

USE OF DIGITAL TERRAIN MODELLING IN CALCULATION OF STONE QUARRY VOLUMES TO RENEW THE EXPLOITATION PERMIT

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Abstract: The following project contains a topographical map and a 3D model of a stone quarry, used to renew the exploitation notice. The survey was conducted using a REC ELTA 15s total station using „Free Station” program, combined with GNSS technology to determine topographical points in the area for georeferencing. The stone quarry is located in Zlatna-Pătrângenii area, at JIDOVU peak. The survey was conducted in order to determine the volume of stone material that was exploited in one year and to determine the area of the exploitation site.

Keywords: Digital model, Topographical Survey, Volume Calculation, Informational System, GIS

1. Introduction

The topographic work is carried out at the Andesite Quarry „Jidovu Peak, Zlatna-Pătrângenii”, and it serves the beneficiary for the renewal of the exploitation permit. In the paper I will surprise two topographic plans resulted from surveys made at one year difference to highlight the volume of stone exploited during one year. The volume of exploited material will be determined by the differences in volumes of the two resulting plans.

2. Materials and Methods

Spatial Data Aquisition

This phase is preceded by the topographical works to be performed in order to know the terrain, an imperative stage in determining the working tactics, the morphology of the terrain and the obstacles present in the area, thus creating an effective working tactic. In this phase we make use of the 1:5000 site plans and the establishment of the constituent points of the topographic network in order to identify correctly the location of the area of interest [1], [2].

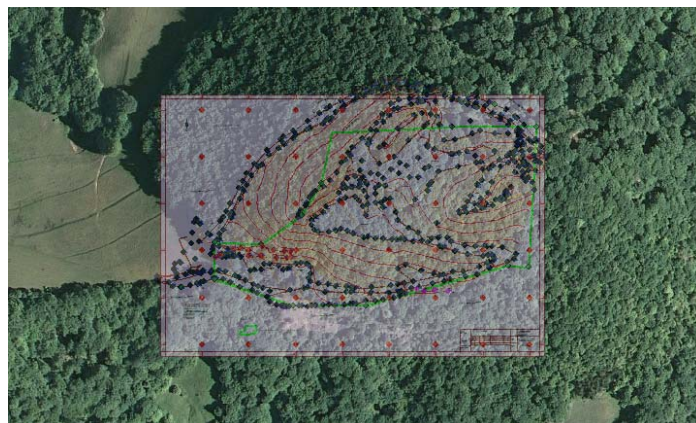


Fig. 1 Identification of the interest area

Design of the topographical network and surveying

The topographical network will be designed in such a way that there are few stationable points and with a clear line of sight to as many detail points as possible. [3]

Marking of points is done by embedding bullets in fixed and time-resistant details. Since the survey is done using „free station” programme, we are not constrained by standing on a known point in coordinates, the points of the topographical network being located on fixed, time-sensitive details that are not subject to alterations (caused by the erosion of meteorological phenomena, and so on)

Coordinates for the reference points will be determined using GNSS technology combined with electrooptical equipment used to measure detail points.

Data Processing

In order to process the data we will follow these steps:

- The transfer of raw data for processing purposes;
- Analytical processing of the land register and obtaining the coordinates of the points of interest;
- Graphic processing and drafting of the topographic map.

The integration stage of the data in the informational system:

In the calculation of the amount of material exploited in order to renew the exploitation permit we shall keep in mind the following aspects [4]:

- Conceptual and logical organization of the database;
- Implementing a physical model in data design and management;
- Determining the domains of attributes in the five standard classes: nominal, ordinal, interval, ratio and cyclic;
- Encoding and validation of fields defining the object of the attribute table;
- The integration of spatial and descriptive data on the basis of conducting CAD-GIS vectoring or conversion operations simultaneously with the population of attribute tables;
- Creation and management of the Land Altimeter Numerical Model (LANM) in the context of highlighting the morphological features of the area under investigation;
- The use of geoprocessing tools in volume determination analysis;
- Elaboration of the final cartographic material in GIS environment

3. Results and Discussion

Topographic Survey

Within this objective, topographic surveys will be made in order to obtain a topographical map that faithfully reflects the situation on the ground, making use of state-of-the-art topographic equipment. [5]

The tools used to perform the survey consists of the REC ELTA 15s total station, with the related accessories, and a UNISTRONG GNSS system for determining the topographical points in the ETRS 89 geocentric coordinate system, to be converted by the transformation module of ANCPPI TransDat.ro, in the Stereo 70` projection system. The measurement

program used is "Free Station" and the measurements were made in polar coordinates.

Data Processing

Data Processing has been realised using specific software specially designed for analytic and graphic processing. Having in mind the importance of graphic information, we will mostly debate this subject [6]. Having said this, most of the processing was done making use of AutoCAD Map 2000i software in the making of the topographical map. Afterwards, using ArcGIS software we obtained the volumes of the two surveys and from their differences we obtained the amount of exploited stone in one year [7].

On the topographical map will be drawn the perimeter of operation (marked with green), set by the beneficiary and the area of exploitation will be calculated using analytical methods. To determine the exact surface, the plan will be reduced to "elevation 0" because the points are characterized by the three spatial sizes (XYZ), and the elevation of points influences the fidelity of surface determination [8], [9].

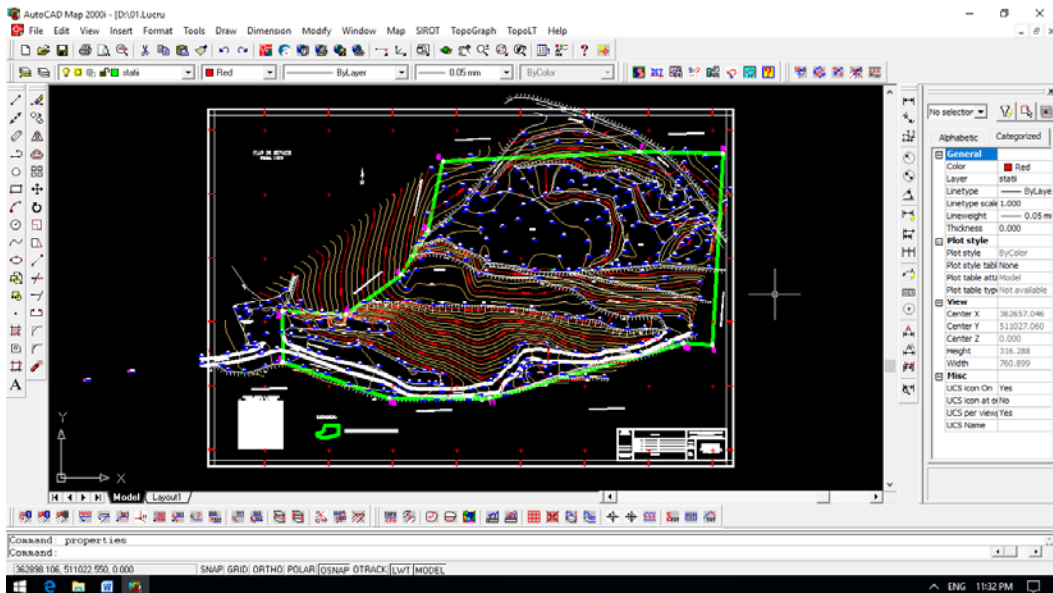


Fig. 2 Topographical Map

Digital Terrain Modelling

Digital terrain modelling is done in ArcGIS, making use of the points from the two consecutive surveys [10], [11].

The digital terrain model will be constructed from a reference plane that will have the value equal to the point with the minimum elevation of the altimetry coordinate in the field book, this plane being considered a reference surface [12], [13]. The digital modelling of the terrain will be done only on the area of interest (excavation area), which is imposed by the beneficiary:

- The 2D terrain model is based on both the inserted points obtained from the surveys conducted and the level curves;
- The input data for the model is taken from the field book, 540 points that have been merged into a .XYZ file and then converted to the .DBF file;
- For digital modelling, the minimum land pitch value will be determined by a downward sorting of the ".XYZ" landform, based on which a reference dimension "0" will be constructed;

- In the next step, a polygon structure will be created, bounded by the contour points of the exploitation perimeter for digital modelling to be performed only within the area of interest;
- After generating volumes, it will be assigned a graduation palette symbol for altitude classification.
- In the first phase of the modelling, the resulting volumes will be considered as "raw", it is necessary to determine the optimal distance of interpolation to reproduce the situation in the field, taking into account the precision required for such a work.
- Once the volume of a measurement period has been determined, in order to verify the correct spatial positioning of the map, it will be superimposed over an orthophotograph, provided by A.N.C.P.I.

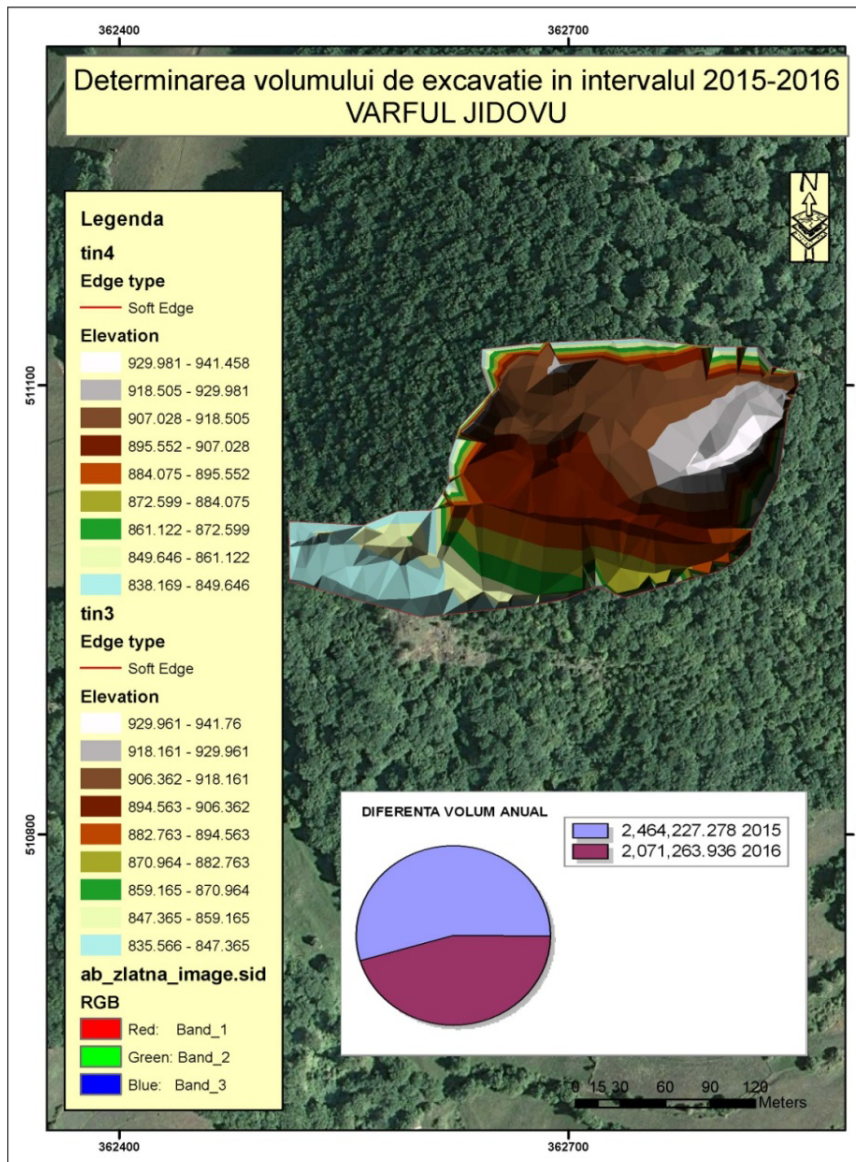


Fig. 3 Final Result of the Digital Terrain Modelling

Calculation of excavated volume

The difference in volumes for the two measurement periods will result in the amount of material exploited over time:

- Volumes will be expressed in both m³ and tonne / exploited material (tonnage Material exploited = volume m³ × density of material / m³). The density of exploited andesite material is about 2.5 t / m³

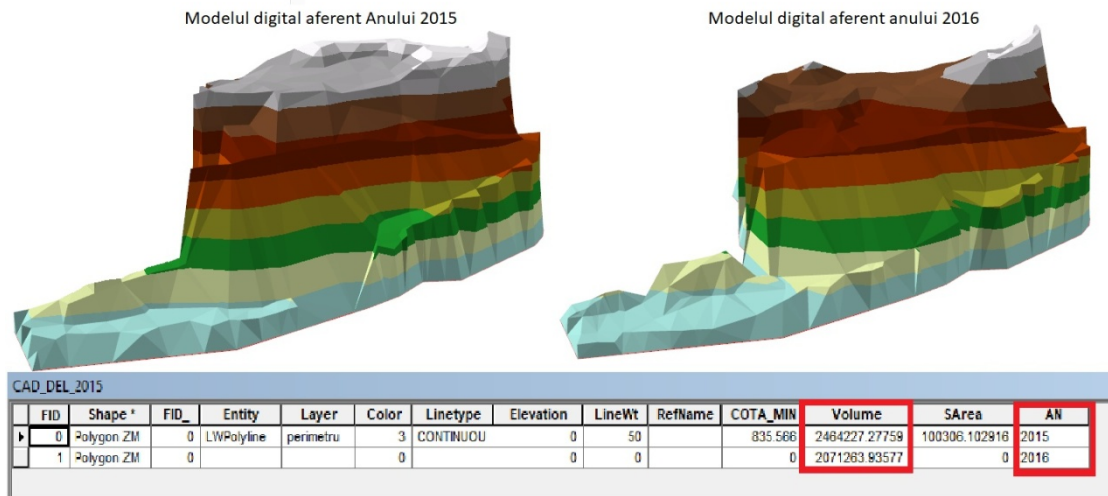


Fig. 4 Volume Calculation

4. Conclusions

The advantages of using modern acquisition technologies, analytical processing and spatial processing in order to solve the problems regarding the excavated volumes, reside in the relatively short working time and the possibility of performing multiple studies on the volume, mass and configuration of the stony material deposits.

The volume, mass and quality of the rock are economically important aspects, while their configuration is important in terms of the dynamic balance of the massif in the mining area.

From the multitude of topographic problems that are required to be solved quickly and efficiently, with a more precise determination of the results, an important place is the problem of determining the volumes of materials that have been exploited.

The present paper aims to solve this problem with the help of electro-optical and GNSS technologies, as well as suitable transfer computer equipment, analytical data processing and, last but not least, GIS analysis tools for data processing and interpretation

An advantage of using 3D modelling programs is the ability to track real-time excavation work so as to maintain the geomorphologic balance of the land in the exploitation area to avoid landslides and determine the optimum position for temporary storage of the material exploited before is transported to the sorting station.

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