BUILDING OF IMPROVIZED SHELTERS IN PANEL BUILT-UP AREAS

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Abstract

The article deals with the building of improvized shelters in a panel built-up area. The theoretical introduction includes the description of individual types of improvized shelters in the Czech Republic, and the possibilities of their use. It is followed by an analysis of a panel built-up area in the housing estate in the town Ostrava. The attention is focused on GOS as the most frequent type of a panel built-up area representing 28 % of all town constructions. The most suitable space for the building of improvized shelters in such a type of prefab buildings is proposed in the next part of the paper including three options of improvized shelters. The key part of the paper is aimed at the most suitable option which is selected according to pre-set criteria and is followed by the description of necessary measures which must be taken prior the building of the improvized shelter and the strengthening of protective properties of a selected space. The measures include mainly the reinforcement of roof construction, the building of a ventilation system, the reinforcement of windows and doors, and the building of escape ways. The paper may be used as a methodical guideline for the building of improvized shelters in a mentioned type of a panel built-up area.

Keywords

Civil protection, panel built-up area, GOS Bichler, improvized shelter, methodical guideline, protective coefficient, strengthening of protective properties.

INTRODUCTION

One of the fundamental areas of civil protection is together with warning and notification, evacuation, and provision of emergency survival of population also provision of sheltering [1]. At present, sheltering is provided either in permanent or improvized shelters whereas new construction, reconstruction and repairs of current permanent shelters is not supported by the state any longer and the state is neither interested in their preserving in peace time. [1]. Therefore presently, when the Central Europe is not threatened by a war conflict, permanent shelters are in many cases too costly especially those which were built as the single purpose constructions. For this reason permanent shelters are gradually on the decline and the protection of population is in case of the threat substituted by improvized sheltering.

In the Czech Republic there are approx. 32 % of population living in panel houses. With regard to the fact that a panel built-up area in the Czech Republic is made of only several basic types of panel buildings, it is possible to form a universal model of an improvized shelter for a large number of citizens. Using the existing space for population sheltering is more effective than maintenance of permanent shelters whereas the sheltering in these spaces can effectively protect the population against immediate radiation better than the imminent evacuation can ensure. Other advantages are also financial costs of the maintenance of these shelters and they are within reach distance.

THEORETICAL INTRODUCTION

An improvized shelter is according to a methodical guideline [4] a beforehand selected optimally convenient space in suitable parts of apartments, block of flats, operational and production entities which will be adapted by physical and legal persons for their protection and for protection of their employees against the effects of extraordinary events using own material and financial sources.

Improvized shelters are classified according to monitored characteristics into four groups [5]:

- the ground floor or partially embedded shelter with the superstructure (the floor is embedded less than 1.7 m);
- the shelter located in a middle wing of multi-floor buildings providing that no wall of a shelter is external;
- the embedded shelter with the superstructure (the floor is embedded more than l.7 m bellow the terrain level);
- completely embedded shelter without the superstructure.

Improvized shelters can be built for protection of population:

- against the effects of luminous and thermal radiation, initial radiation, contamination by radioactive dust and partly against air pressure effects of weapons of mass destruction (e.g. as a result of the failure in a nuclear facility or a terrorist attack);
- against the fall of debris, effects of fractions and burning objects (e.g. as a result of an earthquake or air-raid).

The most suitable space for the building of improvised shelters are basement or cellar spaces of buildings in the middle wing of a facility with the deepest embedding against the surrounding terrain. Also cellars with vaulted or reinforced concrete ceilings with thick external walls with the smallest surface of all window openings are suitable spaces. Against the escape of dangerous substances themselves, especially in peace time, the most suitable space for the sheltering is in higher floors of buildings, best on the reverse side of a building from the direction of the escape of an injurant. Besides a suitable location of a shelter also its structural design is important.

For each sheltered person we need 1-3 m^2 of the surface in the space with forced ventilation and 3-5 m^2 of the surface without the ventilation equipment. The capacity of an improvised shelter is then the sum of sitting and lying persons whereas the total number should not exceed 50 persons per one shelter. The clearance of the space is supposed to be minimally 2.3 m following the minimal stair clearance 1.9 m [4].

Protective properties of the facilities are partly or completely embedded rooms whose external walls and ceilings have the necessary properties, main doors leading to a shelter opens outwards from the shelter etc. The improvement of protective properties of entities is carried out with regard to the danger against which the sheltered persons are to be protected. Protective properties of an improvised shelter against atomic irradiation are expressed by a protective coefficient of a building. In abroad there are also relevant methods for the evaluation of protective properties of buildings against biological weapons [7].

Protective coefficient of a building which is marked Ko determines how many times the dose of atomic irradiation in a shelter is lower than the dose of atomic irradiation at height of 1 m above the open terrain provided that the radioactive fallout is evenly distributed on horizontal surfaces. Radioactive fallout on vertical surfaces is not considered. The value of a protective coefficient of a building is determined by a benchmark calculation according to a military regulation[1] [5]. The determination of the calculating value of a protective coefficient is dependent on the type of an improvized shelter.

For the in part embedded improvized shelter with the superstructure where the floor is embedded more than l.7 m bellow the terrain level we use the relation 1.

$$K_o = \frac{0{,}65 \cdot K_1 \cdot K_{st}}{(1-V_2)\cdot(K_z \cdot K_{st}+1)\cdot K_M} \cdot K_x \qquad \textbf{(Relation 1)}$$

The influence of external walls given by the coefficient K_1 and the coefficient K_Z which shows the penetration of radiation into a room through the openings is substantial here.

For an improvized shelter constructed in the middle wing of a building we calculate the value of Ko using the relation 2.

$$K_o = \frac{3{,}25 \cdot K_{st}}{(1-V_2)\cdot(K_z \cdot K_{st}+1)\cdot K_M} \qquad \textbf{(Relation 2)}$$

For the variant where the floor of an improvized shelter is embedded more than 1.7 m bellow the terrain level we apply relation 3.

$$K_o = \frac{0{,}77 \cdot K_1 \cdot K_{st} \cdot K_p}{(1-V_2)\cdot(K_z \cdot K_{st}+1)\cdot(K_p+1)\cdot K_M} \cdot K_x \qquad \textbf{(Relation 3)}$$

If an improvized shelter is constructed in completely embedded facility without the superstructure, then relation 4 is applied.

$$K_o = \frac{0{,}77 \cdot K_{pr}}{V_1 + K_{vch} \cdot K_{pr}}$$ **(Relation 4)**

Protective coefficient of a construction is calculated both prior the strengthening of protective properties, and after it. The minimal value of a coefficient is 50 and with its growing value the protection of sheltered persons increases. The value K_O is maximized when using so called enhancement of protective properties of a building which can be achieved through the optimization of the following variables values:

K_1 **coefficient of external walls influence** is determined from the graph in dependence on the length of external walls in % to a room circumference,

K_{st} **coefficient of radiation reduction by external wall** is determined by the graph from the table of areal density of protective construction or by its calculation,

V_2 **coefficient dependent on the width of a building** is determined from the table,

K_z **coefficient of radiation penetration into room through openings** is determined for a specific shelter in dependence on the height of a bottom edge (window-sill) in external wall,

K_M **coefficient of the reduction of exposition speed of radiation in buildings** due to shading effects of neighboring buildings is determined from the table,

K_x **coefficient of surrounding space contamination –** if the contamination by radioactive dust of rooms next to the shelter or above it is not excluded, the value of a coefficient $K_{O,}$ obtained from the formula for shelters located on the ground floor, is multiplied by coefficient 0.8 using the variant of a partly embedded improvized shelter where the embedding is less than 1.7 m. When using the variant of a shelter in the middle wing of a building, the value of this coefficient is 0.45,

K_p **coefficient of radiation reduction penetrating into a shelter through ceiling construction** is determined by the graph from the table of areal density of protective construction or by its calculation,

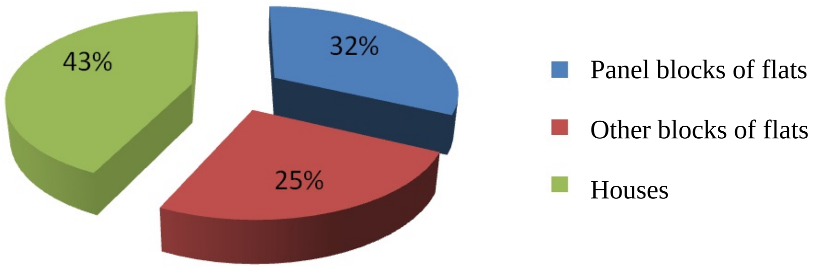
K_{pr} **coefficient of radiation reduction through ceiling construction of a shelter** is determined by the graph from the table of areal density of protective construction or by its calculation,

K_{vch} **coefficient of radiation penetration into the shelter through the entrance space** is determined by the relation: $\mathbf{K_{vch} = K_v \cdot P}$, where K_v means disposition placement of an entrance and its protective properties (determined from the table) and P means the type and a character of an entrance (determined from the table).

PANEL BUILT-UP IN THE CZECH REPUBLIC

The initiation of panel construction dates back to the beginning of the 20th century. The inventor of panel construction was Thomas Alva Edison who had a housing estate of several tens, mostly working-class houses built in the United States as the first houses of this technology. After the World War I the construction of panel houses started in the Netherlands, from 1923 in Germany and from 1939 also in Paris. Very similar blocks started to be built also in Sweden and Finland. Panel constructions were used as fast and cheap housing; however, in western countries this kind of buildings were not built in a mass scale as in eastern countries. Western Europe terminated their construction already in the 70th in comparison with Eastern Europe where they were built till the beginning of the 90th of the 20th century. [8]

The first panel houses in the Czechoslovak Socialist Republic were erected in 1956. From 1958 to 1990 due to a housing crisis the most mass construction of panel houses occurred. [9]. Completely new quarters of towns were established, e.g. Prague South Town or Brno Bohunice. The structure of the built-up areas in the Czech Republic till 2001 is demonstrated in the graph 1.



Graph 1
The structure of the built-up areas in the Czech Republic in 2001[2]

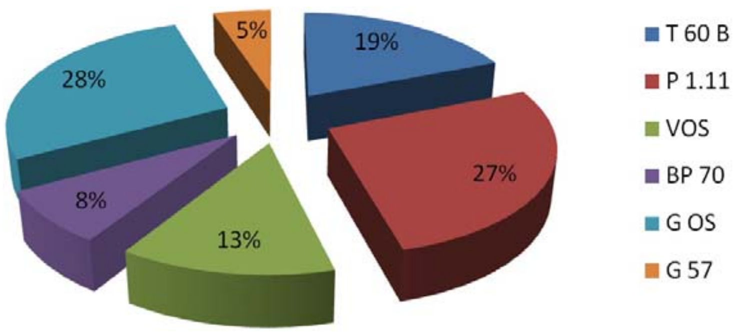
At present almost one third of all citizens live in towns and right in panel built-up areas. The highest number of panel houses is in Moravia-Silesia region, in the capital city Prague and Usti region. The first panel construction in the Czech Republic finished in 1953 in Prague quarter Dablice. It had a new construction system, so called skelet-panel [10]. This was substituted by the type G 40 (G as the former Gottwaldov and 40 after the number of flats in individual houses), the first one built in town Zlin where the construction of prefab panels was used. Panel houses were at that time decorated by various details, house emblems, arcade entrances, mosaic, which, however, disappeared quite early due to mass building. The type G 40 was completed by the type G 57 which was developed for more extensive serial construction and was applied until 1973.

From the viewpoint of the extent of the construction, the major building structure remains the houses type G 57 III (Prague), G 57 OL (northern Moravia), GOS 64 (Ostrava). In 1960 new kinds of buildings started to be built and they were very widespread systems T 06 and T 08 which were built till the 80th [11]. Those years in Eastern Bohemia the systems HK 60 and HK 65 were built. From 1972 the era of the system VVU-ETA started which originated from the system T 09 B and was developed by the Research and Development Institute of Construction Company Prague first of all for central Bohemia and Prague. Then tree-module systems followed e.g. Larsen & Nielsen, B 70 or BANKS.

Among the last ones belongs a four-module system HKS G, which was substituted in 1970 by the system OP 1.11 used till 1984. The construction of panel houses terminated in 1990. In the course of the above mentioned years there were built approx. 50 standardized panel structures [12].

SPACES SUITABLE FOR SHELTERING OF POPULATION

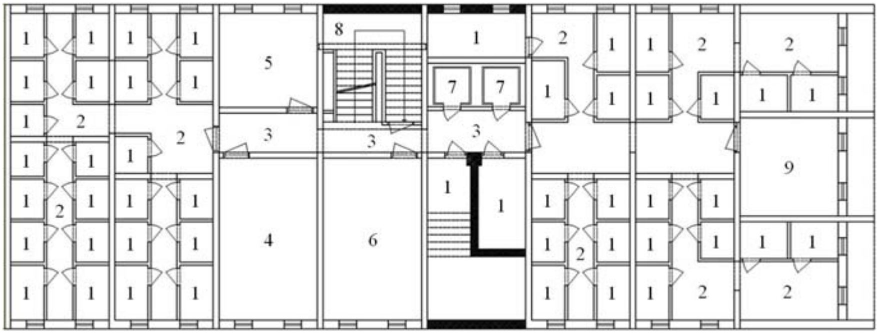
The following part of this paper is focused on panel buildings in town Ostrava. Panel houses G 57, GOS and T 06 B were constructed approx. in the same time and encompass 52 % of a total panel built-up area. The representation of individual types of panel construction systems in selected localities of the town Ostrava (Ostrava-Poruba, Ostrava-Zabreh, Ostrava-Hrabuvka, Ostrava-Dubina) you can see in the graph 2.



Graph 2
Representation of individual types of panel construction systems in selected localities of the town Ostrava [13]

The most numerous type of a panel built-up area in Ostrava is the type GOS which covers 28 % the total built-up. GOS is the variant of the type G 57 which was used only in Ostrava. The type GOS can be divided into three variants which differ from each other by the number of floors. GOS 64 is a four-floor version of a house, GOS 66 is an eight-floor version of a house, GOS Bichler is a twelve-floor version. [14]

Suitable spaces for the construction of improvized sheltering is the basement of a panel house. This space consists of a large number of cellar boxes, basement corridors, a laundry, ironing room, dry kiln, stair-case, well and a workshop (see picture 1).



<u>The key:</u> *1 – cellar boxes, 2 – basement corridors, 3 – corridors, 4 – laundry, 5 – ironing room, 6 – dry kiln, 7 – wells, 8 – stair-case, 9 – workshop.*

Fig. 1
Graphic illustration of the placement of rooms in basement spaces of a panel house GOS Bichler

The selection of an optimal variant of spaces suitable for sheltering was made according to the following criteria:

- the number of sheltered persons,
- the advantages and disadvantages of the arrangement,
- protective coefficient,
- time consumption of building-up,
- economy assessment.

The analysis of the floor projection of the basement of a panel house GOS Bichler showed that it is possible to make up three basic variants of the distribution of spaces suitable for sheltering. Their main features are described below. Regarding a disposition and technical arrangement of a pertinent building the protective coefficient is calculated from the relation 1 for all variants.

Variant 1

For the construction of an improvized shelter the rooms 4, 5, 6, 9 (see picture 2) are used. Their area and protective coefficient are as follows:

- IU-1: S = 11,05 m^2, K_O = 71,97
- IU-2: S = 19.04 m^2, K_O = 107.55
- IU-3: S = 19.04 m^2, K_O = 107.55
- IU-4: S = 11.39 m^2, K_O = 73.58

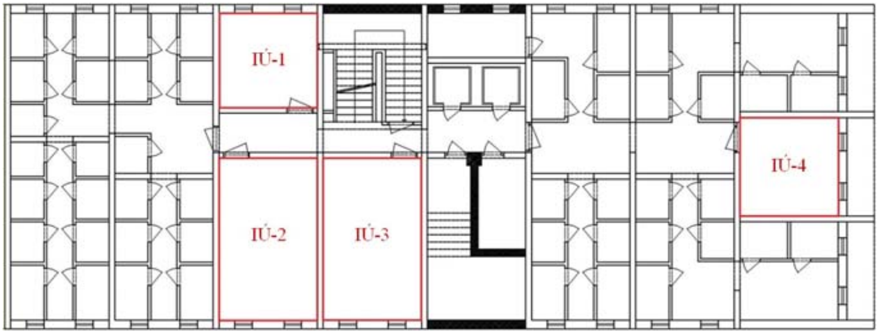


Fig. 2
Ground plan of selected spaces for the sheltering (Variant 1)

The description of the variant according to determined criteria:

- maximal number of sheltered persons: 60 persons (on the assumption that a shelter is maximally used, i.e. 1 m^2/person);
- the advantages of the arrangement: lower costs, faster and simpler readiness, simpler ventilation system;
- the disadvantages of the arrangement: lower capacity of sheltered persons, worse social conditions;
- protective coefficient: higher value of a protective coefficient which provides better protection for sheltered persons;
- time consumption of building-up, smaller area for dismantlement, simpler ventilation system and the number of workers needed for the building-up guarantee lower time consumption for the readiness of a shelter;
- economy assessment: low financial costs, minimum of construction adjustments, simple ventilation system.

Variant 2

For the construction of an improvized shelter the room 9 can be used together with adjacent corridors and cellar boxes (see fig. 3). The area and protective coefficient of this kind of improvized shelter is as follows:

- IU-5: $S = 51.04\ m^2$, $K_O = 37.85$

The description of the variant according to determined criteria:

- maximal number of sheltered persons: 45 persons (on the assumption that a shelter is maximally used, i.e. 1 m^2/person);
- the advantages of the arrangement: all persons are placed in one improvized shelter, cellar boxes can be used as a separate social facility, possibility of minimal privacy;
- the disadvantages of the arrangement: considerably intricate construction of ventilation, the necessity of additional construction adjustments in peace time;

- protective coefficient: with regard to the number of window openings and three external walls, the value of a protective coefficient is low;
- time consumption of a shelter construction: large dismantling area, large number of adjustments in order to enhance protective properties;
- economy assessment: increased costs due to construction adjustments and enhancement of protective properties.

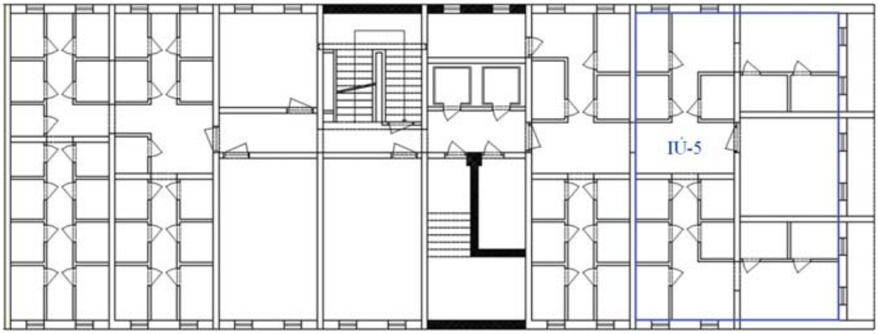


Fig. 3
Ground plan of selected spaces for the sheltering (Variant 2)

Variant 3

For the construction of an improvised shelter are used rooms 4, 5, 6, 9 and adjacent corridors and cellar boxes (see fig. 4). The area and protective coefficient of individual rooms of an improvized shelter are as follows:

- IU-1: S = 11,05 m^2, K_O = 71,97
- IU-2: S = 19.04 m^2, K_O = 107.55
- IU-3: S = 19.04 m^2, K_O = 107.55
- IU-5: S = 51.04 m^2, K_O = 37.85

Description of the variant according to determined criteria:

- maximal number of sheltered persons: 100 persons (on the assumption that a shelter is maximally used, i.e. 1 m^2/person);
- the advantages of the arrangement: better social conditions, more capacity;
- the disadvantages of the arrangement: intricate construction of a ventilation system, high costs for necessary adjustments;
- protective coefficient: expressively lower protective coefficient of IU-5;
- time consumption of a shelter construction: the dismantling area is the largest, large number of adjustments in order to enhance protective properties;
- economy assessment: this variant is more demanding due to required material and construction works.

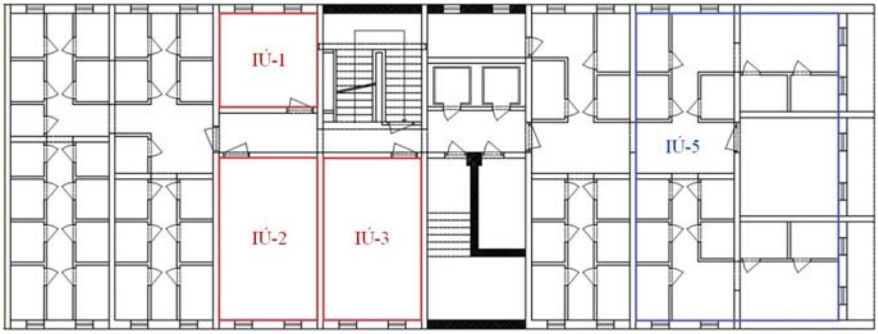


Fig. 4
Ground plan of selected spaces for the sheltering (Variant 3)

Selection of a most suitable variant

The selection of a most suitable variant was made with the help of multi-criteria evaluation of variants applying a norm balance. First we adjusted a norm balance for individual criteria. For the determination of a balance we used a point scale with lower differential capability, i.e. from 1 to 5 where 5 points mean a basic criterion and 1 point less important criterion (table 1).

Table 1
Determination of a criteria balance using a point scale

Criterion	P	V	N	K	C	E	Total
Number of points	5	3	3	5	3	5	24
Norm balance	**0,208**	**0,125**	**0,125**	**0,208**	**0,125**	**0,208**	1

The key: P *the number of sheltered persons,*
V_U *the advantages of the arrangement,*
N_U *the disadvantages of the arrangement,*
K_O *protective coefficient,*
C *time consumption of building-up,*
E *economy assessment.*

After the determination of a criteria balance we can start multi-criteria evaluation of variants. In this phase of evaluation all variants were put through individual criteria. When evaluating separate criteria the variants were compared to each other and the best variant got 3 points, the other variant 2 points and the last one got 1 point. Subsequently these values were multiplied by a determined balance and summarized for the final evaluation. The variant which gained the most points is considered the most suitable and vice versa. The results of multi-criteria evaluation of variants are introduced in table 2.

Table 2
Multi-criteria evaluation of variants using a norm balance

Variants	Criteria						Number of points
	P	V	N	K	C	E	
Variant 1	$2 \cdot 0{,}208$	$2 \cdot 0{,}125$	$3 \cdot 0{,}125$	$3 \cdot 0{,}208$	$3 \cdot 0{,}125$	$3 \cdot 0{,}208$	**2,664**
Variant 2	$1 \cdot 0{,}208$	$1 \cdot 0{,}125$	$2 \cdot 0{,}125$	$1 \cdot 0{,}208$	$2 \cdot 0{,}125$	$2 \cdot 0{,}208$	**1,457**
Variant 3	$3 \cdot 0{,}208$	$3 \cdot 0{,}125$	$1 \cdot 0{,}125$	$2 \cdot 0{,}208$	$1 \cdot 0{,}125$	$1 \cdot 0{,}208$	**1,873**

According to the results of multi-criteria evaluation we can start the prioritization of individual variants and their classification from the most to the least suitable one. The results of multi-criteria evaluation of spaces suitable for sheltering of population in the basement of a panel house GOS Bichler are as follows:

- Variant 1
- Variant 3
- Variant 2

OPTION OF A SUITABLE IMPROVIZED SHELTER

Regarding the above mentioned results, the variant 1 was chosen for the proposal of an improvized shelter especially due to simpler implementation for the population and a shorter time for readiness. Its advantage is a higher protective coefficient which means lower probability of the contamination of the organism of sheltered persons. At the same time it is necessary to recall that this variant has lower capacity and a lower level of social background. For the building of this variant of improvized shelter in the basement of a panel house we will need to take the following measures according to methodic guidelines:

- reinforcement of ceiling construction,
- construction of a ventilation system and windows materialization,
- doors materialization,
- building of escape breakthroughs.

Reinforcement of ceiling construction

The construction system of a house GOS Bichler is composed of not pre-strained reinforced concrete pre-fabric panels which are joined by scalding of the reinforcer and consequent cementing by cement mixture. The assessed house is formed by a traverse bearing system with shiplap cladding, one section of a house is usually formed by the modulus of the span of 3.6 m. The house G OS Bichler has ceiling constructions made of reinforced concrete heavy panels of modulus lengths and widths. Construction height of a cellar floor is 2.6 m and the width of ceiling panels is 15 cm. According to a technical norm [15] the load of ceiling construction for common situation is 8.9 kN·m^{-2}. In case of the crash of a part or the whole building, there will be a substantial growth of the load on ceilings of basement rooms. Almost the eight-time increase of values of loading on ceiling constructions is estimated, therefore up to 72 kN·m^{-2} [16]. The ceiling construction is not capable to sustain such loading and therefore it is necessary to reinforce the ceilings appropriately.

One of the ways how to reinforce them is to reinforce the ceiling constructions with the backing from wood beams of the square cross-section with the edge of 16 cm bound with carpenter cramp irons of the size 10/280 mm. The pillars must be put on bearing boards of the width of 30 mm and must be chocked up against the release (see fig. 5, left side). For IU-2 and IU-3 with a ceiling ground plan surface of 19.04 m^2 it will be needed 6 pieces of wood pillars 16/16 cm evenly distributed on the surface of a room. For better distribution of the tension it is necessary to insert a wood supporting joist of 16/16 cm. In the traversal direction the pillars on the level of supporting joists must be strutted into adjacent walls (see fig. 5, right side).

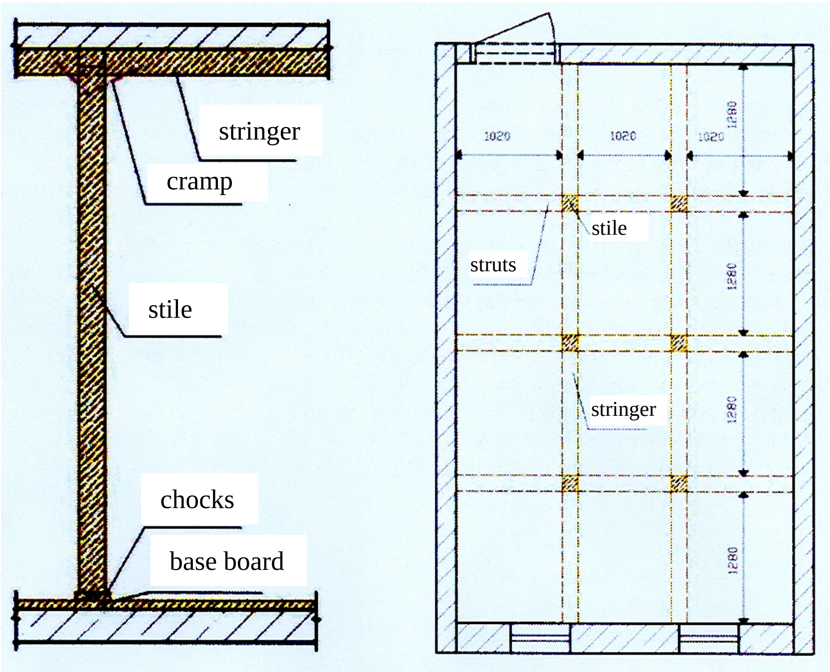


Fig. 5
Reinforcement of ceiling construction

Construction of a ventilation system and windows reinforcement

Windows reinforcement will be solved within the construction of a ventilation system through the strengthening using curbs from pavements and a support wall made of unhanging doors strutted by curb stiles which will be partially imbedded into the ground. The space between a support wall and curbs applied to a window will be filled up with soil which will be available from the nearby grassy surrounding. From the inner side the window space can be filled up with insulation material such as e.g. thermal insulation of a panel house or polystyrene and a sticking tape.

Construction of a ventilation system in each of four rooms of an improvized shelter will be made with forced ventilation. This ventilation system will be made of novodur pipes of a circular section. The pipes are of a minimal required diameter 20 cm [4]. Sealing of seams around the pipes will be made with silicon glue. Forced ventilation will be provided by a responding ventilator charged from the auto battery. During the selection of a suitable ventilator we have to take into consideration the volume of sheltering space and a total number of sheltered persons as well as the capacity of a used auto battery.

Each room has two small windows whereas one window will be used for the ingoing ventilation chimney and the second for the outgoing ventilation chimney. The ingoing chimney of the ventilation will have the inflow opening placed minimally 1,5 m above the ground level and the outflow in the improvized shelter in the height of 50 cm from the shelter floor (see fig. 6, left side). The inflow opening of the outflow chimney is 25 cm from the shelter ceiling and its outgoing must be minimally 2 m above the inflow opening of the ingoing ventilation chimney (see fig. 6, right side). The openings of ventilation chimneys in the improvized shelter are equipped with the cover and outside the improvised shelter equipped with a strainer to capture rough dirt.

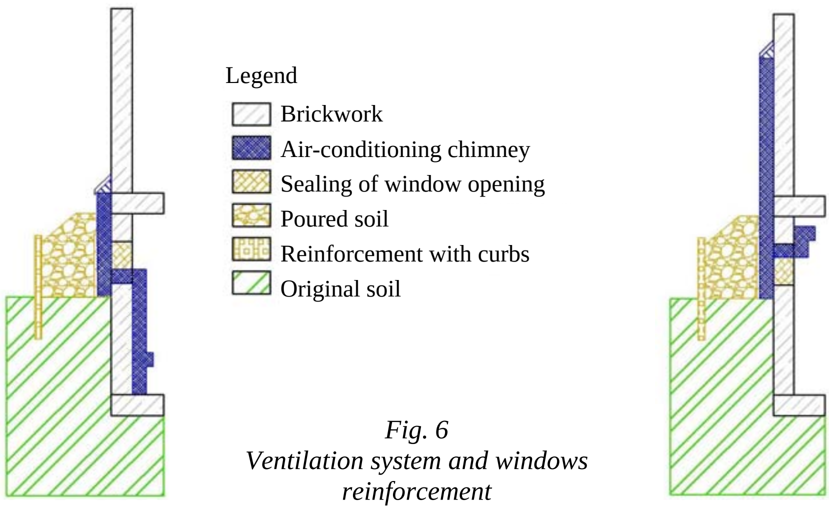


Fig. 6
Ventilation system and windows reinforcement

Doors reinforcement

For the readiness of an improvized shelter it is necessary to materialize the doors, to secure against their opening due to the effects of a blast wave and sealing of seams. This materialization is carried out especially due to potential load of doors with under-pressure from the outside caused by a blast wave. During the reinforcing of doors of improvized shelters we differ if the door opens towards the shelter or outwards.

In three rooms of the improvized shelter (IU-2, IU-3 and IU-4) the door opens outwards the shelter. The materialization of this door from the inner side is ensured by concreting the threshold of the height minimally 5 cm. From the outside of the door the wood boards of 200x20x8 cm are topped up in a vertical direction. Their adhesion is enhanced by topping up three boards in the "Z" shape (see fig. 7, from the corridor to the shelter). To ensure the opening of the doors against the under-pressure we place from each side up to the height of 1/3 and 2/3 of doors wood crossbeams of 10x10x100 cm so that the beams on the inner and outer side form a couple (see fig. 7, from the shelter into the corridor). Then these couples are joined with the stretching wire (see fig. 7, section). After the closure of the shelter door the wire is stretched and the door seams are sealed especially along their circumference using a sticking industrial tape.

From a corridor to a shelter | From a shelter to a corridor | A section

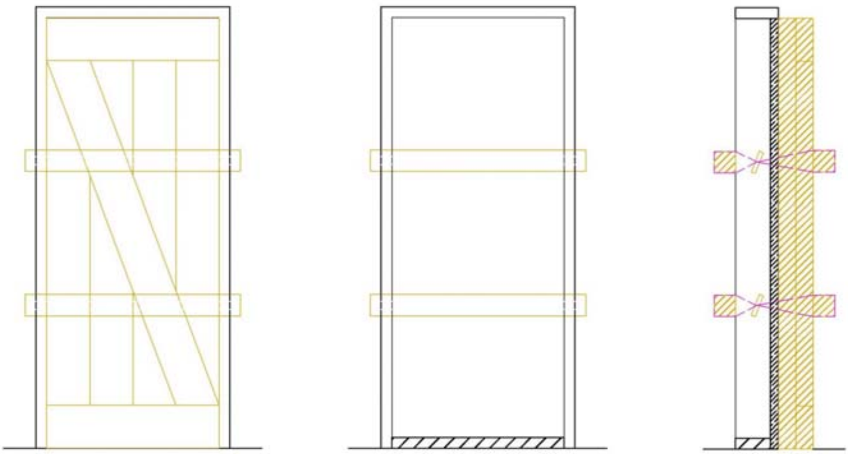


Fig. 7
Doors reinforcement

The IU-1 room door where the door opens towards the shelter we materialize in the same way as in the previous case, therefore we fasten the boards.

Only the security against the opening because of the effects of the under-pressure is different. From the inner side of the shelter up to the 1/3 and 2/3 height of the door we nail the hooked nails so that we might put into them the wood crossbeams of dimensions 10x10x100 cm. Wood beams are here to work as a crossbar. With this way ensured doors we have to, at the end, seal the seams using sticking industrial tape as in the previous case.

Building of escape breakthroughs

The breakthroughs for escape ways are cut in the height of 45 cm from the floor and their dimensions are 60 cm wide and 80 cm high. For static security it is necessary to set a lintel of a minimal length 100 cm. At the end the breakthrough is bricked in with two rows of bricks where each is minimally 15 cm wide. The lime mortar is used as the glue. The brick-in will be set into the opening with the outer overlap 2-3 cm. In order to ensure the gas tightness, the construction adjustment is plastered using the color for differentiation. The points of the breakthroughs are marked in the ground plan with the violet color (see fig. 8). The breakthrough no. 2 leads to a neighboring cellar box and then to a cellar corridor, similar as the breakthroughs no. 3, 6 and 7. The breakthrough no. 4 interconnects the room of the improvized shelter no. 2 and no. 3. From the room no. 3 leads another breakthrough no. 5 which goes to a neighboring room.

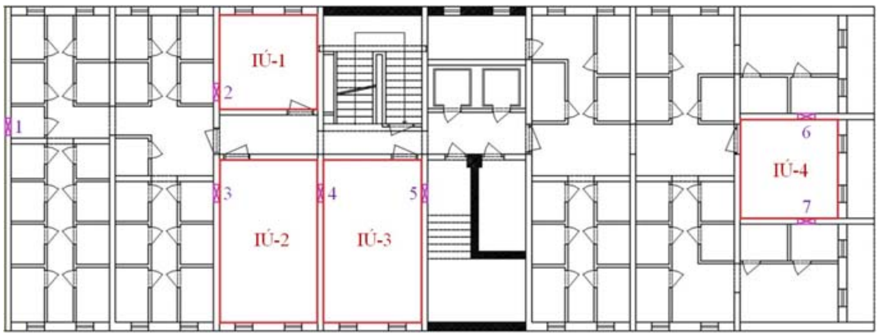


Fig. 8
Graphic illustration of escape breakthroughs

Comparison of protective coefficient with economy evaluation

After the implementation of suggested measures we achieved expected increase of protective coefficient which was calculated the same way as the values K_O before the adjustment. The comparison of values before and after the adjustments is in table 3.

Table 3
Comparison of the value of protective coefficient before and after the adjustments

Room	Value K_O before adjustment	Value K_O after adjustment
IU-1:	71,97	268,93
IU-2, IU-3	107,55	278,36
IU-4:	73,58	268,93

The material and work costs necessary for the construction of a chosen variant of an improvized shelter are in table 4. The table shows that the material costs amount about 41.000,- Czech crowns whereas this amount is final provided that the inhabitants built this improvized shelter by self-help including demolishing and brick work. The final price does not include the improvized shelter equipment costs and the costs of the tools used during its construction.

Table 4
Material costs necessary for improvized shelter construction

Type of material	Number of pieces	Use	Place of use	Orientation price/ps	Price for material total
Curbs 80x250x1000	20	windows reinforcement	IU - 1	0	0
Doors 800x1900	4	windows reinforcement	IU - 1	0	0
Polystyrene insulation 60x60	1	windows reinforcement	IU - 1	0	0
Bricks 290x140x140	20	breakthroughs	IU - 1	16	320
POROTHERM lintel 7 Length 100 mm	1	breakthroughs	IU - 1	180	180
Boards 0,2x0,08 4 m	5	door reinforcement	IU - 1	290	1450
Nails 1 kg 60 mm	1	door reinforcement	IU - 1	8	8
Hooked nails	8	door reinforcement	IU - 1	2	16
Wood joist 10x10 2 m	1	door reinforcement	IU - 1	100	100

Carpet sticking tape, width 48 mm, length 10 m	2	door sealing	IU - 1	29	58
Wood joists 16x16 4 m	8	ceiling reinforcement	IU - 1	540	4320
Cramps 10/280	70	ceiling reinforcement	IU - 1	21	1470
Pipes S 5 (PN 10) DN 20x2,2 4 m	3	ventilation	IU - 1	20	60
Ventilators	2	ventilation	IU - 1	0	0
Auto batteries	2	ventilation	IU - 1	0	0
Curbs 80x250x1000	20	windows reinforcement	IU - 2	0	0
Doors 800x1900	4	windows reinforcement	IU - 2	0	0
Polystyrene insulation 60x60	1	windows reinforcement	IU - 2	0	0
Bricks 290x140x140	40	breakthroughs	IU - 2	16	640
POROTHERM lintels 7 length 100 mm	2	breakthroughs	IU - 2	180	360
Boards 0,2x0,08 4 m	5	door reinforcement	IU - 2	290	1450
Nails 1 kg 60 mm	1	door reinforcement	IU - 2	8	8
Ledges	4	door reinforcement	IU - 2	80	320
Zink-coated wire 5.00 42 1 m	4	door reinforcement	IU - 2	15	60
Wire clamps ZB 5 mm	4	door reinforcement	IU - 2	2	8
Wood joist 10x10 2 m	1	door reinforcement	IU - 2	100	100
Carpet sticking tape, width 48 mm, length 10 m	2	door sealing	IU - 2	29	58
Wood joists 16x16 4 m	12	ceiling reinforcement	IU - 2	540	6480
Cramps 10/280	100	ceiling reinforcement	IU - 2	21	2100
Pipes S 5 (PN 10) DN 20x2,2 4 m	3	ventilation	IU - 2	20	60

Ventilators	2	ventilation	IU - 2	0	0
Auto batteries	2	ventilation	IU - 2	0	0
Curbs 80x250x1000	20	windows reinforcement	IU - 3	0	0
Doors 800x1900	4	windows reinforcement	IU - 3	0	0
Polystyrene insulation 60x60	1	windows reinforcement	IU - 3	0	0
Bricks 290x140x140	20	breakthroughs	IU - 3	16	320
POROTHERM lintel 7 length 100 mm	1	breakthroughs	IU - 3	180	180
Boards 0,2x0,08 4 m	5	door reinforcement	IU - 3	290	1450
Nails 1 kg 60 mm	1	door reinforcement	IU - 3	8	8
Ledges	4	door reinforcement	IU - 3	80	320
Zink-coated wire 5.00 42 1 m	4	door reinforcement	IU - 3	15	60
Wire clamps ZB 5 mm	4	door reinforcement	IU - 3	2	8
Wood joist 10x10 2 m	1	door reinforcement	IU - 3	100	100
Carpet sticking tape, width 48 mm, length 10 m 48 mm, length 10 m	2	door sealing	IU - 3	29	58
Wood joists 16x16 4 m	12	ceiling reinforcement	IU - 3	540	6480
Cramps 10/280	100	ceiling reinforcement	IU - 3	21	2100
Pipes S 5 (PN 10) DN 20x2,2 4 m	3	ventilation	IU - 3	20	60
Ventilators	2	ventilation	IU - 3	0	0
Auto batteries	2	ventilation	IU - 3	0	0
Curbs 80x250x1000	20	windows reinforcement	IU - 4	0	0
Doors 800x1900	4	windows reinforcement	IU - 4	0	0
Polystyrene insulation 60x60	1	windows reinforcement	IU - 4	0	0

Bricks 290x140x140	40	breakthroughs	IU - 4	16	640
POROTHERM lintels 7 length 100 mm	2	breakthroughs	IU - 4	180	360
Boards 0,2x0,08 4 m	5	door reinforcement	IU - 4	290	1450
Nails 1 kg 60 mm	1	door reinforcement	IU - 4	8	8
Ledges	4	door reinforcement	IU - 4	80	320
Zink-coated wire 5.00 42 1 m	4	door reinforcement	IU - 4	15	60
Wire clamps ZB 5 mm	4	door reinforcement	IU - 4	2	8
Wood joist 10x10 2 m	1	door reinforcement	IU - 4	100	100
Carpet sticking tape, width 48 mm, length 10 m	2	door sealing	IU - 4	29	58
Wood joists 16x16 4 m	8	ceiling reinforcement	IU - 4	540	4320
Cramps 10/280	70	ceiling reinforcement	IU - 4	21	1470
Pipes S 5 (PN 10) DN 20x2,2 4 m	3	ventilation	IU - 4	20	60
Ventilators	2	ventilation	IU - 4	0	0
Auto batteries	2	ventilation	IU - 4	0	0
Bricks 290x140x140	20	breakthroughs	common spaces	16	320
POROTHERM lintel 7 length 100 mm	1	breakthroughs	common spaces	180	180
MVJ 310 soft lime mortar for hand processing /30 kg - white	3	breakthroughs	common spaces	83	249
Baumit Concrete B 20 40 kg	1	door reinforcement	common spaces	121	121
Silicon glue 310 ml	8	sealing of all seams	all spaces	70	560
Total material costs					**41054**

[Note: *Material without the price per unit will be obtained from local sources (e.g. curbs or pavings will be taken from the pavements in front of a building).*

CONCLUSION

Improvized shelters are built to protect the population against the effects of luminous and thermal radiation, initial radiation, contamination by radioactive dust and in part against blast effects of the weapons of mass destruction or against the fall of debris, effects of splinters and burning objects in case of the state of emergency, jeopardy of the state or the war state. Due to the fact that in the Czech Republic permanent shelters are being gradually discharged from the registration, it is necessary to ensure protection of population against the above mentioned threats. With this view we elaborated the submitted article which documents that building of improvised shelters in a panel built-up area (which represents one third of all building-up in the CR) is in case of the need financially and materially feasible. At the same time it documents the capability of the population, especially in urban agglomerations timely and adequately react to the impacts of the above mentioned threats.

Building of improvized shelters does not cover from the capacity viewpoint 100 % inhabitants living in buildings, therefore before their construction it is necessary to assess important criteria such as the number of floors, disposition of the arrangement and floor area of cellar spaces. The most suitable space for the building of improvised shelters are generally the basement or cellar spaces of buildings in the middle wing of a facility with the deepest imbedding against the surrounding terrain. Suitable spaces are also cellars with vaulted or reinforced concrete ceilings with thick external walls with the smallest surface of all window openings.

In the Czech Republic almost one third of all inhabitants live in a panel built-up area. This type of building is significantly diversified because the construction was carried out in individual regions in various periods and with different intensity. The largest number of panel houses is especially in Moravia-Silesian region, Ustecky region and the capital city Prague. The most numerous type of a panel built-up area in Ostrava is the type GOS which covers 28 % the total built-up. Following the chosen criteria we chose and elaborated the most suitable variant of the improvised shelter for this type of the panel built-up. This variant can seat 60 persons (i.e. 50 % of the inhabitants of a twelve-floor panel house) and ensures a high protective coefficient of the construction. The material costs necessary to build this variant amounts about 41.000 Czech crowns. Pursuant to this fact we can say that the costs per person reach approx. 700 Czech crowns. The improvized shelter built this way is capable at least in part protect the sheltered persons against the effects of the above mentioned threats; however, the time needed for its construction is estimated from 3 to 5 days. Within this paper we also elaborated a script of an improvised shelter which is available at the authors.

Connection to a project

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NOTES:

[1] At present the matter of the calculation is not solved through any norm or guideline within the Fire and Rescue Service of the CR. For the calculation we can use the military regulation CO-6-1 "Preparation, projection and construction of anti-radiation shelters" which was, however, already cancelled by the Ministry of Defense of the CR.

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