Monitoring of Excavation Works Using Modern Measuring Technology

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Abstract

Modern technology plays a fundamental role in the engineering activities undertaken in day-to-day operations, in order to obtain the necessary material for construction or to obtain certain useful materials that are found near the surface. A special contribution of this branch of terrestrial measurements, of the topography, using modern technology, is materialized by specific studies carried out from a preliminary phase of design of the operation and up to the phase in which the perimeter is ecologized. The present article aims to test and evaluate the accuracy of the data for volumetric measurements of exploited material, using modern technology and specialized software based on topographic altitude, with which we will be able to realize the three-dimensional model of the operating perimeter. For this purpose, an exploitation has been chosen on the appropriate surface, materialized through a case study, with reference to the Doman Quarry, Caras Severin, in which we determined the volumes exploited during the activity period.

Keywords: engineering measurements, Leica GS08, volumetric calculation

Introduction

Engineering measurements have an important role in the process of surface mining, supporting the good development of the extraction process, providing indispensable information in the hygienic activities undertaken. The results obtained from the measurement activities in a surface exploitation are quite numerous, we will list only a few of them, the most important ones for the exploitation activity: - realization and updating the topographic situation plans; - making plans and sketches with the working fronts and their modifications; - permanent monitoring and verification of the quarry geometry; - the volumetric calculation of the material to be exploited or one

that has already been exploited (Dima *et al*, 2014; Păunescu *et al*, 2017; Sălăgean *et al*, 2019). New techniques and methods have to be presented in many fields, due to the fact that dynamics are part of our world. The precise acquisition of the measured data regarding the exploitation process that takes place in a career is the key to an efficient and stable maintenance. In other words, this means obtaining an objective evaluation of the working processes, state-of-the-art technologies, up-to-date and the accuracy of the data taken to be reliable. Accurate measurements can be made using GNSS technology. In the last two decades or so, GNSS technologies have become part of the geodesic world. The receivers can be diverse

and can be used for various purposes. Most often, for engineering tasks, RTK receivers are used (Popescu C. *et al*, 2016; Voina *et al*, 2016). The GPS receiver used for the case study is the Leica viva GS08 (Fig. 1) plus with the possibility of real-time measurement with code and phase measurements. The GPS receiver is a dual frequency instrument, with the following technical parameters regarding accuracy, specified by the manufacturer - 5 mm + 0.5 ppm RMS horizontal and 10 mm + 0.5 ppm vertical (Cosarca, 2003; Șuba *et al*, 2017).

Materials and methods

DOMAN deposit - REȘIȚA develops in the left slope of the Doman valley, at its confluence with

the Stârnîc stream at the south and with the Rece stream at the north, at approx. 0.5 km south-west of the municipality of Resita, having a length of about 850 m and a width of 550 m. Administratively it belongs to the municipality of Resita (Fig. 2).

Access to the area is via the national road DN58 Resita-Anina, approx. 1.5 km from the national road the access to the deposit - the quarry being made by an operating road of approx. 600 m.

The area is hilly, with altitudes of up to 400 m, with a difference of level of 120 m, with steep slopes, with inclinations of 40-50°, inclines that lower towards the top, (10-15°). Within the deposit, the land dimensions vary within the limits +325 m to +365 m

Figure 1. GNSS receiver GPS viva GS08

Figure 2. Localization of Doman Quarry – Reșița

Figure 3. Doman Quarry – 3D horizontal descending operating steps

The exploitation of the DOMAN-REȘIȚA deposit was performed by the method of “horizontal descending steps” (Fig. 3).

The exploitation method is the specific one for the mining exploitation in quarries, namely - “mechanical blasting with the help of explosives after the drilling-blasting operations”, characteristic for the surface exploitation of homogeneous deposits of useful rocks, developed at the level of the land with a low sterile/useful ratio (Dragomir *et al*, 2012, Farcaș *et al*, 2016).

The choice of the method of exploitation for the DOMAN - REȘIȚA limestone deposit has been made taking into account:

- the configuration of the deposit, its arrangement;
- geological and morphological conditions;
- deposit thickness;
- tailings thickness;
- the quality of the deposit;
- maximum extraction depth;
- the characteristics and productivity of the machines;
- safety in execution.

The exploitation method used, ensured:

- high productivity,
- the rational exploitation of the deposit,
- safety from the execution point of view,
- optimal possibilities for environmental recovery,
- the possibility of quickly attacking several extraction fronts.

The determination of the volumes in the exploitation of the deposits is an autonomous procedure compared to other works of engineering

character in fact it represents a purpose in itself which requires the collection, processing and interpretation of geospatial data (Popescu G. *et al*, 2016, Sălăgean *et al*, 2016, Solcan *et al*, 2019). Basically, a volume of material discovered or exploited is calculated with reference to a period of time, based on the calculation being information taken in situ, currently processed with the help of specialized software programs. One of the methods used for the volumetric calculation is the prism method, TopoLT, mainly used, being the basis of most computing software programs (Fig. 4).

The method involves a division into triangles or elementary rectangles, which constitute the basis for the infinity of prisms that will represent the studied field (Manu *et al*, 2014). Volume V_i of a straight triangular prism is calculated from the projection surface, the magenta area is shown on the top left (Fig. 4) and the centers of weight of the triangles of the two surfaces defining the volume, located at a distance D_i one from the other (1).

$$V_i = A_i * D_i \quad (1)$$

$$\text{Where: } A_i = \frac{l^2 + \sqrt{3}}{4} \quad (2)$$

And the total volume between two surfaces is given by the sum of all the volumes related to the right prisms in the area taken in the studio (3).

$$V = \sum_{i=1}^n V_i \quad (3)$$

Figure 4. The principle of volume determination of a right triangular prism (left) and the network of triangles (right)

Results and discussion

Measurements were performed using the G.N.S.S. technology, revealing the location and geometrical shape of each existing operating front in the perimeter of the mining surface (Tab.1) .

The points of interest were for the working front, slope up, slope down, quota points for the upper part of the step, and for the lower part (Fig. 5).

Table 1. Delimitation coordinates – 1970 Stereographic coordinates

Point No.	Coordinates		Point No.	Coordinates	
	X	Y		X	Y
1	424.668,904	255.963.127	9	423.685,870	256.098,350
2	424.670,99	256.400,00	10	423.612,868	215.433,835
3	424.600.00	256.470.00	11	423.845,091	255.395,350
4	424.400,00	256.520,00	12	423.740,790	255.980,929
5	424.400,00	256.590.00	13	423.687,304	255.989.277
6	424.200,00	256.600,00	14	433.935,989	256.182,918
7	424.050,00	256.535,00	15	424.305,904	256.154,303
8	423.805.813	256.280,721	16	424.543,949	255.958.898

Figure 5. The points of interest were for the working front

Figure 6. Operating steps - transverse profile

Figure 7. Surface Mining - Doman Quarry

As a result of the exploitation works carried out, within the deposit 4 operating stages are outlined (Fig. 6), with the following technical characteristics:

step IV: upper elevation: +352 to +356 m

- base elevation: +343 to +345 m
- the height of the step: 11-13 m
- slope angle: 85°
- working berm width: 10-15 m
- length of the work front: 100 m

step III: upper elevation: +343 to + 345 m

- base height: +332 to +336 m
- the height of the step: 11-13 m
- slope angle: 85°

- width of working berm: 15-20 m

- length of the work front: 150 m

step II: upper elevation: +332 to +336 m

- base height: +323 to +326 m
- step height: 9-13 m
- working berm width: 15-25 m
- slope angle: 80°
- length of the work front: 130 m

step I: upper elevation: + 323 to +326 m

- base height: + 312 to +315 m
- the height of the step: 11-14 m
- slope angle: 75°
- working berm width: 25-35 m
- length of the working front: 240 m

material volume was the result of calculations made by the specialists in the field, referring to +365 m maximum height of the land, as well as to the minimum height of +270 m, which represents the quota below the quarry floor.

Based on a new calculation of useful mineral resources, carried out in 2003 (Fig. 11), by the method of “vertical geological sections”, a calculation was performed that took into account the quota of the quarry base at that date - the quota of +314.0 m and of the research limit in depth of limestone - quota of +275.0 m, the following amount of useful material exploited by category B (limestone) of 46.096 mc was registered.

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For the date of 01.01.1989, an estimated total volume of sterile material of 280,996.73m³ was taken into account (Fig. 10). The estimated sterile

Figure 8. The updated situation plan for Doman Quarry

Figure 9. The digital model of the land for the Doman Mining Exploitation in 1989

Figure 10. Total volume calculation in Doman Quarry

Fig. 11. Doman Quarry Configuration in 2003 - 3D Model

Figure 12. Doman Quarry Configuration in 2005 - 3D Model

Figure 13. Doman Quarry Configuration at the end of the activity - 3D Model

The volume of useful material exploited in the period 2003 – 2005 (Fig. 12), evaluated from the category B balance sheet reserves, located above the quota +314.0 m., taking into account the coefficient of quantitative transformation K_q -0.97%, represents 36 500 m³.

Following the last balance sheet with the annual reports on the useful material exploited in the Doman Quarry, located above the quota of +314.0 m in the working fronts, in 2009 an exploited volume of 168,000m³ was noted. Starting with 01.01.2009, the exploitation activity within the deposit has been suspended and it has not been resumed until June 2018, the renunciation of the exploitation license and the surrender of the deposit in A.N.R.M. Bucharest.

Conclusion

Regarding the software used, AutoCAD together with TopoLT, both represent the same specialized software range for topographic works, using one of the fastest volumetric calculation methods, easily programmable, containing features that help to make the terrain plans. The prism method has a number of features and options to generate a model and to edit complex, irregular surfaces with higher accuracy. These work software are useful in the area of surface mining topography, especially for the elaboration of the situational plans, in the processing of the terrain data, as well as in the creation of sketches.

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