

CHAPTER 25

Integrating Lean and Circular Economy Principles to Enhance IGBC Certification Process

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ABSTRACT

Sustainability in construction is a key global objective, and integrating Lean Construction with Circular Economy principles into the green building certification framework offers a transformative opportunity. This research focuses on embedding these principles within the IGBC certification system to enhance sustainability in high-rise residential projects. The study aims to develop a conceptual framework that systematically integrates Lean and Circular Economy principles into the IGBC green building certification process for high-rise residential developments. The methodology follows a structured approach, beginning with a comprehensive literature review to identify key Lean Construction and Circular Economy parameters relevant to IGBC standards. A comparative analysis of existing IGBC-certified projects evaluates their sustainability performance against Lean and Circular Economy benchmarks. This research contributes significantly to the Indian building sector by introducing a systematic framework to enhance sustainability and operational efficiency in IGBC-certified buildings. The integration of Lean and Circular Economy principles promotes resource optimization, waste minimization, and improved cost management. The findings serve as a guide for policymakers, developers, and certification bodies, facilitating the incorporation of these principles into India's green building strategies and advancing the nation's sustainable development initiatives.

Keywords: Lean construction, Lean and circular economy, lean and sustainability, IGBC.

1.0 Introduction

The construction business industry is very important with respect to the economic development, urbanization and social wellbeing but it is also among the most resource consuming and the most environmentally devastating industries worldwide.

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The high-rise residential projects, especially in countries which are fast urbanizing like India are linked with high consumption of materials, energy and water, as well as huge amounts of construction and demolition garbage. Green building certification systems have developed in answer to these problems, as organized systems that can be used to inform sustainable construction (Aristizábal-Monsalve et al., 2022; Weinheimer, 2016). In India, the Green house rating system proposed by Indian Green Building Council (IGBC) has gained popularity as a system of encouraging residential buildings to be environmentally friendly.

Although IGBC certification offers overall checklist-based sustainability method, in practice, its application is usually compliance focused and not performance oriented. Meeting minimum requirements or being selective to the credits that are easier to reach can produce developers who are often interested in achieving overall sustainability potential of projects. This has especially been marginal in high-rise residential properties, where the lack of integration in project delivery, decision-making on its sustainability at a later stage, and the lack of co-ordination between the design and construction personnel make the green strategies less effective. This has led to the situation where a large number of projects are certified without effective resource optimisation or environmental performance. Both Lean Construction (LC) and Circular Economy (CE) principles have been called to focus on in their turn as the alternative to ineffective ways of handling the issues of construction.

The idea of production serves as the basis of Lean Construction and was first introduced by Koskela, with its main focus on removing non-value-adding processes, decreasing variability, and enhancing improvement on the project lifecycle. Its main emphasis is in enhancing efficiency of its processes, the reliability of its planning, and its coordination with its stakeholders (Khodeir & Othman, 2018; Ogunbiyi, 2014; Chen et al., 2024). Circular Economy, in its turn, encourages the regenerative model of resource utilisation through the focus on material reuse, recycling, life-cycle thinking and closed-loop systems in the planning, development, upkeep, maintenance and demolition of structures. The research attempts to show how process-based and resource-based approaches can be mutually reinforcing in certification results through direct mapping of the integrated Lean-Circular ideas onto the mandatory requirements and credits in the credentials provided by the Integrated Green Building Certification.

In line with this, the research question to be used in the main research is: What is the most effective way to combine Lean Construction and the principles of the Circular Economy and achieve better effectiveness and results of the IGBC Green Homes certification process of high-rise residential buildings?

By providing this answer, the study adds a systematic approach that would enable the filling of the gap between theory, certification systems, and the actual project implementation. The results are also meant to assist the developers, consultants and policymakers to enhance

sustainability performance without jeopardizing constructability, cost efficiency and operational viability (Benachio et al., 2021; Salibi et al., 2022; Wibowo & Ammar, 2025). This paper fills this gap and presents a proposed integrated conceptual framework of Lean and Circular in line with:

1. To assess the conceptual interaction between Lean and Circular Economy principles with IGBC certified buildings.
2. To propose a process map for incorporating Lean and Circular Economy concepts for enhancing the outcome of IGBC Green Existing Buildings.
3. To validate the proposed framework through expert feedback and practical insights from stakeholders involved in sustainable construction.

2.0 Literature Review

The literature review delves into the theoretical and practical bases in order to deployment of Lean Construction alongwith Circular Economy concepts for sustainable building certification schemes, namely the Indian Green Building Council (IGBC). Initially, it looks at the application of Lean principles, which were initially meant for manufacturing, to increase project efficacy and cut waste in the construction industry. Likewise, it discusses the contribution of Circular Economy principles in the area of conserving materials and sharing the materials in a closed-loop manner throughout the building lifecycle. The research points out a worldwide trend that is increasingly adopting the integration of these two techniques to deliver more eco-friendly building outcomes.

Table 1: Literature Review Table

Paper Title	Name of Author(s)	The Year of Publication	Journal/ Conference	Abstract	Summary
The Process of Green Building Certification: An Examination Regarding Lean Principles	Nina Weinheimer	2016	24th Annual Conference of the International Group for Lean Construction (IGLC), Boston, USA	This paper examines the procedure of DGNB certification of Green Building, analyzes inefficiencies, and proposes Lean principles to improve them. It reveals sources of waste and shows how Lean can enhance sustainability.	Explores inefficiencies in the German DGNB certification process and shows how Lean Thinking's 5 principles can optimize it. Emphasizes customer value, waste reduction, and continuous improvement.
ISO and Lean Can Contribute to a Culture of Continuous Improvement	Christy P. Gomez, Hashima Hamid	2018	26th Annual Conference of the International Group for Lean Construction	This study investigates whether ISO QMS alone ensures continuous improvement (CI) and argues that integrating the Last Planner System	Reveals that ISO-certified firms have only moderate CI maturity. Advocates using Lean tools like LPS under the TFM framework to better

			(IGLC), Chennai, India	(LPS) significantly boosts maturity involved for construction planning.	establish a CI culture in construction organizations.
Improving Green Building Project Management Processes through the Lean Approach	Alessandro Orsi, Tariq S. Abdelhamid, Eugenio Pellicer, Ignacio Guillén- Guillamón	2021	Lean Construction Journal	Applies Lean principles to design-stage issues in four European green building projects. Identifies process waste and proposes improvements aligned with sustainability goals.	Offers a Lean-based framework to optimize project management in green buildings using case studies. Aligns LEED/BREEAM certifications with Lean waste-reduction strategies to enhance efficiency and performance.
Lean Diagnosis for Chilean Construction Industry: Towards More Sustainable Lean Practices and Tools	José L. Salvatierra, Luis F. Alarcón, Angela López, Ximena Velásquez	2015	23rd Annual Conference of the International Group for Lean Construction (IGLC), Perth, Australia	Diagnoses Lean implementation across 10 Chi-lean construction firms using surveys, interviews, and site visits. Identifies barriers like poor training and lack of leadership and varying use of the Last Planner System.	Highlights challenges in sustaining Lean practices in Chile. Recommends focusing on leadership, training, cultural alignment, and comprehensive Lean adoption beyond just the LPS tool.
Lean and the Circular Economy: A Systematic Literature Review	José Geraldo de Oliveira Rangel Salibi, Ana Laura De Souza Medina Rodrigues, Pedro Augusto Bertucci Lima, Fernando Bernardi de Souza	2022	Journal of Lean Systems, Vol. 7, No. 4, pp. 23– 46	This paper explores how Lean principles can support circular economy (CE) via an organized review of literature review. It identifies overlapping the concepts of waste reduction alongwith resource reutilization, proposing a concept known as “Circular Lean.” Lean tools like 5S and VSM are highlighted for their relevance to CE practices such as eco-design and the 6Rs.	Provides a foundation for integrating Lean and CE, suggesting that both concepts share sustainability goals. Introduces “Circular Lean” to merge material and energy reutilization strategies, emphasizing continuous improvement and closed-loop systems in production
Interactions between Lean Construction Principles and Circular Economy Practices for the	Gabriel Luiz Fritz Benachio, Maria do Carmo Duarte Freitas, Sergio Fernando Tavares	2021	<i>Journal of Construction Engineering and Management</i> (ASCE	Investigates how Circular Economy alongwith Lean Construction interact within construction. Through content analysis, this study finds 74 interactions (70 positive, 4 negative) between CE	Establishes a comprehensive interaction matrix between LC and CE concepts in the built environment. Concludes that combining these approaches enhances

Construction Industry				practices and LC principles. Key insights include LC's focus on non-value-adding activities and CE's off-site construction emphasis.	sustainability and construction efficiency, though research is still emerging and requires standardization and incentives
Integrating Lean Construction with Sustainable Construction: Drivers, Dilemmas and Countermeasures	Yunxin Chen, Dong Qiu, Xiaomin Chen	2024	<i>Sustainability</i> , MDPI	This review examines synergies and conflicts between Lean Construction (LC) and Sustainable Construction (SC). It identifies drivers like cost reduction and waste minimization, alongside dilemmas, disagreements over worker welfare and environmental compromises are examples. It proposes using Dynamic Capabilities (DC) to mitigate these issues and develop an integration strategy.	Analyzes 654 papers using qualitative and bibliometric methods. Suggests integrating LC and SC improves efficiency and sustainability, and promotes DC (like organizational learning and adaptability) as key enablers for better LC–SC synergy in practice. Offers a strategic framework for implementation.

Source: Author's compilation based on previous studies

3.0 Research Methodology

3.1 Structure and Approach towards Research

Through qualitative exploratory strategy combined with an embedded case study methodology is the basis of this research. The goal is to investigate the potential strategic integration using ideas from the Circular Economy (CE) and Lean Construction (LC) to improve high-rise residential structures sustainability performance and point score in the IGBC certification system. The study aims to respond to the pivotal question:

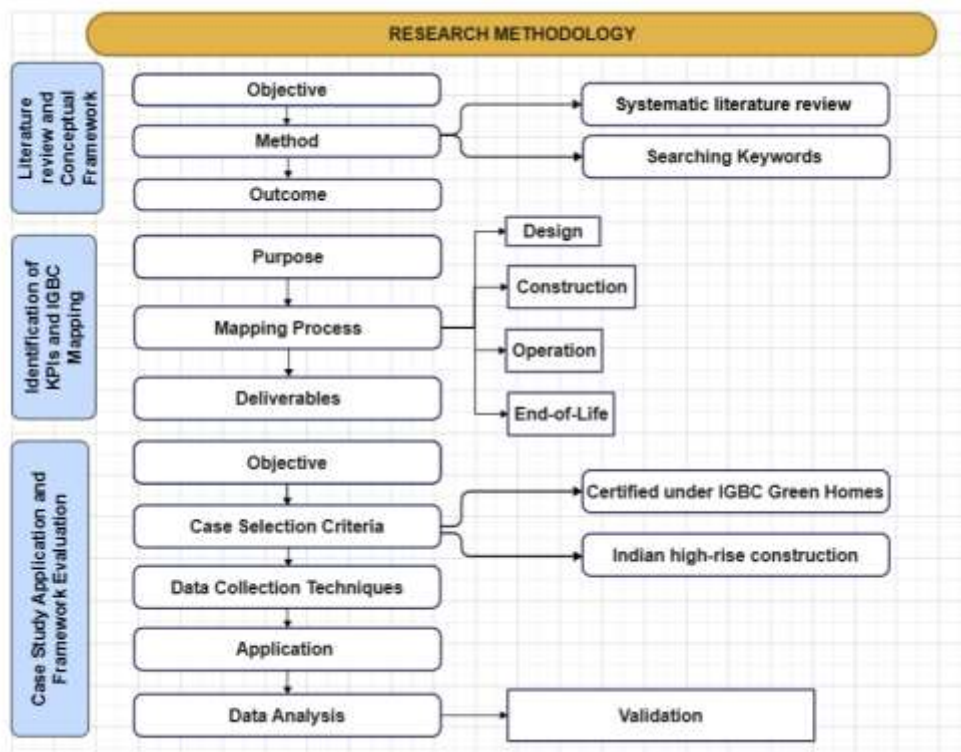
How can Circular Economy and Lean Construction principles be merged to leverage the sustainability effectiveness and impact, and efficiency of the IGBC certification process, for high-rise residential projects?

The proposed study follows a case-based analytical and framework-development strategy to study the applicability Circular Economy (CE) and Lean Construction (LC) procedures, as they can methodically be applied towards IGBC v3 Green Home Rating System. The research design is exploratory in its approach because it aims at developing

organized conceptual links between management concepts, sustainability practices and certification requirements. The study also forms and uses conceptual matrices as methodological tools to test the data instead of using the statistical test.

3.2 Methodology flowchart

Figure 1: Proposed Methodology



Source: Created by authors

3.3 Lean-circular integrated concepts development

Lean Construction aims at enhancing the efficiency of the processes by removing waste, decreasing variability and increasing coordination whereas Circular Economy aims at enhancing the resource efficiency through reuse, recycling, consideration of the life-cycle and closed-loop. The fact that sustainability issues in the residential construction business are caused by process and resource inefficiencies, therefore, makes this study combine between the LC and CE ideas into a single analytical definition.

Eight Integrated Lean -Circular Concepts (C1-C8) have been created as a result of synthesising construction management and sustainability literature. These ideas are the analytical basis of the study and represented with the help of the Integration Logic Matrix.

3.4 Framework development

3.4.1 Circular economy × lean construction integration logic matrix

Lean Construction and Circular Economy are usually introduced as several approaches in management of construction research. Lean Construction can be aimed to enhance reliability of planning, minimize the waste of processes, and optimize the workflow, whereas Circular Economy is oriented on responsible usage of resources, reusing materials, and minimizing the environmental impact of the whole building life cycle.

Table 2: Integration Logic Matrix: Lean Construction × Circular Economy

Code	Integrated Lean-Circular Concept	Lean Construction Basis	Circular Economy Basis	Integration Rationale
C1	Waste elimination & material reuse	Elimination of material waste, rework, excess inventory	Reuse and recycling of materials	Lean prevents waste generation; CE retains material value
C2	Life-cycle thinking & value optimisation	Value stream mapping across project stages	Life-cycle assessment and durability	Integrates process value with long-term resource value
C3	Design for adaptability, flexibility & disassembly	Simplification and standardisation of design	Design for disassembly and reuse	Lean simplicity enables circular reuse strategies
C4	Process transparency, planning & control	Last Planner System, visual management	Resource tracking and documentation	Enables traceability and accountability
C5	Resource efficiency in energy & water systems	Reduction of energy and water losses	Closed-loop water and renewable energy systems	Supports operational sustainability
C6	Localisation & reduced transportation impacts	Logistics optimisation and reduced movement	Local sourcing and reduced embodied carbon	Reduces emissions and supply-chain dependency
C7	Human wellbeing, safety & social responsibility	Respect-for-people principle	Social sustainability and healthy materials	Addresses social dimension of sustainability
C8	Continuous improvement, innovation & learning	Kaizen and feedback loops	Circular innovation and regenerative practices	Supports adaptive and future-ready projects

Source: Developed by authors

As a practical method of construction, particularly residential construction, the two methods are frequently used hand in hand and not separately. The lean principles assist in the minimization of unnecessary activities and wastes of materials in the process of planning and implementation, and the Circular Economy practices deal with what occurs to materials at the use, reuse, and disposal stages. It is this inherent overlap of application that will bring the two concepts of Lean Construction and Circular Economy together in this study in a unified conceptual framework.

In a bid to describe this integration, a Lean-Circular integration logic matrix was created. The matrix provides the alignment of the individual Lean concepts with the respective practices of the Circular Economy and the reason of treating the two as one intertwined entity. They are not supposed to be a convergence of theories at the conceptual level, but are aimed at being a mirror of the way sustainability-oriented construction practices are practiced in practice on the site and throughout the building life cycle.

Table 2 presents the Integration Logic Matrix used in this study. The matrix explains how Lean Construction principles and Circular Economy practices are combined and why they are treated as integrated concepts.

The utilization of the Concept Relationship Matrix as the second methodological tool, which illustrates the mapped integrated Lean-Circular concepts (C1-C8) versus the mandatory requirements and credits of IGBC Green Homes v3.0 in total. The matrix describes the conceptual alignment through binary presence-absence logic.

Table 3: Concept Relationship Matrix: Lean-Circular Concepts × IGBC Green Homes

IGBC Credits	C 1	C 2	C 3	C 4	C 5	C 6	C 7	C 8
1. Sustainable Design (SD)								
Local Building Regulations		✓	✓	✓				
Soil Erosion Control	✓	✓		✓	✓		✓	
Natural Topography & Vegetation		✓	✓		✓	✓	✓	
Heat Island Effect		✓	✓		✓			✓
Passive Architecture		✓	✓		✓			✓
Universal Design			✓	✓			✓	
Green Parking Facility				✓	✓	✓		
Access to Amenities				✓		✓	✓	
Construction Workforce Facilities	✓			✓			✓	
Green Education & Awareness				✓			✓	✓
2. Water Conservation (WC)								
Water Efficient Fixtures	✓	✓		✓	✓			
Rainwater Harvesting	✓	✓		✓	✓	✓		

Landscape Design		✓	✓		✓	✓	✓	
Irrigation Management	✓	✓		✓	✓			
Recycle & Reuse of Wastewater	✓	✓		✓	✓			✓
Water Quality		✓		✓	✓		✓	
Enhanced Rainwater Harvesting	✓	✓		✓	✓	✓		✓
Water Metering		✓		✓	✓			✓
3. Energy Efficiency (EE)								
HCFC-Free Equipment	✓	✓		✓	✓			
Minimum Energy Performance		✓		✓	✓			
Enhanced Energy Performance		✓	✓	✓	✓			✓
Alternate Water Heating		✓		✓	✓			
On-site Renewable Energy		✓		✓	✓	✓		✓
Efficient Common Equipment	✓	✓		✓	✓			
Energy Monitoring System		✓		✓	✓			✓
4. Materials & Resources (MR)								
Waste Segregation	✓			✓				
Green Procurement Policy	✓	✓		✓		✓		
Structural Optimisation		✓	✓					✓
Certified Green Products	✓	✓		✓		✓		
Local Materials	✓					✓		
Eco-friendly Wood	✓	✓				✓		
Alternative Construction Materials	✓	✓	✓			✓		✓
C&D Waste Management	✓	✓		✓				✓
Organic Waste Treatment	✓	✓		✓				✓
5. Resident Health & Wellbeing (RHW)								
Minimum Daylighting		✓	✓		✓		✓	
Ventilation Design		✓	✓		✓		✓	
No Smoking Policy				✓			✓	
Enhanced Daylighting		✓	✓		✓		✓	✓
Enhanced Ventilation		✓	✓		✓		✓	✓
Cross Ventilation		✓	✓		✓		✓	✓
Connectivity to Exteriors		✓	✓				✓	
Low VOC Materials	✓	✓					✓	
Physical Wellbeing Facilities				✓			✓	
6. Innovation & Design (ID)								
Innovation	✓	✓	✓	✓	✓	✓	✓	✓
Exemplary Performance	✓	✓	✓	✓	✓	✓	✓	✓
IGBC Accredited Professional				✓				✓

Source: Developed by author with reference from IGBC Green Homes v3.0

3.5 Role of the matrices in the overall methodology

The Integration Logic Matrix constitutes the principal conceptual part of the framework, while the Concept Relationship Matrix applies this basic building block by connecting the combined Lean-Circular concepts to the IGBC certification requirements. The combination of these two matrices represents the principal methodological contribution through this research and permits the methodical analysis through potential for certification improvement in the sections that follow.

4.0 Data Analysis

4.1 Purpose and analytical approach

The objective through this data analysis is to discover how the Integrated Lean Circularity framework, created using the Integration Logic Matrix and Concept Relationship Matrix, shows in an actual IGBC-certified high-rise residential project. The analysis is directed towards spotting the Lean-Circular concepts that are present in the project and assessing how they correspond to the IGBC Green Homes v3.0 credits that have been achieved. This part of the study evaluates the way in which the Integrated Lean-Circular framework is realized through several IGBC-certified high-rise residential projects. A comparative case study approach is used to analyse the integration of the two methodologies across different certification levels which results in greater analytical strength and less project-specific bias.

The analysis is grounded in:

- the Integration Logic Matrix (Lean × Circular), and
- the Concept Relationship Matrix (Lean-Circular × IGBC Green Homes v3.0).

4.2 Overview of case studies

Table 4: Profile of Selected IGBC-Certified Case Studies

Case Study	Location	Building Type	IGBC Certification Level	Primary Sustainability Focus
Joyville Hinjewadi	Pune	High-rise residential	Gold (Pre-certified)	Energy and water efficiency
Rohan Abhilasha	Pune	High-rise residential	Platinum (Pre- certified)	Integrated sustainability practices
5 Maidan	India (Urban)	High-rise residential	Gold / High Gold	Compliance-driven green measures

Source: Developed by author from project documentation

Three high-rise residential projects certified under the IGBC Green Homes framework were analysed:

- Joyville Hinjewadi, Pune - IGBC Green Affordable Housing, *Gold (Pre-certified)*
- Rohan Abhilasha, Pune - IGBC Green Affordable Housing, *Platinum (Pre-certified)*
- 5 Maidan, Pune - IGBC certified residential project representing mid-to-high certification performance

These projects were selected to capture variation in certification outcomes, scale, and maturity of sustainability implementation, enabling comparison of Lean-Circular integration patterns across different performance levels.

4.2 Comparative presence of integrated lean–circular concepts

Using the Integration Logic Matrix, the presence of Integrated Lean - Circular Concepts (C1-C8) was examined across all three projects.

Table 5: Comparative Presence of Integrated Lean–Circular Concepts

Integrated Concept	Joyville	Rohan Abhilasha	5 Maidan
C1 Waste elimination & material reuse	Moderate	Strong	Moderate
C2 Life-cycle thinking & value optimisation	Moderate	Strong	Moderate
C3 Design for adaptability & disassembly	Limited	Moderate	Limited
C4 Process transparency & planning	Moderate	Strong	Limited
C5 Resource efficiency (energy & water)	Strong	Strong	Moderate
C6 Localisation & reduced transport impacts	Moderate	Strong	Moderate
C7 Human wellbeing & social responsibility	Strong	Strong	Strong
C8 Continuous improvement & innovation	Limited	Strong	Limited

Source: Author's analysis based on Integration Logic Matrix

4.3 Alignment with IGBC credit categories

The Concept Relationship Matrix was then used to evaluate how the presence of integrated concepts translates into IGBC credit performance.

Table 6: Lean - Circular Alignment with IGBC Credit Categories

IGBC Category	Dominant Lean-Circular Concepts	Observed Pattern Across Case Studies
Sustainable Design	C2, C5, C7	Strong design-stage alignment, limited adaptability focus
Water Conservation	C4, C5	Consistently strong across all projects

Energy Efficiency	C2, C5, C8	Higher certification linked to monitoring and optimisation
Materials & Resources	C1, C6, C8	Clear differentiation between Gold and Platinum projects
Resident Health & Wellbeing	C7	Uniform performance, limited differentiation
Innovation & Design	C8	Key differentiator for higher certification

Source: Author's analysis based on Concept Relationship Matrix

4.4 Comparative credit realisation trends

To further clarify differences in certification outcomes, credit realisation trends were analysed qualitatively.

Table 7: Comparative IGBC Credit Realisation Patterns

Credit Category	Joyville	Rohan Abhilasha	5 Maidan
Sustainable Design	Moderate - High	High	Moderate
Water Conservation	High	High	Moderate to High
Energy Efficiency	High	Very High	Moderate
Materials & Resources	Moderate	High	Moderate
Resident Health & Wellbeing	High	High	High
Innovation & Design	Low - Moderate	High	Low

Source: Author's interpretation based on IGBC documentation and matrices

5.0 Impacts and Conclusion

5.1 Conclusion

Through above paper which is intended at discussing incorporation of Circular Economy alongwith Lean Construction (LC) principles, as they are applicable to high-rise residential buildings to improve the effectiveness of the IGBC Green Homes Rating System. Instead of considering Lean and Circular approaches as similar sustainability practices, the study generated and implemented an integrated Lean-Circular framework, which is operationalised using an Integration Logic Matrix and a Concept Relationship Matrix that is consistent with IGBC Green Homes v3.0.

The results indicate that the achievement of the higher IGBC certification results is not motivated only by the implementation of the personal green technologies or the measures of compliance. Rather, improvement of accreditation is highly associated with the level of integration of process efficiency with resource efficiency throughout the project lifecycle.

The projects with a higher level of certification demonstrate a wider and deeper implementation of the integrated Lean-Circular ideas especially in the convention of process transparency, material circularity, and continuous improvement.

The comparative analysis of three IGBC-certified residential case studies also confirms that though the energy efficiency and water conservation actions are well developed and consistently applied to projects, they mostly assist in meeting minimum certification criteria. Conversely, the categories like Materials and Resources and Innovation and Design are very important in distinguishing between the Gold and Platinum outcomes. They are the categories that can be best benefited through combined Lean-Circular application since they need to be planned together, have their waste systematically reduced, documented, and learn instead of being subject to a single design intervention. Overall, the study supports the central hypothesis that integrating the ideas and principles of Lean Construction and the circular economy improves the IGBC certification process by lessening the disconnect between sustainability mindset, implementation, and performance checks.

5.2 Theoretical implications

This study has added to the current mass of knowledge by making Lean-Circular integration go further than the conceptual debate on sustainability and reach the area of formal green building certification systems. Though the interaction of Lean and sustainability or Lean and Circular Economy were examined previously in individual studies, this paper illustrates that such a combination can be designed and implemented on a developed rating system. Concept mapping to analyze the interdisciplinary interaction in construction management research using integration and relationship matrices is a methodological approach that can be duplicated. The study closes a major gap in the relationship between sustainability theory and certification practice by integrating Lean-Circular ideas into the very framework of the credit structures of IGBC.

5.3 Practical Implications

The results of this study are numerous and significantly impact the stakeholders involved in IGBC certified residential projects:

- The real estate development community and property owners can consider the major lesson learned through this research as the opportunity to achieve the highest level of certification without the need for redesign and applying expensive technologies. The union of Lean and Circular makes this possible.
- The project managers and construction personnel will know the importance of process transparency, workflow efficiency, and continuous monitoring in receiving sustainability credits, thanks to the research outputs.

- IGBC - certified auditors and consultants will be able to follow the proposed model as a guided procedure to pinpoint areas in which the best designs are still losing or can lose the battle, particularly in areas related to material management and innovation documentation.

6.0 Limitations

The study's restrictions are that it does not use performance measurement (quantitative) but rather conceptual mapping and case study analysis. Although the framework is quite insightful in terms of the analysis, the next phase of research might involve longitudinal performance data, interviews with stakeholders, or statistical validation on a broader sample of projects.

Future studies may also be done on how the proposed framework applies to other building typologies and certification systems or how digital tools like BIM could be used to facilitate Lean-Circular integration in certification-based projects.

The extension of the research should be on the validation of the Lean-Circular framework proposed, based on quantitative performance indicators on a larger sample of IGBC-certified projects. The longitudinal research of a post-occupancy performance may help to explore more profoundly the advances of Lean-Circular integration over the course of time. Additional research can be also done on how the framework can be applied in other building typologies and green building rating systems.

7.0 Recommendations

In accordance with inference of this research and implementation of the integrated Lean-Circular model to IGBC-certified high-rise residential buildings, the following recommendations can be offered to the most important stakeholders of residential buildings planning, design, construction, and certification.

7.1 Project developers and owners

Project developers must not just use an approach that is more focused on compliance to IGBC certification but instead embrace the use of Lean -Circular principles as one of the components of their overall project delivery approach. With prior adoption of Lean planning and Circular resource strategies, coordination between design and construction teams can be enhanced, wastage of materials can be minimized, and the life-cycle performance could be improved. Promoters are urged to incorporate the Lean-Circular goals in project briefs and project contracts in order to have uniform implementation throughout the project lifecycle.

7.2 Design team and consultants

The Lean and Circular thinking should be combined by architects, engineers, and sustainability consultants at the initial design stages. The decisions covering design must be based on flexibility, efficient design, and material optimisation in addition to end-of-life recovery and re-use. Records of Lean-Circular integration by the consultants should be made in written reports to the IGBC as part of IGBC Innovations and Exemplary Performance credits to enhance the certification results.

The Lean Construction tools that should be embraced by the construction teams include a dependable planning, the workflow coordination and the continuous monitoring so that the sustainability measures that were identified during the design phase are achieved on the ground. The implementation of the Circular Economy practices, including organised construction waste management, material recovery, and local sourcing would contribute greatly to the performance in Materials and Resources credits. Data collection and documentation should also be emphasized to assure the certification verification.

7.3 IGBC and policy stakeholder

IGBC can look into reinforcing its message on integrated process-based sustainability strategies as the part of its certification. Project teams could be persuaded to be more holistically-sustainable through the introduction of Lean-Circular thinking into training-programmes, best-practice manuals, and evaluation standards. Realisation of integrated management frameworks in Innovation and Design credits would also encourage continuous improvement and innovation.

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