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DEVELOPMENT AND TESTING OF RESCUE DESTRUCTION CHARGES FOR THE DEMOLITION OF STATICALLY UNSTABLE BUILDINGS

Due to the industrial accidents (the effects of explosion of improvised explosive devices or gas) or other unexpected events, heavily damaged buildings represent threat to environment. Generally, their damage is so serious that their reconstruction is not considered and the only solution is a demolition. Advantageously emergency shaped explosive charges can be used in these risk situations of buildings that are beyond repair. With such shaped charges is possible to execute a fast and effective implosion of an unstable building without the posing any threathening effects on surrounding, mainly in urban areas. This papers is focused on the design and development of mentioned shaped explosive charges, their testing in the field test and practical applications.

Keywords: *rescue destruction charge, statically unstable building, shock wave, Semtex*

1. Introduction

One of the possible approaches for the demolition of the building without threat to persons is using the cumulative shaped charges. Strength of used construction materials and elements can be decreased for about 30-60 % due to the buildings disruption. Such values can be obtained only by professional estimation and practical skills of structural engineers. Using of explosives charges in the weakened part of building is related to the knowledge of explosion effects, structural system of a building and the resistance of used materials. The development of shaped charges is an aim of the project "Development of rescue destructive charges for liquidation of static disrupted buildings". During the realisation of the mentioned project specialised departments of Fire Rescue Service of the Czech Republic will have a possibility to demonstrate a demolition of dangerous buildings using direct, effective and quick method of rescue destructive charge (RDC).

2. Shaped charges

The medium, using the explosive cumulated into the high pressure flow, is in the front part of the straight section. In the back part of a charge e is placed an imitated volume of water in the so-called "plug area", enabling the higher effect of the working beam and creating the water fog in the back space of the charge. Such a fog eliminates inflammation of easily flammable objects and dampens the blast wave in the zone. With such an approach, damage to surrounding objects and buildings is eliminated [1], [2], [3].

2.1 Mass accelerating with explosion

When a brisant explosive explodes, created gases would propagate in all the directions, specifically influenced by the shape of the charge. The higher detonation velocity is, the directional effects are more prominent. The created gases have a tendency to propagate more quickly from the places with the higher concentration of explosives. By creating the adequate cavity in a brisant explosive charge, the flows of gases can be directed in such a way that they are unified in a compact flow and so it would be possible to obtain flow with high speed response to immense accumulation of energy (see Figure 1) [4], [5], [6].

2.2 System of sequentially time shaped charges

System of sequentially time shaped charges is an alternative method developed for ice breaking in the rivers and which could

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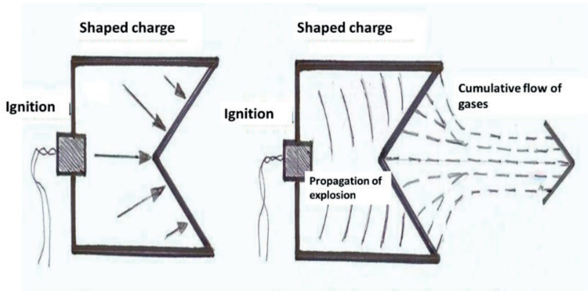

Figure 1 Creating of cumulating flow of gases generated by explosion [5]

Figure 2 Detasheet explosive Semtex Pl SE

Figure 3 Industrial Perunit E - Ø28 mm

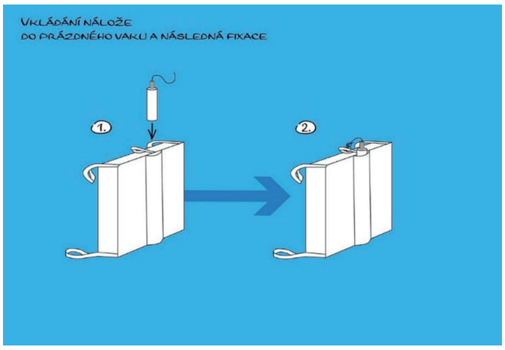

Figure 4 Bag placement and fixing of explosive

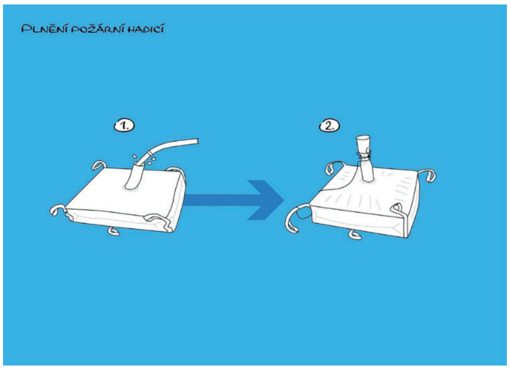

Figure 5 Bag filling with water

be even optimally used for demolition of damaged buildings. Design of technical solution arises from the use of exactly timed charges placed on the ice surface. For the arising of explosive effect of ice surface, the charges are plugged in the upper part by textile water bags. Such a method is not as effective as using of explosive under the ice, but the effect of such modified charges is remarkably higher than that of the freely placed explosive charges. The main advantage of the proposed procedure is that the water bag absorbs the explosive energy from the back part, under the charge and minimise the fragmentation of ice. With the exact timing and optimal placing of such determined charges, it is possible to obtain effect of ice layers breaking and to regulate the weight of the freed ice. The system was developed in the security research N°VG20132015117. Described system is composed from three components:

Explosive - for the ice barriers replacement, various industrial or special explosives can be used. The higher brisance helps to smaller fragmentation of ice, the higher work capacity increases the total volume of freed ice mass. The explosive has to be impermeable, capable of initiation and detonation in the diameters to 30-35 mm. From generally used explosives, such conditions fulfil dynamites of small diameter. Another alternative is a special detasheet explosive as Semtex 10-SE, prepared in the form of thin slices.

Two types of explosives (produced by company Explosia Pardubice a.s.) were selected: detasheet explosive Semtex 10-SE with detonation velocity of 7000 m/s and industrial explosive Perunit E with detonation velocity of 5500 m/s, see Figure 2 and Figure 3.

Textile plug bags - construction of textile plug bags was designed with regard to the sufficient resistance for manipulation, filling with water and blast resistance. Their construction allowed: to insert adjusted charge with the ignition into the pocket on the external part of bag, to fixate the ignition system using loop against it losing from the explosive charge when bags are placed or filled with water, Figure 4 and Figure 5.

All parts of bags are made from the soft textile. So, no rigid and sharp debris from bags are present after the explosions. Thanks to the loops at the bag corners, bags can be joined. Such loops are even used for their fixations on the flexible ropes for removing from freed ice mass. The filling sleeve, placed in the centre of the upper side of a bag, can be tied after filling. Bags are produced with the standard volume of 250 litres (Figure 6), square base with the area of 1 m^2.

Figure 6 *Photo of textile bags with the volume of 250 litres of water*

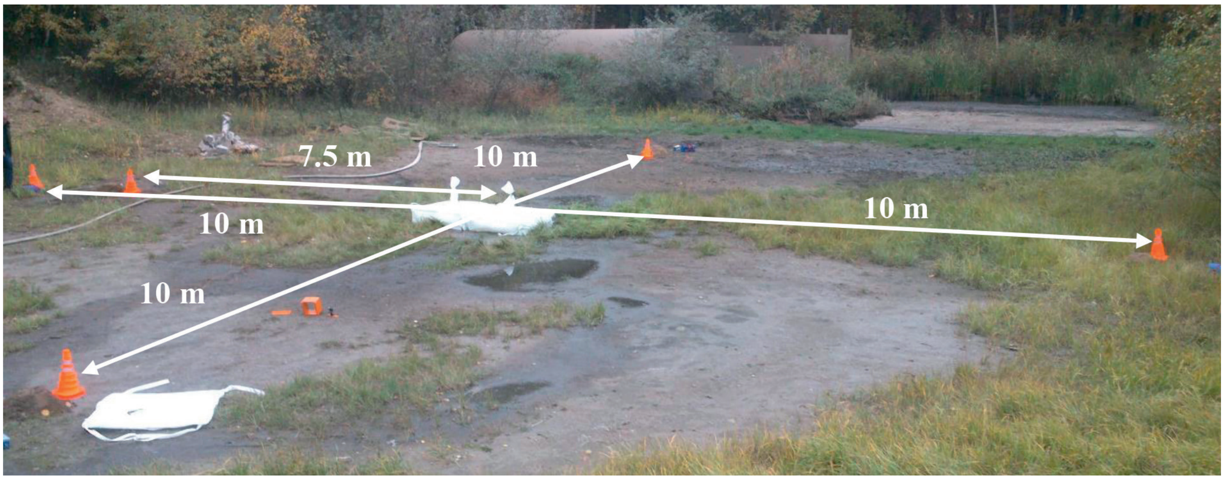

Figure *7 Disposition of sensors in seismic tests*

Initiation system - as an initiation system, an electrical or nonelectrical ignition can be used or even a timed electronical initiation system. From the point of view of the possibility to programme any initial time sequence, in practical cases is advantageous to use system of variable electronic timing. For longer times, with the smaller precisions of timing in the interval from 25 ms to 75 ms, electronical ignition was used. Initial times were chosen with regard to the maximal seismic effect by using of charges at determined distances.

3. Seismic measurements of the system effectiveness

Seismic measurements of the system effectiveness were conducted by companies_Austin Detonator s.r.o. and Geodyn, spol. s.r.o., with the system of seismographs type Instantel MiniMate plus, BE 7901, 9146 and 13846. Four perpendicular directions were measured with first charge in the centre (see Figure 7). Acoustic pressure was measured by a linear microphone with weighting filter. Sensors were placed at a distance of 10 m from the first charge and in the direction of timing sequence a complementary sensor at a distance of 7.5 m was placed. Two shaped charges were always set off with the determined timing sequence.

Total energetic effectiveness is displayed in Figure 8.

The total effective energy of explosion was obtained with the value of 19.17 $(mm/s)^2$ and in the second case of 8.38 $(mm/s)^2$. With the increase in the distances from charges and with the higher timing, resulting value of energy is more shattering than summing (see Figure 8).

4. Practical use of developed system

Use of the presented system of sequential charges is variable in practice. The fundamental advantage is that it can be prepared on the river bank, transferred to the ice surface and filled with water. Possible placement and timing sequence of initial system is shown in Figure 9, where*, czech word "řada" means row, positions of bags*.

Time sequence of charge explosion (Figure 10) shows a minimal secure space for practical use.

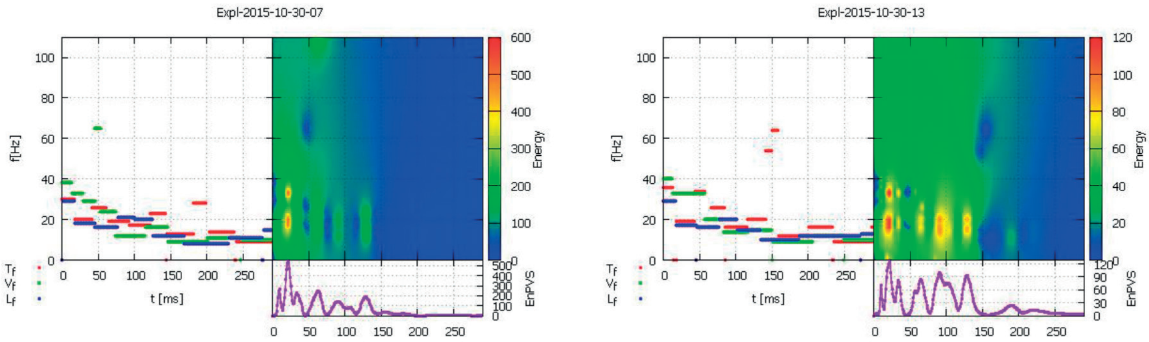

Figure 8 *Energetic effectiveness of measurements dependent on the time and frequency of seismic waves vibration*

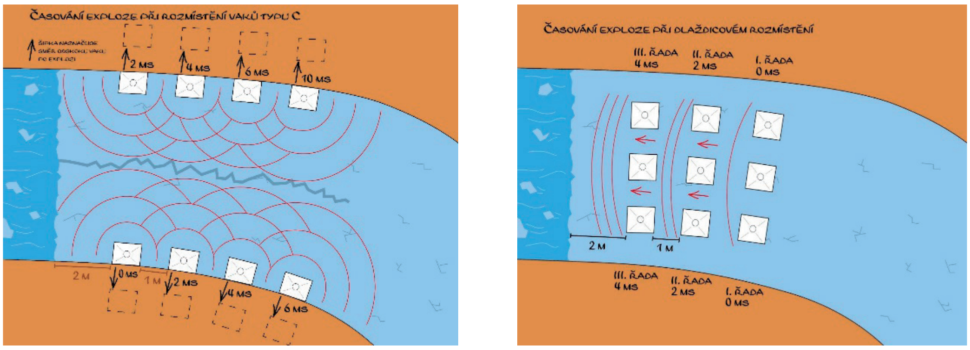

Figure 9 *Placement of charges for freeing of ice mass - along the river bank (left) and in the river bed (right)*

Figure 10 *Time sequence of charge explosion - 3 water bag placed*

a) *b)* *c)*

Figure 11 *Field tests a) position of charges b) cracks on concrete slabs c) destruction of samples*

Other practical test realisation was made in simulated conditions in the block of flats. Charges where placed at the concrete floors (see Figure 11). Similar test were conducted by Stoller [7], [8].

The force of accumulated energy is demonstrated in the Figure 12, where a cut of steel floor bars is registered.

Figure 12 Detail of cut steel bars in the floor slab

Figure 13 Test of the explosion regularity of Semtex 10-SE, t = 5.236 ms

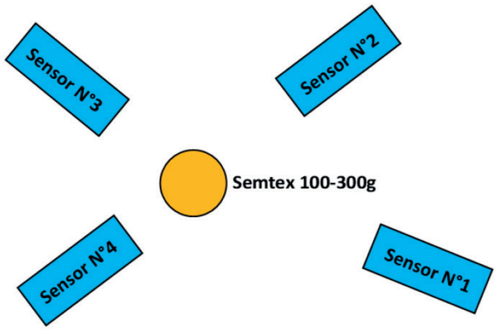

Figure 14 Disposition of blast sensors used in field test

Table 1 Stand-off distances (from the source to blast sensors)

Sensor N°	1	2	3	4
Distance (m)	5	4	3	2

Described method of shaped charges is possible to use for demolition of buildings. Problem of the fixation of huge water bags in perpendicular direction has arisen. Due to this difficulty, security research project was initiated, where charges with smaller dimensions were taken into account.

5. Development of rescue destructive charges

The rescue destructive charge (RDC) are based on the method described above. The plastic explosive Semtex 10-SE is convenient to use it for experiments, since it is easy to work with. It is produced as detasheet explosive with the thickness of 2 mm, width of 300 mm and length of 10 metres. It is in a sticky form and can be easily placed on any shaped cavity. Its detonation capacity is stable and regular in all directions (see photo in Figure 13).

6. Experimental test results

The propagation of blast wave was measured in the preliminary tests. Maximal pressures, created by plastic explosive Semtex 10-SE in the form of a sphere, with the weight of 100, 200 and 300, were measured. Disposition of blast sensors are shown in Figure 14; dimensions are listed in Table 1.

For practical realisation of the field test a prototype of cumulative shaped charge was realised. The test had to confirm if the water beam was adequate for demolition of selected building elements. Test had to confirm the effectiveness of water mass for elimination of blast wave in the back area of the charge. As a charge, the following wrapping was used (see Figure 15):1 is an area for cumulative cavity for water mass, 2 an explosive Semtex fixed on cumulative cavity and 3 the back area of the charge with the plug function.

Two different sizes of cumulative shaped charge were constructed - with the volume of 5 and 10 litres of water. Figure 16 is documenting the creation of pressure water beam in the front part of the charge with the velocity of 620 m/s.

7. Conclusions

Based on the above facts, one can conclude that the development of special rescue destruction charges and their

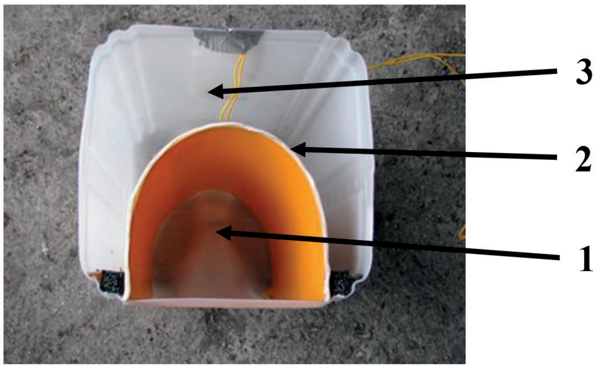

***Figure 15** Body of cumulative shaped explosive*

practical implementation are substantially complemented by a range of means for the safe disposal of statically degraded buildings. The benefits are:

- Simple construction - one solid element, consisting of two separate parts, is equipped with an initiator explosive and is filled with water,
- The charge is placed on walls of the building very quickly as a load, without drilling holes in its skeleton,
- The transport time, composition and activation on site are very short,
- The production of segmented canisters is not complicated,
- It does not contain metallic elements and therefore there is no risk of fragmentation with metal fragments,
- Fragmentation of plastic debris using improvised IEDs occurs within a maximum of 5-8 meters,
- The back plug canister has adequate volume of water to create sufficient water mist to suppress the fire and heat effects of an explosion, thereby avoiding secondary fires and at the same time suppressing the impact of the blast wave spreading to the back part of IEDs, which would not endanger the surrounding objects.

a)

b)

***Figure 16** Test of improvised water charge: a) volume of 5 l in t = 0.6 ms b) volume of 10 l in t = 1.5 ms*

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