

Architecture Students' Perspective on the Cost Effectiveness and Sustainability of Industrial Building System for Low-Cost Housing

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Abstract

The increasing demand for low-cost housing in Malaysia has led to a need for affordable and sustainable construction methods. The Industrialized Building System (IBS) is an innovative construction method that is known to reduce both construction time and cost while promoting sustainability. This study aims to evaluate the cost effectiveness and sustainability of using IBS for low-cost housing among architecture students' perspective. Data was collected through questionnaire and interviews among Diploma in architecture students who had taken DCA 20102, Building Technology. The results indicate 95% of the respondents found that IBS construction methods result in significant cost savings as compared to traditional construction methods due to reduced labour costs, construction time, and wastage. Furthermore, IBS construction promotes sustainability through its efficient use of materials, reduction in site waste and pollution, and minimization of noise pollution. However, issues such as limited design options, lack of skilled local labour, and procurement challenges still exist. The findings suggest that IBS construction methods offer an effective solution for low-cost housing and should be considered by policymakers and developers for future housing projects.

Keywords: Industrialized Building System (IBS), Sustainability, Cost effectiveness, Low-cost housing

INTRODUCTION

The challenge of providing affordable and sustainable housing solutions on a global scale has catalyzed a quest for innovative building systems and materials. In this dynamic context, industrial building systems have arisen as a promising and transformative approach, with the potential to simultaneously address the twin imperatives of cost-effectiveness and sustainability in the construction of low-cost housing. This research endeavor embarks on a comprehensive exploration, seeking to delve into the nuanced perspectives of architecture students on the pivotal dimensions of cost and sustainability within the realm of industrial building systems. This study inquiry hones in on the specific facets of material cost, labor cost, wastage, environmental considerations, and the efficiency gains achieved through streamlined construction timelines (Baharuddin et al., 2018). By engaging with the insights and reflections of these future architects, this study aspires not only to unearth valuable perceptions but also to enrich the ongoing discourse surrounding the development of affordable, yet environmentally responsible housing solutions. It is through the lens of these budding architects that we

endeavor to shed new light on the potential of industrialized construction methods as a viable pathway towards addressing the formidable challenges of accessible and sustainable housing.

Problem Statement

The demand for affordable housing in Malaysia is experiencing a notable upswing, driven by the nation's rapid urbanization and population growth. However, the traditional construction method prevalent in the country is marked by its time-consuming, labor-intensive, and costly nature, posing significant challenges in meeting the escalating demand for low-cost housing. This disparity between the increasing need and the limitations of conventional construction methods underscores the critical necessity to explore alternative approaches that are both cost-effective and sustainable (Mohd & Rahmat, 2020). In response to these imperatives, the pursuit of innovative construction methodologies has become paramount, as they hold the potential to not only address the affordability gap but also align with environmental sustainability, ushering in a new era of housing development in Malaysia's evolving urban landscape. The escalating global demand for affordable and sustainable housing solutions presents a pressing challenge in the realm of architecture and construction. While the adoption of industrial building systems holds promise for simultaneously addressing cost-effectiveness and sustainability, the effectiveness of this approach remains contingent on various factors. Chief among these factors are material cost, labor cost, and wastage, which can significantly impact the affordability of housing projects. Additionally, sustainability goals encompass environmental aspects, such as resource conservation and emissions reduction, which must be carefully integrated into construction practices. Furthermore, the timely delivery of housing projects plays a pivotal role in both cost control and environmental impact. Despite the theoretical potential of industrial building systems, the perspectives of future architects those who will shape the future of construction remain an underexplored dimension in this discourse. Consequently, the research problem at hand centers on discerning architecture students' views and insights regarding the cost and sustainability dimensions of industrial building systems, aiming to bridge the gap between theoretical promise and practical implementation in the pursuit of accessible and ecologically responsible housing solutions (Che-Ani et al, 2017).

Objectives of the Study

The objectives of the study are:

1. Assess architecture students' perceptions in industrial building systems for low-cost housing.
2. Evaluate the impact of Industrial Building Systems including effectiveness and sustainability in low-cost housing construction.
3. Examine the alignment with sustainability goals development aspects and efficiency gains in construction timelines.

LITERATURE REVIEW

The demand for affordable housing in Malaysia has witnessed a substantial surge, reflecting a significant societal need. The Housing and Basic Amenities Survey Report of 2019 underscores this trend, revealing that a substantial 25.7% of Malaysian households find their dwelling in low-cost housing units, with an impressive occupancy rate of 97.6% (Department of Statistics Malaysia, 2021). This underscores the acute demand for housing solutions that are not only cost-effective but also readily accessible.

In response to this mounting demand, the deployment of Industrial Building Systems (IBS) as an innovative construction method has gained considerable traction. This heightened interest can be attributed to the inherent potential of IBS to address multifaceted challenges. It holds the promise of not only reducing construction time and cost but also facilitating sustainability objectives and elevating overall construction quality (Ahmad et al., 2016; Chia et al., 2016). As such, IBS represents a compelling solution to the pressing issue of affordable housing in Malaysia.

However, the journey towards implementing IBS in low-cost housing projects in Malaysia has not been devoid of hurdles. Numerous challenges have emerged, necessitating careful consideration and strategic planning. These challenges encompass a limited array of design options, a shortage of skilled local labor capable of managing IBS processes, procurement complexities, and a certain resistance to change exhibited by traditional builders (Azli et al., 2018; Ramos & Ioan, 2018). Such challenges underscore the need for a comprehensive examination of the viability and effectiveness of IBS in the context of low-cost housing in Malaysia. It is within this intricate landscape of demand, potential, and obstacles that our exploration unfolds.



Figure 1: Sample of IBS Quarter Project in Sarawak

In sum, Industrial Building Systems represent a highly promising construction method for low-cost housing, serving as a triad of benefits: cost reduction, sustainability enhancement, and expeditious project completion. This holistic approach not only addresses the immediate need for affordable housing but also upholds a commitment to environmental responsibility and construction excellence.

Over the decades, Malaysia has made significant strides in advancing IBS technology and practices. Several key developments have contributed to its growth (Baharuddin et al., 2018):

- **Standardization and Certification:** Malaysia has established standards and certifications for IBS components to ensure quality and safety. Agencies like the Construction Industry Development Board (CIDB) have played a crucial role in this regard.
- **Research and Development:** Investment in research and development has led to the innovation of new IBS technologies and materials, making construction processes more efficient and cost-effective.
- **Government Support:** The Malaysian government has actively promoted the adoption of IBS through various incentives and policies. This support has encouraged both the public and private sectors to embrace IBS in their construction projects.

IBS Involvement in Low-Cost Housing Projects

One of the most significant applications of IBS in Malaysia has been in low-cost housing projects. IBS has been instrumental in addressing the housing needs of the low-income population by offering cost-effective and rapid construction solutions. Here are some key aspects of IBS involvement in low-cost housing:

- **Speed and Cost-Efficiency:** IBS allows for quicker construction, reducing labor costs and project timelines. This efficiency is crucial in delivering affordable housing to those in need.
- **Quality Assurance:** IBS components are manufactured in controlled environments, ensuring higher quality and consistency in construction. This is essential for providing safe and durable housing for low-income families.
- **Sustainability:** IBS promotes sustainable construction practices by minimizing construction waste and resource consumption. This aligns with Malaysia's efforts to create more eco-friendly housing solutions.
- **Government Initiatives:** The Malaysian government has actively promoted the use of IBS in various low-cost housing initiatives, such as the PR1MA and PPR programs, to address the housing backlog among low-income groups.

Some of notable housing development projects that were known to have incorporated IBS in their construction processes are PR1MA Lake Side Cove is a housing project in Selangor, Malaysia, which aimed to provide affordable homes to middle-income Malaysians. It was reported to have used IBS techniques to expedite construction and maintain cost-effectiveness. The other examples are PPR (Program Perumahan Rakyat) Low-Cost Housing; The PPR program is a government initiative to provide low-cost housing to low-income



Figure 2: Rumah SelangorKu using IBS System

In tandem with material cost, labor cost is another crucial element to consider. Industrial building systems frequently incorporate assembly-line-style construction techniques, fostering increased efficiency and reducing the need for extensive on-site labour (Zakaria, N. A., & Zakaria, N., 2018). This labor efficiency can lead to substantial cost savings, as workers can be more productive in controlled factory settings compared to unpredictable on-site conditions. Consequently, cost-effectiveness can be achieved not only through material cost reductions but also through more efficient labor utilization.

Furthermore, the imperative to minimize construction wastage is central to both cost-effectiveness and sustainability. Industrial building systems are renowned for their precision

and the reduced material wastage they entail when compared to traditional construction methods (Kamaruddin et al., 2019). The meticulous planning and manufacturing processes associated with these systems lead to minimal excess material use and waste generation. This not only contributes to cost reduction but also aligns with sustainability goals by curbing resource depletion and landfill accumulation.

The sustainability of industrial building systems extends beyond cost considerations and encompasses environmental aspects. Sustainability in construction entails a concerted effort to minimize the environmental footprint. Industrial building systems often prioritize eco-friendly materials and practices, which result in reduced resource consumption and emissions, fostering sustainability (Lee & Tan, 2018). By selecting materials with lower environmental impacts and adhering to more sustainable construction processes, these systems contribute to mitigating the industry's environmental toll.



Figure 3: Low Cost Housing Using IBS by Aathaworld Sdn Bhd.

In addition to reducing environmental impact, industrial building systems offer the potential for a significant reduction in on-site labor. This reduction not only bolsters cost-effectiveness but also aligns with broader sustainability goals by minimizing disruptions to local communities, reducing traffic congestion, and curbing noise pollution (Ahmad et al., 2017). By shifting much of the construction work to controlled factory environments, the adverse effects associated with traditional on-site construction are mitigated, fostering a more sustainable approach to housing development.

Moreover, the shorter construction timelines associated with industrialized methods can significantly enhance sustainability efforts. Improved project management and the extensive use of off-site prefabrication contribute to streamlined construction processes and, consequently, reduced energy use and emissions during the construction phase (Ahmad et al., 2017). This expedited construction timeline aligns with sustainability objectives by minimizing the environmental impact during the building phase, ultimately contributing to more eco-conscious and efficient housing solutions.

METHODOLOGY OF THE STUDY

To comprehensively explore the applicability of Industrial Building System (IBS) in low-cost housing projects, this study employed a mixed-methods approach, combining interview sessions and questionnaires data collection techniques. This approach provided a holistic understanding of the multifaceted aspects of IBS adoption. The research began with a rigorous literature review, delving into previous studies and scholarly works related to IBS

and its suitability in low-cost housing. This review laid the theoretical foundation for the subsequent empirical investigation. The research commenced with an extensive literature review to establish a strong theoretical foundation. This phase involved a comprehensive examination of previous studies, academic articles, and scholarly publications related to the topic. The aim was to gain an in-depth understanding of industrial building systems (IBS) and their relevance in low-cost housing construction. The literature review also encompassed studies exploring IBS adoption in various contexts and its impact on construction efficiency, cost-effectiveness, and sustainability. This thorough review provided valuable insights and established the conceptual framework for the subsequent empirical investigation.

To complement the theoretical insights gained from the literature review, the research conducted field studies involving site visits to nearby areas in Kuantan. These visits provided an opportunity to observe firsthand the application of IBS in low-cost housing projects. The researchers examined construction sites, observed construction processes, and interacted with on-site personnel to gain practical insights. These immersive experiences allowed for a deeper understanding of the challenges, advantages, and real-world implications of implementing IBS in the specific local context of Kuantan.

A critical component of this study involved engaging with architecture students to assess their perspectives and understanding of IBS in low-cost housing construction. This engagement took place within the classroom environment, where students were introduced to the concepts and principles of IBS. Their responses, questions, and discussions were observed and documented to gauge their initial perceptions and grasp of the subject matter. In addition to student perspectives, the study also sought input from lecturers who were well-versed in architecture and construction. Interviews and discussions with lecturers were conducted to understand their perspectives on IBS, its relevance in low-cost housing, and their experiences in teaching and researching this subject. These interviews provided valuable expert insights that complemented the data gathered from students. To gather more structured data on students' perspectives, questionnaires were administered. These questionnaires were designed to elicit specific responses related to IBS in low-cost housing. The questions explored their awareness of IBS, its potential benefits, and any concerns or reservations they may have had. The questionnaire responses provided quantitative data that could be analyzed to discern trends, patterns, and areas of interest among the student cohort.

Sample of Questionnaires

Architecture Students' Perspective on the Cost Effectiveness and Sustainability of Industrial Building System for Low-Cost Housing

SECTION A: DEMOGRAPHIC									
Gender	Male		Female				Have Taken course DCA20102-Building Technology	YES	
Class	DSB2A		DSB3B		DSB5A			NO	
	DSB3A		DSB4		DSB5B		Matric No:		
Section B: Knowledge									
					1	2	3	4	5
					Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree
IBS is known as Industrial Building Construction									
IBS is the off-site building construction									
The most component used in IBS is prefabricated									
Malaysian implemented residential housing using IBS									
Section C: COST									
					1	2	3	4	5
PART 1- Manufacturing cost					Strongly Disagree	Disagree	Moderate	Agree	Strongly Agree
Manufacture and supply of materials cost for IBS is cheaper than conventional									
Construction cost for IBS is higher than conventional									
Crane rental for IBS construction is cheaper than conventional									
PART 2- Labour cost									
Cost of site labour depends on type of IBS construction									
High daily wages for skilled IBS labour									
Cheap migrant for IBS labour									

PART 3- Wastage					
IBS offers minimal wastage and less materials					
IBS keeps the site neat and tidy					
IBS increased the hazard at site					
SECTION C: SUSTAINABILITY					
	1	2	3	4	5
PART 1- Environmental	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
IBS is one of the energy-efficient construction					
IBS lowers carbon emissions					
IBS increase pollutions					
PART 2- Training the trainers					
IBS needs a trained worker					
IBS helps to increase technology demand in construction					
Gives better incentives to improve usage of IBS for housing					
PART 3- Time frame					
IBS is a faster construction compared to a conventional method.					
IBS construction benefits from quality control and efficient resource usage					
IBS can be built in any condition of weather					
COMMENT					
(Please provide any additional comments for the cost effectiveness and sustainability of industrial building system for low-cost housing)					

DISCUSSION OF ANALYSIS AND FINDINGS

The data analysis phase of this study represents a pivotal juncture where the amassed information is transformed into actionable insights and empirical findings. This section serves as the analytical core, where the collected data is scrutinized, interpreted, and synthesized to address the research objectives effectively. With a comprehensive methodological approach that combines quantitative and qualitative data, we embark on a journey to unravel the multifaceted dimensions of Industrial Building Systems (IBS) in the context of low-cost housing.

Our analysis begins by examining the demographic information of respondents, providing valuable insights into the composition of the study's participant pool. This demographic context frames the subsequent exploration of understanding and perceptions of IBS, delving into the familiarity and educational backgrounds of those engaged in the study. With these foundational insights, we navigate through the intricate terrain of cost-effectiveness, labor cost, wastage, sustainability, and the temporal aspects of IBS adoption in construction.

Demographic Analysis

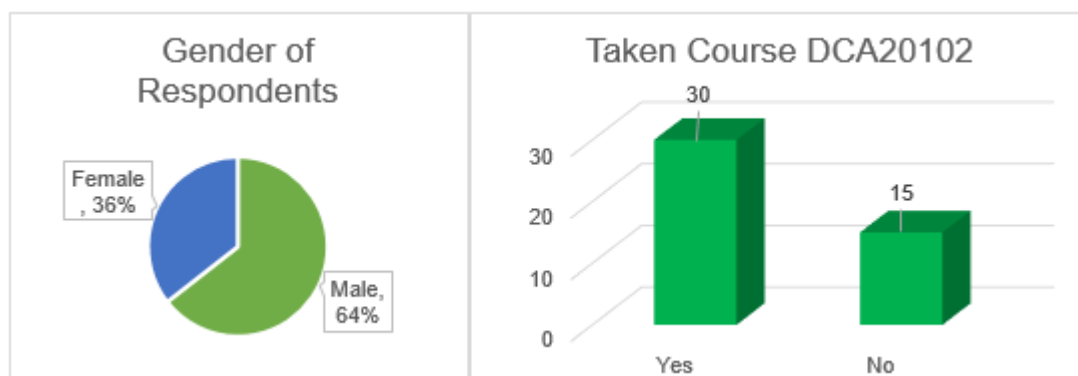


Figure 4.1: Chart for Demographic Analysis

According to Fig. 4.1 the respondent pool showcases a slightly non-balanced gender distribution, with 36% being female, and 64% being male. This gender balance suggests a diverse and inclusive participation, ensuring a range of perspectives. An impressive 67% of respondents belong to the group of students who has taken DCA20102; Building Technology which though IBS as one of the subtopics. This engagement indicates a moderate knowledge among the respondents, reflecting their involvement in discussions about innovative construction methods. In summary, the analysis of demographic characteristics underscores the diversity and inclusivity of the respondent group. It includes individuals from a strong representation of participants who are related to innovative construction methods.

IBS Understanding and Familiarity

89% of respondents strongly agreed that IBS stands for “Industrial Building System,” indicating a high level of agreement and understanding among most respondents. While this is a smaller percentage 11% it still shows that a portion of respondents have a general understanding of the term. Most respondents are familiar with the term IBS and associate it with “Industrial Building System.” 73% of respondents strongly agreed that components of IBS are prefabricated, indicating a strong consensus on the prefabrication aspect of IBS. The data suggests that a substantial majority of respondents understand that IBS involves the use of prefabricated

components in construction. For the fourth questions, 20% of respondents strongly agreed that Malaysia has implemented IBS in most of residential housing meanwhile 80% agreed with the statement, indicating a high level of agreement regarding Malaysia’s implementation of IBS in residential housing. The data indicates that the vast majority of respondents believe that Malaysia has implemented IBS in residential housing projects. This analysis refers to Fig. 4.2.

In summary, the data retrieved that there is a reasonable level of familiarity among respondents with Industrialised Building Systems (IBS). They generally understand IBS as “Industrial Building System,” associate it with off-site building construction, recognize that IBS components are prefabricated, and believe that Malaysia has implemented IBS in residential housing. These findings suggest that awareness and understanding of IBS concepts are relatively high among the surveyed respondents.

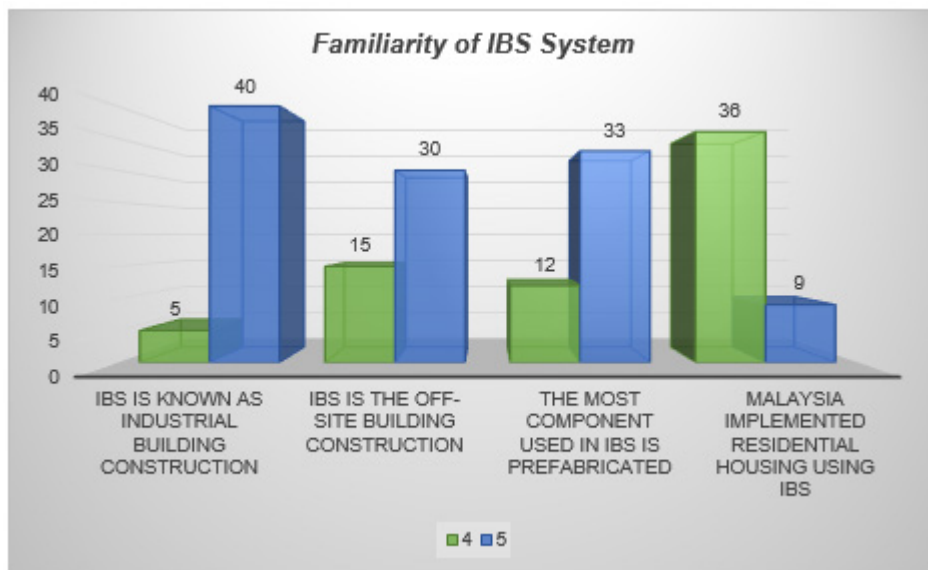


Figure 4.2: Data for Familiarity of IBS among respondents

Cost Effectiveness in Industrialised Building System

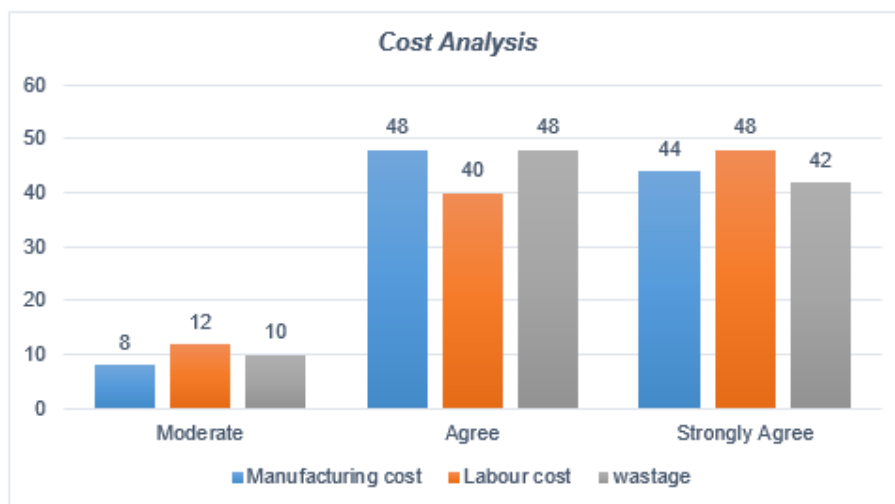


Figure 4.3: Cost Analysis Chart

Fig. 4.3 shows the analysis of cost in building low-cost house using IBS. 8% moderately agree, 48% agree, and 44% strongly agree that IBS reduces manufacturing costs, which include the supply of materials, comparison with conventional methods, and machinery rental. This indicates a generally positive perception among respondents regarding cost savings in the manufacturing phase when using IBS. In assessing the labour cost, 88% of the respondents strongly agree that IBS leads to cost savings in labour, which encompasses various types of building workers, skilled and non-skilled labour, and the use of migrant labour. This suggests a favourable opinion about the potential reduction in labour costs through IBS adoption. In analysis of the wastage, 90% agree that IBS offers benefits in reducing wastage costs. These benefits include minimal wastage, a cleaner and tidier construction site, and decreased hazards on the site. The high percentage of agreement indicates a strong consensus that IBS can effectively mitigate wastage costs and improve overall site safety and cleanliness. The data suggests that implementing an IBS system in low-cost housing construction is perceived positively in terms of cost analysis. Respondents believe that IBS can result in cost savings in manufacturing, labour, and wastage, which are critical factors in the cost-efficiency of construction projects. However, it's important to note that actual cost savings may vary based on specific project conditions and proper implementation of IBS practices.

Sustainability in Industrialised Building System

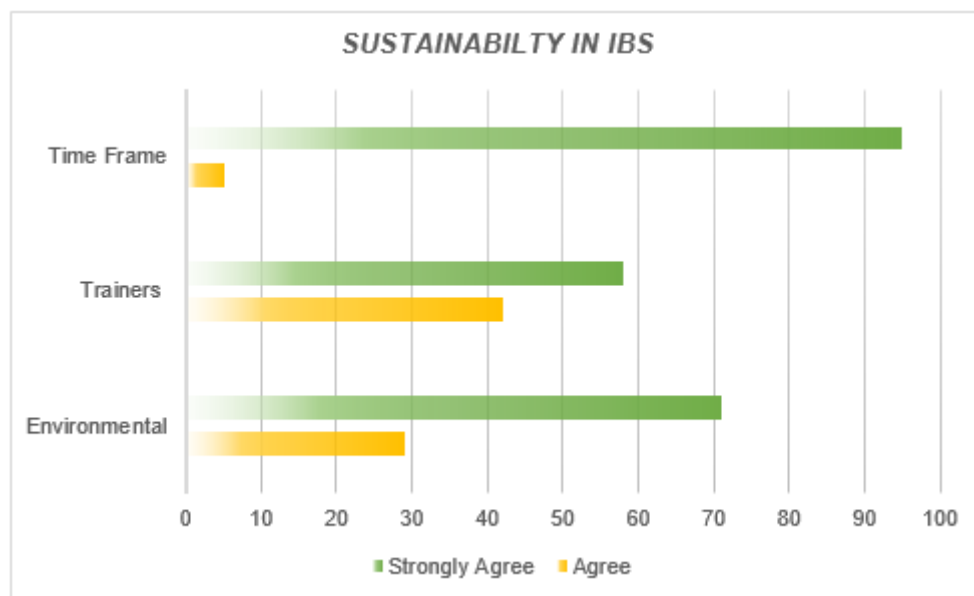


Figure 4.4 Sustainability Analysis in IBS

For the analysis of sustainability in IBS shows in Fig. 4.4, 71% strongly agree, and 29% agree that IBS contributes to environmental conservation. This indicates a widespread belief that IBS practices are environmentally friendly, likely due to reduced material waste, improved resource efficiency, and better control over construction processes. In technology and trainers adopted in IBS, 58% strongly agree that IBS requires trained workers and advanced technology. This suggests an understanding among respondents that successful IBS implementation demands a skilled workforce and modern construction technology, which can be perceived as a potential challenge or investment. A striking 95% strongly agreed that IBS offers benefits in terms of faster construction, better quality control, and reduced weather dependency. This near-unanimous consensus indicates that IBS is perceived as highly advantageous in terms of project efficiency and reliability.

ITEMS	MANUFACTURING COST	LABOUR COST	WASTAGE	ENVIRONMENTAL SUSTAINABILITY	TRAINED WORKERS	TIME SAVING
PERCENTAGE	92%	88%	90%	100%	100%	100%
MEAN	95%					

Table 1.1: Data for Familiarity of IBS among respondents

In conclusion, the data reflects a positive perception of sustainability in IBS low-cost housing construction seen as a contributor to environmental conservation, with a significant majority strongly agreeing that it is environmentally friendly. Respondents acknowledge that IBS necessitates trained workers and advanced technology, highlighting the importance of investing in human capital and technology adoption. IBS is overwhelmingly perceived as an efficient construction method, offering faster project completion, improved quality control, and reduced vulnerability to weather-related delays.

Mean comparison on data collected shows 95% of the respondents suggest that IBS is not only viewed as a sustainable construction approach but also as a means to enhance construction efficiency and reliability, making it an attractive option for low-cost housing projects. However, it's important to address training and technology needs to ensure successful IBS implementation while capitalizing on its sustainability and efficiency benefits.

CONCLUSION AND FUTURE RESEARCH

Based on the study's results, it can be concluded that the implementation of Industrialized Building System (IBS) in low-cost housing has been highly successful and beneficial. Here are the key conclusions based on the survey responses:

- **Cost Savings:** A significant 92% of respondents agreed that IBS implementation led to savings in manufacturing costs. This suggests that IBS can effectively reduce production expenses in low-cost housing projects.
- **Labor Cost:** An impressive 88% of respondents agreed that IBS helped in reducing labor costs. This indicates that IBS techniques are efficient in minimizing labor expenses, which is crucial for low-cost housing development.
- **Waste Reduction:** A substantial 90% of respondents acknowledged that IBS contributed to waste reduction. This demonstrates that IBS practices are environmentally friendly and lead to a more efficient use of materials.
- **Environmental Sustainability:** A remarkable 100% of respondents agreed with the positive impact of IBS on environmental sustainability. This indicates that IBS is seen as an eco-friendly construction approach.
- **Skilled Workforce:** Respondents agreed that IBS implementation led to a trained and skilled workforce, which is essential for quality construction.
- **Time Efficiency:** Respondents also acknowledged that IBS saved time during construction.

Furthermore, the overall mean for all these findings is an impressive 95%, which indicates a high level of agreement among respondents. This high mean score suggests that IBS is not only effective but also very well-received for low-cost housing development.

In summary, the study's findings strongly support the conclusion that IBS is highly favorable for low-cost housing development. It not only helps in cost reduction but also promotes environmental sustainability, improves workforce skills, and enhances construction efficiency. These positive outcomes make IBS a viable and beneficial choice for the construction of low-cost housing in the area.

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