GIS MODELING FOR VOLUMETRIC ANALYSIS OF AGGREGATES EXTRACTED FROM A QUARRY

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Abstract: Geographic Information Systems (GIS) are essential in volumetric calculations due to their ability to manipulate and analyze complex spatial data. In the context of quarry operations and aggregate extraction, GIS provides a feasible framework for collecting, managing, and analyzing data used in volume calculations. By utilizing GIS tools, it is possible to accurately assess the volumes of materials extracted from various quarry areas, thereby facilitating efficient planning of operations and sustainable resource management.
Optimal quarry management is crucial to avoid depletion of natural resources, minimize negative environmental impact, and ensure the sustainability of extraction activities. GIS analyses within the quarrying domain assist in resource assessment, identification of sustainable extraction practices, and appropriate management of the impact on local ecosystems.

Keywords: GIS modeling; aggregate extraction; chronological approach; volumetric analysis

1. Introduction

Quarries provide essential construction materials such as sand, gravel, and crushed stone, used in various projects, including civil engineering, roads, and other infrastructure works. They are fundamental for infrastructure development, playing a central role in ensuring the availability of these essential materials, thus contributing to economic growth and improving quality of life.

GIS modeling provides a detailed understanding of the spatial distribution of aggregate resources within the quarry, enabling efficient management of extraction. By identifying areas with intensive extraction or significant resources, well-founded decisions can be made regarding planning and optimizing extraction processes.

Volumetric analysis within a GIS system allows monitoring changes over time, providing a chronological approach to aggregate extraction. This capability to track quarry evolution is essential for long-term planning and anticipating potential issues related to resource availability. Furthermore, by integrating temporal data, the impact and sustainability of extraction activities can be assessed.

Moreover, volumetric analysis also facilitates a more environmentally responsible approach. It allows for the identification and monitoring of areas with significant ecological impact, facilitating the implementation of protective measures and sustainable environmental management. This information can be used in decision-making processes to balance the needs

of the extraction industry with the conservation of natural resources and local biodiversity. Thus, GIS modeling becomes an essential tool for efficient and sustainable management of aggregate quarries.

GIS offers a spatial perspective on aggregate distribution, which is essential for optimizing extraction processes and identifying areas with high production potential.

2. Materials and Methods

The working method of this study involved Real-Time Kinematic (RTK) positioning performed using Real-Time Kinematic technology (utilizing real-time differential corrections from the reference station integrated into the RGN-GNSS system using the specialized ROMPOS service). For this measurement, the ROVER GNSS RTK Rompos South S82-T system was employed, consisting of a GNSS Rover Receiver with integrated GSM/GPRS modem and Carlson field harness, using the SurvCE GPS measurement software with the Transdat 4.01 - Stereo 70 system implemented.

Fig. 1 GNSS Observations in the Work Area

To manipulate the data extracted from the field log in CSV format, it is necessary to convert it into a TXT file format. This operation was performed using the Excel application as follows:
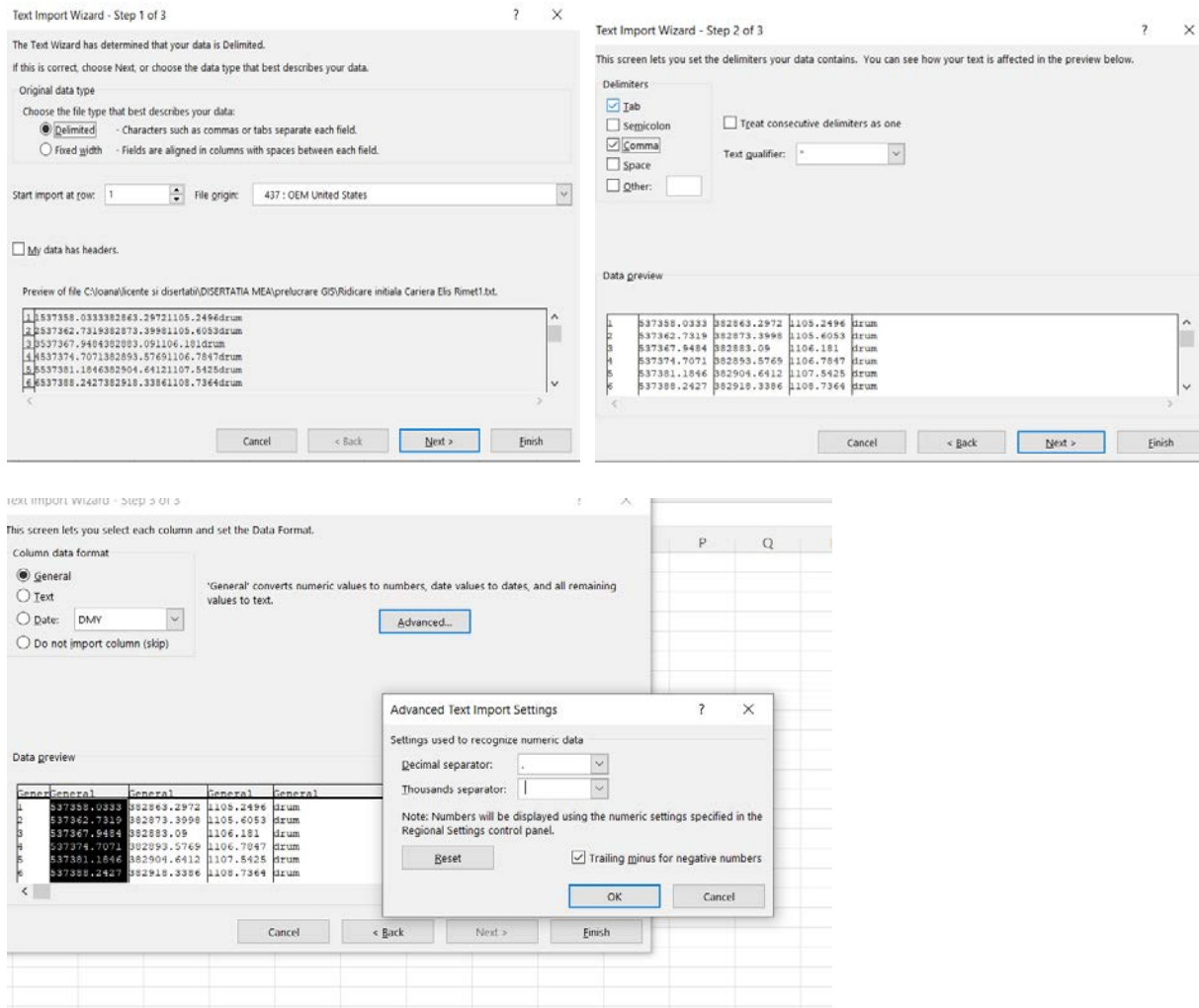
Fig. 2 Converting *.txt Files to Tabular Format

After importing the points into the GIS software, it is observed that an automatic spatial join occurs in areas where there is missing data.
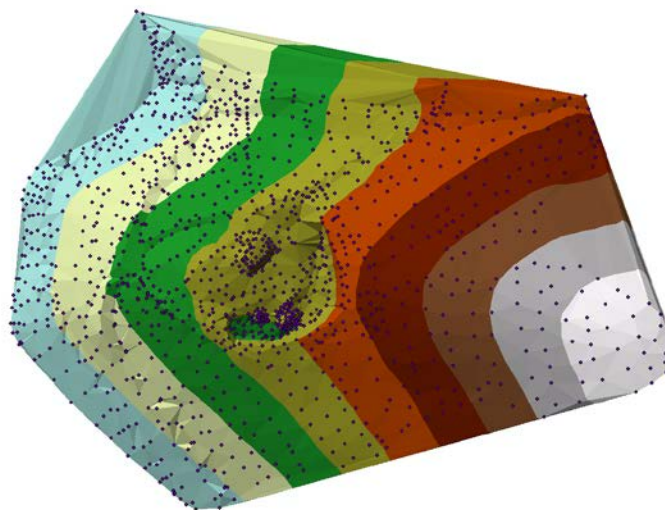

Fig. 3 Creating the Elevation Model

In this regard, the delineation of this area will involve identifying the maximum distance as a data gap, namely 56 meters (the perpendicular line dropped from the concavity maximum onto the last line created in the triangulation model), following the outlined steps:
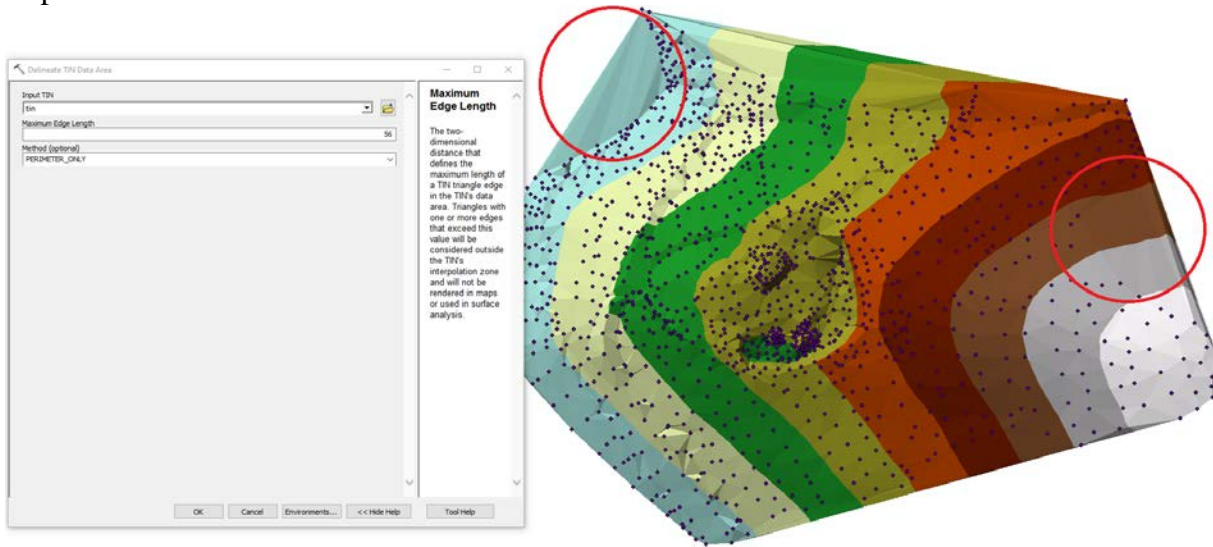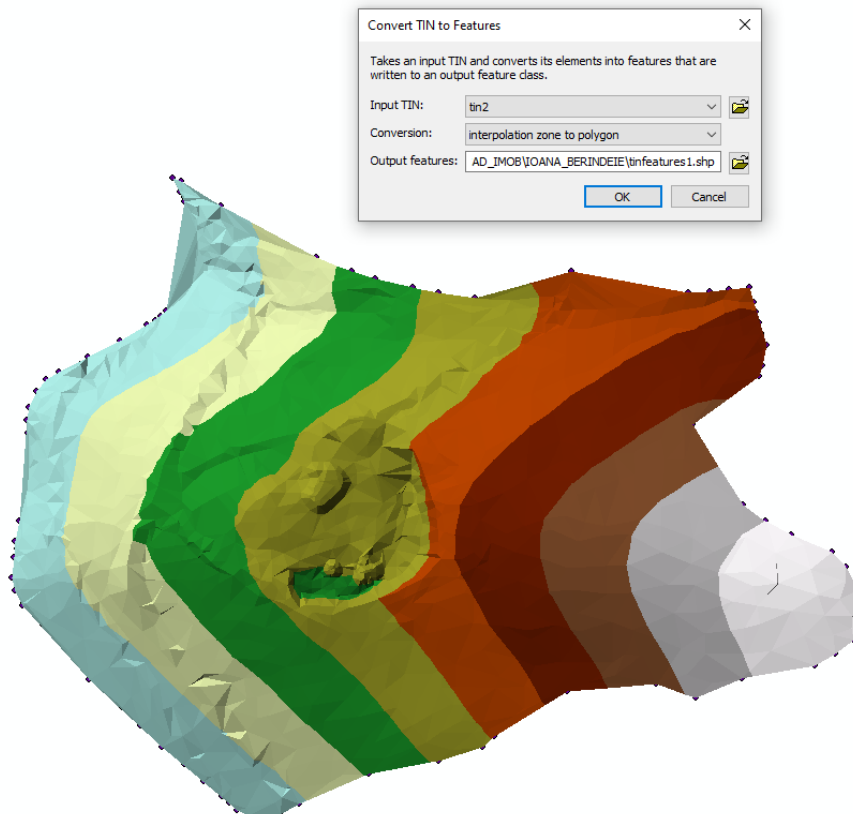

Fig. 4 Model Delineation

Fig. 4 Converting the TIN model to a surface

Finally, using the 'surface volume' tool, the excavated material was calculated, resulting in the following values:
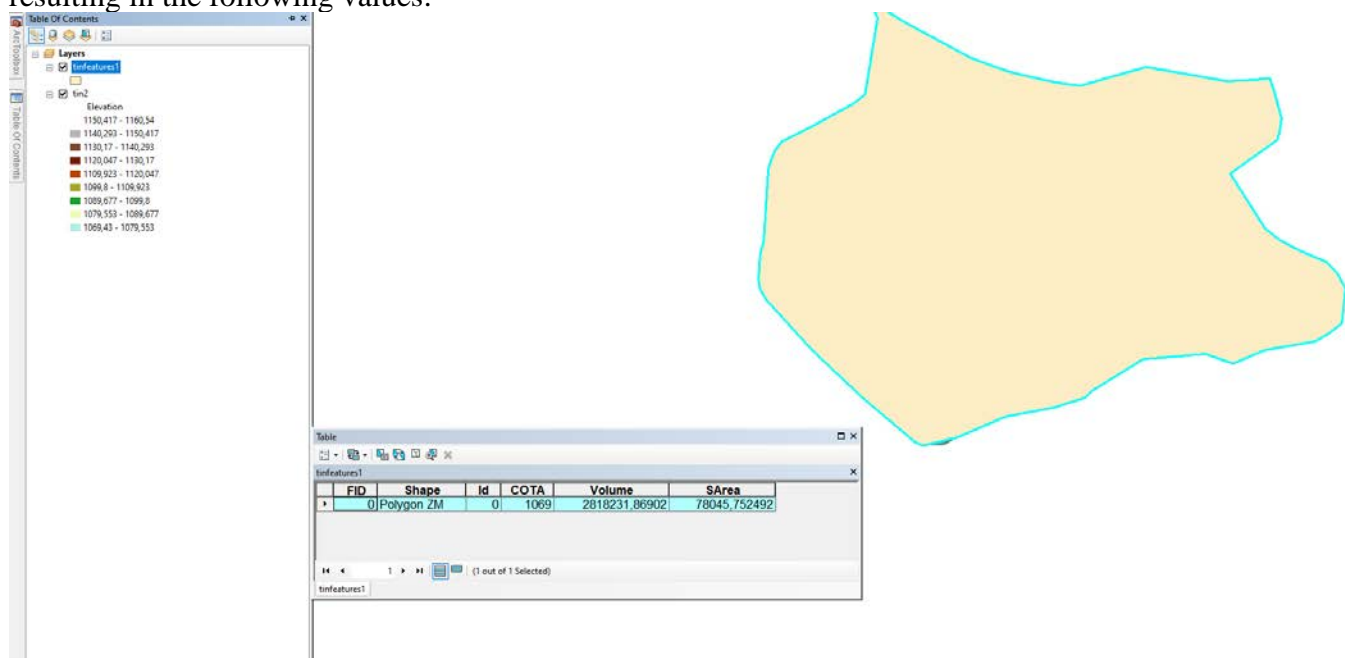

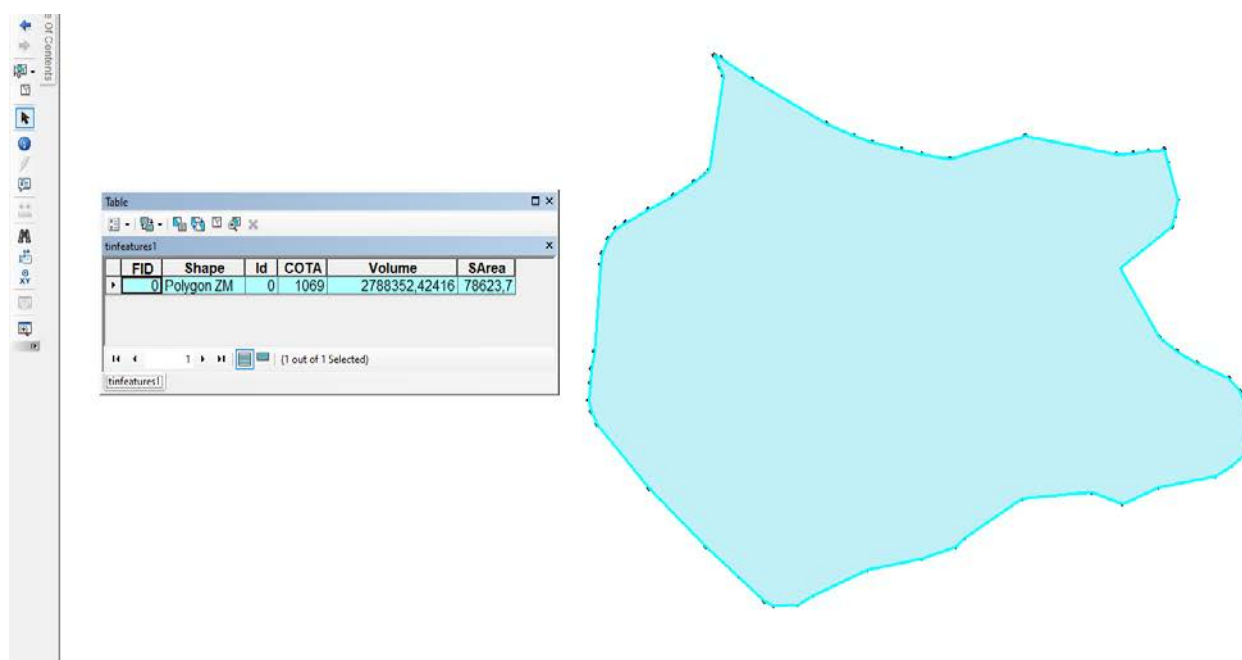Fig. 5 The calculation of the quarry volume before excavation

Fig. 6 The calculation of the quarry volume after excavation

3. Results and Discussion

Through the implementation of GIS modeling, it has been demonstrated that this method serves as an efficient and precise tool for volumetric analysis of aggregates.

The 3D models of the initial terrain and the measured terrain were determined, and by overlaying these models using specialized software within the GIS environment, the

excavated volume was calculated, resulting in a quantity of 32,347.2 m^3 of limestone. Considering an average specific weight of 2.50 tons/m^3, this corresponds to a quantity of 80,868 metric tons.

The obtained results underscore the high level of precision and reliability of this approach, indicating its potential to become a standard method in the aggregate extraction industry.

4. Conclusions

Thus, this research makes a substantial contribution to the understanding and advancement of volumetric analysis techniques in the aggregate extraction industry, carrying practical implications and opening new horizons for future research in this field.

Moreover, the research has highlighted the potential for optimizing quarry resource exploitation through GIS modeling, providing insight into the efficiency of extraction processes and reducing losses. This not only can contribute to more efficient planning but also to a more sustainable management of natural resources.

5. References

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