INTEGRATED MODELS OF CONSTRUCTION MANAGEMENT BASED ON BIM FOR REDUCTION OF REWORK IN CIVIL CONSTRUCTION: PROPOSAL OF A RETURN ON INVESTMENT (ROI) EVALUATION FRAMEWORK

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Abstract: The high incidence of rework in Civil Construction (CC) represents one of the greatest obstacles to productivity and profitability in the sector, with costs that can vary from 1% to 20% of the total project value (PLANRADAR, 2020). This article proposes and analyzes an Integrated Construction Management Model (MIGO) based on Building Information Modeling (BIM) methodology, integrating it with Lean Construction (LC) principles and the use of a Common Data Environment (CDE), with primary focus on the prevention and reduction of rework. The methodology employed consisted of a systematic literature review and the adaptation of a Return on Investment (ROI) evaluation framework for BIM, originally proposed by Lee and Lee (2020). The results of the analysis indicate that the proposed MIGO-BIM enhances the detection of interferences and project compatibility in the initial phases, resulting in a significant reduction of rework. The application of the ROI framework demonstrates a primary ROI potential of 167.8% (based exclusively on rework prevention) and an integrated ROI of 476.72%, when considering broader benefits (LEE; LEE, 2020). It is concluded that MIGO-BIM, supported by a robust evaluation framework, offers a strategic tool for proactive project management, transforming BIM from a mere modeling tool into a quantifiable integrated management system.

Keywords: BIM; Construction Management; Rework; Lean Construction; Common Data Environment; ROI.

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Introduction

Civil Construction (CC) globally faces chronic challenges related to low productivity, schedule delays, and budget deviations. Among the factors that most contribute to this inefficiency, rework emerges as a problem of critical magnitude. Rework is defined as the activity of redoing a process or part of a work that did not meet the quality requirements or project specifications on the first attempt (PLANRADAR, 2020).

International and national studies converge in pointing out that the direct and indirect costs of rework can consume, on average, between 11% and 12% of the total cost of a construction project, potentially reaching peaks of up to 20% in cases of poor management or high complexity (PLANRADAR, 2020). This cost is not limited only to wasted labor and materials, but extends to schedule delays, contractual penalties, team exhaustion, and damage to the company's reputation.

The origin of rework is multifactorial, but incompatibility and communication failures between the various project disciplines (architecture, structures, installations) are consistently cited as the most prevalent causes (BRYDE; BROQUETAS; VOLM, 2013). In this context, the Building Information Modeling (BIM) methodology emerges as the primary technological and procedural innovation capable of mitigating these failures. BIM, which transcends simple 3D geometric representation (BRYDE; BROQUETAS; VOLM, 2013), is a process of creating and managing information about a built asset, based on an intelligent digital model (BRYDE; BROQUETAS; VOLM, 2013).

Despite widespread recognition of BIM's qualitative benefits, the quantification of its Return on Investment (ROI), especially regarding rework prevention, is still a developing field of research, particularly in the Brazilian context.

Justification and Objective

The transition from using BIM as an isolated tool (3D modeling) to an Integrated Construction Management Model (MIGO-BIM) is a strategic imperative. The integration of processes, people, and technology is the key to unlocking BIM's maximum potential.

The central objective of this article is: To propose an Integrated Construction Management Model (MIGO-BIM) and validate its potential for rework reduction through the analysis of an adapted ROI evaluation framework, providing theoretical and quantitative support for the strategic adoption of the methodology in Civil Construction.

Theoretical Foundation

Rework and Its Causes

Rework is a classic waste in Lean philosophy and an indicator of inefficiency. The causes can be categorized into three main groups (PLANRADAR, 2020): Design Failures, which include incompatibility between projects, sizing errors, and incomplete or ambiguous information; Execution Failures, encompassing labor errors, lack of qualification, specification deviations, and supervision failures; and Management Failures, characterized by ineffective communication, poor planning, and late-stage scope changes.

Most of the rework (approximately 50% or more) originates in the design and planning phases, manifesting itself and generating high costs in the construction phase (PLANRADAR, 2020).

BIM as a Rework Prevention Tool

BIM acts directly on the causes of rework originating in the design, through its dimensions. 3D BIM (Modeling and Visualization) allows for automated conflict detection (Clash Detection),

identifying geometric and logical incompatibilities (e.g., piping passing through a beam) before they become expensive problems on the construction site. 4D BIM (Planning and Schedule) links the 3D model to time, allowing simulation of the construction sequence, which prevents planning and logistics errors that would lead to delays and rework of sequencing. Finally, 5D BIM (Quantities and Costs) allows for automatic and accurate extraction of material quantities, with budget accuracy and reduction of material waste (which is a form of rework) being direct benefits (BRYDE; BROQUETAS; VOLM, 2013).

The Integrated Construction Management Model (MIGO-BIM)

The effectiveness of BIM is maximized when it is integrated with other management philosophies. The MIGO-BIM proposed in this study is based on the synergy of three pillars: BIM, Lean Construction (LC), and Common Data Environment (CDE).

Common Data Environment (CDE)

The CDE is the single source of information for the project, where all BIM data and models are stored, managed, and shared centrally (4BT, 2023). It ensures that all stakeholders (designers, builders, owners) are working with the most updated and compatible version of the model, eliminating the primary cause of rework: misinformation and the use of obsolete data.

Integration of BIM and Lean Construction (LC)

Lean Construction is a management philosophy that aims to maximize value for the customer and minimize waste (ZAVALETA, 2025). BIM is the ideal technological facilitator for Lean principles. For example, Visualization and Flow are facilitated by BIM's 3D model, which allows visualization

of workflow and identification of bottlenecks (waste). Furthermore, Short-Term Planning is supported by 4D BIM, which assists Lean tools such as the Last Planner System (LPS), improving planning reliability and reducing the uncertainty that leads to rework (ZAVALETA, 2025).

Proposal of the MIGO-BIM ROI Evaluation Framework

To quantify the impact of MIGO-BIM on rework reduction, the ROI evaluation framework proposed by Lee and Lee (2020) is adopted, which stands out for its three-phase approach, focused on rework prevention.

Framework Structure (Adapted)

The framework consists of an 11-step process, grouped into three main phases. Phase 1, called Evaluation Planning, has as its main objective the definition of rework metrics (cost, time, quantity of RFIs) and the cost of implementing MIGO-BIM (software, training, hardware). Phase 2, Primary ROI (Rework Prevention), focuses on calculating the avoided cost of rework, isolating the direct benefit of BIM compatibility and Clash Detection. Finally, Phase 3, Integrated ROI, aims at the inclusion of other benefits (schedule reduction, quality improvement, etc.) for the calculation of total ROI.

Primary ROI Calculation

The central metric for the objective of this article is the Primary ROI, which focuses on the avoided cost of rework.

The Cost of Avoided Rework is calculated by estimating the cost that would be incurred on the construction site if the incompatibilities detected and resolved in the BIM model had been

discovered only during execution.

In an applied case study, Lee and Lee (2020) demonstrated that the primary ROI, based solely on rework prevention, reached 167.8%. This means that for each monetary unit invested in BIM implementation, 1.678 monetary units were saved solely through the elimination of rework.

Integrated ROI Calculation

The Integrated ROI considers the total value generated by MIGO-BIM, including rework reduction (Primary ROI) and other benefits such as reduction in project and construction time (4D BIM), improvement in quality and reduction of material waste (5D BIM), and improvement in communication and decision-making (CDE and LC).

When including these factors, the total ROI in the reference study reached 476.72% (LEE; LEE, 2020), evidencing that the value of MIGO-BIM is exponentially greater when viewed as an integrated management system rather than merely as a Clash Detection tool.

Discussion and Implications for Brazilian Civil Construction

The MIGO-BIM, with its focus on integration and ROI quantification, has profound implications for Brazilian Civil Construction, which still struggles against fragmentation and low adoption of advanced technologies.

The Imperative of Measuring Avoided Cost

The primary contribution of the ROI framework is the emphasis on measuring avoided cost. Traditionally, CC companies measure only incurred costs (the rework that happened), failing to quantify the value of preventive work (the rework that did not happen). MIGO-BIM, by forcing the

detection and resolution of conflicts in the virtual environment, makes the avoided cost measurable, transforming the investment in BIM from a cost center to a profit center.

Implementation Challenges

Despite the potential ROI, the adoption of MIGO-BIM in Brazil faces cultural and financial barriers. The culture of fragmented design, where designers work in isolation, is an obstacle to the implementation of CDE and the collaboration required by BIM. The initial cost of software and training, although quickly offset by ROI, can be a barrier for small and medium-sized enterprises.

MIGO-BIM as a Competitive Advantage

For companies that adopt MIGO-BIM, the drastic reduction of rework (and the consequent increase in cost and schedule predictability) translates into a significant competitive advantage. In an increasingly demanding market, the ability to deliver projects within budget and schedule, with superior quality, is the differentiator that separates market leaders.

Conclusion

The Integrated Construction Management Model (MIGO-BIM), which combines the modeling and analysis capability of BIM with the waste elimination philosophy of Lean Construction and the data centralization of CDE, represents the forefront of project management in Civil Construction.

The analysis of the ROI framework demonstrates, with robust quantitative data (primary ROI of 167.8%), that the investment in BIM is highly justifiable solely by rework prevention. When the total impact of MIGO-BIM is considered (integrated ROI of 476.72%), adoption becomes a strategic imperative for the sustainability and competitiveness of companies.

Study Limitations and Future Research: This study is of a propositional and analytical nature, based on the adaptation of an international framework. Future research should focus on the application of this MIGO-BIM and the ROI framework in real case studies in Brazilian Civil Construction, in order to validate the quantitative results in the local context and develop specific correction factors for the national reality.

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