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IMPROVEMENT OF INFRASTRUCTURE WORKS BY REMOVAL OF EXPLOSIVE REM OF WAR - CASE STUDY „DENINO BRDO" -

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Abstract: *Throughout history, the territory of the Republic of Serbia has been the scene of a large number of different types of armed conflicts. Remnants of wars are manifested by different types of projectiles (mortars, cluster bombs and mines, grenades - artillery or cannon, artillery-rocket missiles, air bombs) and mines (anti-personnel, anti-tank, anti-ship and mines that were used for mining remains of sunken ships). A significant number of the mentioned ordnances were not activated during use, but remained unexploded on the surface or inside the ground. The consequences of the aforementioned explosive remnants of war are shown through various examples (deaths of the population, damaged roads, impossible work due to the destruction of construction or agricultural machinery, disability among residents, fear, etc.). In the light of today's infrastructure development with the aim of expanding the construction industry, the importance of creating conditions for the safe execution of infrastructure works is growing.*

Key words: *mine action, infrastructure, explosive remnants of war*

1. EXPLOSIVE REMNANTS OF WAR - POSSIBILITIES OF THEIR DETECTION

Over the years behind us, significant progress has been made in removing the explosive remnants of war that are on the surface of the ground. This is evidenced by the successful projects of the Mine Action Centre of the Republic of Serbia.

The issue of explosive remnants of war that are under the surface of the ground requires special attention. Their depth of penetration, under the ground, is conditioned by the type of projectile or bomb, and thus it is conditioned by the configuration of the terrain, the composition of the soil and whether the area has been exposed to flooding, earthquakes and similar circumstances.

The previously mentioned construction works on infrastructure projects are highly dependent on the safety conditions achieved. To this end, extraordinary efforts are being made to create a database with surveys of areas contaminated by explosive remnants of war (ERW). The base was formed on the basis of non-technical survey, which was carried out for many years, and then more precisely defined by certain methods of technical survey.

After detecting a potential danger, the necessary work is started according to the defined Standard Operating Procedure (SOP).

Based on many years of practice, it has been determined that significant successes are achieved by applying magnetic and electromagnetic methods, according to which certain devices function.

Considering the type and scope of work, the procedure for working with ERW suspected to be at depths of up to 4 m will be explained in more detail here. That is why the main goal of this work is to define the principles of functioning of active detection systems in the work with ERW, which is supported by the results of the specific case "Denino brdo".

2. ACTIVE ANOMALY DETECTION SYSTEMS

Magnetic and electromagnetic methods are widely used to investigate anomalies below the ground surface. These can be divided into active and passive methods.

UPEX 740 M belongs to active methods or systems, and is used for the detection or in-depth search of metal objects of large mass and the rapid survey of large areas. Depending on the vegetation, areas of up to 2.5 hectares per day can be surveyed with one device.

UPEX detects ferromagnetic and non-ferromagnetic metals, as well as alloys and is very suitable for locating explosive remnants of war, pipelines, underground landfills, hideouts, shafts and sewers, etc.

The device UPEX 740M works on the principle of the electromagnetic method. It uses an actively generated electromagnetic field to disturbe metal objects. These objects then radiate their own detectable electromagnetic field. The width of the track surveyed by the UPEX 740M device is 2m with the possibility of overlapping the readings of each subsequent track. This method of surveying is applied in order not to make mistakes when surveying the terrain and to obtain more accurate surveying and better quality data processing.

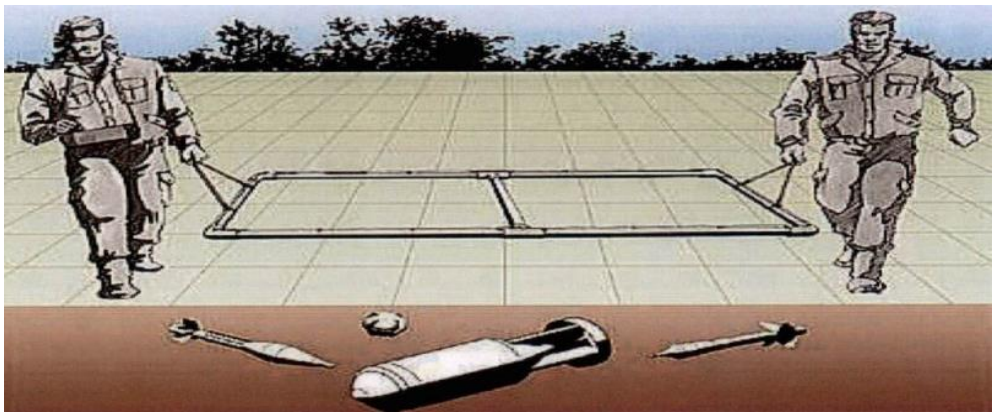

Figure 1. Method of surveying with the UPEX 740m
Source:(SOP Millennium Team)

The surveying depth with the UPEX 740m device is a maximum of 4m below the ground surface. It should be taken into account that the recording depth also depends on the size of the requested ERW, while the maximum recording speed is 10 km/h.

The UPEX 740m device is equipped with the most modern GPS positioning system, the accuracy of which is measured up to 1cm depending on the satellite coverage at the location where it is being worked on.

The data is recorded on a PDA device that is connected to the GPS positioning system and the device itself via a cable or via Bluetooth. Data is recorded on a memory card on the PDA device.

Figure 2. PDA device
Source: (SOP Millennium team)

When the data is recorded on the memory card of the device, it is transferred to the computer and the data is processed. Processing of recorded data is done using EPAS-GPS software.

3. METHODS OF MECHANICAL EXCAVATION OF ANOMALIES

Once a located anomaly is identified as an ERW or an anomaly is suspected to be a potential ERW, excavation of the object is undertaken.

Manual excavation at greater depths requires accurate locating of the target object at the surface level. An assessment of the subject's depth should be made as accurately as possible. Mechanical methods of search and excavation are possible only on a clean and safe surface. Therefore, it must be ensured that the designated area is: declared clean and free from all suspicions and risks of UXO and mines; or that the surface is cleared at least 50 cm below the ground surface before any mechanical activities.

In order to reduce the risk during mechanical excavation, the operator must have special protection when performing the ERW excavation task, that is, armored construction machines must be used. The minimum protective equipment consists of a frontal shrapnel shield covering the lower part of the operator's cabin, including a windshield and additional armor plates covering the lower part of the cabin. The design and level of protection must be in accordance with the standards determined by the competent service.

Standard minimum safety distances of 50m must apply. However, for each object, a damage assessment must be done beforehand using the data obtained from the survey. Based on these assessments, the Project Manager will increase the safe distance and, if necessary, reduce the number of teams working simultaneously.

When excavating certain objects, it is desirable to have a plan of all electrical or other installations that may be located underground on a given project.

Open excavation without supporting structures can only be carried out safely up to a certain maximum depth depending on the characteristics of the soil. Accurate classification of soil types is mandatory before any excavation without support structures. During excavation, the soil should be re-evaluated several times to ensure stability through all phases of excavation.

Trench reinforcement structures used during excavation must meet general safety standards.

When the anomaly is defined as a possible ERW excavation is carried out as follows:

An armored construction machine (excavator) is used to remove soil up to the anomaly. In this case, of course, it is assumed that before this stage, the contractor cleared the land to a depth of 50 cm with metal detectors and removed all anomalies. The removal of soil around the defined anomaly is done layer by layer. Namely, with an armored excavator, the operator removes the first layer of soil and deposits it on a safe, previously inspected surface. In the next step, the deminers, using metal detectors, examine the surface around the previously defined anomaly, and remove smaller signals. Then the armored excavator operator removes a new layer of soil, and so the process is repeated until the anomaly is located. The contractor's task is to define or identify whether an anomaly is a harmless metal object or an explosive remnant of war. If it is an ERW, the contractor is obliged to inform the Mine Action Centre of Republic of Serbia on the same day. The removal and destruction of UXO is organized and carried out by the Competent Service, i.e. the Department for Emergency Situations, in accordance with Article 73, Paragraph 1, Items 3 and 4 of the Law on Disaster Risk Reduction and Emergency Management ("Official Gazette of the RS", No. 87/2018*),* and in terms of Article 25, paragraph 1 of the same Law.

The Mine Action Centre of Republic of Serbia, during the introduction of contractor into the Project, performs checks and test all devices and detectors that will be used on that Project.

4. CASE STUDY IN THE „DENINO BRDO“ COMPLEX

At the request of the City Administration for the Development of the City of Kragujevac, the Mine Action Centre of Republic of Serbia, developed the Project for the clearance of the ERW in the "Denino brdo" complex, number 0229/20, the city of Kragujevac in 2020. The area for clearance was located in the territory of the city of Kragujevac. In view of the planned infrastructure works (construction of water and sewage lines and roads), clearance of the area of 17,870m2, in the "Denino brdo" complex, was required. The Project for clearance was on the site for construction of apartments for members of the security forces. The criteria that were applied during the implementation of this Project were divided into phases:

- 1st phase - clearance up to 50 cm ;
- 2nd phase - clearance up to 3m ;
- 3rd phase - clearance up to 6m.

The task of the contractors in the second phase was to determine the existence of anomalies that indicate the possible presence of ERW up to 3 meters depth by surveying using an active method. Any unexploded ordnance and ammunition regardless of mass, type and caliber was considered a critical error; metal objects weighing 500 grams when phase I of the project was applied, or 50 kilograms when phases II and III of the project were applied.

Quality control was performed on 3% of the cleared area, basically using the same method and type of detector used by the contractor, using the capacities of the Mine Action Centre and the contractor. During quality control, no anomalies defined by the term „critical error“ were found.

The Mine Action Centre carried out the introduction of the contractor, according to phase II of the "Denino brdo" project, on 17.11.2020. years. During the introduction of operational staff, the equipment used by the contractor in this phase of the Project was inspected and introduced. The contractor used the UPEX 740m device to survey the surface up to a depth of 3m.

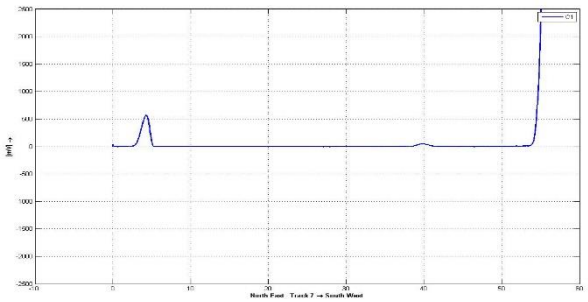

Figure 3. Anomaly identified through data using EPAS-GPS software
Source: (EPAS - GPS software)

To survey the Project area of 17,870 m2, the contractor needed one working day, which is documented by the contractor's daily report of the completed works. After that, the contractor performed the mechanical excavation of the anomalies, with an armored construction machine, while adhering to all safety procedures and distances according to the SOP. The contractor needed 10 working days for the mechanical excavation of the anomalies. During the implementation of the project, the contractor found a total of 11 unexploded ordnances (artillery shells of different calibers). The image below shows the anomaly identified using the UPEX 740m device, which was determined to be an artillery shell after mechanical excavation.

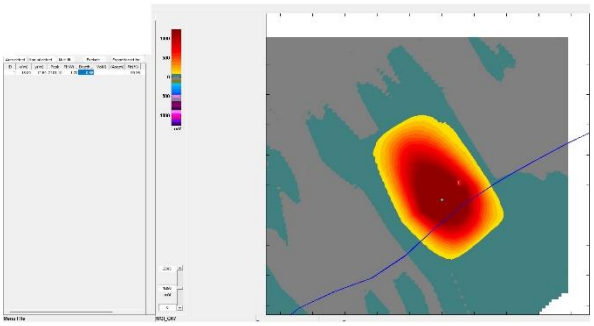

Figure 4. Anomaly identified through data using EPAS-GPS software
Source: (EPAS - GPS software)

The final quality control of the Mine Action Centre was carried out on November 30, 2020. Before the start of the quality control, UPEKS 740m device was checked and tested. By checking the samples, it was determined that there are no missed anomalies that indicate a critical error defined by the Project.

Figure 5. An artillery shell found using the UPEX 740m device
Source: (Final report for the "Denino brdo" project - Millennium team)

The implementation of the Project for clearing the explosive remnants of war in the "Denino brdo" complex, number 0229/20, the city of Kragujevac, i.e. the implementation of all phases of the Project and the removal of found ERW contributed to the removal of the danger posed by explosive remnants of war for the construction of water and sewage lines and roads. The project was viewed as a project of national importance, because its implementation enabled the construction of 216 apartments for members of the security services, out of a total of 972 planned.

5. CONCLUSION

The use of devices for deep detection of explosive remnants of war, in this case active methods - deep detection systems, greatly increases the safety of deminers when performing ERW clearance works, and also contributes to increasing the safety of the local population and creating conditions for safe land use.

Specifically, in the case of the Project for clearing explosive remnants of war in the "Denino brdo" complex, number 0229/20, Kragujevac, the implementation of all phases of the Project contributed to the safe identification and removal of 11 unexploded ordnance. This created the conditions for the continuation of construction works in the "Denino brdo" complex.

Starting from the intensive infrastructural development in the Republic of Serbia, which implies the need for clearing the explosive remnants of war during the construction of roads and factories, then the fact that the Mine Action Centre have in database 150 locations on land that are suspected of being contaminated by unexploded aerial bombs, and about 18,500,000 m2 of surface suspected to be contaminated with unexploded ordnance due to the explosion of municipal warehouses at several locations, the significant location, significant activity of the exploitation system and necessary detective activities in the significant activities of explosive systems are highlighted.

All of the above is supported by numerous examples from practice, where the application of active anomaly detection systems, and through the realization of projects of the Mine Action Centre, created conditions for the safe execution of construction works on projects of the greatest national importance, such as the Project for clearing the ERW from area for construction „Fruskogorski koridor", then the Project for clearing ERW on the Sremska Raca

- Kuzmin section along the planned route of the Belgrade - Sarajevo highway, the Project for clearing ERW at the factory construction site „Linglong“ - town of Zrenjanin, ect.

However, the consequences of war conflicts and the remaining problems associated with the pollution of explosive remnants of war on the territory of the Republic of Serbia indicate the need and necessity for further improvement of the system for deep detection of ERW. Emphasis is also placed on comprehensive training of operational personnel who use these systems in the field and during data processing. Therefore, the Mine Action Centre of the Republic of Serbia, as an entity that coordinates and controls the work of all participants in ERW clearance projects, takes care of the adequate training of the operational staff.

REFERENCES

Law on Disaster Risk Reduction and Emergency Management. Official Gazette of the RS No. 87/2018

Standard operating procedures of the " Millennium Team " company

https://ebingergroup.de/de/