The System of Population Protection by Sheltering from the Perspective of Municipalities

Jakub Rak, Lucie Jurikova, and Milan Adamek

Abstract—*This contribution analyses the ways of provision, planning and management of the population protection by sheltering from the consequences of mass destruction weapons in the territory of the municipalities with extended powers. The main objective of the paper is to introduce "standards" for the improvised shelter design, to describe the individual parts of the shelter together with its processing. Further, the paper clarifies the practical utilisation of theoretical knowledge and its employment within the state administration. The conclusion of the article is devoted to the significant aspects of the improvised shelters and especially their protective characteristics from the perspective of the protection from radioactive emissions, which considerably influenced the proposed tool for support and management of the population sheltering.*

Keywords—*Information systems, population protection, sheltering, information technologies, process control*

INTRODUCTION

The population sheltering represents the only permanently functional means of protection from the consequences of the long-term effects of chemical, biological, radiological, and nuclear weapons (CBRN). After the Cold war the anticipation of weapon usage has been lowered considerably, which led to the reduction in attention paid to the possibilities of shelter providing in the Czech Republic. This move was understandable, especially from the point of view of the savings in costs arising from the shelters' construction and maintenance. However, it is debatable if this move was not too extensive with the destructive influence on existing facilities.

On the other hand, there are countries that are aware of the situation and give substantial attention to population sheltering. These are for instance developed Nordic countries (Sweden, Finland) and Switzerland.

As shown by history, the periods of peace and tension, including the wars, keep repeating. A great many countries, including the instable ones, keep extensive arsenals of CBRN at their disposal; together with the growing tensions and instability in the world, the possibility of the weapon abuse is on the increase. Therefore, it would be unwise to ignore this threat and to be unprepared.

In the Czech Republic, sheltering is provided by means of the municipal authorities that are also held responsible for it. Nevertheless, sheltering is rather underestimated on the part of the municipalities, namely on the grounds of the less likelihood of threats requiring the population sheltering and also thanks to the high financial demands. Therefore, it is necessary to propose new sheltering that allows a decrease in financial resources and enables public involvement in the whole process.

PROBLEM FORMULATION

The Czech Republic is confronted with the issue of how to tackle the question of population protection from the CBRN effects in the future. Today, the system is based on employing permanent structures for the population protection – the permanent shelters. To a lesser extent it counts on quick conversion of suitable sites into shelters – the improvised shelters. In peacetime these sites serve other purposes (garages, warehouses etc.) and in the case of enhanced risk they are intended to be modified for the needs of sheltering.

These tendencies indicate the changes in the way of primary shelter provision. In particular, this was caused by the necessity to lower the financial costs expended on the shelter infrastructure. "The extensive onset" of the IS employment in sheltering provision can lead to considerable financial savings; however, there are several risks. For comparison, in Table 1 and Table 2 the advantages and disadvantages of the PS and IS are stated in peacetime and the period of national emergency or a state of war. [2]

Jakub Rak, Faculty of Applied Informatics, Tomas Bata University in Zlín, Nad Stráněmi 4511, 760 05 Zlín, Czech Republic. E-mail: jrak@fai.utb.cz

Ing Lucie Juriková, Faculty of Applied Informatics, Tomas Bata University in Zlín, Nad Stráněmi 4511, 760 05 Zlín, Czech Republic. E-mail: ljurikova@fai.utb.cz

Milan Adamek, Faculty of Applied Informatics, Tomas Bata University in Zlín, Nad Stráněmi 4511, 760 05 Zlín, Czech Republic. E-mail: ljurikova@fai.utb.cz

Permanent shelters		
	Advantages	***Disadvantages***
Peace	Utilisation for emergency accommodation	Financial demands
	Possibility of education and training of the staff	Necessity of maintenance
		Necessity of checking
Emergency state/ state of war	Speed of putting into operation	Minimal
	Guaranteed parameters	
	A higher degree of protection	
	Verifying the functionality	
	Interior arrangement	
	Number of staff	

Table 1: Characteristics comparison of permanent shelters [3]

Improvised shelters		
	Advantages	***Disadvantages***
Peace	Financial unpretentiousness	
	Utilisation for peaceful purposes	
	Minimal maintenance	
Emergency state/ state of war	A large number of objects	The need to transport materials and equipment
	Relatively continuous geographic	The lack of facilities (sanitary facility, filtration devices)
		Unverified functionality
		Limited layouts of the interior
		Unguaranteed parameters
		The need of construction modifications

Table 2: Characteristics comparison of improvised shelters. [3]

Based on the comparison of advantages and disadvantages of the shelters, the IS are preferable to PS in peacetime. On the contrary, in a state of emergency and a state of war the PS are definitely more beneficial. Thus, the optimal system of population protection by sheltering appears to be the combination system of the IS together with the PS. The Czech Republic employs a similar system with the continually increasing number of improvised shelters. Moreover, the Czech Republic joined the countries whose effort is to transfer their existing systems based mainly on the utilisation of the PS' to the combined system, which relies on the PS to a lesser extent while the rest is ensured by means of the IS.

Sheltering in the settings of the Czech Republic is provided by the municipalities within their territorial scope. The whole system runs within the control of the General Directorate of Fire Rescue Service and its executive branches (the fire rescue services of regions). The existing system in the CR that provides population sheltering is depicted in the Fig. 1.

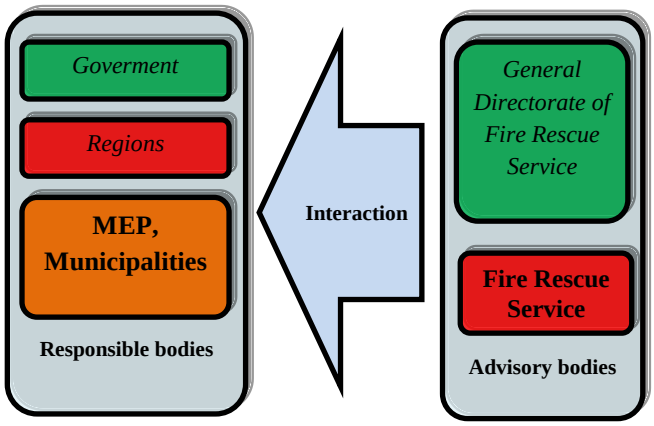

Fig.1: The system of population sheltering in the CR [3]

A. Problems involved in shelter provision

The non-existence of a unified methodology for the IS design in the CR is the issue. Although there exist some recommendations and procedures for modifications and constructions of the IS, they are rather instructions for the population and as such they are not fully utilisable by the municipal authorities. The fundamental document within the field of population protection: Regulation No. 165/2008 – the Concept of protection of the population by the year 2013 until 2020 ("the Concept of protection of the population") determines uniquely the responsibility for the shelter provision at the municipal territory of the municipal authorities whose task is to prepare the IS at a time when there is no state of emergency.

Within the municipal framework, sheltering is provided by appointed staff members. Nevertheless, their consequential coordination is problematic as population sheltering is at different levels in different municipalities. Some municipalities deal with the problem quite well and have elaborated shelter plans. However, there exist such municipalities that are engaged in sheltering only formally and the actual condition is unsatisfactory. [1]

B. The possible development

The possible solution to ensure a systematic approach of MEP to population sheltering is the creation of a population shelter system in the territory of MEP. In cooperation with municipal authorities of the town of Zlín the basic structures and sections of the system were proposed. The keystone of the system is depicted in the Fig. 2.

The main elements of the system are:

- ***Shelter infrastructure.***

Facilities instrumental for population sheltering and shelter support. These are, for instance PS and IS materials necessary for the construction works and putting into operation the

shelter and shelter teams' equipment and eventually other instrumentation equipment for the support of the shelter operation.

- ***Managing and planning elements.***

Forces and resources necessary for the management of the preparation and implementation process of sheltering. Especially the creation of plans and projects etc.

- ***Implementation elements.***

Forces and resources necessary for putting into operation the construction work of the shelters and eventually the supply of building materials etc. [2]

A significant part of the system is the methodology of the IS design. With respect to a vast number of planned IS the methodology is very important as it contributes to the standardisation of the whole process. Nevertheless, such a methodology does not exist in the Czech Republic. Therefore, we are currently working on a methodology in cooperation with the municipality of the town of Zlín; its utilisation within the shelter system of the MEP Zlín is being planned.

In the framework of the methodology one encounters several problems. One of them is the analysis of the protective characteristics and the availability of building materials necessary for the IS modification. These problems are being dealt with in the second section of this contribution.

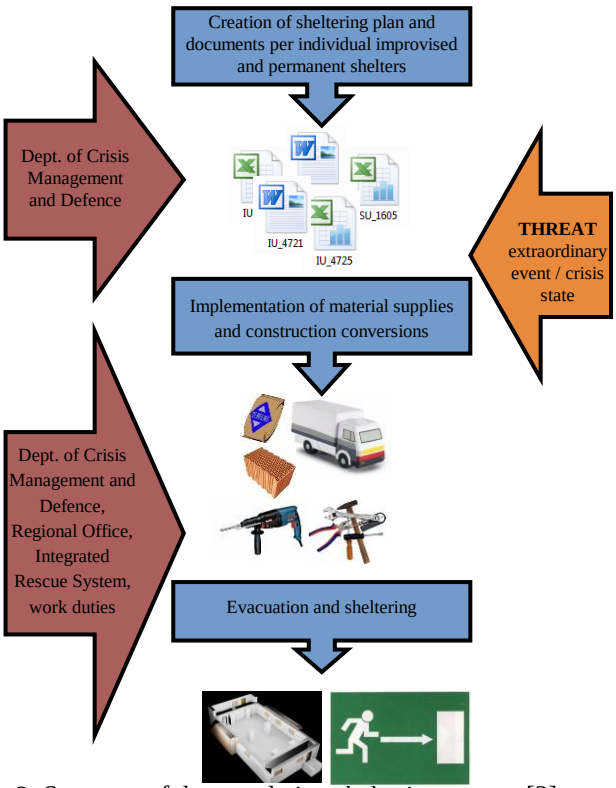

Fig.2: Structure of the population sheltering system [3]

PROBLEM SOLUTION

The creation of the unified methodology for designing and planning of the IS is the advisable solution. This methodology enables the standardisation of planning and the approach towards the IS and particularly it simplifies the process of their design and evidence together with the realisation of the construction works. The next task is the choice of suitable materials to be used during the construction works.

C. The methodology of the IS design

The methodology of the IS design is the basic element of the planned shelter system in the MEP Zlín. It is divided into two sections:

- The full standard.
- The reduced standard.

The reduced standard is a short version of the full standard. It includes information necessarily needed for the realisation of the construction work of the IS. It is mainly intended for people engaged in the planned construction works. On the contrary, the full standard includes all information related to the IS designing and planning together with other significant information (calculations, contracts etc.).

The fundamental premise on which the methodology proposal is based is the necessity to create a lucid and simple tool.

The full standard is being processed in order to clarify and simplify the filling in of the check-list form. It comprises of the following areas:

a) The basic specification of the shelter processor-owner

- Address
- Responsible persons
- Registration (evidence) number of the shelter
- Created by
- Map location of the shelter
- Use of the shelter
- Specification of the shelter
- Utilization
- The type of the shelter
- Time to get ready (construction time)
- Operation time

b) The present situation without modifications (Janeček et al 1978)

- TTD of shelter
- Place proportion (size of rooms)
- Shelter plan (setup)
- Photo documentation
- Building construction (type, material, value calculations of protective features)
- Potential sources of risks in the shelter's surrounding
- Shelter's equipment

c) The suggested (proposed) modifications

- Required (needed) material
- A list of suggested modifications
- Work procedure
- Minimal modifications
- Optimal modifications

- Installed equipment – material
- Time schedule for performing shelter's modifications

d) Situation after finishing the suggested (proposed) modifications

- TTD of shelter
- Place proportion (Size of place): area of openings + eventual changes of made proportions
- Building construction (type, material, value calculations of protective features)

e) Notes, attachments, links to related documents and etc.

To facilitate the work the standard is processed in MS Word and MS Excel, which enables the effective usage in business administration (Brož 2009). It is supplemented by interractive plans, maps and software tools for automated calculations. [1]

However, the creation of a user-friendly tool is not enough. During the design it is important to be particular about:

- Maximising the simplification of construction works.
- Utilisation of widely available materials.

The final tool (the full standards) comprises of five fundamental documents (subject cards) and supplemental information:

- General part
- Procedure for putting into operation
- Construction
- Construction works
- Construction calculations
- Supplemental information

At present, the tool is being implemented in real conditions by the MEP Zlín. Demonstrations of the created tool are depicted in figures 1 to 10.

- General part

This is used for the identification of the object intended for the conversion to the IS. It contains the basic identification data (address, utilisation, map etc.) and information on the construction, measurements and equipment of the shelter. Also, it is important for the appointment of persons responsible for the construction works and for putting it into operation. Besides the characteristics of the object, the data necessary for the IS operation, such as a period for which persons may stay in the shelter or the method of air exchange is also included. The general part is depicted in the figures 3 and 4.

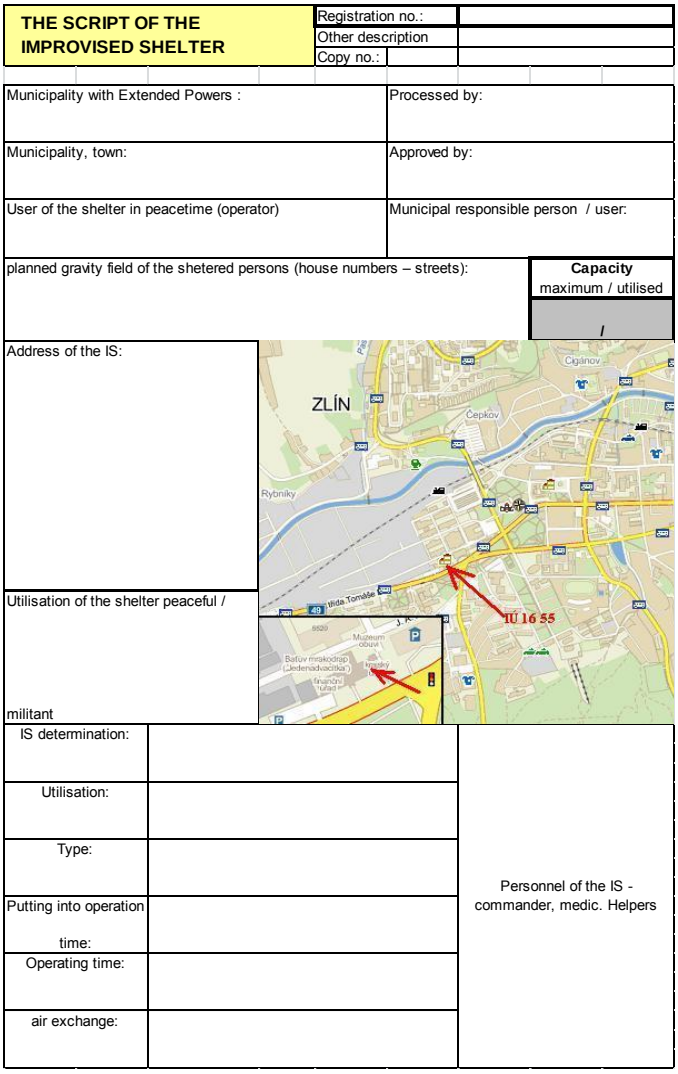

Fig.3: General part of the "standard".

THE PRESENT STATE OF THE AREA (without modifications)		
The equipment of the area		
		Notes
Telephone		
Public address system		
Lighting (type)		
Water supply		
Drainage		
Power supply		
Gas inlet		
Sanitary facility (toilet / washroom)		
Filtered ventilation (type)		
Other equipment of the area		
		Notes

Area data	Real	Corrected
Room length	m	
Room width	m	
Room height	m	
Length of the external perimeter wall	m	
Floor space of the room	m^2	
Volume of the room	m^3	
Surface of the openings in the perimeter wall	m^2	m^2
Average height of window sills	m	m
Surface of openings in the perimeter wall in the IS	m^2	m^2
Average height of window sills	m	m
Surface density of the perimeter wall	kgm^{-2}	kgm^{-2}
Surface density of the ceiling over the IS	kgm^{-2}	kgm^{-2}
Type of entrance	from the building	

Construction data		
		Notes
Type of construction		
Number and types of doors		
Material of the ceiling structure		
Material of the perimeter walls		
Number of openings in perimeter wall		

Fig.4: General part of the "standard".

- Procedure for putting into operation

This briefly states the operational procedures necessary for putting the IS into operation and the realisation of the construction works. The procedure is being described in time sequences based on the individual activities to be realised. The chief objective is to provide instructions to individual operations and to avoid errors and possible non-implementation of some essential procedures. The procedure for putting into operation is tightly connected to the next sections "Construction works" in which some procedures are described in detail.

In this section the demands on material used during the construction works are also defined. The list of the required building material together with quantities is stated in the table. Besides, the contacts, places of material collections and names of people responsible for the provision of the particular material are stated in this section.

The proposal for the procedure for putting into operation is also based on the practical experience of the MEP Zlín staff. The basic assumption is for the maximised simplification of the required operations and their standardization. This should enable unqualified persons (civilian population) to provide for the putting into operation and construction works of the IS.

The putting into operation procedure in the full standard document is depicted in the figure. 5.

Process of putting into operation			
Putting into operation - description			
Note: *In case of need, state the main points only; a detailed description can be stated overleaf*			
Material needed			
Source	***Name***	***Quantity***	***Type***
Local			
Source	***Name***	***Quantity***	***Type***
Supplies			
Name	***Places of material collection***		***Responsible person***

Fig.5: Card – "Procedure for putting into operation".

- Construction

The subject card "Construction" includes an itemization of the basic construction data taken from the "General part". These are mainly detailed layouts of the modified areas, measurements, specifications and types of materials to be used.

Tab. K/1b

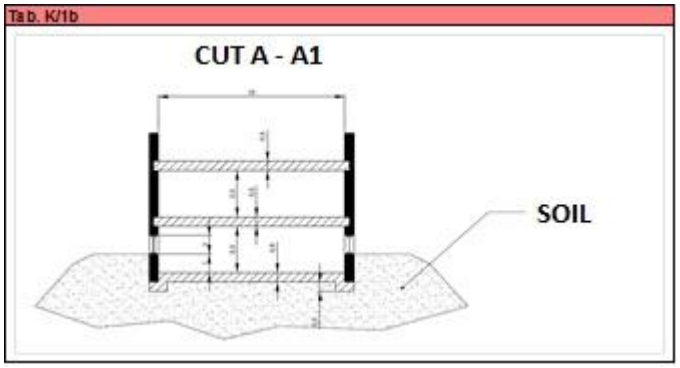

Fig.6: Card ”Construction” - graphic part. [5]

Construction - characteristics

Construction work	number	Description	reference
Walls, ceilings	1	Material, measurements, thickness, condition, function (perimeter wall, bearing wall, transverse etc.), internal - external, notes	Tab. K/1
Openings	2	Number, measurements, function, internal - external, distance from the floor, distance from the surrounding terrain, notes	
Adjoining room	3	Material, measurements, thickness, function, internal - external, openings, notes	
Other aspects	4	Surrounding estate, power and water supplies etc.	

Tab. K/1a

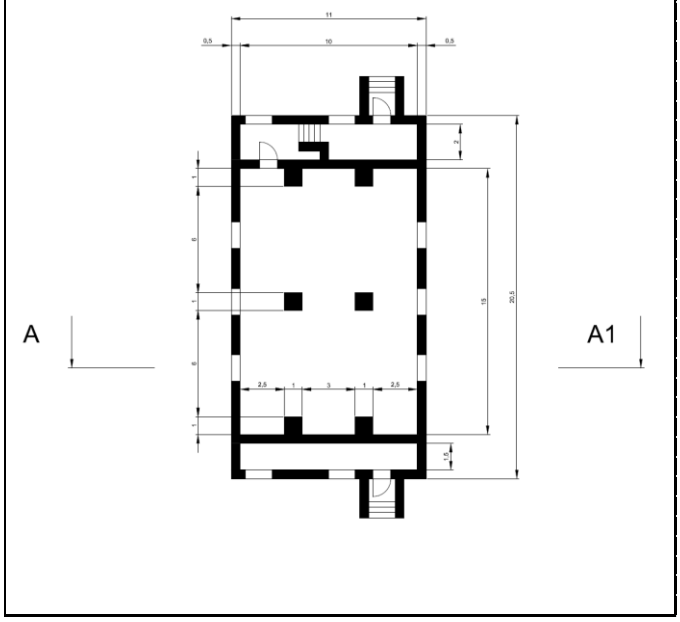

Fig.7: Card ”Construction” – characteristics and graphic part.

In this subject card the relevant characteristics of the surrounding areas and objects are stated.

- Construction works

The subject card contains a detailed description of the construction works. It features the main modifications, their descriptions and the procedure for their implementation by means of text and images.

All activities are placed in a work schedule that at the same time serves as a check list. Individual tasks are subjected to termination times of 2 and 12 hours. In the event of extensive modifications the time period may extend. These termination times have been determined based on the requirements for a fast realisation and launching of the IS. This allows the employment of shelters even in events of vast industrial accidents and others.

Construction Works

Construction works	number	Description	reference
Windows fortification and tamping - openings filling	1		Tab. K/1
Filtered ventilation device	2		
Entrance alcove, fortification and tamping of the entrance	3		
Other modification	4		
Other modification	5		

Tab. K/2a

Work flow	Time
A)	within 2 hours
B)	within 12 hours
C)	extended period

Fig.8: Construction Works - description of the work.

- Construction calculations

The subject card “Calculations” serves mainly for the design and definition of the particular modifications and protective characteristics of the shelter.

It contains four kinds of calculations which are dependent on the shelter type for which the calculation is implemented.

The actual subject card if filled in is a part of the full standard and serves for use of the particular MEP. It is not

distributed among the population in order to prevent a decrease in the clarity of the provided project.

Shelter type	description
1.	*A shelter located in the middle tract of multistage buildings*
2.	*Ground floor or partially embedded shelter with a superstructure*
3.	*Embedded shelter with a superstructure*
4.	*Entirely embedded shelter without a superstructure*

Fig.9: Types of shelters.

For the calculation of the protective coefficient of the construction of the individual types of the shelters the following equations are used [1] :

$$Ko = 3{,}25*K_{st} / (1-V_2)* (K_z*K_{st}+1)*K_m \quad (1)$$

$$Ko = 0{,}65*K_1*K_{st} / (1-V_2)* (K_z*K_{st}+1)*K_m \quad (2)$$

$$Ko = 0{,}77*K_1*K_{st}*K_p / (1-V_2)*(K_{zn}*K_{st}+1)*(K_{zn}*K_p+1) *K_m \quad (3)$$

$$Ko = 0{,}77*K_{pr} / V_1+K_{vch}*K_{pr} \quad (4)$$

Where:
K_1 – the coefficient of the influence of external walls,
K_{st} – the coefficient of the radiation weakening by the external wall,
K_Z – the coefficient of penetration of radiation into the room by openings,
K_m – the coefficient of the reduction in exposure radiation speed in buildings due to a screening effect of the adjoining buildings,
K_{pr} – the coefficient of the influence of the ceiling structure,
K_{vch} – the coefficient of the penetration of radiation through an entrance,
K_p – the coefficient of the reduction in radiation by the ceiling structure of the shelter,
V_2 – the coefficient dependent on the width of the building,

CALCULATIONS

Calculations TYPE 1.

The figure

Ko = 3,25*Kst / (1-V2)* (Kz*Kst+1)*KM

	Without modifications	With modifications
Ko =	2672	4553

	Fill in the value	With modifications
Kst =	760	760
V2 =	0,5	0,225
Kz =	0,00216	0
Km =	0,7	0,7

Fig.10: Card – "Calculation".

Data from the army regulations has been used for the needs of calculations. These are, for example, already repealed "Czechoslovakian regulation - CO-6-1/c Preparation, Projection and Construction of Antiradiation Shelters" intended for "Czechoslovak People's Army" during the "Cold War".

- Supplemental information

The supplemental information refers mainly to the calculation part. They are methods of the determination of various coefficients and values needed for the calculation of the protective coefficient of the individual shelters. Similar to the subject card "Calculation" they are not distributed among the population.

D. Methods (techniques) of gathering information and procedure for filling a standard

Information can be obtained in several ways. It is mainly done by a perusal of the project and documents of buildings and areas designated for improvised shelters. These are also used for finding the physical measurements of the areas. In the event that the required data cannot be obtained, it is estimated. The estimated data is based on established facts and practical experience. When a standard is being filled, a correction coefficient is used for the estimated data to reduce possible errors caused by the estimation.

E. Main elements of the IS

The definition of the main elements enables the correct focus of the construction works and at the same time reduces the possibility of chaotic and non-systematic approach towards modifications.
The objective of the IS is to lower radiation inside the shelter compared to the external environment. This capability is measured by means of the so-called Protective coefficient of a building (Ko) which is determined by a general form of equation no. 1 [1]

$$Ko = 3{,}25*K_{st} / (1-V_2)* (K_z*K_{st}+1)*K_m \quad (1)$$

Where:
K1 – the coefficient of the influence of external walls,
K_{st} – the coefficient of the radiation weakening by the external wall,
K_Z – the coefficient of penetration of radiation into the room by openings,
K_m – the coefficient of the reduction in exposure radiation speed in buildings due to a screening effect of the adjoining buildings,
V_2 – the coefficient dependent on the width of the building,

The basic equation enables the protective coefficient of a building to be calculated for shelters embedded below the surrounding terrain. For other kinds of shelters the equation is supplemented by several coefficients of ambient influence. A detailed information on the protective coefficient calculations is for instance in the papers cited in the article.

Further significant aspect for a survival of sheltered persons

is a ventilation filter for air inlet and also the provision of a sufficient amount of food and fresh water.

Based on these requirements we have determined 3 basic elements of the IS. They are:

- Enclosure walls.
- Ventilation filter.
- Insulation properties of the shelter.
- Logistics

The next section of the article analyses the first of the attributes which represents the most significant aspect in construction works proposal and which is also a primary aspect of the protection from prompt radiation.

F. Protective characteristics of materials for construction works

One of the fundamental aspects influencing the protective characteristics of the designed shelters is material to be used for the construction works. [5]

Based on the analysis of the most common building materials used in objects intended for a conversion to the IS and based on evaluation of availability of suitable materials, they were divided into 3 categories. Categories are divided from the point of view of the delivery:

- IS with locally obtainable material.
- IS where some material has to be delivered.
- IS where most material has to be delivered.

Based on the analysis, a list of the most common materials was processed and their density assessed (Table 3). The density substantially influences the protective characteristics, and especially the coefficient Kst (see the equation 1).

Kind of material	**Weight (kgm^{-3})**	**Obtainability**
brick rubble	1200	Medium Supplies
compacted crushed stone	1800	Easy Supplies
crushed gravel from dense stone	1700	Easy Supplies
fireclay bricks	1900	Medium Supplies
foam concrete blocks	800	Medium Supplies
paving stone	2600	Easy Supplies
soft wood	650	**Easy Supplies**
hard wood	850	**Easy Supplies**
steel – iron	7850	Medium Supplies
sand, clayey sand, gravel sand	2000	**Easy Local**
slay, silty clay, clay	2000	**Easy Local**
solid clay bricks	1800	**Easy Local**
plain concrete, tamped concrete	2200	**Easy Supplies**
tamped reinforced concrete	2400	Medium Supplies
foam concrete	300	Medium Supplies
cement mortar	2000	**Easy Supplies**
lime mortar	1700	Easy Supplies

Table 3: Comparison of characteristics of building materials.

Obtainability is of great importance and presents a primary evaluation aspect. It is necessary to bear in mind that a need of the IS can originate during a state of war when it might not be possible to provide the material supplies. Therefore, materials from local resources should be used as much as possible.

The most suitable materials in the territory of MEP in Zlín appear to be common soil and wood material – boards, beams etc. (see the Table 3). These materials are planned to be employed in the majority of the designed IS. [5]

G. Information gathering methods and progress of works

The protective characteristics of building materials and their obtainability have been analysed based on their previous measurements (Janeček 2001) and their comparison with the required protective values determined by the calculations.

The analysis and the consequential synthesis have been utilised in the determination of the material availability. Based on the distance and required time the most suitable method of supplies has been chosen.

CONCLUSION

The main problem in planning and designing of the IS 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. Owing to the cooperation with the staff of the MEP in Zlín it is possible to anticipate practical solutions to these problems.

The main objective is to lower financial demands on population protecting by sheltering and also the engagement of the population and their shared responsibility. The MEP in Zlín presents a unique approach in this field. Their aim is to create and distribute plans for putting IS into operation. At the moment, these plans are being created and they are to be distributed to chosen groups of the population within this year. The project will further be developed and its final objective is to provide shelters for 60 – 80 % of the population of the town of Zlín.

The research will further be devoted to a ventilation filter and insulation properties of the shelters.

In this respect, the research should verify our hypotheses and assumptions. The successful solution should be assured by an internal grant from the FAI UTB in Zlín devoted to the fields discussed together with cooperation with specialists. The cooperation with the staff of The Population Protection Institute in Lázně Bohdaneč appears to be quite promising as they can provide the required knowledge and equipment. In the event of a successful solution, the certification of the methodology and its utilisation by the municipal authorities in the CR is expected.

ACKNOWLEDGEMENTS

This paper is supported by the Internal Grant Agency at TBU in Zlin, project No. IGA/46/FAI/10/D, IGA/38/FAI/11/D and by the European Regional Development Fund under the project CEBIA-Tech No. CZ.1.05/2.1.00/03

REFERENCES

[1] F. Janecek, J. Marusak, J. Valasek. CO-6-1/c Preparation, Projection and Construction of antiradiation shelters, Prague : Ministry of National Defence 1978.

[2] J. Kovarik, M. Smetana. Fundamentals of Civil Protection, Ostrava : SPBI 2006, ISBN 86634-85-X

[3] J.Rak, L. Jurikova, M. Adamek, Improvised shelters - projecting methodology and chosen aspects of building materials, 13th WSEAS International Conference on AUTOMATIC, Canary Islands, Spain, 2011. ISBN: 978-1-61804-004-6

[4] L. Jurikova, J.Rak, M. Adamek, Suggestion of improvised shelter design, 13th WSEAS International Conference on AUTOMATIC, Canary Islands, Spain, 2011. ISBN: 978-1-61804-004-6

[5] L. Jurikova, J. Rak. Proposal for technology of improvised shelters design in conditions of the Czech republic, Annals of DAAAM for 2010 & Proccedings of the 21 st International DAAAM Symposium, Austria - Vienna: DAAAM International, Croatia 2010, ISBN 978-3-901509-73-5

[6] L. Lukas , M. Hromada, Utilization of the EASI model in the matters of critical infrastructure protection and its verification via the OTB SAF simulation tool, 13th WSEAS International Conference on AUTOMATIC, Canary Islands, Spain, 2011. ISBN: 978-1-61804-004-6

[7] L. Necesal, L. Lukas, Entities of critical infrastructure protection in the Czech Republic, 13th WSEAS International Conference on AUTOMATIC, Canary Islands, Spain, 2011. ISBN: 978-1-61804-004-6

[8] M. Hromada, L. Lukas, Management of Protection of Czech Republic Critical Infrastructure Elements, 13th WSEAS International Conference on AUTOMATIC, Canary Islands, Spain, 2011. ISBN: 978-1-61804-004-6