COMPARISON OF THE EFFICACY OF HOMEMADE AND INDUSTRIALLY MADE ANFO EXPLOSIVES AS AN IMPROVISED EXPLOSIVE DEVICE CHARGE

More than 95% of all the terrorist attacks are carried out using the ANFO explosives. The ANFO explosives are explosives made from ammonium nitrate and fuel oil. They can be in three different variants (ammonium nitrate with oil, ammonium nitrate with oil and aluminium powder or ammonium nitrate with oil and TNT). This paper describes analysis of the field test results of ANFO explosives of different types. The efficacy of industrially made and the homemade ANFO explosives is compared and their possible usage in terrorist attacks for the treatment or the damage of critical infrastructure elements is described.

**Keywords:** ANFO explosives, field tests, homemade explosives, industrially made explosives, explosive device charge, critical infrastructure element

1. Introduction

The global threat of terrorism presents a grave security problem in the 21st century. Combating this threat in the coming decades will require constant adjustment of forces, concepts, as well as capacities. Those changes will also affect the issues of protection of persons and property in the civilian environment. Improvised explosive devices (IED) as means of asymmetric threat in the present, as well as in the future, pose significant threat for the democratic states. IEDs are insidious and effective weapons being used by terrorists, alien militants and criminals, primarily for the purpose of crippling or killing people, destroying country’s economy or for instilling fear among the civilians. Their aim is to challenge the legitimacy of governments and their ability to give their citizens freedom and security. Where the democratic processes end, the radical solution begins [1].

More than 95% of all the terrorist attacks are carried out using the ANFO explosives or other type of agents [2] and [3]. After the human targets, elements of the critical infrastructure are the second most important target. The critical infrastructure element can be from one of critical element sectors (government buildings, embassies, traffic nodes - airports, railways and bus stations, banks, hospitals, dams, pipe infrastructure, power or information centers and others). As is obvious from the [4] those elements have greater safety risks and are the objects, the security breach of which can cause extensive damage, not only in terms of protection of human life and health, but also to the economy and to the performance of state functions.

2. ANFO explosives

The ANFO explosive is a widely used explosive mixture. It can be prepared industrially or it can also be made at home very easily.

From the chemical-technological point of view it is possible to differentiate three different versions of the ANFO explosives:

- ammonium nitrate + fuel,
- ammonium nitrate + fuel + powder metal (usually aluminium or magnesium) and
- ammonium nitrate + fuel + wooden powder - delaborated TNT.

Optimal content of diesel or oil in ANFO is about 5.5-6%, in porous AN about 10-11%. Mixture where the fuel content is less than the optimum decreases the energy of the explosion while simultaneously significantly increases the content of nitrogen oxides in products of the explosion. On the contrary, the higher content of fuel leads to an increase in the content of carbon

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uniform size. Prilling tower conditions must enable production of a “porous” prill that will absorb the proper amount of fuel oil (6 percent by weight). High density prills will not properly absorb the fuel oil and blasting performance will suffer [6].

Prilled ammonium nitrate is capable to absorb 11 percent of fuel oil weight. The final explosive characteristics of prepared ANFO depend on the sizes and porosity of prills (on the density). Generally, ANFO with small porous prills has a higher detonation velocity and the higher detonation sensibility [7]. Dense prills are often not detonable, or if initiated, perform at very low rate of detonation [6].

For this research the products DAP - 2, DAP - E (see Figure 2) and POLONIT, manufactured by a of the Slovak company called Istrochem Explosives a.s. Bratislava, were chosen. Their characteristics and the represented type of explosive are given in Table 1. It should be pointed out that all used explosives were fabricated industrially, meeting the standards of the production technology.

**DAP - 2**

The explosive is a mixture of ammonium nitrate, kerosene and dye. The explosive is of loose consistency, red in colour and is used for blasting on the surface, as well as in the underground, without the danger of gas, vapour and dust explosions as a rock mining explosive.

**DAP - E**

The explosive is a mixture of ammonium nitrate, methyl esters of higher fatty acids, vegetable oil and red dye. The explosive is of loose consistency, red-grey in colour and it can be used in blasting operations on the surface, as well as in the underground, in an environment without the danger of gas, vapour and dust explosions as a rock mining explosive.

**POLONIT - V**

The explosive is a mixture of ammonium nitrate, kerosene, charcoal, ground TNT with water-resistant additives. The explosive is of loose consistency, white to yellowish in colour and it can be used in blasting works on the surface, as well as in...
5. Field tests

The field tests were focused on the measurement of the overpressure differences in the homemade and industrially made ANFO explosives. The set of field tests took place at the development and testing set of the Ministry of Defence of the Slovak Republic called Military Technical and Testing Institute Zahorie. They took place in the period from 2011 to 2014. Methodology of the measurement is based on [8]. Maximum overpressure was measured using the blast pressure sensors type 137A23 and 137A24 PCB Piezotronics. The explosive charge was positioned at a wooden base at the height of 1.6 m over the ground, i.e. in the height of human chest. Sensors were placed at the distances of 2, 5, 10 and 20 meters from the source (see Figure 5). Besides the maximum overpressure, the velocity of blast wave and the noise level were also measured.

Figure 2 Ammonium nitrate prill manufacturing [6]

the underground, in an environment without the danger of gas, vapour and dust explosions.

4. Homemade ANFO explosives

These types of explosives are very dangerous for the society. Prices of needed components are very low; the preparation does not require specialised knowledge and components for the preparation are freely available. Described explosives can be made by fertilizer based on ammonium nitrate used for agricultural purposes. Availability of fertilizers and oils (oil, fuel oil, kerosene) is not controlled. A malaxer for the production of chocolate or a concrete mixer can be used as mixing machines.

It is thought that the homemade explosives are not mixed well, made from low quality raw material (nitrogen content), they contain chemical impurities, possibly water and thus one can suppose that their efficiency is 70-90% of standardly fabricated explosives.

Blasting prill, considered a porous prill, better distributes the fuel oil (fuel oil distribution for fertilizer prill is on surface only and for blasting prill goes throughout prill) and results in much better performance on blasting job (velocity of detonation of fertilizer prill is 1829 m/s and of blasting prill is 3353 m/s) [6].

Table 1 Characteristics of industrially made ANFO explosives

<table>
<thead>
<tr>
<th>Explosive</th>
<th>Type of represented ANFO explosive</th>
<th>Explosive velocity [m/s]</th>
<th>Heat of combustion [kJ/kg]</th>
<th>Density [g/cm³]</th>
<th>Explosive pressure [GPa]</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAP - 2</td>
<td>AN+oil</td>
<td>2650</td>
<td>3830</td>
<td>0.65</td>
<td>2.95</td>
</tr>
<tr>
<td>DAP - E</td>
<td>AN+oil+Al</td>
<td>3100</td>
<td>4200</td>
<td>0.65</td>
<td>4.58</td>
</tr>
<tr>
<td>Polonit - V</td>
<td>AN+oil+TNT</td>
<td>4000</td>
<td>5138</td>
<td>0.9</td>
<td>6.93</td>
</tr>
<tr>
<td>TNT</td>
<td>Reference</td>
<td>6800</td>
<td>4200</td>
<td>1.58</td>
<td>18.4</td>
</tr>
</tbody>
</table>

Figure 3 Ammonium nitrate used in the field tests a) sack b) prills
6. Conclusion

The results of the presented field tests as from the field tests conducted by J. Stoller [9], [10] demonstrated the difference between the homemade and industrially made ANFO explosives. The homemade explosives have by 75% lower efficacy than the industrially made ones. It was confirmed that the differences of preparation between explosives (homemade explosives are not mixed well, made from the low quality raw material (nitrogen content), they contain chemical impurities and water, and blasting of charges was 1000 g (see Figure 4). From industrially made ANFO explosives the products DAP - 2, DAP - E (see Figure 2) and POLONIT were chosen. In the case of pure ammonium nitrate there was an uncompleted detonation of the explosive and the portion of ammonium nitrate prills was spread into the environment in the radius of 3.5 m from the explosive source.

The measured data of the ANFO explosives were chosen for the comparison at the distance of 2 m from the explosive source. The maximum over pressure of the homemade and industrially made ANFO explosives, used in the field tests, are shown in Figure 6. From the comparison it is obvious that the homemade ANFO explosives feature the lower efficacy than the industrially made ones. There is a big difference between the different types of industrially made ANFO explosives, which presents three different types of possible ANFO explosives.

Table 2 shows the comparison of average overpressure of industrially and homemade ANFO explosives of the same explosives type from the field tests.

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### Table 2: Comparison of industrially made and homemade ANFO explosives

<table>
<thead>
<tr>
<th>Explosive Type of represented ANFO explosive</th>
<th>Pressure [kPa]</th>
<th>Difference [kPa]</th>
<th>Difference [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrially made ANFO AN + oil</td>
<td>80.9</td>
<td>60.7</td>
<td>75.03</td>
</tr>
<tr>
<td>Homemade ANFO AN + oil</td>
<td>20.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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prills are porous prills, which better distribute the fuel oil) influences the efficacy of the explosive.

When the safety of persons and property is being considered, safety treatment measures are based on the values of industrially made explosives. More than 95 % of all the terrorist attacks are carried out using the homemade ANFO explosives and therefore the treatment measures employed for the protection are sufficient and even overcharged.

References


