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ASSESSMENT OF THE SET OF REQUIREMENTS CONCERNING THE USAGE OF UNDERGROUND FACILITIES FOR CIVIL PROTECTION PURPOSES

Abstract

At present two major categories of safety-of-life facilities are known, as classified and emergency shelters are differentiated. We can obtain brief information about such buildings through their main technical parameters, but do we have ample information concerning the inspection preceding the examination regarding the suitability of these shelters for civil protection? This article presents the set of requirements concerning the examination of such facilities, through scarcely available literature and empirical experiences, and on the basis thereof the author also examines whether a certain underground facility, located in the Mecsek, is suitable for protection purposes.

Az életvédelmi létesítményeknek két nagy csoportja ismert napjainkban, az osztályba sorolt és szükségóvóhely kategóriáját különböztetjük meg. Egy-egy ilyen építményről, a legfőbb műszaki paraméterek segítségével, néhány sorban mindent megtudhatunk, de vajon rendelkezünk-e megfelelő információkkal arra vonatkozóan, hogy milyen elemzési folyamat előzi meg az óvóhelyek polgári védelmi célú alkalmasságra való vizsgálatát. A cikk nehezen fellelhető szakirodalom, és empirikus tapasztalatok alapján mutatja be a létesítmények vizsgálatára vonatkozó követelményrendszert, amely alapján a szerző, egy mecseki földalatti építmény védelmi célú alkalmasságát is vizsgálja.

Keywords: *shelter, civil protection, set of requirements, examination of underground facilities ~ óvóhely, polgári védelem, követelményrendszer, földalatti terek vizsgálata*

INTRODUCTION

The categorized classification characterizing the shelters, as well as the determined capacity and structure of underground facilities and the parameters of the infrastructure corresponding to the level of protection are well-known, and together they constitute the level of protection for a given facility. However, we have little information concerning the set of requirements used to define these basic characteristics of protective facilities.

In my article I describe the set of requirements concerning defence facilities, and present the analytic steps that precede the classification of such buildings. I also present the main principles concerning the conversion of underground facilities for civil protection purposes. On the basis of these principles I perform the analysis of an underground facility located in the Mecsek in practice, and I state whether the building is suitable to be used for civil protection purposes.

REQUIREMENTS CONCERNING DUAL-PURPOSE SHELTERS

In the 1960s national shelter construction programmes began in Hungary as well, in the course of which the architects aspired to design and implement dual-purpose facilities. Dual-purpose facilities are such civil-purpose facilities that can also be used exclusively for defensive purposes in periods of war. Thus, these facilities become suitable for serving two functions after their construction, and no complementary building work is necessary when converting from one function to the other. [1] Dual-purpose facilities can be used to protect significantly valuable material property, or for the protection of the population, that is, for civil protection purposes.

Fundamental requirements concerning dual-purpose shelters

From the viewpoint of protection, a dual-purpose shelter is a defence facility constructed in accordance with a set of requirements, which, due to its special outer structures, equipment and fixtures, provides protection against the primary and associated impact of both the classified conventional, and classified mass destruction weapons.

According to the Construction Industry Standard, these buildings are called near-surface civil protection shelters.

Fundamental requirements concerning dual-purpose shelters:

- Classification: protection must be ensured against dynamic impact within the frontal pressure range defined for the given class, besides, the gastightness values defined for the given class, and the related shelter and installation modes must be ensured.
- Accessibility: with the appropriate accessibility, the given shelter must be equipped with the ample number of escapes routes in appropriate directions for the inmates. In addition, it is important that the facilities should be constructed near the most concentrated locations from the point of view of the persons to be protected.
- Capacity: in accordance with the relevant standard, the facility should be suitable to accommodate the defined number of people and should be equipped with the appliances and equipment necessary for ensuring basic living conditions while operating in shelter mode.

Suitability for civil protection purposes can be defined, if the given facility is fully compliant with the above mentioned set of requirements. The establishment of dual-purpose facilities requires even more complex examinations, as both the sets of requirements concerning civil usage and usage for civil protection purposes must be observed during the selection, planning and implementation.

On-site examination – general assessment

In the course of planning an institution's suitability for civil protection purposes, the first step is the review of on-site plans and available blueprints. The most ideal solution is to take the fulfilment of requirements concerning dual-purpose usage into consideration as early as the time of planning. However, it is also possible to define the suitability of existing buildings for civil protection purposes, in accordance with the above listed criteria. In each case, the examination of the underground facilities, the review of planned technical devices, the analysis of geometric data and geological conditions are included in the analysis.

During the on-site examination, the examiners have to create an overall picture of the conditions of the underground facility through visual observation, besides, its location and the peace-period purpose must be defined, as well as the way this purpose can be connected to the function of protection. The possibility of evacuation (emergency exits), accessibility, the treatment of water infiltration, the depth the facility is located at and the surrounding rock types must also be examined. One of the most important requirements concerning usage for protection purposes is fast accessibility by the population, thus calculations need to be made concerning the number of inhabitants in the range of the facility (in a circle with the diameter of approximately 400m), and the number of people working in the vicinity. Furthermore, equipment with public utilities, the conditions of the surface and the extent to which the vicinity is built up (natural and man-made environment), and the conditions of ventilation must be reviewed. [2]

Defining the geometric details of the underground facility

In the course of defining the geometric details of the underground facilities, the floor plan, longitudinal section, cross section, the area and air capacity in cubic metres of each adjacent branches, the position and size of air shafts, entrances and the adjacent structures, the thickness of the covering layer, the position of neighbouring underground facilities and the road network leading to the building must be mapped.

On the basis of the gathered data, the examined facility is ranked into one of the four basic types. In accordance with their floor plan, tunnel type, columnar type, hall type and cave type facilities can be differentiated.

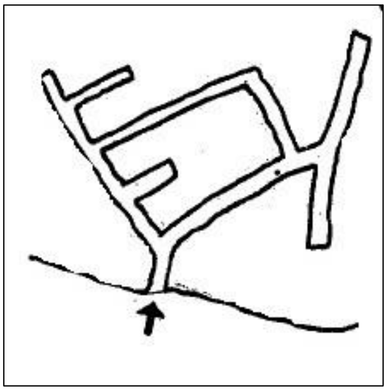

Figure 1. Tunnel type [2]

The tunnel type shelter consists of tunnel systems of various diameter that branch out of one another. It normally has an arched roof, and it is the main type of underground facilities in the countryside.

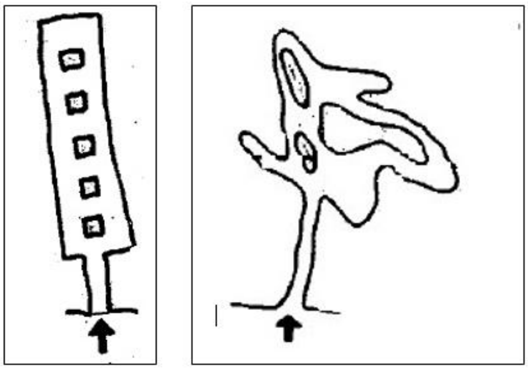

Figure 2: Columnar or hall type [2]

The columnar or hall type consists of one or more columns, a room with colonnade or systems of halls. This type is mainly found in Budapest.

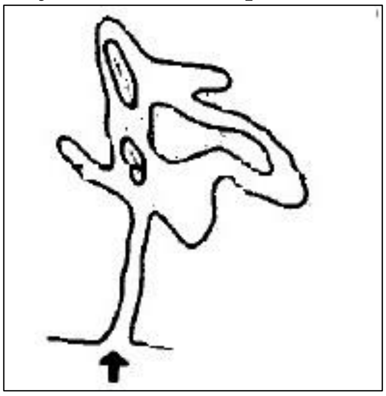

Figure 3. Cave type [2]

The cave type mainly includes natural spaces, and it is characterized by the simultaneous presence of narrow tunnel systems and large spaces. They are not easily accessible, and the wetness of walls and spaces means a problem.

Defining geological conditions

Exploring the geological conditions means the focus point of preliminary examinations related to the classification, planning and construction of underground facilities. On the basis thereof, the level of usage for civil protection must be considered. These examinations constitute the basis of classification and planning. The knowledge of geological materials, and of the guiding laws that determine the construction of geological spaces, provide the basis for organising the data. Thus, when defining geological conditions, the types and petrophysical characteristics and general geological features of the rocks surrounding the underground facility must be specified. [3]

The rating of underground facilities

The underground facilities are rated on the basis of the above described assessment of conditions. In the course of the rating it is explored whether the given underground facility is capable of enduring the excess load from explosions of nuclear weapons. During the examination, we must calculate the critical surface load that can be endured by the rocks surrounding the facility without endangering its stability. The thus calculated load can be ranked into classes, which is actually the rating according to protective ability. [4]

The rating is carried out in three steps:

- First the standard tension (σ_m) must be defined, which occurs in the rocks surrounding the unpaved underground space after opening the cavity. Thereafter, the standard loads occurring in the support structure of the underground facility as a result of rock pressure (Y_m) is specified.

- In the second step, the limit tensions (σ_h) and limit loads (Y_h) are determined, which can be endured by the rocks and the supporting structure without deformation.
- In the third phase the difference of tension and load is calculated, which occurs between the standard tensions and limit tensions and the limit and standard load. [5]

On the basis of the thus obtained result, the critical relief load (p) is determined, which creates a tension or load equal to the tension – or load – difference. The resulting (p) value the characteristic level of the protective capability of the examined underground facility, which can be classified, thus the underground facility can be rated.

In formulas:

In case of unpaved underground facility

$$\sigma = \sigma_h - \sigma_m$$

$$p = \sigma \ (f_1)$$

In case of paved underground facility

$$Y = Y_h - Y_m$$

$$p = Y \ (f_2)$$

On the basis of the above, it can be stated that if the standard tension or standard load of an unpaved or paved underground facility is equal to the limit tension or limit load, then the underground facility does not have sufficient reserves, thus does not have ample protection against the impact of nuclear weapons. In this case the underground facility needs to be fortified in accordance with specialized planning, or it can be used as so-called emergency shelter. The facilities whose protective capability is not defined are called emergency shelters. A basic requirement concerning these buildings is that it should approach the protective capability of class IV or III shelters through the available equipment and materials. This shelter type was typically created in the cellars of buildings. It was characteristically created by the population through their own resources – using the available building materials – during a short period of time in case of war or air-raid alerts.

The higher the limit tension or the limit load of the facility is, the stronger protection it provides against the impact of offensive weapons. The safety-of-life facilities are ranked into five classes on the basis of their protective abilities.

The facility has class V. protection if the value of the critical surface load (p) is equal to or higher than 0.3 bar excess pressure, but does not reach 1 bar excess pressure.

$$1.0 \text{ bar} > p \geq 0.03 \text{ MPa} \geq 0.3 \text{ bar}$$

The facility has class IV protection if the value of the critical surface load (p) is equal to or larger than 1 bar excess pressure, but does not reach 5 bars excess pressure.

$$5.0 \text{ bar} > p \geq 0.1 \text{ MPa} \geq 1.0 \text{ bar}$$

It has class III protection, if the value of the critical surface load (p) exceeds 5 bar excess pressure. [6]

$$p = 0.5 \text{ MPa} \geq 5 \text{ bar}$$

Class I and II facilities provide protection against the impact of destructive bombs and nuclear bombs as well. These are not classified as civil shelters.

Capacity

The capacity of shelters is in every case determined by the regional civil protection (currently: disaster management) authority following the examination of the facility. In case of classified shelters, the capacity was given, however the determination of the number of inmates was not always an easy task. In order to determine capacity, the elaboration of a procedure became necessary that is rationally suitable for defining the number of people who could stay in a given facility. This rational procedure was a categorization based on ventilation facilities, which resulted in the differentiation of two types:

If only natural ventilation (filtered air supply) is possible, the capacity can be calculated from the useful air space, knowing the period of seclusion. For instance, the useful air space of a facility is V=3 600 m^3 and its useful area is F= 1 600 m^2, the period of seclusion is defined at a maximum of 6 hours, and we also know that the minimum air demand is 3 m^3/person for 4 hours. If we only take the area into consideration, then 2x 1600 = 3200 persons could stay in the given facility. However, the six-hour long seclusion limits possibilities, as the necessary amount of air must be taken into account

$$\frac{6}{4}x3 = 4{,}5\ m3\ air\ demand\ (for\ 1\ person\ for\ 6\ hour\ period)$$

If the available 3600m^3 is divided with 4.5, the result is 800 persons, thus the capacity is much lower if the length of the seclusion period is taken into consideration.

The capacity of the protective facilities can generally be calculated with the following formula:

$$Capacity = \frac{useful\ air\ space\ x\ 4}{seclusion\ period\ x\ 3}$$

If artificial ventilation is permitted, that is, there is no need for complete seclusion, or the facility has regenerating ventilation, then 2 persons can be calculated for each square meter.

$$Capacity = useful\ area\ x\ 2$$

The examination of ventilation provides a basis for determining the capacity. The concept developed in the 1960s corresponds to the currently prevailing set of civil protection requirements.

Accessibility

Concentrated location and the provision of sufficient exits is a fundamental requirement concerning facilities planned or constructed for civil protection usage. On average, a circle with a diameter of 400 metres provides a basis for access, which is a distance that can reasonably quickly covered even on foot. During the Second World War shelters created in the cellars of apartment blocks were planned in accordance with these guidelines. When planning a facility, four hundred metres was the longest distance that was taken into account.

The possibility of creating emergency exits is of special importance in the examination of underground facilities. Taking the special characteristics of underground facilities into consideration, the following options arise concerning the creation of emergency exits:

- Through the neighbouring cellar: this solution can be used if a safe escape route is designated in the neighbouring cellar, and the connection of the two cellar sections does not require significant effort. The tunnels of the neighbouring cellar designated as escape routes must be isolated from the other cellars.
- Through a shaft: the emergency exit shaft can be created in an existing or newly constructed shaft. It is practical to break the line of the shaft near the surface, as this makes the exit safer.

- Through a tunnel: this type of emergency exits leads to the surface from an airlock, under the entrance. The section opening onto the surface must be positioned outside the rubble line. [8]

As it can be seen from the above, the type of emergency exit depends on the features and characteristics of the underground facility. It is not necessarily the aim of the emergency exit to provide an escape route for the total number of protected inmates, it rather serves the purpose that a small number of people can escape to the surface and clear the entrance of the facility. In accordance therewith, the emergency exits must be planned and constructed with the least possible permeability.

THE EXAMINATION OF AN UNDERGROUND FACILITY LOCATED IN THE MECSEK

On the basis of the requirements presented above, I carried out the examination of an underground facility located in the Mecsek. The aim of my examination is to determine whether the building, with its current parameters, is suitable to be used for civil protection.

In the first step of the on-site examination, I observed the surface environment of the facility. The facility in question is located near main road number 66, and it can be accessed from the south and west via a causeway, which has good quality paving. 80% of its surroundings consist of natural, forest environment, and in 20% it is surrounded by man-made buildings. The majority of these are industrial facilities, forestry buildings, a wood processing plant (workplaces), and a small number of residential buildings (suburb with detached houses). The underground facility can scarcely be seen from the outside, as it has a 1.8 metre tall earth coverage, only the entrance is free.

When examined more closely, an emergency exit can be found both on the northern and southern side of the facility. The entrance is secured by a steel door, and air vents are located on the earth coverage roof. The underground facility, located 4.5 metre deep from the surface, can be accessed through stairs inside the entrance. The temperature is relatively cool, no signs of water infiltration can be seen. It is sufficiently equipped with utilities (sewers, drinking water, electricity and air supply). The facility is 40 metre long and 12 metre wide, with a height of 2.5 metre.

The underground facility is surrounded by quartzite and grey sandstone, which are both highly solid rocks. Their weight per one cubic metre is between 2000 and 3000 kilograms. Their crush resistance is 1500-2000kg/cm^2. Their strength factor value is between 15-20.

In the course of the geometric examination of the underground facility, I observed that it has a hall type floor plan, where the rooms are connected with corridors. The internal area can be divided into service and habitation areas, besides, the technical devices are placed on a separate room. „The thickness of the covering layer of the cavity is less than its width one and half times, thus significant bending and shearing stress can occur in the roofing" [7], therefore a building expert should be involved in the examination.

On the basis of the above presented formulas, when calculating the capacity with taking the conditions of natural ventilation into account first, the facility can accommodate 960 persons. Calculating with a seclusion of 6 hours, the underground building can only be a safe shelter for 266 persons.

The on-site examination provided me with an overall picture of the facility, however, its level of protection against offensive weapons cannot be clearly specified, as, compared to the width of 12 metres, the roofing only has a 1.8 metre thick earth coverage. However, I could specify the capacity, the basic physical characteristics of the surrounding rocks, the accessibility and the environment on the basis of the set of requirements presented above. In accordance with the features I examined, the facility is only partly suitable to be used for civil protection purposes, as the physical characteristics necessary for classification must be examined by a civil engineer. Without the technical inspection, the examined underground facility can only be classified as emergency shelter.

CONCLUSION

In my article I have presented the set of requirements, based on three pillars, that provides a basis for the classification of underground facilities for civil protection purposes. The most important step is the definition of the purpose the facility shall be used for: whether solely for protection or for dual purposes. Usage for protection must be preceded by an examination, which can be carried out in accordance with the procedure described in the article. In my paper I analysed the applicability of the set of requirements through a practical example, which provided me with an overall picture of the protective capabilities of an underground facility of my choice.

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