

Labour Productivity in Industrialised Building System (IBS) Projects

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Received: 23 May 2025 | Accepted: 23 July 2025 | Published: 1 October 2025

DOI: <https://doi.org/10.55057/ijbtm.2025.7.5.37>

Abstract: *The Industrialised Building System (IBS), is a modern building technique that combines off-site production with prefabricated components which has gained popularity because it is deemed to possess superior technical characteristics. Although IBS offers several advantages, including increased cost-effectiveness, sustainability, and efficiency, worker productivity in IBS projects in Malaysia is still below ideal. Therefore, the objective of this study is to identify factors affecting labour productivity and to recommend ways to increase labour productivity in IBS projects. The methodology involved gathering quantitative data via questionnaires of 234 professionals working on IBS projects in the Klang Valley, Malaysia. However, only 90 meet the requirements to give accurate answers since they have the required IBS handling projects experience. The key findings show that several factors significantly influence productivity, including worker efficiency, clear communication, use of technology, and workers well-being. Enhancing employee training, implementing modern technology, encouraging collaboration, and ensuring that project planning is executed are some recommendations to increase labour productivity in IBS projects. By addressing these challenges, the construction industry can fully utilise IBS and create innovation, sustainability, and economic growth. The research contributes to the larger discussion on increasing worker productivity in the construction sector and gives stakeholders helpful recommendations on making IBS projects more successful.*

Keywords: Labour Productivity, IBS Projects, Prefabrication, Construction Industry

1. Introduction

Labour productivity is a critical factor influencing the success of construction projects, particularly in Industrialised Building System (IBS) projects, which rely heavily on prefabrication and modular construction techniques. IBS has been widely promoted as a solution to enhance construction efficiency, reduce labour dependency, and improve quality control (Ismail et al., 2022). However, despite its advantages, labour productivity in IBS projects remains a significant concern due to various challenges, including skill gaps, workflow disruptions, and inefficient site management (Nurhendi et al., 2022). Understanding and optimising labour productivity in IBS projects is essential to maximise the benefits of this construction method and ensure project success.

The construction industry faces persistent productivity issues, with traditional methods often suffering from delays, cost overruns, and inconsistent workmanship. IBS projects, though designed to mitigate these problems, encounter unique productivity challenges. Workers must adapt to new assembly processes, coordination between prefabrication and on-site installation must be seamless, and project schedules must align with manufacturing lead times (Tarang et al., 2022). When labour productivity is suboptimal, it leads to extended project durations, increased costs, and reduced competitiveness of IBS compared to conventional construction (Rashid, 2019). Despite the growing adoption of IBS in many countries, empirical studies on labour productivity in such projects remain limited, particularly in identifying key influencing factors and proposing effective improvement strategies.

This study aims to investigate labour productivity in IBS projects by examining the factors that impact workforce efficiency and evaluating potential solutions to enhance performance. The primary objectives of this research are: (1) to identify the key factors affecting labour productivity in IBS construction and (2) to propose practical strategies for improving productivity in IBS construction projects. By addressing these objectives, this research seeks to provide valuable insights for industry practitioners, policymakers, and researchers to optimise IBS implementation and foster sustainable construction practices. The findings of this study will contribute to the existing body of knowledge on IBS productivity and offer actionable recommendations to enhance labour efficiency, ultimately supporting the broader adoption of industrialised construction methods.

2. Labour Productivity

Labour productivity measures output per unit of labour input and is a key indicator of workforce efficiency, particularly in construction, where it impacts cost and schedule performance (Khor et al., 2023; Jatinkumar & Patel, 2020). Higher productivity improves resource utilisation and economic growth. Factors such as technology, training, and infrastructure investment play crucial roles in enhancing productivity (Karlson & Ozola, 2023).

2.1 Industrialised Building System (IBS)

IBS involves prefabricating building components off-site before on-site assembly, improving efficiency, quality, and safety (Othman et al., 2020; Alawag et al., 2023). In Malaysia, IBS adoption has grown significantly, supported by government policies like the Construction Industry Transformation Programme (CITP) 2016-2020 and National Construction Policy (NCP) 2021-2025, with implementation reaching 84% in government projects and 60% in private projects in 2021 (Bernama, 2023). IBS evolved from prefabrication and modular construction techniques, gaining prominence in the mid-20th century for its precision and efficiency (Khor et al., 2023). The U.S. adopted prefabrication for disaster relief, such as FEMA's hurricane-resistant modular shelters (Lee & Ma, 2021), demonstrating IBS's role in rapid, high-quality construction.

2.2 Benefits of IBS in Terms of Labour Productivity

IBS revolutionise construction through prefabrication, enhancing speed, efficiency, sustainability, and quality (Yusof et al., 2024). By manufacturing components off-site and assembling them on-site, IBS improves labour productivity in several keyways:

2.2.1 Enhanced Project Efficiency

IBS reduces on-site labour and construction time significantly. Prefabricated elements such as walls, beams, and slabs minimise on-site assembly tasks, cutting cycle times by up to 76% compared to conventional methods (Kadir et al., 2006). For instance, while traditional construction takes 17 days per house, IBS reduces this to just four days (Akinola et al., 2024). Controlled factory production also reduces errors, rework, and on-site disruptions, improving overall efficiency (Rocha et al., 2022; Alawag et al., 2023).

2.2.2 Increased Labour Productivity

IBS optimises labour use by shifting work to controlled factory environments, reducing on-site manpower needs (Rocha et al., 2022). Prefabrication ensures precision, minimising errors and rework, which enhances workforce efficiency (Adekunle et al., 2023). Faster project completion and higher output contribute to economic growth, particularly in Malaysia, where IBS adoption has boosted construction productivity (Ahmad et al., 2022).

2.2.3 Enhanced Quality Control

Factory-based production under strict quality controls ensures consistency and reduces defects (Ibrahim et al., 2022). Automated processes and skilled supervision minimise weather-related and craftsmanship issues common in traditional construction (Othman et al., 2020). This reduces rework, allowing labour to focus on productive tasks rather than corrections (Stennett et al., 2023).

2.2.4 Cost Savings

Though initially IBS costs are high, long-term savings arise from shorter construction times, reduced labour expenses, and lower maintenance (Ibrahim et al., 2022). Prefabrication cuts project timelines, reducing financing and equipment rental costs (Zhao & Yang, 2023). Standardised processes also decrease rework and labour hours, lowering overall expenses (Akinola et al., 2024).

2.2.5 Sustainability

IBS promotes resource efficiency by minimising waste through precise manufacturing (Alawag et al., 2023). Off-site production reduces construction debris and optimises material use (Ismail et al., 2023). Energy-efficient practices and eco-friendly materials further enhance sustainability (Lan, 2022). In conclusion, IBS significantly improves labour productivity by enhancing efficiency, quality, and cost-effectiveness while supporting sustainable construction. Its adoption aligns with global trends toward faster, greener, and more economical building practices.

2.3 Factors Affecting Labour Productivity in IBS Projects

Labour productivity in Industrialised Building System (IBS) projects is shaped by multiple interrelated factors, including workforce efficiency, team communication, work environment, technological integration, workload pressure, material quality, and worker health. A thorough understanding of these factors is essential for optimising productivity and ensuring successful project outcomes.

2.3.1 Efficiency of Workers

The specialised nature of IBS requires a skilled workforce adept at handling prefabricated components. A shortage of trained personnel often leads to project delays and increased costs (Andrew, 2022). Key elements influencing worker efficiency include:

- i. **Skills and Training:** Competent workers execute tasks with greater precision, minimising errors and rework (Jatinkumar & Patel, 2020). Conversely, inadequate training hampers productivity and compromises project quality (Akinola et al., 2024).
- ii. **Resource Allocation:** Delays in the supply of materials or equipment disrupt workflow, increase idle time, and reduce overall output (Almamlook et al., 2020). Efficient project management ensures timely and optimal resource distribution (Lan, 2022).
- iii. **Worker Motivation:** Motivated workers demonstrate higher productivity levels. Providing recognition, opportunities for career advancement, and a supportive work environment enhances morale and performance (Nasir et al., 2022). On the other hand, overworked or unappreciated employees tend to underperform (Rocha et al., 2022).

2.3.2 Communication in a Team

Effective communication is critical for coordination within IBS project teams. Miscommunication can result in errors, delays, and inefficiencies. Clear communication ensures team members understand their responsibilities, thereby reducing errors and rework (Nasir et al., 2022). Strong communication networks facilitate quick adaptation to project changes, maintaining workflow efficiency (Khor et al., 2023). Regular meetings and feedback sessions also enhance decision-making and collaborative problem-solving (Rocha et al., 2022).

2.3.3 Work Environment

A safe, clean, and organised work environment significantly enhances productivity by minimising disruptions and hazards. Safety practices, such as the use of personal protective equipment (PPE) and preventive measures, reduce accidents and downtime (Abas et al., 2018). A well-organised site reduces time lost searching for tools or materials (Hairi et al., 2020). Moreover, ergonomic designs and equipment mitigate physical strain, thereby improving worker performance (Nasir et al., 2022).

2.3.4 Use of Technology

Technology is a key driver of productivity in IBS through the use of automation and digital tools. Automation reduces dependency on manual labour and accelerates work processes (Karlsone & Ozola, 2023). Data analytics support real-time monitoring and informed decision-making (Abas et al., 2018). Additionally, digital maintenance systems optimise equipment upkeep, minimising operational downtime (Oladiran & Onatayo, 2019).

2.3.5 Work Pressure

Excessive workload and tight schedules negatively affect productivity. Stress and fatigue impair focus, increase the likelihood of mistakes, and contribute to worker burnout (Ponmalar et al., 2020). Fatigued employees are also more susceptible to accidents, compromising site safety (Izzati, 2018). Rushed work often leads to poor craftsmanship, necessitating rework and affecting overall quality (Almamlook et al., 2020).

2.3.6 Construction Materials

The quality and timely availability of construction materials directly influence productivity and structural performance. Poor-quality materials cause installation issues, delays, and rework (Nasir et al., 2022), and may compromise the structural integrity of the building (Hairi et al., 2020). Efficient logistics and supply chain management help ensure the consistent delivery of materials, avoiding workflow interruptions (Alawag et al., 2022).

2.3.7 Health and Well-being of Workers

Worker health is a crucial factor in maintaining consistent productivity. Illness-related absenteeism reduces workforce availability and delays project progress (Jatinkumar & Patel, 2020). Physically and mentally exhausted workers are less efficient and more prone to errors (Izzati, 2018). Mental health issues such as stress further impair focus and work quality (Hairi et al., 2020).

To sum up, labour productivity in IBS projects is influenced by a combination of skilled labour, effective communication, a safe and organised work environment, technological integration, manageable workloads, quality materials, and the health and well-being of workers. A holistic approach to addressing these factors is essential for enhancing productivity, ensuring efficient project execution, and promoting sustainable construction practices.

2.4 Ways to Increase Labour Productivity

Improving labour productivity in IBS projects is crucial for enhancing efficiency, reducing costs, and ensuring timely project completion. This can be achieved through targeted strategies focusing on workforce development, technology adoption, and effective project management.

2.4.1 Improve Workers' Training and Education

A well-trained workforce is fundamental to increasing productivity in IBS projects. Specialised training programs can equip workers with the necessary skills to handle prefabricated components efficiently (Karlson & Ozola, 2023). Key benefits include:

- i. **Reduced Errors:** Training in IBS assembly techniques minimises installation mistakes and rework (Ayorinde et al., 2021).
- ii. **Enhanced Safety:** Workers learn to adhere to safety protocols, reducing accidents and downtime (Zainuddin et al., 2022).
- iii. **Higher Efficiency:** Skilled labour completes tasks faster and with greater precision, improving overall output (Akbar et al., 2021).

Investing in continuous professional development ensures workers stay updated with the latest IBS technologies and methodologies.

2.4.2 Incentive Programs

Performance-based incentives motivate workers to maximise productivity and maintain high-quality standards (Zainuddin et al., 2022). Effective incentive strategies include:

- i. **Monetary Rewards:** Bonuses for meeting project milestones or reducing rework encourage efficiency (Alyew, 2020).
- ii. **Non-Monetary Benefits:** Recognition programs and career advancement opportunities boost morale (Ali, 2019).
- iii. **Timely Payments:** Ensuring workers receive wages promptly maintains motivation and reduces turnover (Alyew, 2020).

Incentive programs align worker goals with project objectives, fostering a results-driven work culture.

2.4.3 Utilisation of Technology

Adopting advanced technologies streamlines IBS construction processes and enhances labour productivity. This can be achieved by utilising:

- i. Building Information Modeling (BIM): Facilitates precise digital modelling, reducing design conflicts and rework (Zainuddin et al., 2022).
- ii. Automation and Robotics: Automates repetitive tasks like material handling, allowing workers to focus on complex activities (Ayorinde et al., 2021).
- iii. Real-Time Monitoring: Digital tools track progress and resource allocation, enabling proactive decision-making (Krishnan, 2022).

Technology integration minimises manual labour, accelerates workflows, and improves accuracy.

2.4.4 Collaborative Work Environment

A cooperative workplace enhances communication and coordination among stakeholders, leading to smoother project execution (Ayorinde et al., 2021). Key practices include:

- i. Open Communication Channels: Regular meetings and feedback sessions ensure alignment on project goals (Zainuddin et al., 2022).
- ii. Transparency: Encouraging knowledge sharing reduces misunderstandings and delays (Nawi et al., 2023).
- iii. Team Coordination: Effective collaboration between subcontractors and suppliers optimizes resource use and task scheduling.

A collaborative environment fosters problem-solving and innovation, driving productivity.

2.4.5 Effective Project Planning

Strategic planning is essential for maximising labour efficiency in IBS projects (Krishnan, 2022). Critical elements include:

- i. Resource Allocation: Proper scheduling of labour, materials, and equipment minimizes downtime (Zainuddin et al., 2022).
- ii. Risk Management: Proactive identification of potential bottlenecks prevents disruptions (Nawi et al., 2023).
- iii. Workflow Optimisation: Clear task delegation and realistic timelines ensure steady progress.

Efficient project management reduces waste, balances workloads, and maintains high productivity levels.

To sum up, enhancing labour productivity in IBS projects requires a multifaceted approach that involve investment in training to build a skilled workforce, implement Incentives to motivate and retain workers, leveraging technology for precision and efficiency, fostering collaboration to improve communication and coordination and optimising planning to ensure seamless project execution. By adopting these strategies, construction firms can achieve higher productivity, cost savings, and successful project delivery in IBS-based construction.

3. Methodology

The study was carried out quantitatively. Quantitative research methods generate numerical data and convert it into valuable statistics (Gnawali, 2022). Ge et al. (2022) explained that quantitative

research involves collecting and analysing numerical data to understand events, relations and trends. According to Gnawali (2022), however, quantitative research often uses structured instruments, such as surveys, experiments or statistical methods to collect and evaluate data. That is why the research strategy used in this research was online questionnaire survey that were distributed to the selected respondents among the established sample size through email, WhatsApp and Telegram. The questionnaire was designed into 3 sections which were 'Background of respondents', 'Factors affecting

A purposive sampling method was used to gather data from the research population. The population data were taken from the Construction Industry Development Board (CIDB) database (CIDB, 2024). The Raosoft sample size calculator was used to determine the number of respondents needed to achieve a desired level of accuracy (McCrum-Gardner, 2010), and the sample size was 146. However, only 90 feedbacks from architecture, engineering, and quantity surveying backgrounds who work with the G7 contractor organisations in the Klang Valley area met the requirements of the research meaning they had involved in IBS projects. Thus, the data were then be analysed descriptively using SPSS version 29 software.

4. Findings and Discussion

This section discussed the research findings based on the first objective, which is the factors affecting labour productivity. But firstly, let's look at the demographic of the respondents. Respondents' average age is 41.36 years, and their average experience in the construction sector is 15.36 years. This alignment implies that those individuals get more professional experience as they age. Accordingly, age substitutes maturity and exposure, contributing to the skills, knowledge, and experience essential for labour productivity in IBS projects. For example, Maqsoom et al. (2022) investigated the influences of age and industry experience on construction worker productivity and identified the effect of employee factors, such as age, on productivity performance.

There are seven factors that are related to the productivity of the labours in IBS projects. Table 1 highlights the most critical factors influencing IBS projects regarding labour productivity. With a mean score of 4.37, "Work environment," particularly "strong safety procedures," came in first, highlighting how crucial safety is to sustaining productivity. In IBS projects, where accuracy and compliance are essential, a suitable safety procedure reduces accidents and disruptions and guarantees that employees can concentrate on their jobs without worrying about getting hurt. Given that appropriate safety measures at construction sites do not only shield workers from injury but also ensure smooth operations which boosts productivity. According to Abas et al. (2018), demonstrates that structured settings minimise disturbances and enhance the efficiency of construction processes. Besides minimising the chances of accidents, having a safe and orderly environment would make it easier for workers to focus, leading to less interruption of activities and better management of projects.

With a mean score of 4.34, "Communication in the team," which emphasises clear and transparent channels, came in second, demonstrating its importance in productive teamwork. Clear communication improves productivity by lowering miscommunication, boosting teamwork, and guaranteeing tasks are finished on schedule and to a high quality. This agrees with Khor et al. (2023), who emphasise the importance of transparent communication channels to maintain teamwork and reduce mistakes. The respondents stated that open communication eased teamwork and ensured that everyone in the team knew their roles and responsibilities, both of

which were significant in the chaotic IBS environment. Rocha et al. (2022) also highlighted how it is essential to have good communication throughout to pivot as fast as possible based on unexpected obstacles and to ensure projects are still on track. It constantly updates the team on what they are expected to do, especially in a fast-paced environment such as IBS projects. Poor communication leads to misunderstandings, delays, and waste of resources in general, which, in turn, results in a reduction in production (Sweis et al., 2020). Given its effect on workforce availability and productivity, "health and well-being of workers" came in third (4.31). In addition to delaying schedules and lowering the quality of work, poor health might limit the availability of skilled workers. A stable and experienced workforce may be maintained by placing a high priority on employee well-being.

Other factors that might affect project results include "Construction material (material quality)" (4.02), "Efficiency of workers" in terms of sufficient training (4.04), and "Work pressure" (4.17). Material quality, with a mean of 4.02, was seen to affect efficiency, for instance, where poor materials led to delays and rework. This result is consistent with the work of Nasir et al. (2022), which states that selecting good-quality supplies can prevent waiting time. Another similarity is work pressure, with a mean score of 4.17, which also reveals that stress and physical tiredness tend to decrease productivity. As indicated by the conduct surveys, "sufficient training" got an average score of 4.04, meaning that employees must have the required skills for IBS projects. This finding is also supported by the report of Jatinkumar & Patel (2020), who stated that employees with assumed competency are better suited to dealing with complex jobs and thus increase productivity. Lastly, "The use of technology" received the lowest score (3.98) but still emphasised its importance for equipment maintenance and mistake reductions. Overall, the findings highlight the important factors which will affect the labour productivity in IBS project.

Table 1: Summary of ranking for Factors Affecting Labour Productivity in IBS Projects.

RANKING	ITEMS	MEAN SCORE
1	Work environment (Strong safety procedures)	4.37
2	Communication in the team (Establishing clear and transparent channels of communication)	4.34
3	Health and well-being of workers (Employees with poor health may result in a reduction of the workforce and lower overall productivity)	4.31
4	Work pressure (Workplace stress can cause physical exhaustion in employees)	4.17
5	Efficiency of work (Sufficient training)	4.04
6	Construction material (Could enhance or reduce the overall project)	4.02
7	The use of technology (Using technology for equipment maintenance and frequent inspection helps guarantee that tools are in peak condition)	3.98

Next, the findings for the second objectives are presented. The rankings of ways to increase labour productivity in projects are shown in Table 2. "Effective project planning" (mean score 4.37), the top-ranked way, is closely related to labour productivity as it guarantees efficient workflows, reduces mistakes, and increases total site efficiency. Lan (2022) mentioned that planning carefully to foresee obstacles and distribute the resources efficiently is necessary to reduce delays and inefficiencies. Additionally, everyone involved in a project must cooperate for coordinated planning to succeed. Optimal scheduling, resource allocation, and job execution are made possible by effective planning, which all improve worker performance.

By encouraging employees to perform better, the second-ranked strategy, "Incentive program" (mean score 4.33), also directly correlates with labour productivity. It has been demonstrated that incentives boost employee happiness, motivate more effort, and enhance total output, which is

essential for accomplishing project objectives in the IBS building. "Utilisation of technology" (mean score 4.22) is another crucial factor because it can improve accuracy, decrease errors, and simplify repetitive tasks. By incorporating advanced tools into IBS projects, workers can work more productively and concentrate on higher-value tasks. Finally, although it received a somewhat lower rating, "Improve labour training and education" (mean score 4.14), it is still crucial for labour productivity. The proper training minimises errors during assembly and installation by giving employees the abilities and information they need to handle IBS components efficiently. Although it may not be as instantly beneficial as the other ways, it is a long-term investment in establishing a competent and experienced team for IBS projects.

Table 2: Summary for Method to Increase Labour Productivity in IBS Projects

RANKING	ITEMS	MEAN SCORE
1	Effective project planning (Optimise procedures, eliminate mistakes, and boost overall efficiency)	4.37
2	Incentive program (Leads to better project results and customer satisfaction)	4.33
3	Collaborative work environment (Makes the construction work across different teams and subcontractors be timely coordinated)	4.32
4	Utilisation of technology (Lowers mistakes and inconsistencies)	4.22
5	Improve labour training and education (Leads to fewer errors during assembly and installation)	4.14

5. Conclusion

The research concludes that although IBS has the potential to transform the construction sector, its implementation calls for addressing significant barriers and implementing focused ways to improve labour productivity. By emphasising stakeholder collaboration, technology integration, and workforce development, IBS can significantly improve project outcomes and support the long-term expansion of the construction industry. This research serves as a foundation for future studies to explore broader scopes, deeper technological integrations, and the long-term impacts of IBS, paving the way for innovative and sustainable construction practices. Addressing these factors holistically can significantly improve efficiency and project outcomes in IBS construction.

Acknowledgement

We extend our gratitude to the International Virtual Go Green (iVGG) 2025 committee for providing a platform for researchers to share knowledge and network, as well as to the Asian Scholars Network for publishing this article. Furthermore, the authors sincerely thank the International Undergraduate Conference 2024 (IUCon2024) and Universiti Teknologi MARA, Perak Branch, for their invaluable support through the publication incentive, which has significantly contributed to promote the publication spirit among the committee members. This financial assistance has facilitated the dissemination of this research and underscored the importance of academic contribution and knowledge sharing.

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this research.

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