŚCIĄ PRZEKSZTAŁCENIA JEDNEJ SYPIALNI NA GABINET. DO TEGO KUCHNIA Z OTWARCIEM NA SALON ORAZ DWIE ŁAZIENKI.

TYP 3
MIESZKANIE TRZYOSOBOWE DLA PARY Z DZIECKIEM. SALON POŁĄCZONY Z KUCHNIĄ, NIEWIELKA ŁAZIENKA ORAZ DWIE SYPIALNIE.

BUDYNEK M
TYP 1
MIESZKANIE PRZEZNACZONE DLA SINGLA ALBO PARY. ZNAJDUJE SIĘ W NIM KUCHNIA Z MOŻLIWOŚCIĄ ODGRODZENIA OD SALONU, SYPIALNIA, GARDEROBA ORAZ ŁAZIENKA.

TYP 2
MIESZKANIE PRZYSTOSOWANE DO POTRZEB OSOBY PORUSZAJĄCEJ SIĘ NA WÓZKU INWALIDZKIM. RÓWNIEŻ DLA DWÓCH LUB JEDNEJ OSOBY, POSIADA PRZESTRONNĄ STREFĘ DZIENNĄ, SYPIALNIĘ ORAZ DUŻĄ ŁAZIENKĘ.

TYP 3
MIESZKANIE DLA RODZINY 2+2. POSIADA TRZY SYPIALNIE, ŁAZIENKĘ ORAZ KUCHNIĘ Z OPCJĄ ODDZIELENIA OD SALONU. MA DOSTĘP DO PRYWATNEGO BALKONU.

TYP 4
MIESZKANIE DLA PARY. SALON POŁĄCZONY Z JADALNIĄ, KUCHNIA Z MOŻLIWOŚCIĄ ODGRODZENIA, ŁAZIENKĄ ORAZ SYPIALNIĄ. MIESZKANIE MA DOSTĘP DO PRYWATNYCH BALKONÓW ZARÓWNO Z SALONU, JAK I Z SYPIALNI.

BUDYNEK L
TYP 1
MIESZKANIE DLA RODZINY 2+1. PRAWDOPODOBNIE DLA MAŁŻEŃSTWA ZE STARSZYM DZIECKIEM. DWIE SYPIALNIE, SALON, JADALNIA POŁĄCZONA Z KUCHNIĄ. MIESZKANIE ADAPTABILNE.

TYP 2
MEZONET. MIESZKANIE TRZYOSOBOWE; POSIADA DWIE SYPIALNIE, Z CZEGO JEDNĄ NA PIĘTRZE. ZNAJDUJĄ SIĘ TAM TAKŻE PRZESTRONNY SALON POŁĄCZONY Z KUCHNIĄ I JADALNIĄ ORAZ ŁAZIENKA. GÓRNA SYPIALNIA POSIADA UDOGODNIENIE W POSTACI GARDEROBY I OSOBNEJ ŁAZIENKI. MIESZKANIE ADAPTABILNE-PRZY SCHODACH MIEJSCE NA WSTAWIENIE WINDY W PRZYSZŁOŚCI.

TYP 3
KAWALERKA. SALON Z ROZKŁADANĄ KANAPĄ I ANEKSEM KUCHENNYM, DO TEGO ŁAZIENKA. MIESZKANIE ADAPTABILNE.

TYP 4
MEZONET. MIESZKANIE TRZYOSOBOWE Z DWIEMA SYPIALNIAMI, PRZESTRONNYM SALONEM I OTWARTĄ KUCHNIĄ. GÓRNĄ SYPIALNIA POSIADA OSOBNĄ ŁAZIENKĘ I GARDEROBĘ.

TYP 5
MIESZKANIE PRZEZNACZONE DLA RODZINY 2+2. POSIADA TRZY SYPIALNIE, ŁAZIENKĘ, SALON Z JADALNIĄ ORAZ KUCHNIĘ Z OPCJĄ ODSEPAROWANIA. DOSTĘP DO PRYWATNEGO BALKONU O DUŻEJ POWIERZCHNI. MIESZKANIE ADAPTABILNE.

BUDYNEK N
TYP 1
MIESZKANIE PRZYSTOSOWANE DO POTRZEB OSOBY PORUSZAJĄCEJ SIĘ NA WÓZKU INWALIDZKIM, DLA JEDNEGO LUB DWÓCH MIESZKAŃCÓW. POSIADA SALON POŁĄCZONY Z KUCHNIĄ, PRZYSTOSOWANĄ ŁAZIENKĘ ORAZ DUŻĄ SYPIALNIĘ.

TYP 2
MIESZKANIE PRZEZNACZONE DLA RODZINY PIĘCIOOSOBOWEJ Z MOŻLIWOŚCIĄ PRZEKSZTAŁCENIA JEDNEJ SYPIALNI NA GABINET. DO TEGO KUCHNIA Z OTWARCIEM NA SALON ORAZ DWIE ŁAZIENKI.

TYP 3
MIESZKANIE TRZYOSOBOWE DLA PARY Z DZIECKIEM. SALON POŁĄCZONY Z KUCHNIĄ, NIEWIELKA ŁAZIENKA ORAZ DWIE SYPIALNIE.

BUDYNEK M
TYP 1
MIESZKANIE PRZEZNACZONE DLA SINGLA ALBO PARY. ZNAJDUJE SIĘ W NIM KUCHNIA Z MOŻLIWOŚCIĄ ODGRODZENIA OD SALONU, SYPIALNIA, GARDEROBA ORAZ ŁAZIENKA.

TYP 2
MIESZKANIE PRZYSTOSOWANE DO POTRZEB OSOBY PORUSZAJĄCEJ SIĘ NA WÓZKU INWALIDZKIM. RÓWNIEŻ DLA DWÓCH LUB JEDNEJ OSOBY, POSIADA PRZESTRONNĄ STREFĘ DZIENNĄ, SYPIALNIĘ ORAZ DUŻĄ ŁAZIENKĘ.

TYP 3
MIESZKANIE DLA RODZINY 2+2. POSIADA TRZY SYPIALNIE, ŁAZIENKĘ ORAZ KUCHNIĘ Z OPCJĄ ODDZIELENIA OD SALONU. MA DOSTĘP DO PRYWATNEGO BALKONU.

TYP 4
MIESZKANIE DLA PARY. SALON POŁĄCZONY Z JADALNIĄ, KUCHNIA Z MOŻLIWOŚCIĄ ODGRODZENIA, ŁAZIENKĄ ORAZ SYPIALNIĄ. MIESZKANIE MA DOSTĘP DO PRYWATNYCH BALKONÓW ZARÓWNO Z SALONU, JAK I Z SYPIALNI.

BUDYNEK L
TYP 1
MIESZKANIE DLA RODZINY 2+1. PRAWDOPODOBNIE DLA MAŁŻEŃSTWA ZE STARSZYM DZIECKIEM. DWIE SYPIALNIE, SALON, JADALNIA POŁĄCZONA Z KUCHNIĄ. MIESZKANIE ADAPTABILNE.

TYP 2
MEZONET. MIESZKANIE TRZYOSOBOWE; POSIADA DWIE SYPIALNIE, Z CZEGO JEDNĄ NA PIĘTRZE. ZNAJDUJĄ SIĘ TAM TAKŻE PRZESTRONNY SALON POŁĄCZONY Z KUCHNIĄ I JADALNIĄ ORAZ ŁAZIENKA. GÓRNA SYPIALNIA POSIADA UDOGODNIENIE W POSTACI GARDEROBY I OSOBNEJ ŁAZIENKI. MIESZKANIE ADAPTABILNE-PRZY SCHODACH MIEJSCE NA WSTAWIENIE WINDY W PRZYSZŁOŚCI.

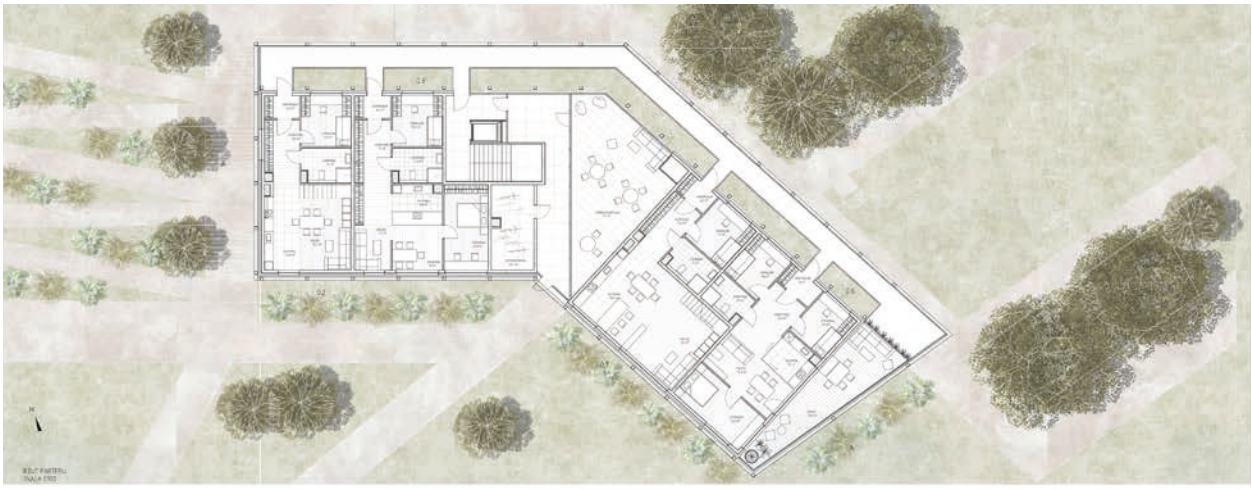
TYP 3
KAWALERKA. SALON Z ROZKŁADANĄ KANAPĄ I ANEKSEM KUCHENNYM, DO TEGO ŁAZIENKA. MIESZKANIE ADAPTABILNE.

TYP 4
MEZONET. MIESZKANIE TRZYOSOBOWE Z DWIEMA SYPIALNIAMI, PRZESTRONNYM SALONEM I OTWARTĄ KUCHNIĄ. GÓRNĄ SYPIALNIA POSIADA OSOBNĄ ŁAZIENKĘ I GARDEROBĘ.

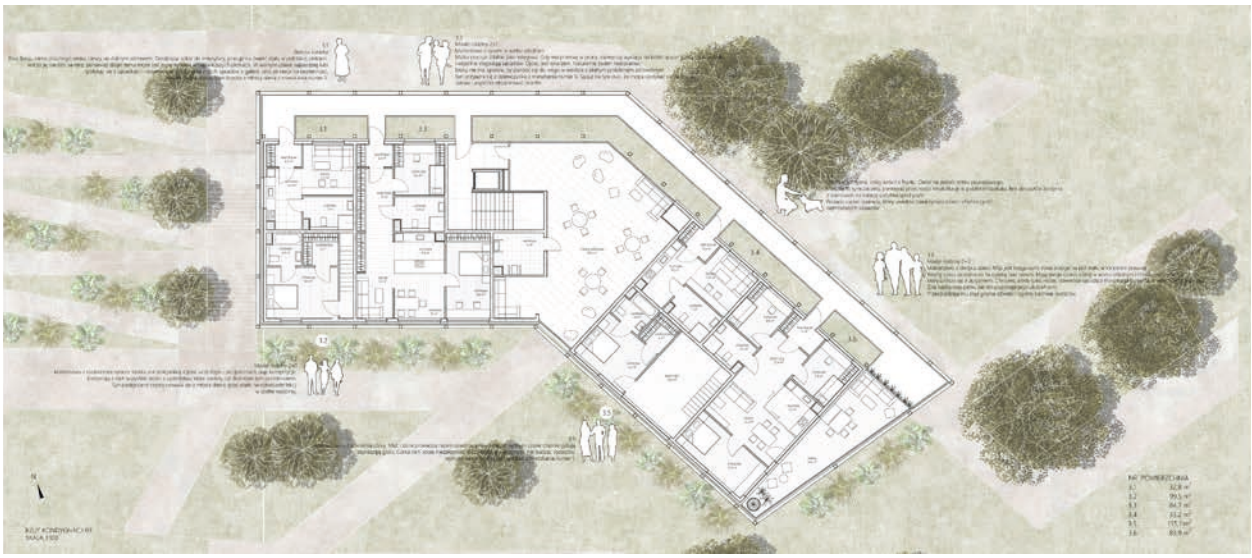
TYP 5
MIESZKANIE PRZEZNACZONE DLA RODZINY 2+2. POSIADA TRZY SYPIALNIE, ŁAZIENKĘ, SALON Z JADALNIĄ ORAZ KUCHNIĘ Z OPCJĄ ODSEPAROWANIA. DOSTĘP DO PRYWATNEGO BALKONU O DUŻEJ POWIERZCHNI. MIESZKANIE ADAPTABILNE.

ELEWACJE I PRZEKROJE

ELEWACJE I PRZEKROJE



RZUT PARTERU BUDYNKU L



RZUT KONDYGNACJI POWTARZALNEJ BUDYNKU L

RZUT PARTERU BUDYNKU N

RZUT KONDYGNACJI POWTARZALNEJ BUDYNKU N