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Methodology for measuring the seismic effects generated by quarry blasting works

Attila Kovacs[1*], *Bogdan* Garaliu-Busoi[1], *Daniela Carmen* Rus[1], *Claudia* Miron[1] , *and Olga* Miclea[1]

[1]National Institute for Research and Development in Mine Safety and Protection to Explosion – INSEMEX Petrosani, Department of Safety of Explosion and Pyrotechnic Articles, G-ral V. Milea Street 32-34, Petrosani, Romania, insemex@insemex.ro

Abstract. Exploitation of useful mineral substances by surface works is an important branch of mining activity. For rocks of low strength or weak aggregation, the method of extraction by mechanical means (excavators of various types, draglines) is successfully applied, but for rocks of medium and high strength, aggregated with or without cracks, or other geological anomalies, the method of extraction generalized exploitation is that by drilling-blasting, using explosives appropriate to the field conditions and correlated according to the technical possibilities and the geometry of the work. One of the major disadvantages to the technologies where drilling-blasting works are applied is the generation of seismic waves, which will propagate after the detonation of the charges. In the common situation, where in the area of operation are civilian or industrial targets, that need to be protected, it is important to monitor these effects by performing seismic measurements and then processing the data to adjust the blasting technique in order to reduce these seismic waves in intensity, but while maintaining adequate performance parameters. The paper presents the methodology based on technical-scientific principles for performing these measurements, applied to surface exploitation.

1 Introduction

The use of explosives in mining is a particularly important aspect due to the significant and low cost growth. The drilling (drilling) and blasting works are based on work technologies that require a multi-criteria design and verification (costs, duration, sustainability, safety of people and goods).

Blasting inevitably leads to adverse effects such as terrestrial or water seismic waves, shock wave air, dust and the generation of toxic explosive gases. Combating these effects as a whole is practically impossible, but reducing them to acceptable levels must be a constant concern of specialists.

Analyzing the seismic effects produced by the blasting works, they must be maintained at safe levels that do not affect (often irreparably) civil or industrial construction structures,

* Corresponding author: attila.kovacs@insemex.ro

infrastructure elements (gas networks, water supply, roads or railway) but and the actual field in operation.

The effects of seismic waves over the limit, generate as a result massive ruptures in the deposit in the exploitation area, cracks or microcracks in rocks, the generation of tectonic effects that can endanger the foundation structure of buildings or infrastructure.

It was found that performing repetitive blasting work in the same area has a cumulative effect in the sense of the appearance of microcracks, cracks or failure of structural elements of the quarry (berms, steps, slopes, access roads) and those of buildings or elements. infrastructure.

The design of blasting technology is a very important activity and with unique applicability as the conditions in practice are very variable both in terms of geology, hydrology, relief, geo-topographic elements, the importance of objectives to be protected [1-3].

2 Design principles from the point of view of seismic safety

The literature recommends calculation principles and briefs for the preliminary estimation of seismic effects that take into account the stated criteria, but the element of unpredictability is present in many situations (geological anomalies, restrictions on access to the area for equipment, etc.) [4].

3 Measuring the effects and validating the seismic safety of the blasting technology

The design of the technology based on the knowledge of the specificities in which the blasting will take place is only a starting point until the validation of the blasting technology in terms of seismic safety [5-7].

The localization of the field monitoring equipment in the area exposed to seismic effects takes place according to a series of criteria in order to create a database that leads to the validation of the applied technology or, if necessary, to its modification and adaptation to have reasonable seismic effects. in the protection zone.

Modern seismic monitoring equipment makes it possible to record the propagation phenomena of seismic waves at the measurement point as a quantified value of a three-dimensional oscillation vector (radial, transverse and longitudinal) which varies in intensity and spatial orientation during the manifestation of the effect, including frequency vibrations, noting that low frequency vibrations (below 4 Hz) at the same intensity (the speed of oscillation of soil particles) are much more dangerous.

Since strikes in a large quarry are performed at relatively short intervals, the maximum seismically usable quantities of explosives are adopted in the engineering calculations by which the seismic rate of oscillation of the soil particles shown in Table 1 is adopted.

The use of explosives to detach rocks from the massif has led to the establishment of practical relationships, which can be applied by designers and professionals to determine the safety distances and maximum explosive loads, with which to work safely against the seismic action of explosions.

Table 1. Scale of the seismic intensity of the vibrations produced by the explosions.

The class of influence	Description of effects	Particle speed v(mm/s)
I	Vibrations are below the limit of human perception and are recorded only by instruments	<2
II	Vibrations are sometimes felt by people in favorable conditions (especially on the upper floors)	2-4
III	The vibrations are felt by some people or by people who are informed about the explosion	4-8
IV	Vibrations are observed by many people there is a rattle of the window panes	8-15
V	Portions of the whitewash are detached; damage to fragile constructions	15-30
VI	Plaster cracks occur; damage to poorly plastered buildings	30-60
VII	Damage occurs to buildings that are in a satisfactory condition such as: cracks in the plaster, falling pieces of plaster, fine cracks in the walls, cracks in stoves and chimneys	60-120
VIII	Considerable damage occurs to constructions cracks in the load-bearing walls and in the resistance elements, large cracks in the partition walls, falling of the chimneys and plaster	120-240
IX	Destruction of the building, ie large cracks in the walls, exfoliation of the masonry, falling parts of the walls, etc.	240-480
X	Great destruction and collapse of buildings	>480

Many developed mining states have developed computational methodologies to assess seismic effects based on both theoretical perceptions and preliminary field assessments, as well as measurements. For example, the United States, Germany or Australia propose criteria for establishing dangerous seismic threshold values with slight differences between the warning or risk limit.

In Romania, unfortunately, a mandatory standard is not regulated, adapted to scientific or technological progress. With the appearance of Law 319/2006, the package of specific regulations for the protection of work was repealed. This is the NSPM code 71 which in the technical prescription PT-E-16 regulated the measurement of the speed of oscillation of the ground and the determination of the quantity of non-seismic explosives.

This standard referred only to a monoaxial wave measurement and without the application of frequency-dependent correction factors.

4 Modern measuring equipment and the procedure applied by INSEMEX in the field based on RENAR accreditation

The procedure applied by INSEMEX describes how to perform in the field the measurement of the oscillation speed of the soil particles due to the blasting works carried out in the mining operations to date.

The method consists in measuring the oscillation speed of the soil particles due to the surface blasting works which have as their object the demolition of useful mineral substances [8-15].

4.1 Measuring instruments

INSEMEX has equipment for the direct measurement of the oscillation speed of the soil particles, on three axial components (vertical, horizontal and transversal) these of the type:
- Nomis seismographs model Mini Supergraph Mini Graph, Nomis seismographs model Mini Supergraph Mini - Graph NCSC 7000 (figure 1).

Fig. 1. Seimograf Nomis MINI SUPERGRAPH II.

- Instantel Minimate Pro4, Instantel Minimate Blaster - (figure 2).

Fig. 2. INSTANTEL Seismografs - Minimate Pro 4 and Minimate Pro 6.

4.2 Apparatus preparation

Preparation of the devices consists of:

- verification of the power supply voltage of the devices and their correct functioning by simulating a seismic event;
- setting the device for the desired measuring range.
- positioning of the devices in the measurement sites established according to the alignments indicated on the situation plans. The location of the field equipment for performing seismic measurements is done after inspecting the field targets and marking them on a topographical map in order to determine exactly the distance from the front to the measurement point (s) both horizontally and making the correction of the difference in the field.

To measure the maximum impulse of the seismic wave, the devices must be set to a sensitivity level at which there are no false signals (car traffic, vibrations from crushing stations or from the flow of the conveyor belt, etc.).

The correct orientation of the sensors must be that indicated on its seat towards the front of the work where the recording is made both visually, if possible, and with a compass, based on the topographic map. The sensor must be positioned horizontally and ensure permanent contact between the bedrock and the sensor support surface. If the bedrock is hard, the sensor must be immobilized with a bag of sand, and if the bedrock is alluvial (clay, fertile soil), the sensor pins must be used, which must be screwed into its body and must be inserted. permeable soil.

Take note of the hour / minute / second in which the explosion is triggered to facilitate the search for the measured value in the device memory.

4.3 Procedure

The working mode for measuring the oscillation speed is as follows:

- identification on the situation level of the blasting location (blasting front);
- the definition on the situation plan of the measurement sites - these will be established in the points of maximum interest, where the lowest value of the ground oscillation speed is allowed, in correspondence with targets located in the area adjacent to the current mining operation , placed at shorter distances from the blasting fronts, on the mediator / direction of the blasting front;
- the placement in the field of the oscillation speed meters, on the previously established places and the placement on the ground in places that do not produce the amplification or attenuation of the oscillation due to rheological and geomechanical characteristics to meet the specifications of the technical manual;
- switching on of the oscillation speed meters before the explosive charges are triggered at a predetermined time difference from the measured event;
- detonation of explosive charges according to the blasting order;
- reading and recording of the oscillation speed of the environmental particles according to the "Register of primary evidences of the measurements of the oscillation speed of the soil particles as a result of the blasting works carried out in the updated mining operations" [16-24].

5 Conclusions

It is necessary to approve at national level a mandatory regulation that allows an objective assessment of the seismic effects generated by the blasting works adopted at the existing level of knowledge and based on existing measurement tools that provide databases with complete information, with the possibility of offering recommendations for the improvement and adaptation of blasting technologies for each career (point of work) of economic agents.

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