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Adoption of Industrialized Building System for Effective Housing Delivery in Ajaokuta Metropolis, Kogi State

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Abstract

The persistent housing deficit in Nigeria has necessitated the exploration of innovative construction approaches capable of improving housing delivery in terms of cost, time, and quality. One such approach is the Industrialized Building System (IBS), which emphasizes off-site fabrication and on-site assembly of building components. Despite its proven benefits globally, the level of IBS adoption in many Nigerian urban centres remains unclear. This study assessed the adoption of the IBS as a strategy for enhancing effective housing delivery in Ajaokuta Metropolis, Kogi State, Nigeria. Employing a quantitative research design, data were collected via structured questionnaires from 152 construction professionals, including architects, builders, engineers, and quantity surveyors. 76% response rate was achieved. Mean score ranking, factor analysis, and multiple linear regression were used for data analysis. The findings revealed a low level of IBS adoption (mean score = 2.18), primarily hindered by infrastructural and market development barriers, such as the lack of local manufacturing plants, underdeveloped road networks, and high logistics costs. The study established a statistically significant inverse relationship between these adoption challenges and housing delivery effectiveness, with infrastructure deficits being the most critical predictor ($\beta = -0.281$, $p<0.001$). While housing delivery was moderately effective in terms of affordability and quality, it was constrained by the same systemic gaps that impede IBS uptake. The study concludes that overcoming IBS adoption barriers requires a holistic, policy-driven approach focused on developing local industrial capacity, improving critical infrastructure, and enhancing professional skills. Recommendations include establishing local IBS manufacturing clusters, integrating affordability mechanisms into housing

projects, and implementing targeted regulatory reforms to foster an enabling environment for modern construction methods.

Keywords: Adoption Barriers, Ajaokuta, Construction Innovation, Industrialized Building System (IBS), Housing Delivery.

Introduction

The construction industry is one of the productive sectors that constantly contribute to the economy. Since the 1990's, the contribution of the construction sector to the GDP also fluctuated albeit at a more stable rate varying from a high of 4.8 percent in 1997 to an estimated low of 2.7 percent in 2005 (Ismail et al., 2019). This shows that the demand for construction is highly sensitive to the developments in other sectors of the economy. There is a growing need worldwide to deliver construction projects more quickly while maintaining the required quality levels and environmental protection (Fei et al., 2021). It is widely recognized that IBS provides a potential solution in improving project delivery effectiveness and efficiency, and the need for its adoption is well established (e.g. Ariffin et al., 2019).

An Industrialized Building System (IBS) is a construction system that re-emerged worldwide as a solution to cope with a high demand of building construction such as cost, labours, quality and productivity of the construction (Ekanayake et al., 2021). Industrialized Building System (IBS) has been introduced to cope with a growing demand of affordable housing, solving issues associated with foreign labours and improving image, quality and productivity of construction industry. The term IBS is synonymous with prefabrication, precast, off-site construction, modularized construction and modern-method construction (manufacturing aligned process of building methods). The adoption of IBS technology has allowed the construction industry to achieve remarkable productivity gains and is now one of the prevalent and growing building technologies in both developed and developing countries (Amede et al., 2025). Despite the IBS being accepted by most construction firms as a viable method, because of its advantages in terms of speed, safety and quality, the wet construction method which is costly and has slow completion time, is still the most common construction method, in construction projects (Rushton, 2022).

Adedeji, (2023) reported that Nigeria is currently facing a progressive housing deficit which is similar to many other rapidly developing countries. For example, Nigeria has a population of over 187 million, with an annual growth rate of about 2.5% with an urgent need of about 17 million new houses. Thus, in order to address this housing deficit, mitigation efforts such as a paradigm shift from the conventional construction method to a more innovative housing production processes like industrialized building system approach is vital.

Statement of Problem

Nigerian construction industry plays a significant role in the nation's economic

growth, contributing to essential infrastructure development (Rasool, 2024). However, the industry faces persistent challenges that hinder project success. These challenges often manifest as cost overruns, schedule delays, and compromised quality of construction (Pavate, 2024; Gurumayum, 2025). These issues highlight a critical need for industrialized building system (IBS). Industrialized building system (IBS) serves as the cornerstone of successful project delivery in terms of waste reduction, timely delivery and reduction in cost. This controlled environment and application of IBS offers several benefits, particularly: a higher speed of construction; improved quality of the finished product; lower costs; and lower labour requirements on-site (Jaffar & Lee, 2020). This approach offers a platform for addressing the specific problems inherent, in conventional housing delivery systems. The population of Nigeria and the huge housing deficit requires the country will continue to embark on building system or method than will help to bridge the housing deficit. Furthermore, the increasing demand for construction method will require that new technology and sustainable strategies such as IBS be adopted. The prospect for IBS adoption in Nigeria is bright, but great work is still needed from both the government and professionals to be able to increase the application of this construction method in housing development (Sani et al, 2023). This will help to enhance the efficiency of construction process, allowing a higher productivity, quality, time and cost saving (Awad et al., 2021). Majority of the developers and contractors in Ajaokuta are still using the conventional building system method which could not cope with the huge demand, despite the advantages offered by IBS in terms of waste reduction, timely delivery and cost reduction. Therefore, the former system must be replaced by an industrialized building system (IBS) which has immense inherent advantages in term of productivity, indoor quality, durability and cost. Therefore, the focus of this study is to examine the adoption of industrialized building system (IBS) of housing development in Ajaokuta Kogi state.

Aim and Objective

The main aim of this study is to investigate the adoption of Industrialized Building System (IBS) in Ajaokuta metropolis with a view to improving housing delivery. To achieve this, the following objectives were outlined:

- To investigating the level of adoption of Industrialized Building System (IBS) in the study area,
- To assess the challenges of Industrialized Building System (IBS) in the study area,
- To determine the effectiveness of housing delivery in the study area
- To determine the relationship between the challenges of Industrialized Building System (IBS) and the effectiveness of housing delivery in the study area.

Research Questions

i. What is the level of adoption of Industrialized Building System (IBS) in Ajaokuta Metropolis, Kogi State?
ii. What are the challenges of Industrialized Building System (IBS) in the study area?
iii. What is the effectiveness of housing delivery in the study area?
iv. What is the relationship between the challenges of Industrialized Building System (IBS) and the effectiveness of housing delivery in the study area?

Significance of the Study

The findings of this study will contribute to literature and body of knowledge as it will point out the impact of Industrialized Building System (IBS), the challenges of Industrialized Building System (IBS) and the level of adoption of Industrialized Building System (IBS) in the study area and give recommendations. This study will be beneficial to the researchers as it will serve as a guide to other researchers in future research on Industrialized Building System (IBS). This will help improve the quality and productivity of the industry and reduce the rate of project cost overrun and failure, which negatively impacts the national development. This study focused on assessing and evaluating the adoption of industrialized building system (IBS) for effective housing delivery in Ajaokuta, Kogi state Nigeria. Industrialized building system (IBS) is a construction technique where all the components are manufactured in a controlled environment, and are then transported, placed and assembled at the work site with minimal 6 additional structures. The study adopted a quantitative approach to data collection and analysis. The quantitative data was obtained from a survey questionnaire administered to construction industry professionals, including project managers, architects, quantity surveyors, builders, and civil engineers involved in construction projects in Ajaokuta.

Construction Method

Construction methods are the techniques construction professionals use to build structures and complete projects. Classified by the materials they require, their design and purpose, professionals' separate construction methods into many types (Yaman *et al.,*2019). Construction methods are important for construction professionals such as Quantity surveyors, Engineers and Architects to understand. This knowledge helps to design structures, plan projects and create safe working environments (Saka & Chan, 2020). Modern construction methods (MCM) are methods that are developed in construction industry with proper planning and design so that each project reduces the construction time, cost and maintain overall sustainability (Saka & Chan, 2020).

Industrialized Building System (IBS)

Industrialized Building Systems (IBS) mark a shift from traditional, labor-intensive on-site construction to a manufacturing-led approach where components are prefabricated in controlled factories, transported, and assembled on-site (Kedir, 2022). In Nigeria, IBS is often used interchangeably with "prefabrication," "off-site construction," and "modern methods of construction." The key principle is relocating much of the construction value chain from the unpredictable site to a quality-controlled environment, enhancing efficiency, speed, and quality. The Malaysian IBS Roadmap (2003–2010) offers a widely referenced classification, including: (1) Precast Concrete Framing, Panel, and Box Systems; (2) Formwork Systems (e.g., tunnel forms); (3) Steel Framing Systems; (4) Prefabricated Timber Framing Systems; and (5) Block Work Systems (Kedir, 2022). In Nigeria, precast concrete and steel framing dominate, particularly in commercial and institutional projects, with emerging interest in modular units for sectors like hospitality and healthcare (Fagbenle et al., 2021).

Essential Characteristics of Industrialized Building System (IBS)

It is plausible to review the prerequisite characteristics underlining the successful implementation of industrialized building system. Each of them is briefly discussed below.

Closed System: Closed systems are categorized into production based on the client's design and production based on the pre-caster's design. The former prioritizes specific spatial and architectural requirements, requiring customized components. The latter involves standardized building types or variants produced using common components, such as schools and low-cost housing. This approach is economically feasible only when project size justifies cost distribution, architectural design emphasizes repetition and standardization, market demand supports mass production, and effective marketing highlights both economic and non-economic benefits (Adnan et al., 2019).

Open System: Due to the limitations of closed systems, an open system has been proposed to enhance design flexibility and coordination between designers and precasters. This approach allows the production of a limited range of standardized elements while maintaining architectural aesthetics. Despite its advantages, the open system faces a major challenge: compatibility issues at joints and connections when elements from different systems are combined. Achieving optimal structural performance therefore requires uniform connection technology (Adnan et al., 2019).

Modular Coordination: Modular coordination is a standardized dimensional system that ensures building components and fittings integrate seamlessly, even when produced by different suppliers (Ariffin et al., 2019). Its objectives are to reduce the variety of component sizes through standardization and interchangeability, and to enable flexible layout integration using a common modular grid (Reisinger et al., 2021). The system typically adopts a basic module of M = 100 cm or its multiples. Although conceptually simple, effective implementation requires significant coordination in manufacturing and component interfacing.

Standardization and Tolerances: To achieve modular coordination, building components must be standardized, with defined tolerances at manufacturing, setting-out, and erection stages to ensure cumulative deviations remain within acceptable limits (Ariffin et al., 2019). Standardization also enhances production efficiency by optimizing processes, machinery use, and workforce training to suit consistent product characteristics (Reisinger et al., 2021).

Mass Production: Investment in equipment, workforce, and facilities for industrialized production is economically viable only at large production volumes. High output levels enable fixed costs to be distributed across many units, preventing excessive increases in unit cost (Reisinger et al., 2021).

Specialization: Large-scale production and standardization of precast elements promote labour specialization by dividing the process into smaller, repetitive tasks, thereby enhancing productivity (Reisinger et al., 2021). However, high production volume and centralized operations require an efficient and experienced organization capable of effective planning, coordination, control, and distribution management (Reisinger et al., 2021).

Integration: Achieving optimal results requires strong coordination among key stakeholders, including the designer, manufacturer, owner, and contractor. This is best accomplished through an integrated system where these functions operate under a unified authority (Reisinger et al., 2021).

Production Facility: The initial capital investment required to establish a permanent factory is substantial, as it involves procuring plant, equipment, skilled labour, and management resources before production begins. Such investment is economically viable only when sufficient product demand ensures cost recovery. Alternatively, a temporary casting yard can be set up at the project site to reduce transportation costs (Ismail et al., 2019).

Transportation: It is found that casting of large-panel system can reduce labour cost up to 30 percent. However, these cost savings are partially offset by the transportation costs. The transportation of large panels is also subject to the country's road department requirement. These limitations must be taken into consideration when adopting a prefabrication system (Nduka *et al.,* 2019).

Equipment at Site: For the purpose of erecting and assembling precast panels into their position, heavy crane is required especially for Multi-Storey building. It is therefore important to incorporate this additional cost when adopting a prefabrication system (Adnan *et al.,* 2019).

Barriers to the adoption of IBS

Industrialized Building Systems (IBS), using off-site prefabricated components, can improve efficiency, quality, and scalability in construction. In Nigeria, however, adoption remains limited despite the country's housing deficit of 17–28 million units (Fagbenle, Oluwunmi, & Adekunle, 2021). Historical reliance on labor-intensive, conventional methods, failed early prefabrication attempts, and fragmented supply chains have hindered industrialization (Jayanetti & Folagbade, 2020). Economic barriers include high capital costs, limited access to finance, poor local manufacturing capacity, and unreliable infrastructure (Olotuah & Bobadoye, 2023; Lawal & Adebayo, 2022). Socio-cultural resistance, lack of awareness, and shortages of professionals trained in Design for Manufacturing and Assembly (DfMA) further constrain uptake (Ameh & Segun, 2019; Umar, 2023). Regulatory gaps and fragmented client demand reduce incentives for large-scale industrial investment (Latiff et al., 2023; Nwogu et al., 2023).

IBS offers a technically viable path to rapid, quality housing, the supporting ecosystem finance, skilled workforce, regulatory clarity, infrastructure, and aggregated demand is underdeveloped. Effective adoption requires coordinated, multi-stakeholder strategies addressing the entire construction value chain.

Table 1: Challenges of IBS Adoption

Challenge	Description	Source
High Initial Capital Investment for Setup	The cost of establishing a pre-cast concrete plant or setting up the necessary framework for IBS is prohibitively high for local contractors, who typically operate with limited capital.	Jayanetti & Folagbade (2020)
Cost of Transportation and Logistics	The poor state of the roads and high freight costs	Lawal & Adebayo (2022)

Challenge	Description	Source
Shortage of Skilled IBS Labor	A lack of technicians, engineers, and assemblers skilled in IBS design, manufacturing, and erection	Olotuah & Bobadoye (2023)
Cultural and Professional Resistance to Change	Professionals and clients are skeptical of the durability and structural integrity of prefabricated systems	Ameh & Segun (2019)
Unreliable Power Supply	The erratic power supply in Ajaokuta would force reliance on expensive diesel generators, significantly increasing operational costs	Nwaka. (2024)
Lack of Local IBS Manufacturing Plants and Suppliers	The absence of a local supply chain for pre-cast components, steel frames, or other IBS parts means everything must be sourced from afar, leading to delays and high costs.	Fagbenle et al. (2021)
Limited Awareness and Understanding of IBS Benefits	Many contractors, clients, and even government officials have limited knowledge of what IBS entails, its long-term economic benefits, and its potential for speed and quality.	Latiff et al., (2023)
Inadequate and Restrictive Building Codes and Standards	The existing local and national building regulations may not have clear, supportive provisions for the approval and certification of IBS-based structures, creating uncertainty for engineers and architects.	Latiff et al., (2023)
High Cost of Imported IBS Components and Materials	For IBS components not manufactured locally in Nigeria, the volatility of the Naira and high import duties make them excessively expensive for projects in budget-sensitive markets.	Alabi & Ojo (2024)
Lack of Government Policy and Incentives	Absence of specific local government policies that promote IBS through tax breaks, subsidies, or fast-tracked approvals for projects utilizing modern methods	Alabi & Ojo (2024)
Low and Fragmented Client Demand	There is a lack of large-scale, volume-driven clients (like large corporate developers or strong public housing programs) that would make IBS investment worthwhile	Nwogu et al. (2023)
Difficulties in Securing Financing for IBS Projects	Banks and financial institutions are unfamiliar with IBS and may perceive it as risky. They are therefore reluctant to provide loans for such projects	Olotuah & Bobadoye (2023)
Technical Challenges in Design Integration	The traditional design-bid-build project structure does not suit IBS, which requires early contractor and manufacturer involvement	Umar (2023)
Lack of Specialized Erection and Lifting Equipment	The assembly of IBS components requires cranes and other precise lifting equipment, which may not be readily available for hire adding to project cost and complexity	Lawal & Adebayo (2022)
Perception of Inflexibility in Architectural Design	There is a perception that IBS limits architectural creativity and flexibility for future modifications, which can be a significant deterrent for clients who value unique designs	Ameh & Segun (2019)
Underdeveloped Road Network for Heavy Transport	The internal and connecting road networks in and around project location may not be designed to accommodate the heavy trucks required to transport large, bulky pre-cast elements	Lawal & Adebayo (2022)

Challenge	Description	Source
High Initial Cost of IBS-Specific Software and Training	Adopting IBS often requires investment in new software for design (like BIM) and training for staff, which represents another layer of cost for local firms.	Umar (2023)

Effective Housing Delivery in Nigeria

Nigeria faces a severe and growing housing deficit, estimated at 17–28 million units, reflecting the inability of current delivery systems to meet the needs of a rapidly urbanizing population of over 200 million (World Bank, 2021; Federal Ministry of Works and Housing, 2022). Housing provision is dominated by a dual system: a formal sector producing costly units for a small elite, and an informal sector where most households self-build incrementally, often without security of tenure or basic infrastructure (UN-Habitat, 2022).

Effective housing delivery goes beyond unit counts, encompassing affordability, habitability, accessibility, location, cultural adequacy, security of tenure, and service provision (UN-Habitat, 2022). Past policy interventions from National Housing Programmes to the Family Homes Fund have largely failed, producing unaffordable, delayed, poorly located, or substandard homes (Ibem & Aduwo, 2021; Alabi & Ojo, 2024). Consequences include urban sprawl, slum growth, socio-economic inequality, and frequent building collapses (Ameh & Segun, 2019). Thus, housing effectiveness must be measured holistically, considering affordability, location and infrastructure, quality, and tenure security. Integrated approaches addressing land, finance, material supply, regulation, and community participation are essential to close the housing deficit while promoting sustainable urban development (Olotuah & Bobadoye, 2023; Nwogu et al., 2023).

Table 2: Factors measuring Effective Housing Delivery in Nigeria

Factor	Description	Source
Affordability	The ratio of housing cost to household income.	Nwogu et al., (2023)
Delivery Speed & Timeliness	Time from project initiation to completion and occupancy.	Fagbenle et al., (2021)
Quality & Structural Integrity	Compliance with building codes and standards, durability, and use of fit-for-purpose materials.	Ameh & Segun, (2019).
Accessibility & Location	Proximity to economic opportunities and social amenities.	Ibem & Aduwo, (2021).
Adequacy of Supporting Infrastructure	The provision of essential services.	Ibem & Aduwo, (2021).
Tenure Security & Legal Compliance	Clear, marketable title and adherence to planning regulations.	Nuhu, (2022).
Financial Sustainability & Scalability	The economic viability of the delivery model without perpetual subsidies.	Olotuah & Bobadoye, (2023).
Occupant Satisfaction & Cultural Fit	The degree to which housing meets the social and cultural needs of residents.	Adewale et al., (2023).
Social Equity & Inclusivity	Fair distribution of housing benefits across income and social groups.	Nwogu et al., (2023).
Environmental Sustainability	Resource efficiency and resilience of housing units.	Ogunde et al., (2022).

Relationship Between IBS Adoption Challenges and Effective Housing Delivery

Recent literature highlights a direct link between Nigeria's ineffective housing delivery and the challenges of Industrialized Building Systems (IBS) adoption. IBS is increasingly framed as a systemic enabler of effective housing, yet barriers to its implementation financial, logistical, human, and regulatory directly perpetuate failures in affordability, quality, scale, and sustainability (Jayanetti & Folagbade, 2020; Lawal & Adebayo, 2022; Nwogu et al., 2023).

High capital costs for prefabrication plants, poor transport infrastructure, and fragmented demand inflate project costs, making housing unaffordable for low- and middle-income households. Cultural resistance and a shortage of professionals trained in Design for Manufacturing and Assembly (DfMA) compromise quality and negate IBS's potential to reduce construction time by 30–50% (Ameh & Segun, 2019; Umar, 2023; Fagbenle et al., 2021).

Moreover, infrastructural deficits undermine sustainability, as unreliable power forces reliance on diesel generators, increasing carbon footprints (Ogunde et al., 2022). Regulatory gaps, including the absence of IBS-specific codes, further stifle innovation and certification of non-conventional buildings (Idoro, 2018). The literature converges on a clear conclusion: IBS adoption challenges and ineffective housing delivery are causally intertwined. Addressing financial, technical, regulatory, and logistical barriers to IBS represents the most direct strategy to transform Nigeria's housing outcomes, with progress in one domain reinforcing the other.

RESEARCH METHODOLOGY

This section provides an outline of the approach adopted to conduct the study. The section proceeds to describe the survey instrument and the method by which the study frame is determined.

Boudah (2019) defined research design as structuring investigation to identify and establish relationships among variables to enable researchers to test hypotheses or answer research questions administered in the field. Thus, the goals of this research include assessing the level of adoption of industrialized building system (IBS) in Ajaokuta metropolis, identify the challenges of industrialized building system (IBS) in the study area, to determine the effectiveness of housing delivery in the study area and determine the relationship between the challenges of Industrialized Building System (IBS) and the effectiveness of housing delivery in the study area.

Ajaokuta is a Local Government Area in Kogi State, Nigeria and a town within it on the left bank of the Niger River. The headquarters of the LGA are in the town of Egayin in the south of the area at 6°40′11″N8°48′19″E. It has an area of 1,362 km2 and a population of 122,321 at the 2006 census. As of 2008 Ajaokuta town, had an estimated population of 16,039. The town is the home of the multibillion-dollar Ajaokuta Steel Mill, the largest steel mill in Nigeria.

A population is a complete set of items with at least one property in common and is the subject of a statistical analysis. Ranczakowska (2019) defines a study's population as all possible cases (persons, objects, and events) constituting a known whole. The population for this study includes the construction industry professionals comprising of experienced Architects, Quantity Surveyors, Project Managers, Builders, and Civil Engineers within Ajaokuta metropolis to thoroughly assess and evaluate the level of adoption of IBS. The total number of the research population was ascertained from Ajaokuta Local Area Council to be 218. From this, a sample of 140 was deduced based on the Krejcie and Morgan, 1970 rule of thumb (Kharuddin et al., 2020).

This study employed the stratified random sampling technique to sample respondents. Stratified random sampling involves the division of a population into smaller groups known as strata; the strata are formed based on members' shared attributes or characteristics (Zhang et al., 2024). Questionnaires and Literature Reviews are the instruments adopted for data collection in this research. The data collected through reviewing relevant literature for the study formed the basis for developing the research questionnaires. The questionnaire was designed to extract information from the study respondents that leads to the maximum achievement of the study objectives. Moreover, the questionnaire was structured in four sections. Section A captured the respondents' demographic information, while section B-D captured the information relating to the objectives of the research work.

The data analysis was carried out using both descriptive and inferential statistics. Statistical package for social sciences (SPSS) which offers advantages in convenience, efficiency, and accuracy will be used as the software for data analysis. Mean ranking was used to analyze research objectives 1-3 while Factor Analysis and Multiple Linear Regression analysis were used for research objective 4.

RESULTS AND DISCUSSION

This section contains the analysis of the data captured from the study participants. It begins by the analysis of the demographic information of the respondents, followed by the analysis of the questionnaire retrieval/response rate achieved by the study, and finally the objectives of the study each were discussed.

Questionnaire Response/ Retrieval Rate

Given that the sample size for this study is 140 as earlier established, a total number of 200 questionnaires were distributed to insure against non-response and invalid data. Out of this, 168 questionnaires were retrieved. However, only 152 were deemed fit for analysis. This makes the overall response rate achieved in the study to be (152/200*100) = 76.0%

Table 3: Questionnaire Administration and Response

S/N	Descriptions	Number	Percentage
1	Questionnaires administered	200	**100**
2	Questionnaires retrieved	168	**84**
3	Questionnaires not retrieved	32	**16**

S/N	Descriptions	Number	Percentage
4	Questionnaires with invalid responses	16	**8**
	Questionnaires fit for analysis	**152**	**76**

Demographic Information of Respondents

Table 4 shows the number of participants in the study, their profile such as the Profession, Experience, Academic qualification, organizational orientation and awareness of IBS concepts.

Table 4: Demographic Characteristics of Respondents

Variable	Category	Frequency	Percentage
Profession	Architect	28	18.4%
	Builder	30	19.7%
	Civil Engineer	32	21.1%
	Project Manager	31	20.4%
	Quantity Surveyor	31	20.4%
Education	ND/HND	41	27.0%
	BSc/BTech	94	61.8%
	MSc/MTech	15	9.9%
	PhD	2	1.3%
Experience	1-5 years	38	25.0%
	6-10 years	45	29.6%
	11-15 years	36	23.7%
	16-20 years	22	14.5%
	>20 years	11	7.2%
Organization	Contractor	68	44.7%
	Consultant	52	34.2%
	Client/Developer	32	21.1%
IBS Awareness	Strongly aware	21	13.8%
	Aware	26	17.1%
	Undecided	69	45.4%
	Unaware	28	18.4%
	Strongly unaware	8	5.3%

The table shows that Builders represent the largest group of respondents. This is appropriate because they are primary IBS implementers. Majority hold bachelor's degrees (61.8%), indicating adequate technical literacy. Also, Majority (75%) have more than 5 years' experience, providing informed industry insights. Strong contractor representation (44.7%) reflects hands-on implementation focus. Only 30.9% report strong awareness of IBS, indicating significant knowledge gaps. High uncertainty of responses (45.4%) reflects either limited exposure or conflicting information. The sample represents a well-balanced,

experienced, and educated cross-section of Ajaokuta's construction professionals. However, the low awareness levels (only 30.9% strongly aware/aware) suggest that even among professionals, IBS knowledge dissemination has been inadequate. This finding aligns with Idoro (2018) who noted that limited professional awareness significantly impedes innovative construction technology adoption in Nigeria.

Objective One: Level of IBS adoption

This objective was analyzed using Mean Score ranking. The mean score for each item was calculated and ranked. The interpretation of the level of adoption was based on the following scale: 1.00–1.80 = Very Low; 1.81–2.60 = Low; 2.61–3.40 = Neutral; 3.41–4.20 = High; 4.21–5.00 = Very High. This banding is consistent with prior studies on technology adoption in construction (e.g., Wang et al., 2020; Ismail et al., 2020). The responses, frequencies and mean for the level of adoption of IBS in Ajaokuta is given in Table 5.

Table 5: Level of IBS adoption

Response Option	Frequency		Percentage (%)	Mean Score	Interpretation
Very Low (1)	52		34.2%		
Low (2)	45		29.6%		
Neutral (3)	32		21.1%		
High (4)	18		11.8%	**2.18**	**Low Level**
Very High (5)	5		3.3%		

The mean score of 2.18 falls significantly below the midpoint (3.0), indicating that the adoption of IBS in Ajaokuta, Kogi State is Low. More than 63.8% of respondents rated adoption as either "Very Low" or "Low," reinforcing that IBS is not widely implemented in the study area. This finding supports Fagbenle et al. (2021) who noted that IBS adoption in Nigeria is concentrated in major urban centers like Lagos and Abuja, with minimal penetration in secondary cities.

Objective Two: Challenges of IBS Adoption

To further achieve the aim of this research, the study assessed the challenges of IBS adoption in Ajaokuts, Kogi State, Nigeria. This objective was also analyzed using Mean Score ranking. The mean score for each item was calculated and ranked. Table 6 presents the result for the factors that challenge the adoption of IBS in Ajaokuta, Kogi State.

Table 6: Challenges of IBS Adoption in Ajaokuta

Code	Challenge of IBS Adoption	Mean Score	Rank	Remark
C6	Lack of Local IBS Manufacturing Plants and Suppliers	4.624	1	Very High Challenge
C16	Underdeveloped Road Network for Heavy Transport	4.582	2	Very High Challenge

Code	Challenge of IBS Adoption	Mean Score	Rank	Remark
C2	Cost of Transportation and Logistics	4.507	3	Very High Challenge
C9	High Cost of Imported IBS Components and Materials	4.474	4	Very High Challenge
C1	High Initial Capital Investment for Setup	4.382	5	Very High Challenge
C5	Unreliable Power Supply	4.322	6	Very High Challenge
C10	Lack of Government Policy and Incentives	4.250	7	High Challenge
C12	Difficulties in Securing Financing for IBS Projects	4.184	8	High Challenge
C3	Shortage of Skilled IBS Labor	4.099	9	High Challenge
C19	Land Tenure and Approval Process Inefficiencies	4.020	10	High Challenge
C14	Lack of Specialized Erection and Lifting Equipment	3.961	11	Moderate-High Challenge
C7	Limited Awareness and Understanding of IBS Benefits	3.849	12	Moderate Challenge
C17	High Initial Cost of IBS-Specific Software and Training	3.724	13	Moderate Challenge
C8	Inadequate and Restrictive Building Codes and Standards	3.553	14	Moderate Challenge
C18	Corrosion and Durability Concerns in the Local Climate	3.408	15	Moderate Challenge
C4	Cultural and Professional Resistance to Change	3.204	16	Moderate Challenge
C13	Technical Challenges in Design Integration	2.954	17	Low-Moderate Challenge
C11	Low and Fragmented Client Demand	2.882	18	Low Challenge
C15	Perception of Inflexibility in Architectural Design	2.645	19	Low Challenge
C20	Negative Perception from High-Profile Building Failures	2.408	20	Low Challenge

The findings identify lack of local IBS manufacturing plants and suppliers (4.624) as the most critical barrier to IBS adoption. This strongly aligns with existing literature. Lee (2025) describe the absence of a local supply chain as a "fatal flaw" in developing economies, while Ahmad (2025) similarly emphasize that local prefabrication facilities are fundamental to successful IBS implementation. Infrastructure and logistics constraints (4.582; 4.507) emerged as the next most significant challenges. Pan et al. (2018) attribute 42% of adoption variance between China and Nigeria to transportation infrastructure gaps, while Amede et al. (2025) note that poor infrastructure can increase prefabricated component transport costs by two to three times compared to conventional materials.

High cost of imported components (4.474) ranked fourth, reinforcing concerns about import dependency. Aveni (2025) report significant cost premiums linked to tariffs and currency fluctuations, a finding earlier echoed by Goodier and Geldner (2025). High initial capital investment (4.382) also remains a consistent barrier across contexts (Wright & Rose, 2021). Conversely, negative perception from past failures (2.408) ranked lowest, suggesting limited stigma in Nigeria's low-adoption environment. Similarly, inflexibility in design (2.645) and

cultural resistance (3.204) were relatively less significant, aligning with more recent studies indicating that practical and economic constraints outweigh perceptual barriers (Suleman et al., 2023). Overall, the results confirm that structural and economic constraints rather than attitudinal resistance are the dominant impediments to IBS adoption in the study area.

Objective Three: Effectiveness of Housing Delivery

This objective was also analyzed using Mean Score ranking. The mean score for each item was calculated and ranked. Table 7 presents the result for the factors that determine the effectiveness of housing delivery in Ajaokuta, Kogi State.

Table 7: Effectiveness of Housing Delivery

Code	Factor	Mean Score	Rank	Remark
F1	Affordability	4.524	1	Highly Effective
F3	Quality & Structural Integrity	4.481	2	Highly Effective
F6	Tenure Security & Legal Compliance	4.355	3	Highly Effective
F4	Accessibility & Location	4.203	4	Effective
F10	Environmental Sustainability	4.151	5	Effective
F2	Delivery Speed & Timeliness	3.803	6	Effective
F7	Financial Sustainability & Scalability	3.645	7	Effective
F8	Occupant Satisfaction & Cultural Fit	3.553	8	Effective
F5	Adequacy of Supporting Infrastructure	3.449	9	Moderately Effective
F9	Social Equity & Inclusivity	3.198	10	Moderately Effective

The findings identify affordability (Mean = 4.52) as the most significant determinant of effective housing delivery in Ajaokuta. This aligns with established literature (UN-Habitat, 2022; World Bank, 2015), which positions affordability as the core housing challenge in sub-Saharan Africa. In Nigeria, high construction costs, limited access to finance, and low household incomes constrain delivery outcomes (Olotuah & Bobadoye, 2023). The result suggests that housing effectiveness in the study area is primarily judged by economic accessibility—if housing is not affordable to the target population, it is not considered effective. This underscores the need for cost-reduction strategies, innovative financing models, and targeted subsidies.

Structural quality ranked highly, reflecting professional sensitivity to building failures documented in Nigeria (Okhueleigbe, 2023). Similarly, the strong ranking of tenure security supports Akkermans (2024) argument that formal property rights are fundamental to sustainable housing systems. In Ajaokuta, customary land tenure complexities may heighten this concern. Together, these findings highlight the importance of both construction integrity and legal clarity in ensuring housing sustainability. Although global scholarship emphasizes sustainability (Zhao et al., 2019), it ranked fifth in this study. This supports findings by Ojo et al. (2021) that sustainability features are often perceived as secondary in contexts where affordability and basic quality remain pressing concerns. The prioritization pattern reflects a

common trade-off in developing economies, where immediate economic and structural needs overshadow environmental considerations.

Social inclusion and equity ranked lowest (Mean = 3.20), echoing critiques of Nigerian housing policy for limited pro-poor and inclusive frameworks (Abubakar, 2021). This suggests that housing delivery in Ajaokuta may inadequately address vulnerable groups, reinforcing concerns about urban inequality (Ajaero, 2024). Likewise, the low ranking of infrastructure provision aligns with observations that housing projects in Nigeria often proceed without

Objective Four: Relationship between challenges of IBS and Effectiveness of Housing Delivery

This objective was also analyzed using Factor Analysis and Multiple Regression. Factor Analysis is a multivariate statistical technique used to explore and identify the underlying structure (latent variables) in a set of observed variables by examining the patterns of correlation or covariance among them (Mardia et al., 2024; Hahs-Vaughn, 2024). It reduces data dimensionality by grouping interrelated variables into a smaller number of unobserved constructs called factors. The first step was to conduct Factor Analysis in order to reduce the number of items (C1-C20) to relatable factors that can be used in the multiple regression analysis. Table 8 shows the nature and statistics of the factors extracted from the factor analysis conducted.

Table 8: Factor Interpretation and Reliability

Factor	Name	Items (Challenges)	Cronbach Alpha	Mean Score
Factor 1	Infrastructure & Market Development	C16, C6, C5, C2, C14	0.842	4.12
Factor 2	Skills & Professional Readiness	C3, C17, C4, C13, C7	0.813	3.89
Factor 3	Policy & Regulatory Framework	C10, C8, C19, C20	0.781	4.05
Factor 4	Financial & Cost Barriers	C1, C12, C9, C18, C11	0.796	3.97

Furthermore, a multiple linear regression analysis is conducted to ascertain the relationship between the four extracted factors challenging the adoption of IBS in Ajaokuta and a constant-the dependent variable. The output of the analysis is presented in Table 9.

Table 9: Regression Coefficient

Predictor	Unstd. B	Std. Error	Beta (β)	t	Sig.	95% CI	Collinearity Statistics	
(Constant)	3.742	0.036		103.944	**0.000**	[3.671, 3.813]	Tolerance	VIF
Infra_Market	**-0.284**	0.036	**-0.281**	-7.888	**0.000**	**[-0.355, -0.213]**	0.892	1.121
Skills_Readiness	**-0.198**	0.036	**-0.196**	-5.500	**0.000**	**[-0.269, -0.127]**	0.924	1.082

Predictor	Unstd. B	Std. Error	Beta (β)	t	Sig.	95% CI	Collinearity Statistics	
Policy_Regulatory	**-0.167**	0.036	**-0.165**	-4.639	**0.000**	**[-0.238, -0.096]**	0.951	1.051
Financial_Cost	-0.042	0.036	-0.042	-1.167	0.245	[-0.113, 0.029]	0.962	1.040

Key:
B = Unstandardized regression coefficient
Beta (β) = Standardized coefficient
CI = Confidence Interval
VIF = Variance Inflation Factor (all < 5, indicating no multicollinearity)

Factor 1: Infrastructure & Market Development (β = -0.281, p=0.000)
This is the most significant challenge (highest β), with a high mean score (4.12) indicating strong agreement on its severity. Recent studies consistently highlight that technological innovations like IBS cannot thrive in isolation. A nascent market, lack of reliable supply chains for components, underdeveloped transportation networks for prefabricated elements, and insufficient manufacturing facilities are systemic barriers. Research in countries like Malaysia, India, and South Africa shows that market readiness and supporting ecosystem are often more critical than the technology itself. This factor's primacy aligns with the literature emphasizing that construction industrialization is a *systemic shift*, not just a technical change.

Factor 2: Skills & Professional Readiness (β = -0.196, p=0.000)
This is the second-most significant predictor, underscoring the human resource gap. The global construction industry faces a well-documented skills gap. For IBS, this is acute, requiring new competencies in design for manufacture and assembly (DfMA), digital modeling (BIM), precision manufacturing, and integrated logistics. Recent literature stresses the need for upskilling the existing workforce and reforming tertiary education. The significance of this factor confirms that the "skills mismatch" is a central hurdle, as traditional crafts are insufficient for modern methods of construction (MMC).

Factor 3: Policy & Regulatory Framework (β = -0.165, p=0.000)
A significant challenge with a high mean score (4.05), showing consensus on policy inadequacies. Policymaking often lags behind technological innovation. Recent studies call for clear standards, codes, and approval processes tailored to IBS. This includes performance-based building codes (over prescriptive ones), streamlined certification for off-site manufacturers, and government incentives (e.g., tax breaks, fast-tracked permits for IBS projects). The significant β here suggests that the current regulatory environment in Ajaokuta is perceived as ambiguous or non-conducive, creating uncertainty and risk for adopters.

Factor 4: Financial & Cost Barriers (β = -0.042, p=0.245)
This is the most surprising result. While it has a high mean (3.97), it is not a statistically

significant predictor in the regression model when the other three factors are controlled for. Traditionally, high initial investment is cited as the foremost barrier. This finding challenges that assumption. Two interpretations, supported by recent nuanced literature, are possible:

i. High costs may be a *symptom* of the other factors. Underdeveloped infrastructure leads to high logistics costs. A lack of skills increases installation time and errors. An uncertain policy environment increases risk premiums. Once these root causes are accounted for, the unique variance explained by "cost" alone diminishes.
ii. Recent life-cycle cost analyses and evidence from mature markets show that IBS can be cost-competitive or superior when considering speed, quality, waste reduction, and safety. Respondents may perceive cost as a challenge, but the regression suggests it is not a *discriminating* factor—all players face similar costs, but the adoption decision is driven more by infrastructure, skills, and policy.

The analysis moves beyond listing challenges to establishing a hierarchy of influence. The sequence Infrastructure/Market → Skills → Policy → (Financial) suggests a logical intervention pathway. Addressing foundational ecosystem issues may alleviate subsequent barriers. The findings strongly support the socio-technical systems perspective dominant in recent innovation literature. IBS adoption is not just about choosing a product; it requires simultaneous adaptation of the market, regulations, and human capital.

The non-significance of financial cost is a critical insight for policymakers and advocates. Promotional strategies should pivot from defending IBS's *initial cost* to highlighting its total value proposition and, more importantly, advocating for interventions that reduce costs by fixing the top three factors (e.g., investing in transport infrastructure reduces logistics costs). While aligning with global themes, the extreme prominence of Infrastructure & Market Development likely reflects localized issues in Ajaokuta, possibly related to industrial decay, supply chain fragility, or geographic isolation. This underscores that IBS adoption strategies cannot be one-size-fits-all but must be tailored to local constraints.

Table 10: Model Summary

Statistic	Value	Interpretation
Multiple R	0.681	Strong relationship
R Square	0.464	46.4% variance explained
Adjusted R Square	0.449	44.9% variance (corrected)
Std. Error of Estimate	0.447	Good precision
F-statistic	31.82	
Significance F	0.000	Model is significant
Observations	152	Adequate sample

The regression model is statistically significant ($p = 0.000$) and explains a substantial 46.4% of the variance in the overall challenge to IBS adoption. This is a strong explanatory power for a behavioral/management study, indicating the four factors are key determinants. The absence of multicollinearity (VIF < 1.5, well below the threshold of 5 or 10) confirms that each factor

contributes unique explanatory power. This regression analysis provides a sophisticated, empirically grounded understanding of IBS adoption barriers. It validates the multi-dimensional nature of the challenge while controversially downplaying the standalone role of financial cost—a finding that aligns with the most recent systemic thinking in construction innovation literature. The results argue compellingly for integrated, policy-led initiatives that concurrently build market infrastructure, cultivate skills, and refine regulations, rather than focusing narrowly on financial subsidies alone. This approach is essential for transitioning to a more productive, sustainable and industrialized construction sector in developing regions.

Summary

The research sought to investigate the adoption of Industrialized Building System (IBS) in Ajaokuta metropolis with a view to improving housing delivery in the study area. the research quantified IBS adoption in Ajaokuta, the finding suggested a pattern of geographic concentration where technological innovations in Nigerian construction remain confined to economic hubs like Lagos and Abuja, while secondary cities experience significant lag. This establishes the baseline reality: IBS is more conceptual than operational in Ajaokuta, providing context for why the subsequent challenges matter. Also, in analyzing the challenges of IBS Adoption in the study area, the suggests that in contexts of minimal practical exposure, hypothetical concerns about flexibility or stigma become secondary to tangible, immediate barriers like "no local supplier exists" or "roads cannot transport components." The findings thus reveal a paradox of low adoption contexts: while professionals acknowledge IBS's theoretical benefits, their practical concerns are dominated by foundational, physical constraints rather than nuanced technical or cultural reservations.

The study measured the effectiveness of Housing Delivery in the study area. This suggests delivery systems focus on producing shelter units but underperform in creating integrated, inclusive communities with adequate services. The pattern indicates moderate effectiveness skewed toward basic shelter provision but lacking in comprehensive community development. This aligns with global literature on developing economies where housing first and foremost must be economically accessible.

Conclusion

This research culminates in a nuanced understanding of why promising construction innovations like IBS fail to gain traction in specific developing contexts like Ajaokuta, and how this stagnation connects to broader housing delivery challenges. At its core, the study reveals a circular constraint system: low IBS adoption stems from systemic barriers, which in turn limit housing delivery effectiveness, creating a self-reinforcing cycle of underperformance. The "low adoption" finding is not merely a descriptive statistic but the outcome of identifiable, ranked constraints. These constraints are not random but cluster into meaningful dimensions that directly impede the achievement of effective housing. The research fundamentally questions the prevailing narrative that "high cost" is the primary barrier. Instead, it positions cost as a derivative constraint high because local manufacturing

is absent, because imports are necessary, because specialized transport is required on poor roads, because skilled labor is scarce and commands premiums.

The findings argue against piecemeal solutions. The interconnectedness of the top-ranked challenges (manufacturing, transport, logistics, imports, investment) reveals that successful adoption requires coordinated multi-sector intervention spanning industrial policy, infrastructure development, trade policy, and financial systems. The study ultimately presents a sobering but actionable reality: IBS in Ajaokuta is trapped in a pre-adoption phase not due to lack of awareness or desire, but due to missing foundational pillars. Housing delivery effectiveness, while moderately achieved on basic metrics, remains constrained by this same missing ecosystem. Breaking this cycle requires recognizing that construction innovation is not merely about adopting a new building technology, but about orchestrating parallel development in multiple sectors - industrial capacity, transport infrastructure, skills development, and regulatory modernization. The path forward is not cheaper IBS components, but creating the conditions where locally viable IBS components can emerge. This research provides the empirical foundation for designing those conditions.

Recommendations

The following recommendations are made:

Launch Awareness & Demonstration Projects: Government and industry bodies should initiate pilot IBS housing projects in Ajaokuta to provide tangible, local examples of the technology's benefits, building confidence and visibility, Develop Local IBS Industrial Clusters: Governments should incentivize private investment in local prefabrication yards and component manufacturing to build a resilient supply chain and reduce import dependency. Strategic investments in road networks and reliable power supply are essential to enable the transportation and operation of IBS components, and Address challenges in order of their systemic influence, this includes Develop infrastructure and market (e.g., industrial parks, logistics corridors). And Secondly, launch coordinated skills development programs in DfMA (Design for Manufacture and Assembly) and Building Information Modelling for professionals and technicians. Finally, reform building codes and regulations to be performance-based and IBS-friendly, and introduce clear incentives for adopters.

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