CRITICAL SUCCESS FACTORS FOR IMPLEMENTING MODULAR INTEGRATED CONSTRUCTION IN ABUJA, NIGERIA

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ABSTRACT

The adoption of Modular Integrated Construction (MIC) has been increasingly recognised as a transformative approach to improving efficiency, quality, and sustainability in the construction industry. However, its successful implementation in developing countries such as Nigeria remains limited due to industry-specific challenges. This study examines the critical success factors (CSFs) for implementing MIC in the Nigerian construction sector. A survey research design was adopted, targeting professionals from 51 construction firms in Abuja with experience or knowledge of MIC. Data were collected using a structured questionnaire and analysed through descriptive statistics, Relative Importance Index (RII), and Factor Analysis using IBM SPSS. The Kaiser-Meyer-Olkin (KMO) value of 0.594 and Bartlett's Test of Sphericity ($p < 0.05$) confirmed the adequacy of the sample for factor analysis, which extracted seven principal components accounting for 73.35% of the total variance. The identified CSFs include: (1) adequate experience and knowledge of key players, (2) effective project planning and scheduling, (3) strong supply chain integration, (4) infrastructure readiness, (5) standardisation and mass production, (6) suitable procurement strategies, and (7) availability of skilled workforce. Cross-referencing with previous studies reveals a strong alignment with global findings while emphasising the unique contextual challenges in Nigeria, such as skill gaps and infrastructure limitations. The study concludes that strategic emphasis on these CSFs will enhance MIC adoption and recommends policy, training, and infrastructure development to support its growth.

KEYWORDS: *Construction Industry, Critical Success Factors, Modular Integrated Construction, Prefabrication.*

INTRODUCTION

Building construction is often a complex and demanding process, characterized by challenges such as extreme weather conditions, excessive working heights, and limited site accessibility (Yang *et al.,* 2017). These inherent risks have long been recognized, prompting the adoption of various strategies aimed at improving efficiency, safety, and overall project performance (Wuni *et al.,* 2019). One of the most prominent approaches advocated by industry experts is the use of prefabricated building components, which transfers a significant portion of construction activities from the field to a controlled factory environment (Navaratnam *et al.,* 2019).

Prefabrication shifts the construction process from on-site fabrication to off-site manufacturing, allowing site activities to focus primarily on assembly. While this practice is not entirely new since components like doors, windows, and bricks were traditionally produced on-site modern construction now depends largely on prefabricated, factory-manufactured elements that are delivered ready for installation (Generalova *et al.,* 2016). Among the various prefabrication approaches, modular construction stands out for its extensive use of factory-based assembly, with research showing that a higher degree of prefabrication often results in greater project benefits (Anthony *et al.,* 2013).

Extensive literature has documented the positive impact of modular construction on productivity, environmental sustainability, health, and economic outcomes (Wei & Voellm, 2016; Alwan *et al.,* 2017; Dave *et al.,* 2014; Generalova *et al.,* 2016). Studies have explored its application in low- and high-rise buildings (Lawson *et al.,* 2012), assessed its feasibility (Velamati, 2012), and analyzed its time, cost, and quality benefits (Yoon *et al.,* 2015). Furthermore, modular construction has been linked to energy and cost efficiency (Wuni & Shen, 2019), disaster risk reduction (Wagemann, 2012), job creation, green city development (Volder & Dvorak, 2014), and climate change adaptation (Kamali & Hewage, 2016; Lee *et al.,* 2014).

Despite these documented advantages, the adoption of modular construction in many developing countries, including Nigeria, remains limited (Kibert, 2016; Lundholm *et al.,* 2014). The Nigerian construction industry continues to rely predominantly on traditional building methods, often using untested materials and inefficient processes, leading to delays, cost overruns, and quality shortfalls (Sholanke *et al.,* 2019). As a result, project delivery frequently fails to meet planned timelines and budgets. Recent studies suggest that the integration of modular construction could play a vital role in enhancing national development by improving construction efficiency and quality (Sholanke *et al.,* 2019). Given the potential of modular integrated construction (MIC) to address these persistent challenges, there is a need to identify the critical success factors that can drive its effective implementation in Nigeria. Understanding these factors will not only facilitate the adoption of MIC but also support the broader objectives of sustainable construction, cost control, and improved project outcomes in the Nigerian construction sector.

To achieve the aim, the following objective is formulated to:

1. To examine the critical success factors for implementing modular integrated construction as a building construction method.

LITERATURE REVIEW

Modular Construction

Construction processes and the built environment have great impact on the environment, human well-being, as well as the overall economy. Sustainable construction in the environmental, social and economic dimensions is feasible through practical innovations and developments (Nahmans, & Ikuma, 2012). Modular construction portrays the use of off-site pre-designed building units or parts that are conveyed to site as components of a building called modules (Steel Construction ,2017. In). Modular construction offers several advantages over traditional building methods, including the production of high-quality components under controlled factory conditions, cost efficiency through economies of scale, and shorter construction timelines. It also provides valuable opportunities for workforce development by promoting technical skill acquisition among semi-skilled workers, thereby enhancing overall economic value (Boyd, Khalfan, & Maqsood, 2013).

Modular construction can be used for either temporary or permanent building structures and are not subject to severe weather conditions unlike site-built structures. The modular construction concept can be applied to all types of building construction including offices, hotels, houses and retail stores (Akok, & Prakask, 2017; Wuni *et al.,* 2020). Modular construction occurs in phases which are: predesign, design, develop, detail, order, fabricate, deliver and assembly (Smith,2016).

Success factors for modular integrated construction projects

Given the limited amount of published research on MiC projects, bespoke success factors can hardly be retrieved directly from the literature (Wuni and Shen 2019a). However, there are some relevant studies on the success factors for other OSM techniques such as industrialized building systems (IBS), prefabricated prefinished volumetric construction (PPVC), modular construction, prefabrication, prework, and volumetric modular construction which are relevant to

MiC projects (Hwang *et al.,* 2018). This is because MiC has many similarities with the modus operandi of these OSM techniques. Thus, the research conducted a comprehensive review of the relevant literature to identify the success factors which may be applicable to MiC projects.

Song *et al.,* (2005) found that the prominent CSFs for pre work on industrial projects include realistic economic analysis, early commitment to the approach, availability of skilled management team, and availability of sound infrastructure network for transporting the modules to site. Tam *et al.* (2007) identified suitable procurement strategy and contracting to be a CSF for prefabricated construction projects. Blismas (2007) summarized the 5 top CSFs for modular construction projects as robust design specification and early design freeze, effective supply chain management, early involvement of key participants, suitable procurement strategy, and relevant experience and knowledge of key players. Blismas and Wakefield (2009) conducted a questionnaire survey and identified that early commitment is a CSF for OSM projects.

Pan *et al*. (2012) conducted a questionnaire survey in the UK and found that robust engineering specification, design robustness and early design freeze constitute CSFs for industrialized housing projects. Choi *et al.* (2016) concluded that timely design freeze, long lead equipment specification, fabricator/ supplier involvement, and effective risk management are the four prominent CSFs for industrial modular construction projects. Li *et al.* (2018) conducted a questionnaire survey in China and found that the prominent CSFs for planning and control of prefabricated construction projects include involvement of key players at the earliest stages of the project, adequate knowledge and experience of key participants, effective communication and information sharing among project participants, efficient use of information and communication technology, and proper coordination between onsite and off-site trades. Even though a plethora of research have expounded on the CSFs for various OSM techniques, there is no specific empirical study on CSFs for MiC in the extant literature (Wuni and Shen 2019). Nonetheless, the comprehensive review of the literature provided a good framework and reference point to identify the CSFs which may be relevant to MiC projects.

METHODOLOGY

This study adopted a survey research design due to the complexity, diversity, and fragmentation of the Nigerian construction industry. The survey approach enabled the collection of data from professionals across selected construction firms to assess critical success factors for Modular Integrated Construction (MIC). The research population comprised 255 construction firms registered in Abuja, as obtained from the Abuja Business Directory (2024 edition). However, preliminary screening was conducted through phone calls, emails, and brief inquiries to determine which firms had prior knowledge or practical experience with Modern Industrialised Construction (MIC) techniques. This step was necessary because not all construction firms in Abuja are familiar with or have implemented MIC practices, which remain relatively new in Nigeria's construction sector.

Based on the outcome of this screening exercise, only 51 firms indicated that they had either used MIC, had an understanding of its processes, or were considering its adoption in their future projects. These firms therefore constituted the effective population for this study, as they were most relevant to the research objectives. From each firm, one professional such as a project manager, architect, engineer, or quantity surveyor was selected as a respondent, based on their involvement in decision-making or technical implementation of construction methods.

Given the relatively small and specific population, a snowball sampling technique was employed. This approach was appropriate because MIC adoption is relatively rare in Nigeria, making it challenging to locate all potential respondents. Following Masuku and Singh's (2014) recommendation for small populations, the study used the entire

identified population of 51 firms as the sample size. This ensured a desirable level of precision in representing the views of construction professionals experienced or knowledgeable in MIC.
Primary data was collected through a structured questionnaire divided into two sections: demographic information and technical aspects of the research objectives. The questionnaire was designed using a five-point Likert scale to quantify respondents' perceptions and attitudes toward various aspects of Modern Industrialised Construction (MIC). The scale ranged from 1 (Very Low) to 5 (Very High), allowing participants to express the intensity of their agreement or experience with specific statements. This format was adopted because it facilitates the measurement of subjective constructs such as success factors in a structured and comparable manner.

Specifically, respondents rated the degree to which success factors (e.g., government support, training, and collaboration) affect project outcomes.. A pilot survey involving 20 respondents was conducted to test the clarity, reliability, and validity of the instrument. Feedback from the pilot study informed revisions to improve the final questionnaire used in the main survey.
The analysis of data in this study was carried out using IBM SPSS version 22, with a focus on identifying and prioritising the Critical Success Factors (CSFs) for the implementation of Modular Integrated Construction (MIC) in Nigeria. The approach combined descriptive statistics, Relative Importance Index (RII), and factor analysis. Descriptive statistics were used to provide a profile of the respondents and summarise responses to each questionnaire item. The RII method was applied to rank the perceived importance of different success factors, enabling an initial identification of the most influential variables.

RESULTS AND DISCUSSION

The position occupied by the respondents, as shown in respondent Figure 1 revealed that out of the 50 professionals sampled, 18 were site engineers, 15 were construction managers, 12 were project managers, and 6 were procurement officers. The study went on to categorise the respondents by profession: twenty were architects, twelve were civil/structural engineers, eleven were quantity surveyors, and seven were builders as shown in Figure 2.

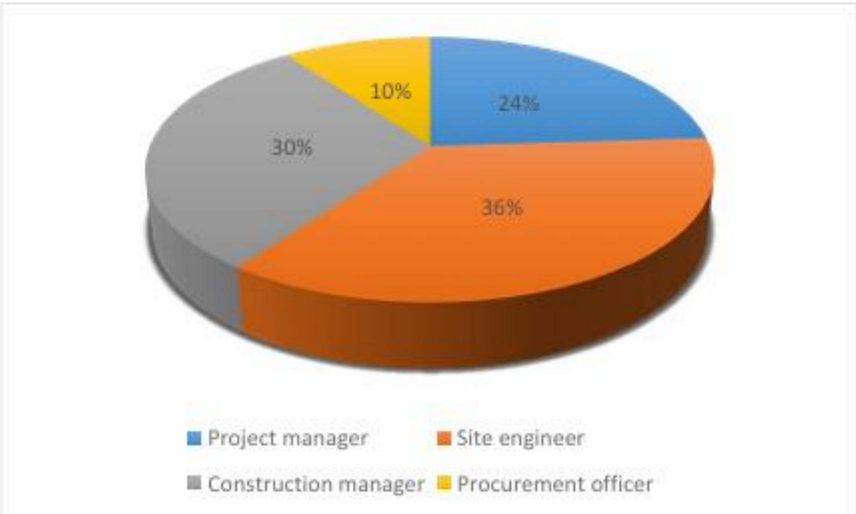

Figure 1: Position of Respondents

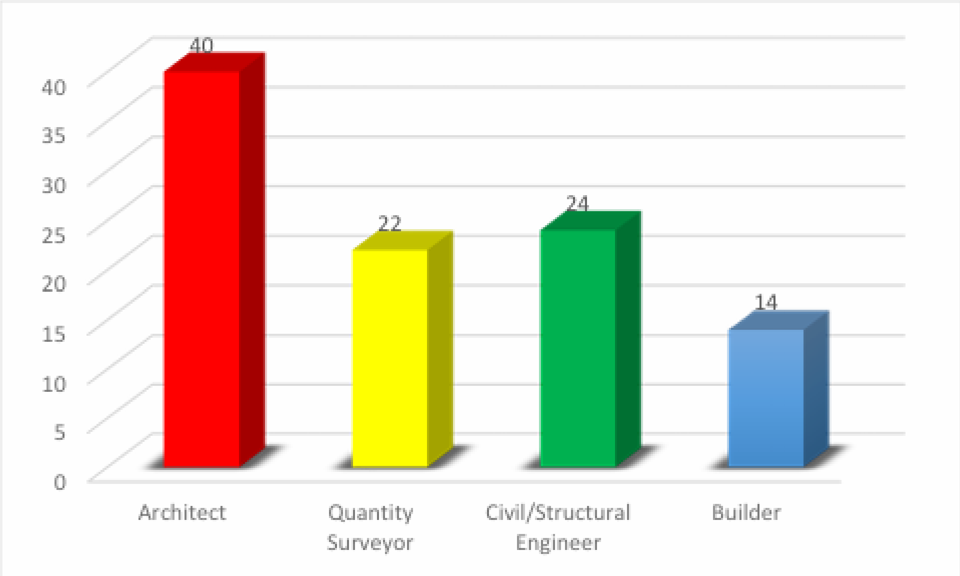

Figure 2: Profession of Respondents

Factor Analysis for Critical Success Factors for Implementing Modular Integrated Construction as a Building Construction Method.

Table 1 presents the results of the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity, which are preliminary diagnostics used to determine the suitability of the dataset for factor analysis. The KMO value obtained was 0.594, which falls within the range considered mediocre according to Kaiser's (1974) classification. While this value is below the ideal threshold of 0.70, it is still above the minimum acceptable level of 0.50, indicating that the sampling adequacy is sufficient to proceed with factor analysis, though the strength of the intercorrelations among variables is moderate.

The Bartlett's Test of Sphericity yielded an Approximate Chi-Square value of 345.489 with 153 degrees of freedom and a significance level (Sig.) of 0.000. This p-value being less than 0.05 indicates that the correlation matrix is not an identity matrix, meaning that there are significant relationships among the variables. This statistical significance confirms that factor analysis is appropriate because the dataset contains adequate interrelationships to extract underlying factors.

Table 1: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.594
Bartlett's Test of Sphericity	Approx. Chi-Square	345.489
	df	153
	Sig.	.000

Table 2 shows the results of the Principal Component Analysis (PCA) for determining the underlying dimensions of the critical success factors for implementing Modular Integrated Construction (MIC). Using the Kaiser criterion (eigenvalues greater than 1), a total of seven components were extracted. The initial eigenvalues reveal that Component 1 accounted for the largest share of the variance at 21.784%, followed by Component 2 with 11.923%, and Component 3 with 10.665%. The remaining four components explained between 6.27% and 8.64% each. Together, these seven components explained a cumulative variance of 73.352%, which is well above the commonly accepted threshold of 60%, indicating that the extracted components capture most of the information in the dataset. After rotation, which redistributes variance more evenly among components for better interpretability, the variance explained by the first component was reduced to 17.262%, while the second component increased slightly to 12.345%. Similarly, Components 3 to 7 each accounted for between 7.676% and 10.365% of the variance after rotation. This redistribution suggests that the rotated solution provides a more balanced and interpretable factor structure, which is particularly important when identifying and naming the critical success factors.

The results indicate that the critical success factors for MIC can be meaningfully grouped into seven distinct dimensions, each representing a cluster of related variables. The relatively high cumulative variance explained demonstrates the adequacy of the factor solution in summarising the data and supports its use for further interpretation and discussion in relation to MIC adoption in the Nigerian construction industry.

Table 2: Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.921	21.784	21.784	3.921	21.784	21.784	3.107	17.262	17.262
2	2.146	11.923	33.707	2.146	11.923	33.707	2.222	12.345	29.608
3	1.920	10.665	44.372	1.920	10.665	44.372	1.866	10.365	39.972
4	1.555	8.637	53.009	1.555	8.637	53.009	1.668	9.264	49.237
5	1.283	7.130	60.140	1.283	7.130	60.140	1.569	8.717	57.954
6	1.249	6.938	67.078	1.249	6.938	67.078	1.390	7.721	65.675
7	1.129	6.274	73.352	1.129	6.274	73.352	1.382	7.676	73.352
8	.862	4.790	78.142						
9	.824	4.576	82.717						
10	.626	3.480	86.197						
11	.597	3.314	89.511						
12	.508	2.820	92.331						
13	.413	2.295	94.626						
14	.348	1.932	96.558						
15	.267	1.484	98.042						
16	.175	.972	99.014						
17	.123	.681	99.695						
18	.055	.305	100.000						

Extraction Method: Principal Component Analysis.

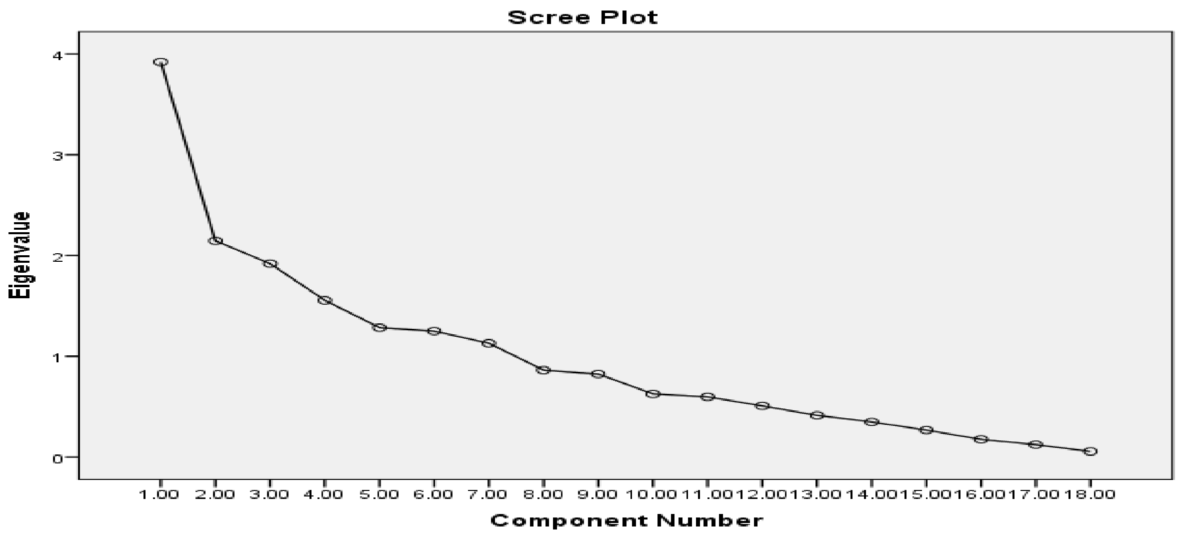

Figure 3: Scree plot of the Components

Table 3 presents the rotated factor loadings for the seven components extracted using Principal Component Analysis (PCA) with Varimax rotation. The rotation has redistributed the variance to maximise high loadings within each factor and minimise cross-loadings, thus improving interpretability. Component 1 is dominated by high loadings on "Adequate experience and knowledge of key players" (0.938), "Experienced workforce and technical capability" (0.908), and "Effective coordination of on-site and off-site trades" (0.890). This factor represents Workforce Competence and Operational Coordination.

Component 2 is defined by "Extensive project planning, scheduling and control" (0.891), "Effective coordination of the supply chain segments" (0.818), and moderate loadings on "Effective supply chain and execution risk management" (0.570). This factor can be interpreted as Project Planning and Supply Chain Integration. Component 3 features strong loadings on "Availability and active involvement of key project team members from the earliest stage of the project" (0.708), "Early completion and cost savings recognition" (0.480), and "Good working collaboration, communication and information sharing" (0.457), suggesting the theme of Team Engagement and Collaborative Practices.

Component 4 is strongly defined by "Availability of sound local transport infrastructure" (0.873) and "Alignment on MiC project drivers and modules architecture" (0.565), which align with Infrastructure Readiness and Project Alignment. Component 5 contains "Standardisation and mass production" (0.773) and "Fabricator experience and capabilities in modules design and production" (0.703), indicating Design Standardisation and Fabrication Expertise. Component 6 is dominated by "Suitable procurement strategy and contracting" (0.878) and "Availability of skilled workforce, management and supervision team" (0.555), reflecting Procurement Strategy and Skilled Resources. Finally, Component 7 is defined by "Realistic economic analysis, early decision and definition of project scope" (0.814), which relates to Economic and Scope Definition Readiness.

Overall, the rotated component structure reveals seven distinct critical success factors for the implementation of Modular Integrated Construction in the Nigerian construction industry. These factors encompass workforce competence, planning and integration, team collaboration, infrastructure readiness, standardisation, procurement strategies, and economic planning. The clear separation of variables into these components enhances the validity of the analysis and provides a strong foundation for targeted recommendations to improve MIC adoption.

Table 3: Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
Adequate experience and knowledge of key players	.938						
Experienced workforce and technical capability	.908						
Effective coordination of on-site and off-site trades	.890						
Extensive project planning, scheduling and control		.891					
Effective coordination of the supply chain segments		.818					
Robust drawing specification and early design freeze	.523	.577	-.385				
Availability and active involvement of key project team members from the earliest stage of the project			.708				
Effective supply chain and execution risk management		.327	.570				
Early advice from experts and consideration of MiC			-.551	.428	-.330	-.331	
Good working collaboration, communication and information sharing			.457		.365	-.348	-.380
Availability of sound local transport infrastructure				.873			
Alignment on MiC project drivers and modules architecture				.565		.304	
Early completion and cost savings recognition			.463	.480			
Standardization and mass production					.773		
Fabricator experience and capabilities in modules design and production					.703		
Suitable procurement strategy and contracting						.878	

Realistic economic analysis, early decision and definition of project scope		.814
Availability of skilled workforce, management and supervision team	-.438	.555

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 18 iterations.

The seven critical success factors identified in this study align closely with findings from previous research on Modular Integrated Construction (MiC) adoption in both developed and developing contexts. For instance, the emphasis on workforce competence, operational coordination, and integrated planning mirrors the conclusions of Jaillon and Poon (2010) and Lu *et al.* (2018), who highlighted skilled labour, early planning, and cross-trade coordination as essential for modular project success. Similarly, the importance of supply chain integration and standardisation reflects the work of Li *et al.* (2014), which underscored the role of robust supply networks and design repeatability in reducing delays and costs. The identification of infrastructure readiness as a key factor also supports Kamar *et al.* (2012), who noted that efficient transportation networks are vital for large prefabricated components. Moreover, procurement strategies and economic analysis as drivers resonate with Pan and Goodier's (2012) assertion that contractual clarity and cost-benefit validation are central to stakeholder buy-in. However, unlike studies in mature markets, this research stresses the availability of skilled resources as a distinct component, reflecting Nigeria's context where technical capacity gaps may hinder execution. Overall, the convergence of these results with earlier studies reinforces the universality of certain MiC success factors while also highlighting context-specific priorities for Nigeria's construction industry.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study examined the critical success factors (CSFs) for implementing Modular Integrated Construction (MiC) in the Nigerian construction industry, with a focus on construction firms in Abuja. Using survey research, descriptive analysis, and factor analysis, seven key factors were identified as essential for MiC success: adequate experience and knowledge of key players, effective project planning and scheduling, strong supply chain integration, infrastructure readiness, standardisation and mass production, suitable procurement strategies, and availability of skilled workforce. The findings align closely with global literature on MiC but also highlight unique challenges in the Nigerian context, including skill shortages, inadequate transport infrastructure, and limited stakeholder awareness. To enhance the successful adoption of MiC in Nigeria, the study recommends: targeted training and capacity development for professionals and artisans; early engagement of all project stakeholders to ensure better design integration and coordination; strengthening local supply chains to reduce dependency on imports; improving transport and logistics infrastructure; promoting standardisation of MiC components; adopting procurement models that foster collaboration and risk-sharing; and introducing government policies and incentives to encourage MiC uptake. To enhance the successful adoption of MiC,

Recommendations

The study recommends that government agencies formulate clear policies and regulatory frameworks to promote modular construction, including incentives such as tax reliefs, grants, or fast-track approvals for MiC-based projects. Professional bodies and academic institutions should incorporate modular construction principles into training curricula and continuing professional development programmes to build technical competence among industry practitioners. Furthermore, investment in infrastructure, particularly in transportation networks and industrial clusters, is essential to facilitate the movement and assembly of prefabricated components. Future research should explore the economic viability, lifecycle cost implications, and environmental performance of MiC within the Nigerian context, as well as comparative studies across regions to identify scalable models for wider adoption. Such investigations would provide deeper insights into how MiC can contribute to sustainable, efficient, and resilient construction practices in developing economies.

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