Evaluation of Volumes and Tonnage of Blast Furnace Slag Stockpiles in PC Ladce, a.s. Using GIS Applications

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Abstract

Blast furnace slag is a byproduct of metallurgy, generated during the production of crude iron in blast furnaces. This material is often deposited in stockpiles, where it is essential to monitor its volume and weight for efficient utilization and environmental management. Accurate determination of the volume and tonnage of slag stockpiles enables optimized handling of this secondary material while minimizing environmental impacts. Modern methods of spatial data collection and analysis, such as GNSS (Global Navigation Satellite System) and GIS (Geographic Information Systems), provide effective tools for this purpose. This study focuses on evaluating the volumes and weight of two blast furnace slag stockpiles in PC Ladce, a.s. using GNSS measurements and GIS applications, specifically ArcMap and ArcScene. The measurements were conducted using the direct method of a GNSS point network with the S999 device. The collected data were subsequently processed into a triangulated and raster-based terrain model. Based on these models, the stockpile volumes and total slag weight were calculated using a bulk density of 1.14 t/m³. The results of this analysis highlight the significance of utilizing modern geodetic technologies for industrial management. GIS and GNSS methods enable more accurate quantification of stored materials and provide reliable data for industrial managers and environmental agencies. In addition to quantifying the volume and weight of the stockpiles, this study also generated visualization models and contour maps, aiding in better result interpretation and more efficient planning for future slag management. The findings of this study demonstrate that the use of GNSS and GIS is a reliable approach for accurately determining the volume and weight of blast furnace slag stockpiles, allowing for improved control over this material and its further processing.

Keywords: *Blast furnace slag, GIS, GNSS, volume, tonnage.*

1. Introduction

Blast furnace slag is a byproduct of metallurgy, formed during the production of pig iron in blast furnaces. The process involves the melting of iron ore along with limestone and coke, which results in the formation of molten iron and slag. This slag, typically composed of silicates and aluminosilicates, has numerous industrial applications due to its physical properties. It is widely used in the construction industry, particularly as a raw material for cement production, where it improves the quality and durability of the final product [1]. Additionally, blast furnace slag is utilized in road construction, where it acts as an aggregate or as a stabilizing agent in base courses [4]. The versatility of blast furnace slag in these applications makes it an essential material in modern construction practices.

Given its wide usage, accurately determining the volume and weight of blast furnace slag stockpiles is crucial for their efficient management and use. Proper evaluation ensures that the material can be allocated effectively for various projects, helping to optimize storage and reduce wastage. Furthermore, precise volume and weight measurements are vital for environmental monitoring and the long-term sustainability of its usage [4].

The use of Geographic Information Systems (GIS) and Global Navigation Satellite Systems (GNSS) in geodesy has significantly enhanced the process of measuring and analyzing spatial data [5]. GIS provides a platform for the visualization, interpretation, and management of geographic data, while GNSS technologies offer high-precision measurements that allow for accurate survey of both natural and artificial structures [2]. GNSS methods are routinely employed to survey various types of landforms and infrastructure, including stockpiles, enabling the accurate collection of geospatial data for further analysis. In GIS environments, this data can be processed using advanced modeling and visualization tools, allowing for more efficient decision-making in fields such as urban planning, environmental management, and resource allocation [3].

Fig. 1. Stockpiles at PC Ladce, a.s.

This study focuses on the evaluation of the volume and tonnage of two blast furnace slag stockpiles at PC Ladce, a.s. The analysis uses GNSS measurements to collect data, which is then processed in GIS applications such as ArcMap and ArcScene. These tools allow for the creation of digital terrain models, enabling accurate volume and tonnage calculations. The results of this study can contribute to more efficient management of slag stockpiles and improve their utilization, providing valuable insights for industries that rely on this material. Moreover, the findings can help optimize the operational processes at the site, offering a more sustainable approach to handling industrial byproducts.

2. Objectives

The aim of this study is to:

- Survey the blast furnace slag stockpiles using GNSS technology.
- Calculate the volumes of the stockpiles based on a digital terrain model.
- Determine the total tonnage of blast furnace slag based on known bulk density.
- Create visualization models of the stockpiles for better management planning.

3. Methods

The measurements were conducted at the PC Ladce, a.s. site using the GNSS instrument S999 with the direct method of a point network. Before the actual measurement, it was necessary to prepare the terrain and ensure optimal conditions for data collection. A network of reference points was created to calibrate the measurements.

During the measurements, the precise coordinates of points on the surface of the stockpiles were recorded and later imported into the ArcMap and ArcScene 10.8 software for further processing. To create the models of the stockpiles, a Triangulated Irregular Network (TIN) model was used, which allows for more accurate volume determination than simple interpolations based on regular grids.

Additionally, an analysis of hypsographic data was performed, visualizing contour maps with a 1-meter interval. This approach enabled a detailed assessment of the topography of the stockpiles and the identification of areas with the greatest elevation differences. Volume calculations were carried out using spatial analyses in ArcMap, and the total tonnage of the stockpiles was then determined using the known bulk density of blast furnace slag.

The accuracy of the measurements was verified through repeated measurements at selected points and comparison with historical data on the amount of material stored. The results demonstrated high reliability and accuracy of the applied methodology.

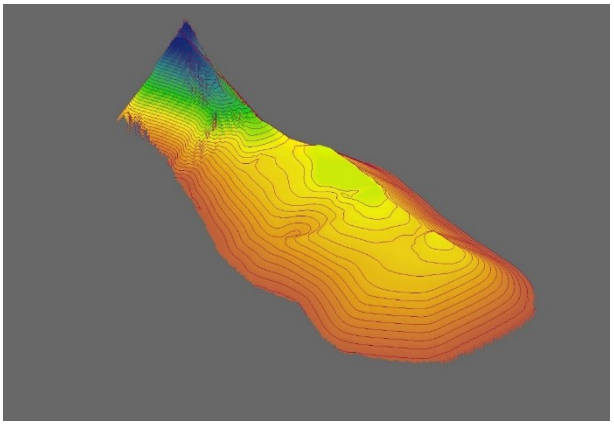
4. Results

The results of the evaluation of the volume and weight of the blast furnace slag stockpiles are presented in Table 1:

Measurement	*Elevation of the stockpile in meters above sea level*	*Area of the stockpile* m^2	*Volume* m^3	*Bulk density of slag* t/m^3	*Weight of the stockpile - t*
Stockpile 1 - under the crane	250	2365,6	**9569,3**	1,14	**10909,0**
Stockpile 2	249,75	6013,3	**31074,5**	1,14	**35424,9**
Spolu		8378,9	**40643,8**		**46333,9**

Based on the analysis of elevation profiles and models, it was demonstrated that the stockpiles have a stable structure and their total volumes are consistent with the expected values. GIS visualization tools provided clear contour maps of the stockpiles, allowing for detailed analysis of their shape and material distribution.

An important factor in evaluating the results was also the examination of the slag density, which was determined to be 1.14 t/m³. Based on this value, the total weight of the stockpiles could be accurately determined, which is a key parameter for further utilization or processing of this material. Compared to traditional volume measurement methods, GNSS measurements proved to be significantly more efficient and accurate, allowing for rapid data acquisition and subsequent processing in the GIS environment.



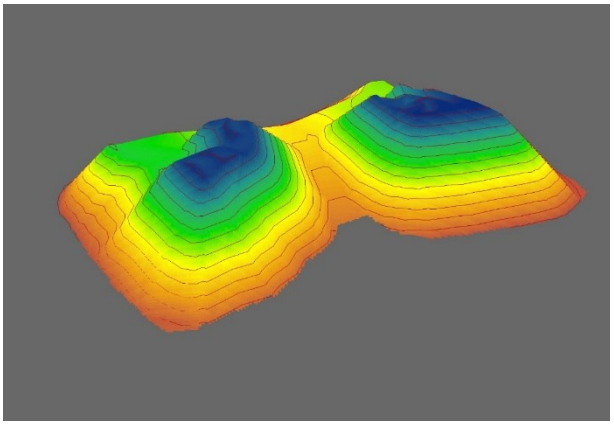
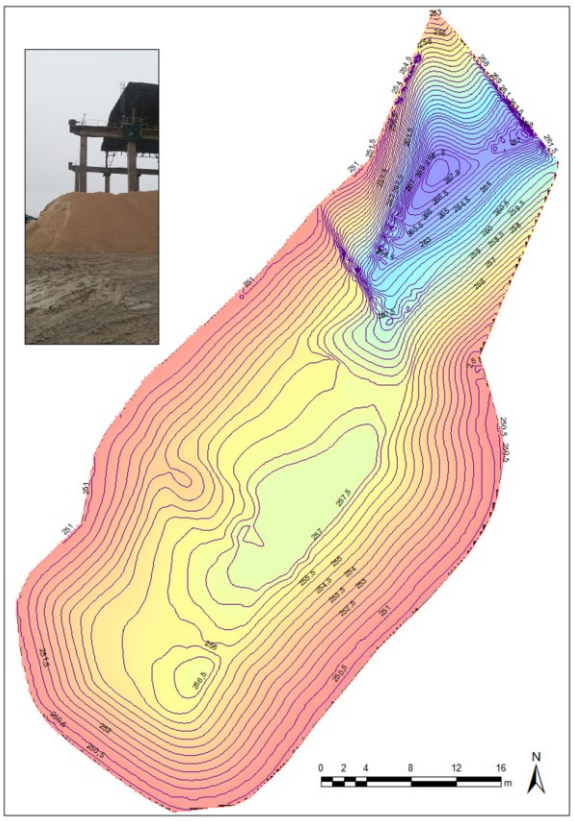


Fig. 2 and Fig. 3. Hypsographic visualization of the blast furnace slag stockpiles with contour lines at 1-meter intervals based on direct GNSS measurements, created using ArcScene 10.8.

In addition to the quantitative results, the acquired data also enabled spatial analysis of the stockpiles, which could be used in future planning and engineering activities. Further optimization of the measurement procedures could involve the use of additional sensors, such as drones or laser scanners, which could increase the resolution and accuracy of the models.



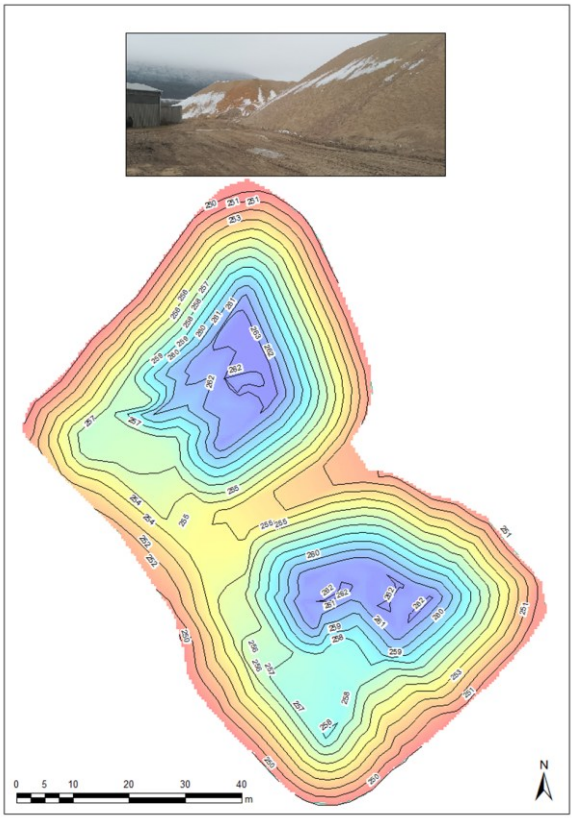


Fig. 4 and Fig. 5. Contour maps of the stockpiles created in ArcMap 10.8

5. Conclusion

This study demonstrated that the use of GNSS and GIS applications is an effective and reliable method for accurately determining the volume and tonnage of blast furnace slag stockpiles. By utilizing GNSS measurements, we were able to create detailed digital terrain models, which provided highly precise data necessary for further analysis and the planning of slag utilization. The incorporation of GIS tools allowed for improved visualization and deeper analysis of the acquired data, which significantly enhanced the understanding of the structure and volume distribution of the stockpiles. Through these sophisticated tools, it became possible to identify various characteristics and irregularities in the topography of the stockpiles that might have otherwise gone unnoticed with traditional methods.

One of the key advantages of this method is its high accuracy and efficiency compared to conventional volume measurement techniques. Manual measurement methods, such as those based on physical measurements or traditional surveying, tend to be time-consuming and prone to errors. In contrast, GNSS and GIS technologies offer precise, real-time data with minimal error, significantly improving the reliability of the results. Additionally, the speed with which the data can be acquired and processed in GIS environments allows for faster decision-making and better resource management. This becomes especially important when monitoring large

stockpiles or areas that need frequent assessment. Furthermore, the ability to easily archive and reprocess the collected data provides an invaluable tool for long-term monitoring and analysis, supporting the ongoing management and optimization of stockpile usage.

The results of this study are not only beneficial for industrial companies managing blast furnace slag stockpiles, but also for environmental agencies and regulatory bodies involved in waste management and environmental protection. By offering accurate measurements and detailed models of stockpiles, this method can assist in ensuring compliance with environmental regulations and aid in the sustainable management of industrial byproducts. Moreover, the ability to track the development and changes in stockpile volumes over time supports strategic planning for waste reduction, recycling, and reuse, contributing to a more circular economy.

Looking ahead, there are numerous opportunities for further research and technological integration that could further enhance the effectiveness of this approach. For instance, the addition of complementary sensor technologies, such as drones or laser scanning, could further improve the precision of measurements and enable automated, real-time monitoring of stockpiles. This would help in managing large-scale sites more efficiently and would provide more dynamic and responsive data collection.

Overall, it can be concluded that the combination of GNSS and GIS represents a powerful, reliable, and efficient tool for measuring and analyzing blast furnace slag stockpiles. By utilizing these technologies, industries can optimize resource management, reduce waste, and improve operational efficiency, leading to better sustainability and cost-effectiveness in industrial processes. This method has the potential to greatly contribute to the advancement of geospatial data analysis in various sectors, improving not just the measurement of stockpiles, but the overall management of industrial byproducts and environmental sustainability.

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