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BUILDING INFORMATION MODELING (BIM) AS A TOOL FOR ENHANCING TECHNICAL SOLUTIONS IN MINING DESIGN: A CASE STUDY OF THE MAIN PROCESS BUILDING IN BRSKOVO, MONTENEGRO

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Abstract
Modern mining systems require advanced architectural and construction solutions to ensure functionality, safety, and efficiency. Traditional two-dimensional design methods are increasingly insufficient for managing complex facilities. Building Information Modeling (BIM) offers a modern, integrated approach to digital project modeling.

This paper examines the use of BIM tools in mining facility design, focusing on architectural and structural aspects. It highlights key benefits such as improved technical coordination, visualization, and documentation quality, while addressing implementation challenges. Through practical examples, the study demonstrates the potential of BIM to enhance the efficiency and quality of mining design processes.

***Keywords**: BIM, mining facilities, architectural and structural design, digital modeling, technical coordination*

1. INTRODUCTION

Modern mining infrastructure demands high standards of technical precision, safety, energy efficiency, and functional integration within complex engineering and technological systems. The architectural and civil engineering phase plays a key role in shaping processing plants, auxiliary facilities, underground spaces, communication corridors, and service areas, as well as resolving structural and spatial relationships within the complex [4]. To improve project documentation, reduce errors, and enhance interdisciplinary coordination, the use of digital tools has increased significantly in recent years. Among these, Building Information Modeling (BIM) has emerged as one of the most transformative methodologies in the Architecture, Engineering, and Construction (AEC) industry. BIM enables the creation of intelligent 3D models enriched with technical and operational data, supporting integrated planning, design, construction, and lifecycle management of complex facilities [8].

Although BIM is widely applied in conventional construction, its use in mining infrastructure — especially within architectural and civil engineering — remains at an early stage. The unique nature of mining facilities, combining complex functionality, limited space, strict safety standards, and multidisciplinary coordination, makes BIM particularly suitable for this field [1]; [5]. Moreover, integrating BIM with digital twins, GIS platforms, and simulation tools is increasingly relevant for optimizing performance and sustainability in large-scale mining projects [10], [11]. The aim of this paper is to examine the potential of BIM solutions in architectural and civil engineering design for mining structures, focusing on principles, benefits, implementation challenges, and practical applications, with emphasis on improving technical documentation, coordination, and spatial visualization.

1.1 Theoretical Background

Building Information Modeling (BIM) is a digital methodology for designing, documenting, and managing construction projects through intelligent 3D models that combine geometric, technical, and functional data [4]. Unlike traditional CAD-based drafting with separate 2D drawings, BIM provides a unified environment where all disciplines work within a single, coordinated digital model [8].BIM can also include additional dimensions such as time (4D), cost (5D), and facility management data (6D/7D), offering advanced tools for planning, visualization, and lifecycle management. These features are particularly valuable in mining, where spatial constraints and multidisciplinary coordination are essential [1]. Standardized formats like IFC ensure interoperability between different BIM tools, while international standards such as ISO 19650 provide a framework for consistent information management throughout the project lifecycle [6]. Although BIM is well established in general construction, its use in mining design is still developing, especially in architectural and civil engineering.

1.2 Specifics of Architectural and Civil Engineering in Mining Design

Mining design presents unique challenges for architectural and civil engineering due to complex functionality, harsh environmental conditions, and strict safety requirements. Unlike standard construction projects, mining facilities often include underground structures, processing plants, ventilation shafts, haul roads, and other specialized infrastructure, each with specific design criteria [2], [3]. Architectural and civil components must address spatial constraints caused by geological conditions and mining operations, requiring precise integration with mechanical, electrical, and process engineering. Effective coordination is essential to prevent design conflicts and ensure structural safety [4].

Mining environments also demand durable materials and resilient structural solutions capable of withstanding vibrations, dynamic loads, and corrosive conditions. These factors make visualization, clash detection, and iterative design critical — areas where **BIM** provides significant advantages [8]; [9]. Applying BIM enables optimized layouts, better multidisciplinary coordination, improved regulatory compliance, and clearer stakeholder communication, resulting in safer and more efficient project delivery [1].

2. DISCUSSION – CASE STUDY OF THE MAIN PROCESS BUILDING IN BRSKOVO

The case study of the main process building in Brskovo, as shown in Figure 1 and Figure 2, clearly demonstrates the practical value of BIM methodology in the architectural and structural design of large-scale, technically complex mining facilities. The design of this structure — which includes flotation, milling, and dewatering zones, with foundations and equipment platforms — required the precise coordination of architectural, structural, technological, and electrical systems within a constrained spatial envelope.

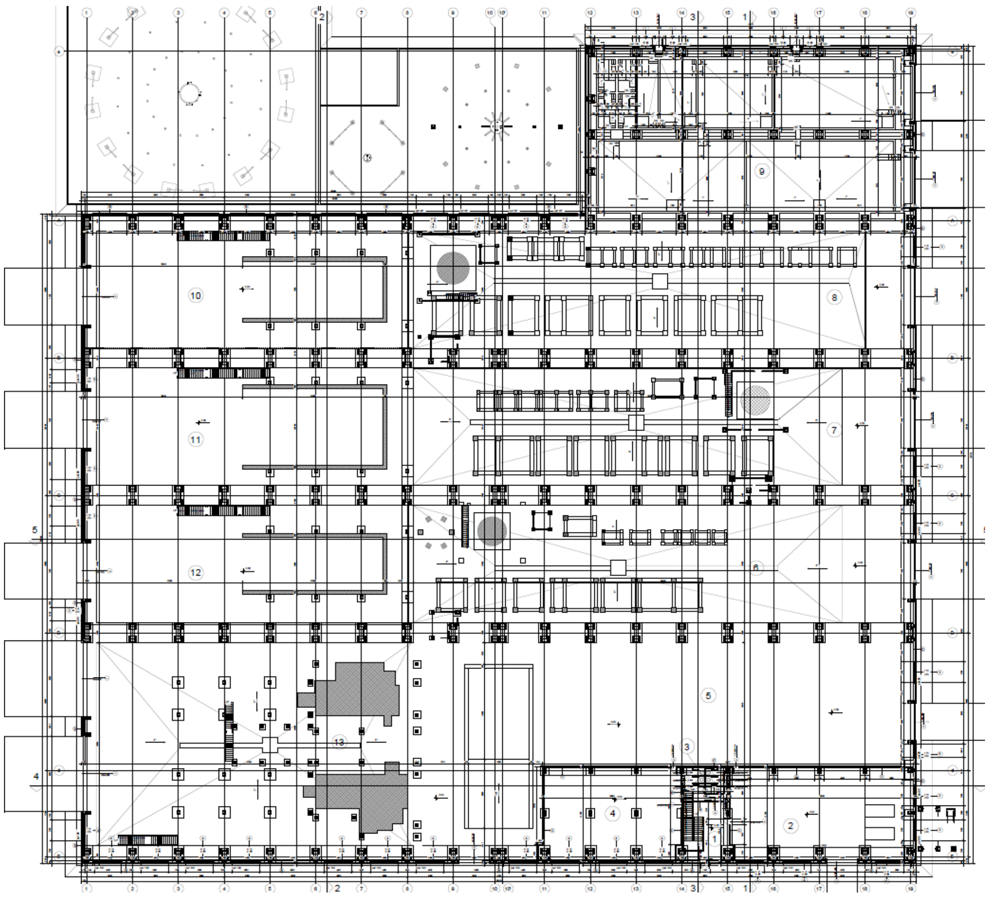

Figure 1. Flotation plant ground floor plan.

One of the most significant advantages observed during the design process was the ability of BIM tools to manage geometric complexity. The hall spans over 108 meters in length and features multiple structural zones with spans up to 29.35 meters, multiple floor elevations, and a series of bridge cranes on different operational levels. BIM enabled the integration of structural elements such as lattice columns composed of HEA600 profiles and HOP bracing systems with the positioning of flotation equipment, stair towers, service platforms, and crane tracks [1]. The hall is divided by a 1-meter expansion joint into two technological areas (milling/filtration and flotation/control), which was fully represented in the BIM model, enabling precise functional zoning and clear construction phases. The model also included elevation changes from +0.60 m to +22.10 m, integrating steel and reinforced concrete elements, equipment platforms, and maintenance walkways essential for operations like reagent preparation and equipment maintenance. Stair towers and vertical ladders were accurately modeled and verified within BIM [4], [8].

Advanced clash detection using Navisworks and Revit resolved over a dozen spatial conflicts early in planning, including misalignments between equipment supports, crane clearance zones, and vertical ducts. While the HOP façade frames and sandwich panels did not contribute to seismic load transfer, their inclusion in the BIM model improved visual planning, daylight simulation, and façade coordination. BIM also optimized the sequencing of steel elements, such as trapezoidal sheet-metal platforms and composite decks, aligning construction with crane installation and process workflows [9].

Figure 2. 3D rendering of the Main process building.

However, several challenges were noted. The absence of mining-specific BIM object libraries (e.g., flotation cells, filter presses, reagent tanks) required custom modeling, increasing design time. Additionally, integration with external software like Tower 8 for structural analysis was limited, as these tools remain partially disconnected from the BIM environment.

Despite these issues, BIM enabled the integration of 3D geometry, technical data, and operational requirements into a single model, improving documentation quality and coordination between disciplines. Given the scale and complexity of the flotation plant, the BIM-based approach proved essential for delivering a safe, efficient, and reliable facility.

3. CONCLUSION

This study has explored the application of BIM in the architectural and structural design of mining facilities, focusing on the case of the flotation plant hall in Brskovo. The findings confirm that BIM represents a powerful tool for managing complexity, improving technical coordination, and enhancing the overall quality of design documentation in the mining sector.By integrating spatial data, equipment geometry, structural systems, and construction sequencing into a unified 3D environment, BIM allowed the design team to address the challenges posed by large spans, multiple elevation levels, heavy equipment loads, and dense process zones. Clash detection, visual simulations, and digital collaboration platforms significantly reduced design risks and increased efficiency in both planning and communication. Despite the evident benefits, the application of BIM in mining projects remains limited by the lack of standardized tools and domain-specific object libraries. Additionally, the need for interoperability between BIM platforms and specialized structural or geotechnical software is still an open issue. Overcoming these limitations will require coordinated efforts by industry stakeholders, software developers, and regulatory bodies.Nonetheless, the Brskovo flotation hall project demonstrates that even within the current constraints, BIM can provide substantial value in the design of mining infrastructure. As digital transformation accelerates across the construction and resource sectors, broader BIM adoption is expected to become a key enabler for more sustainable, efficient, and safe development of mining operations.

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REFERENCES

[1] Autodesk. (2023). BIM for infrastructure: Transforming construction and design. Autodesk Inc. Retrieved from https://www.autodesk.com/solutions/bim
[2] S. Azhar, Leadership and Management in Engineering, 11 (3) (2011) 241–252.
[3] F. Bosché, (2016). Towards automated construction progress monitoring using 3D data and BIM. Automation in Construction, 72 (2016) 145–164.
[4] C. Eastman, P.Teicholz, R. Sacks, K. Liston, (2018). BIM handbook: A guide to building information modeling for owners, designers, engineers, contractors, and facility managers (3rd ed.). Hoboken, NJ: Wiley.
[5] International Organization for Standardization. (2018). Building information modelling – Information delivery manual (ISO 29481-1:2016). ISO.
[6] International Organization for Standardization. (2018). ISO 19650-1:2018 – Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — Part 1: Concepts and principles. Retrieved from https://www.iso.org/standard/68078.html
[7] MMI Bor. (2024). Main Mining Design for the Processing of Mineral Raw Materials from the Žuta Prla, Višnjica and Brskovo Deposits near Mojkovac – Grinding, Flotation and Dewatering Facility (Book VI, Vol. VI.3.1, Certificate 6208/R). Unpublished internal technical documentation.
[8] R. Sacks, C. M. Eastman, G. Lee, P. Teicholz, (2018). BIM handbook: A guide to building information modeling for owners, designers, engineers, contractors, and facility managers (3rd ed.). Wiley.
[9] B. Succar, Autom. Constr., 18 (3) (2009) 357–375.
[10] X. Wang, Y. Song, Autom. Constr., 138 (2022) 104289.
[11] D. Zhao, A.P. McCoy, T. Bulbul, C. Fiori, J.M. Vance,. Tunn Undergr Space Technol., 92 (2019) 103028.