The Population Protection by Sheltering – A Design of the Chosen Shelters Under the Auspices of a Municipality

Lucie Jurikova, Jakub Rak and Milan Adamek

Abstract—*This contribution outlines one of the possible safeguard methods of the chosen shelter. It emphasises the knowledge of the basic parameters of the shelter together with all necessary information for protective element calculations. For clarification and ease of understanding of the proposed design the modifications are presented by means of AutoCad software. Furthermore, the article clarifies a possible cooperation within the framework of the municipality with extended powers, namely through the provision of material supplies necessary for design work. The material is to be provided by a chosen company in order to improve the protective characteristics of the shelters in the event of danger. The main objective is to point out the resulting utilisation of designing and further modifications stated in a Standard by the employees of the public sector. In conclusion the article explains the utilisation of AutoCad software and visual display in 3D which simplifies coordination and heightens the efficiency in case of extraordinary or emergency situations.*

Keywords—*Population Protection, designing, sheltering, protective characteristics, AutoCad*

Introduction

The article responds to the current events in various countries, such as Japan; its focus is mainly on the circumstances under which radiation leakage occurred. This event encourages one to reflect on the already authorized Concept of protection of the population by the year 2013 until 2020 which contributed to the formulation of new issues in the field of the population protection by sheltering. These are, in particular, reductions in maintenance, constructions and building modifications of permanent shelters. The new version of the Concept of protection of the population plans for the sheltering in the improvised shelters (IS) predominantly when it comes to effects of chemical, biological, radiological, and nuclear weapons (CBRN). The constructions of permanent shelters (PS) are being waived. Nevertheless, fundamentals for designing and adjustment of the IS are not being tackled or are tackled insufficiently. Data digitizing and interconnection of various fields would increase preparedness and effective management of the competent authorities.

For the purposes of designing, the old norms are being employed; these are difficult to obtain but are of a high quality and well detailed. The norms serve both for the design and construction of buildings of civil protection, pressure-resistant permanent shelters of civil protection and others. The data obtained from the norms are included in a Standard based on which the calculations for the increase of protective characteristics of constructions are proposed.

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Problem Formulation

As the issue of shelters is treated insufficiently we aspire to solve this problem partially in cooperation with administrative bodies of the corporate town Zlin. The Standard for evaluation and design of improvised shelters as well as the creation of a suitable information tool for planning and management of the population protection by sheltering is to be produced.

The Standard is a crucial element for the IS design. It contains all data necessary for the design of construction modifications, calculations of the essential values and shelter planning. The proposed design of the IS is based on the data stated in the Standard.

A. Problems connected with availability of basic information on shelters

For the shelter design and proposal of required modifications in order to protect from effects of chemical, biological, radiological, and nuclear weapons (CBRN) it is necessary to be familiar with the entire data on the shelter. These are dimensions of rooms, type of construction and further information, such as surroundings, height of walls, embedment depth, locality or a division of shelters into single storey or multi storey buildings.

In order to obtain such data a physical inspection and physical measurement of the individual shelters in a chosen area is necessary. This data will be acquired from several tens of shelters. However, the physical measurement of the shelters is dependent on the goodwill of the owners or operators in order to access the shelters as well as the possibility to use measurement and recording equipment.

The data is recorded into the Standard and consequently substituted into figures and equations for the protective characteristics calculation and their improvement by using suitable building materials. [7]

B. Subsequent verification of the design and further development

Information gathered by means of the physical inspection and measurements is to be employed in shelter design; the data will be used when deciding on the types and quantity of materials to be used in order to improve the protective characteristics of the buildings.

Impermeability is a crucial characteristic of building materials and because of this the research also aims to examine the impermeability of the chosen materials in a test facility. The proposed facility will examine the chosen building materials used in the design. This enables the most suitable material to be chosen.

Another part of the research is closely related to the creation of models of some of the essential parts of the shelter e.g. the model of an air duct. These proposals are depicted by means of AutoCad software in 2D and 3D for easier understanding as well as for the construction of a model. The main reason for the creation of these model parts is for their practical testing together with their verification at least as model rendering.

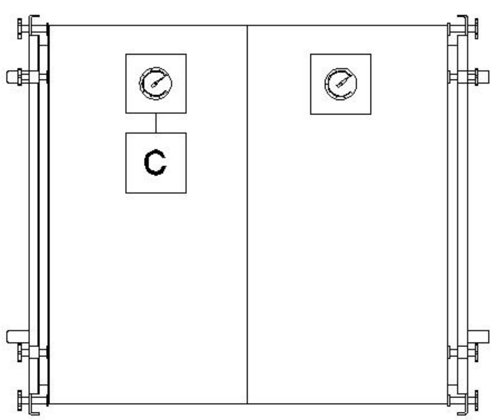


Figure 1: The view of the layout of the test facility in 2D (side view)

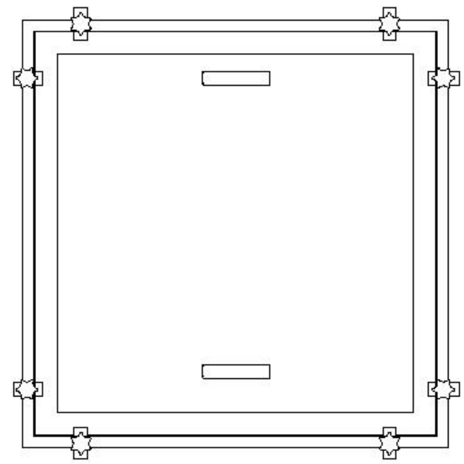


Figure 2: The view of the layout of the test facility in 2D (front view)

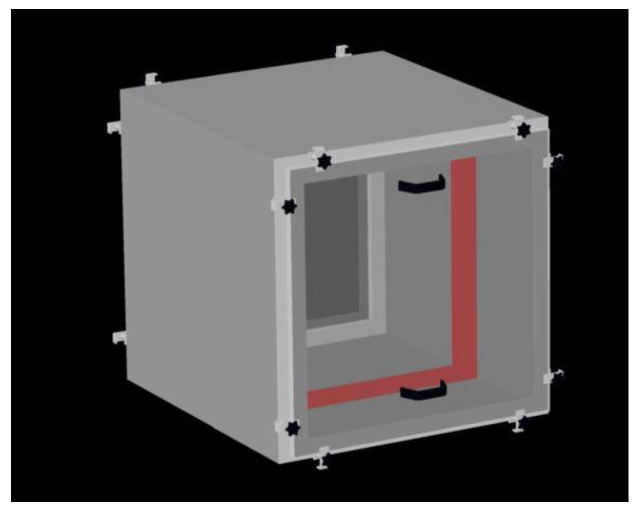


Figure 3: The view of the layout of the test facility in 3D

The test facility will measure the impermeability of the chosen materials within the space marked in red. The material can be easily removed from that space and prepared for further testing.

PROBLEM SOLUTION

For the shelter design and proposal of needed modifications in order to protect from effects of chemical, biological, radiological, and nuclear weapons (CBRN) it is necessary to be aware of the entire data on the particular shelter. These are dimensions of rooms, type of construction and further information, such as surroundings, height of walls, embedment depth, locality or a division of shelters into single storey or multi storey buildings.

C. Primary data on the design

In order to calculate the protective characteristics it is necessary to know the characteristics of the IS which are divided into 4 types. These characteristics are significant for the calculation of the protective coefficient of the building Ko.

a) IS characteristics necessary for the calculation of the Ko

Types of the IS characteristics:
For the purposes of the design one must determine the type of the shelter:

- Ground-floor or partly set-in shelter with a superstructure;
- Shelter located in the central wing of a building;
- Set-in shelter with a superstructure;
- Entirely set-in shelter without a superstructure; [2]

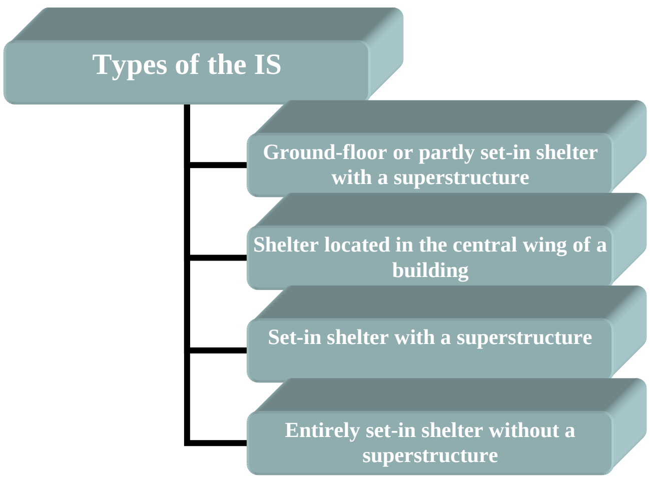


Figure 3: Types of the IS

The protective characteristics of the IS against radioactive emission are expressed by the protective coefficient of the building Ko. The Ko calculation is regulated by the army regulation MO CO-6-1 called "Preparation, Projection and Construction of Antiradiation Shelters" from 1978. [2] [3]

The protective coefficient of the building Ko:
The coefficient specifies how many times the radiation is lower inside the shelter than at a height of one meter above the exposed ground, providing that the radioactive fall is staggered on horizontal surfaces, where the radioactive fall on vertical surfaces is not considered.

b) Construction and dimensions of the building

In order to determine the Ko it is necessary to know the following source data on the cladding of the building together with dimensions of the rooms, namely:

- Surface density of outside and inner walls and the ceiling structures;
- Surface of the window and other openings in the outside enclosure walls together with a height of their position above the shelter floor (the height of a window sill);
- Room dimensions (length, width and height);
- Depth of embedment of the floor below ground level;
- Width of the un-built space or streets adjacent to the shelter. [2]

D.A proposal of the model shelter

The design depicts the ground-floor or partly set-in model shelter with a superstructure.

a) Dimensions determination

Primary data of the model shelter:

- Room length **l = 15 m;**
- Room width **w = 10 m;**
- Room height **h = 3 m;**
- Length of outside external walls **L = 40 m;**
- Number and surface of the window openings in the IS (4*1.5*1) **So = 6 m^2;**
- Height of windows above the floor (height of window sills) **hs = 1.5 m;**
- Surface density of the external wall (0.6 m - plain tamped concrete)
  ρ = D*x = 2,200*0.6 = 1,320 kgm^{-2};
- Embedment below ground level **e = 1.5 m;**
- A domestic house belongs to the category of standalone buildings and production outbuildings of cropping farms;

b) Figures needed for calculations

For the calculation of the protective coefficient of the building Ko of the shelter without modifications the following figure is used:

$$Ko = 0.65 * K_1 * K_{st} / (1 - V_2) * (K_z * K_{st} + 1) * K_m$$

Equation 1: The figure for the calculation of the protective coefficient of the building Ko

Definitions of abbreviations in the figure:
K_1 = the coefficient of the influence of external walls, determined from a graph;
K_{st} = the coefficient of the radiation weakening by the external wall, determined from a graph based on a surface density table;
K_z = the coefficient of penetration of radiation into the room by openings, determined in dependence on the height of the window sill;
K_m = the coefficient of the reduction in exposure radiation speed in buildings due to a screening effect of the adjoining buildings, determined from a graph;
V_z = the coefficient dependent on the width of the building, determined from a table;

$\mathbf{V_2}$ = determined from a table;

All figures, graphs and tables necessary for the calculation of the protective coefficient Ko of the building are stated in the proposed Standard. [2]

c) The description of the calculation of the protective coefficient of the building Ko without modifications

$$Ko = 0.65 * 0.37 * 7{,}800(1 - 0.27) * (0.0018 * 7{,}800 + 1) * 1 = 54$$

Equation 2: The figure for the calculation of the protective coefficient of the building Ko with substituted values [2]

The resultant value of the protective coefficient of the building Ko without modifications is 54. The resulting number is dimensionless, which means that without modifications the radiation effect is 54 times lower in the shelter than outside. The resulting protective coefficient must be multiplied by a coefficient 0.8 as the surroundings above the shelter might be contaminated by radioactive fallout.

$$Ko = 0.8 * 54 = 43$$

Equation 3: The figure for the calculation of the protective coefficient of the building Ko with substituted values [2]

The resulting number of the protective coefficient of buildings Ko = 43. The radioactive emission will be 43 times lower in the IS than outside. In order to improve the protection inside the IS it is necessary to implement modifications which ensure the increase of the protective coefficient of the building Ko. The figure for the calculation of the protective coefficient with modifications is the same as that without modifications.

d) Display of the IS in 2D without modifications

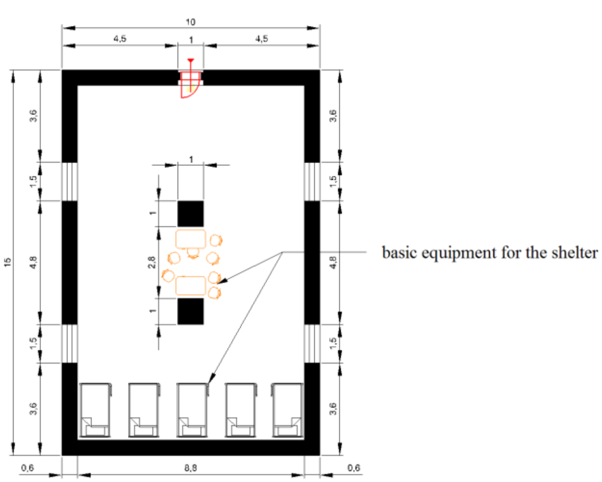


Figure 4: Preview of the IS without modifications

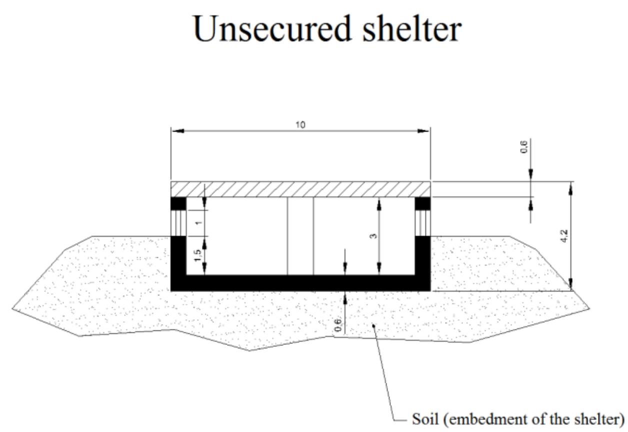


Figure 5: Side view of the IS without modifications

e) The description of the calculation of the protective coefficient of buildings Ko with modifications

Modifications consist in locking off the access of the radiation into the IS through the window openings whose walling width in the model shelter is 0.6 m and also covering the shelter by the building material up to the height of the ceiling. These modifications alter the figure for the calculation of the protective coefficient of buildings in such a way that the value K_z*K_{st} equals zero as there are no window openings to be included in the figure. The resulting protective coefficient of buildings Ko without window openings is 2,570, which means that the inner radiation in the IS is to be 2,570 times lower than radiation outside the shelter provided the given procedure of the shelter safeguarding is observed.

$$Ko = 0.65 * 0.37 * 7{,}800 / (1 - 0.27) * 1 = 2{,}570$$

Equation 4: The figure for the calculation of the protective coefficient Ko with adjusted values [2]

f) Building material proposal

- **plain concrete (0.6 m) = 1,380kgm^{-2};**
- **dried hard wood (0.2 m) = 150 kgm^{-2};**
- **slay, silty clay, clay, sand (1 m) = 2,000 kgm^{-2}.**

By means of these proposed materials the increase of the protective coefficient of buildings Ko is ensured and radiation penetration into the IS lowered. The main objective of these modifications is the provision of safety and health protection of people hidden inside the shelter.

The proposed option is essential for protection against the effects of the radioactive emission and mass destruction weapons. In its final stage the Standard will deal with ventilation, air ducts and pillar designs.

g) The proposal of the IS modifications in 2D and 3D

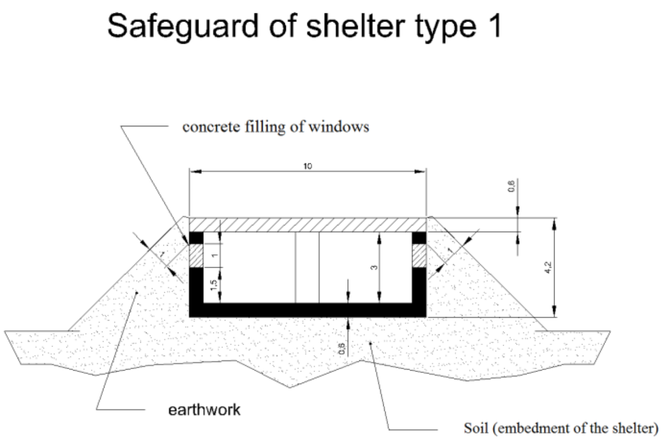


Figure 6: Proposal of modifications – side view (type 1)

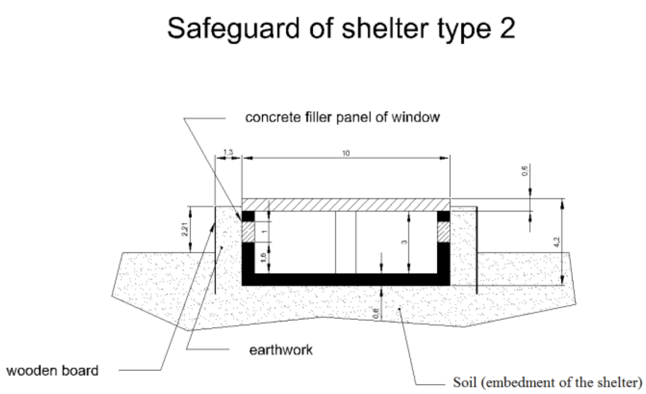


Figure 7: Proposal of modifications – side view (type 2)

As can be seen in the figures the window openings are modified the most. The proposed safeguard of type 1 is the earthwork; the minimum width of the earthwork is 1 m while the window openings are filled with plain concrete. The proposed safeguard of type 2 is the soil used for the earthwork placed within the space enclosed by wood by the so-called wooden board with a width of 1 m similar to type 1. The earthwork can be done by several methods; these are depicted in fig. 6 and 7. The representation of AutoCad software enables easier understanding of the modifications and clarifies the used materials. [4]

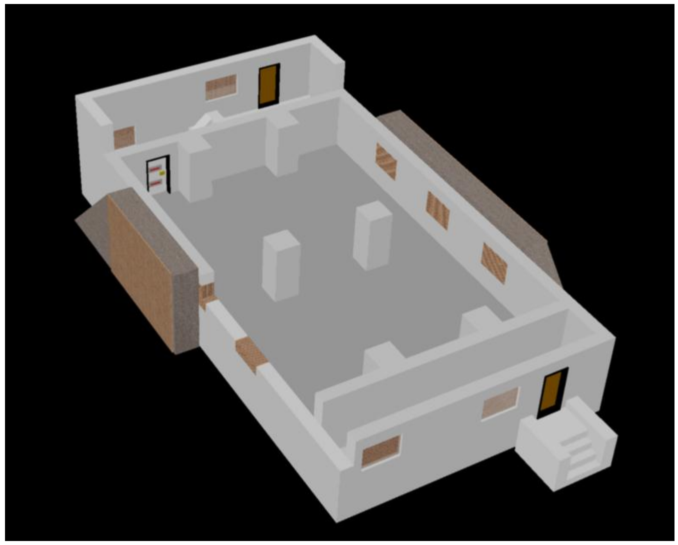


Figure 8: Preview of the safeguard of the IS in 3D (type 2)

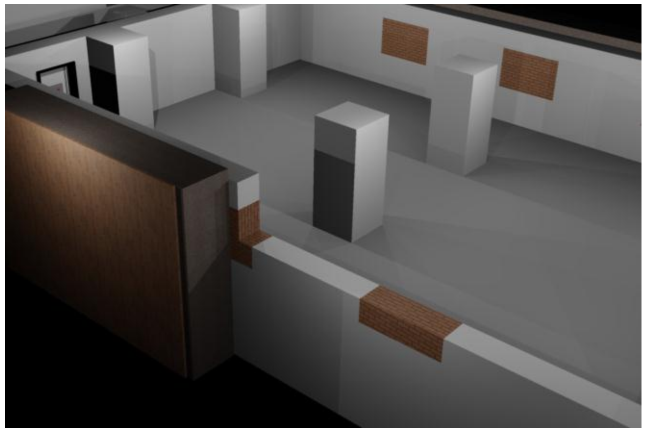


Figure 9: Detailed preview of the used material in 3D (type 2)

E. Cooperation with municipalities and contracting with chosen companies

The results of the project will be fully employed in the event of extraordinary or emergency situations. Owing to the accumulated information recorded in the Standard it will be possible to solve these situations effectively and promptly.

Basic information of the Standard:

- basic shelter data;
- mapping the shelter;
- all calculations of the protective coefficient of buildings;
- equations for the calculation of various types of the IS;
- mapping the shelter;
- the shelter in 2D view;
- 3D view for clarity;
- **Contracting with chosen companies;**
- etc.

The final stage of design is contracting with the chosen companies. Within the cooperation the chosen company is bound to provide the arranged amount of building material in the event of extraordinary or emergency situations.
Companies will be chosen based on the following criteria:

- the distance from the seat of the company to the shelter;
- the type (choice) of building material;
- accessibility through highways;
- the size of the company.

Contracting with chosen companies depicts the following scheme:

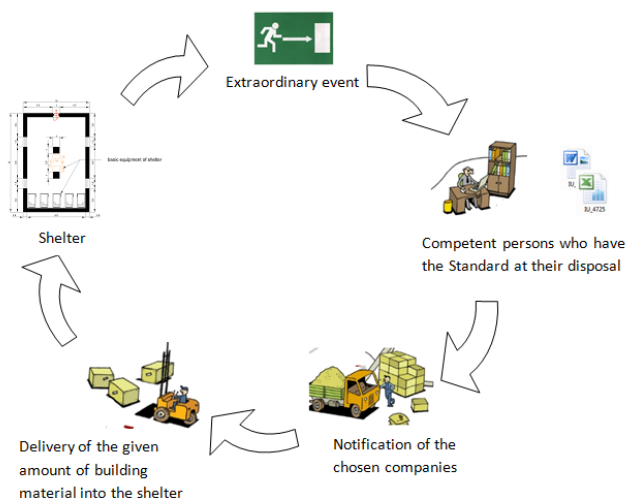


Figure 10: The scheme of the cooperation with chosen companies

Figure 10 depicts a process of coordination amongst construction companies and competent persons. It outlines specifically all procedures, from a notification about an extraordinary event, to the delivery of the required amount of materials to a given place, to the shelters where it is necessary to make adjustments and thereby ensure the protection against danger.

Criteria for a company selection can be expressed in the following progress chart. From the chart it is evident that the most significant criterion is the availability of the construction company. This means that the closest company to the shelter will be preferred provided it offers suitable building materials. The second most important criterion is the available assortment, in other words the required types of materials.

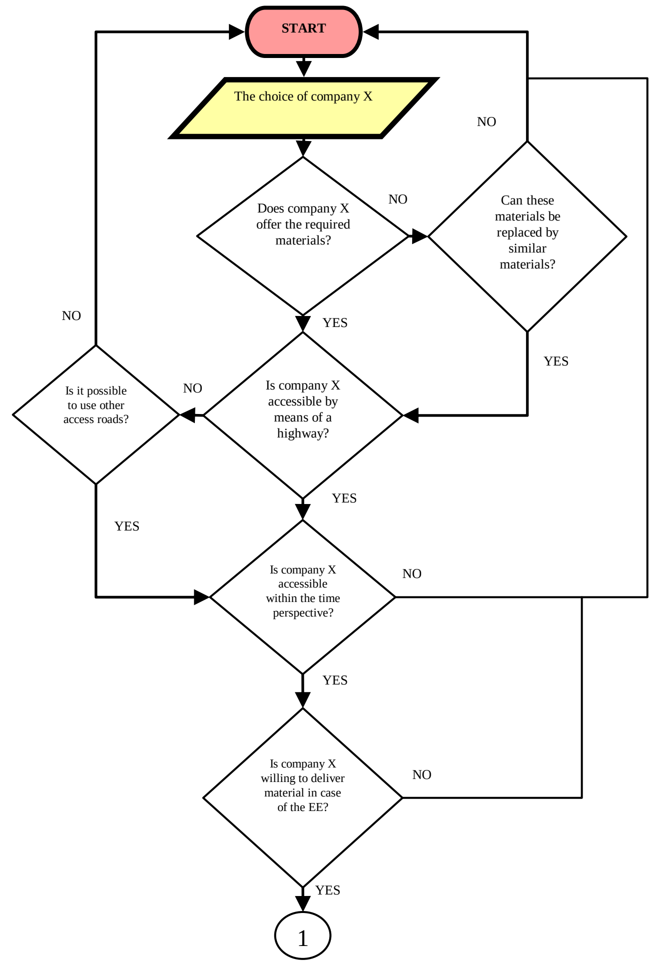


Figure 11: The progress chart of contracting with construction companies for material delivery

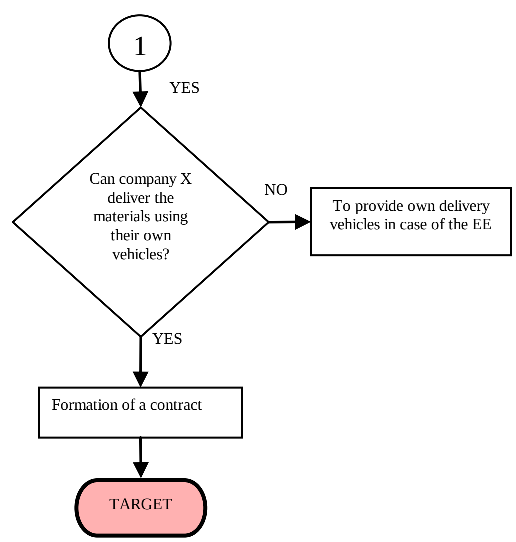
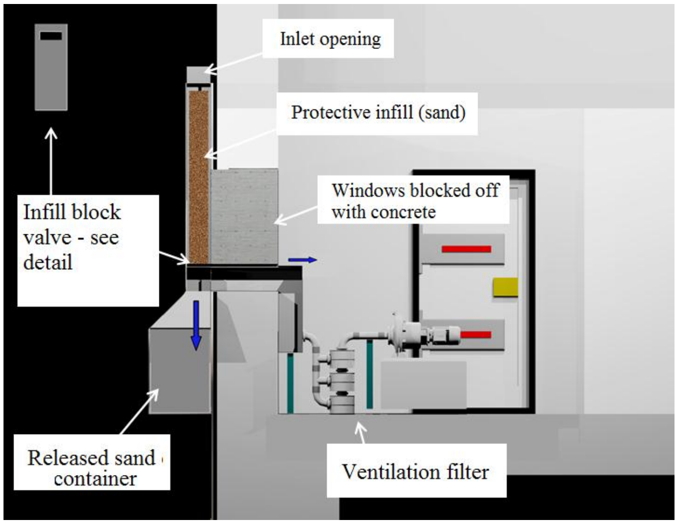


Figure 12: The progress chart of contracting – a continuation of the fig. 11

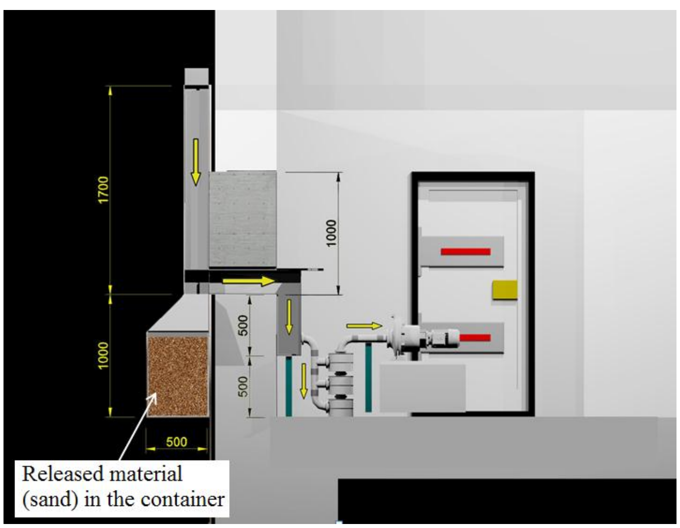
F. Preview of the research results in AutoCad software

A sequence of figures is used to clarify the designing of the IS modifications in AutoCad software. The figures are taken from various articles published at conferences.

The following figures capture an inlet duct for the shelter for the exchange of air.



Legend: the direction of material movement (sand) and a retractable board securing the filling
Figure 13: The display of the inlet duct for a protective function



Legend: a direction of air movement into the interior of the shelter
Figure 14: The display of the inlet duct for a filtered ventilation function

Some of the designs created in AutoCad software are consequently modified in Photoshop software.

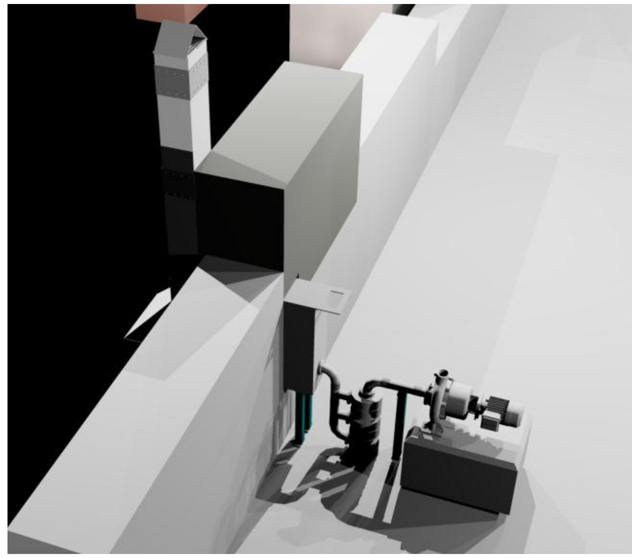


Figure 15: The layout of the inlet duct in 3D

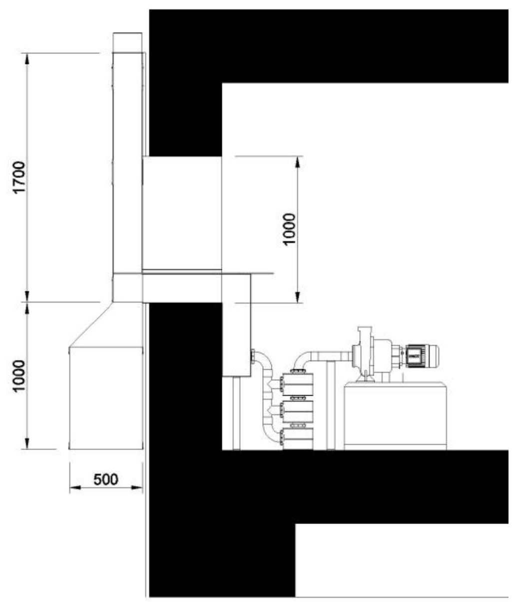


Figure 16: The layout of the inlet duct in 2D

G. Further activities within the research

The following bullets mention further activities within the ongoing research:

- Examination and evaluation of individual premises suitable for construction of improvised shelters in the territory of the corporate town Zlín.
- The proposal of the indigent construction modifications in order to ensure sufficient protective characteristics of the improvised shelter.

• Logistic provision of construction modifications – the provision of labour force and contractual clauses for the provision of works and building material.
• The provision of contractual clauses for the use of the premises in peacetime, proprietary rights etc.

Activities, such as examination and evaluation of premises suitable for construction of the IS and the proposals of the necessary modifications have been successfully solved for 2 years within the framework of the IGA project. In the following year the companies for building material deliveries will be chosen, see Chapter E. The final stage of the project will include contracting with the chosen companies together with provisions of contractual clauses.

Conclusion

The results of the research refer to the successful development and the employment in practice thanks to the cooperation with the town Zlín. The results achieved are to be further elaborated on and the planned activities are to be realised. However, the main problem is the issue of the financial demands on population protection by sheltering. Therefore, it is necessary to streamline and simplify the methodology in such a way that the designing and planning of the improvised shelters requires the minimum of financial resources. This is the main objective of the further research and effort.

The safeguard and modifications of the model shelter are new methods of population protection against the effects of dangerous substances, especially chemical, biological, radiological, and nuclear weapons (CBRN). This contribution proposes construction modifications which must not be ignored in shelter designs. The following research will focus on the creation of a model duct and model facility for testing of the proposed design. In addition, the article responds to the current affairs in the World and the increasing peril of the security situations in some countries. In conclusion, as the shelters are likely to be widely employed in the future, the precaution and preparedness in this field can help responsible bodies to heighten the effectiveness and coordination while solving the extraordinary or emergency situations.

Acknowledgements

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